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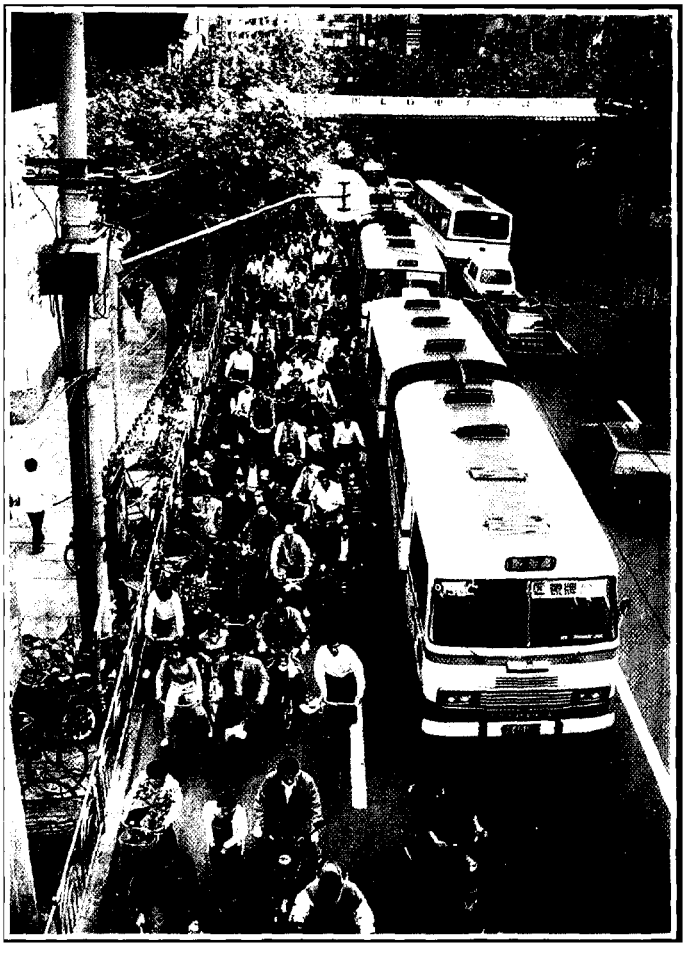
WORLD BANK DISCUSSION PAPER NO. 352

East Asia and Pacific Region Series

China's Urban Transport Development Strategy

Proceedings of a Symposium in Beijing, November 8–10, 1995



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Stephen Stares, until his death in 1996, was senior transport specialist in the Environment and Municipal Development Operations Division of the World Bank's China and Mongolia Department. Liu Zhi is a transport economist in the Transport Division of the Bank's Transportation, Water, and Urban Development Department.

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FOREWORD

The China Urban Transport Symposium, jointly sponsored by the Ministry of Construction, the Ministry of Finance, the People's Bank of China, the World Bank, and the Asian Development Bank, was successfully held in Beijing during November 8-10, 1995. The symposium and the publication of its proceedings is very timely, as China's economy is poised to grow rapidly into the twenty-first century, and yet Chinese cities are grappling with increasingly serious transport problems posed by rapid economic growth.

The symposium brought together senior policymakers from the Central Government and a number of major cities, prominent international and domestic urban transport experts, and staff of the World Bank and Asian Development Bank, to discuss and clarify the complex issues facing China's urban transport sector and to debate future directions for urban transport policy and strategy. Many important themes were covered; they included motorization, motor vehicle pollution, urban transport management, bicycles in cities, mass rapid transit, public transit reform, the role of the private sector, transport pricing, and urban transport planning. We hope that the success of the symposium will serve as an auspicious beginning to a new era of sustainable urban transport development in China.

We would like to dedicate the publication of these proceedings to the memory of Mr. Stephen Stares, Senior Transport Specialist with the World Bank's China and Mongolia Department at the time of his death. His vision in originating the call for this nationwide symposium and his constant attention to detail in its development and presentation lay at the heart of its success.

Li Zhendong
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Ministry of Construction

Jin Liqun
Assistant Minister
Ministry of Finance

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Deputy Governor
People's Bank of China

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Asian Development Bank

ABSTRACT

This Discussion Paper presents the proceedings of China Urban Transport Symposium that was held in Beijing during November 8-10, 1995. The symposium was jointly sponsored by the Ministry of Construction, the Ministry of Finance, the People's Bank of China, the World Bank, and the Asian Development Bank, and was attended by senior policymakers from the Central Government and a number of major cities, prominent international and domestic urban transport experts, and staff of the World Bank and Asian Development Bank. The major purposes of the symposium were to provide a forum for the discussion of increasingly serious urban transport issues and provide a basis for clarifying future directions for urban transport policy and strategy in China. The symposium covered a wide range of important themes, including motorization, motor vehicle pollution, urban transport management, bicycles in cities, mass rapid transit, public transit reform, the role of private sector, transport pricing, and urban transport planning.

CURRENCY EQUIVALENTS

(As of November 1995)

Currency name = Renminbi
Currency unit = Yuan

$1.00 = Y 8.5
Y 1.00 = $0.12

FISCAL YEAR

January 1 - December 31

WEIGHTS AND MEASURES

Metric System

ABBREVIATIONS AND ACRONYMS USED

8FYP	-	Eighth Five-Year Plan (1991-1995)
9FYP	-	Ninth Five-Year Plan (1996-2000)
µg/dl	-	Micrograms per Deciliter
µm	-	Micrometer or Micron
ARF	-	Additional Registration Fee
BOT	-	Build-Operate-Transfer
CAA	-	Clean Air Act
CARB	-	California Air Resources Board
CAUPD	-	China Academy of Urban Planning and Design
CFCs	-	Chlorofluorocarbons
CNAIC	-	China National Automotive Industry Corporation
CNG	-	Compressed Natural Gas
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
COE	-	Certificate of Entitlement
CRD	-	Central Retail District
ECE	-	United Nations Economic Commission for Europe
EIRR	-	Economic Internal Rate of Return
EPA	-	Environmental Protection Agency
ERP	-	Electronic Road Pricing
ETBE	-	Ethyl Tertiary Butyl Ether
FAR	-	Floor Area Ratio
FRT	-	First Registration Tax
GDP	-	Gross Domestic Product
GNP	-	Gross National Product
HC	-	Hydrocarbon
HEI	-	Health Effects Institute
HOV	-	High-Occupancy Vehicle
IARC	-	International Agency For Research on Cancer
I/M	-	Inspection and Maintenance
IQ	-	Intelligence Quotient
ISO	-	International Standards Organization
KCR	-	Kowloon-Canton Railway
kPa	-	Kilipascal
LEV	-	Low-Emission Vehicle
LPG	-	Liquefied Petroleum Gas
LRT	-	Light Rapid Transit
LTA	-	Land Transport Agency
LTD	-	Land Transport Department
LTE	-	London Transport Executive
m^3	-	Cubic Meter
MRT	-	Mass Rapid Transit
MTBE	-	Methyl Tertiary Butyl Ether
MTR	-	Mass Transit Railway
MV	-	Motor Vehicle
NGO	-	Nongovernmental Organization
NH_3	-	Ammonia

NMHC	-	Nonmethane Hydrocarbons
NO_2	-	Nitrogen Dioxide
NO_x	-	Nitrogen Oxide
O&M	-	Operation and Maintenance
O-D	-	Origin-Destination
OMV	-	Open-Market Value
PARF	-	Preferential Additional Registration Fee
PM	-	Particulate Matter
PM_{10}	-	Particulate Matter of 10 Microns or Less in Size
POM	-	Polycyclic Organic Matter
pphpd	-	passengers per hour per direction
psi	-	per square inch
PTA	-	Passenger Transport Authority
PTE	-	Passenger Transport Executive
RON	-	Research Octane Number
RVP	-	Reid Vapor Pressure
SACI	-	State Administration of Import and Export Commodity Inspection
SO_2	-	Sulfur Dioxide
SOF	-	Soluble Organic Fraction
SPC-ITE	-	Institute of Techno-Economics of the State Planning Commission
SPM	-	Suspended Particulates
TBA	-	Tertiary Butyl Alcohol
TOG	-	Total Organic Gases
TSP	-	Total Suspended Particulates
TVE	-	Township and Village Enterprise
UK	-	United Kingdom
US	-	United States
VMT	-	Vehicles Miles Traveled
VOCs	-	Volatile Organic Compounds
WHO	-	World Health Organization

INTRODUCTION AND OVERVIEW

LIU ZHI AND STEPHEN STARES [1]

INTRODUCTION

The papers in this volume were presented at the China Urban Transport Symposium, held November 8-10, 1995, in Beijing. The symposium was jointly sponsored by the Ministry of Construction (MCon), the Ministry of Finance (MOF), the People's Bank of China (PBC), the World Bank (IBRD), and the Asian Development Bank (ADB). The symposium provided a forum for the discussion of increasingly serious urban transport issues and provided a basis for clarifying future directions for urban transport policy and strategy in China.

The symposium was attended by over 180 delegates and twelve theme papers were presented covering a wide range of themes, including motorization, motor vehicle pollution, urban transport management, bicycles in cities, mass rapid transit, public transit reform, the role of the private sector, transport pricing, and urban transport planning. This was followed by two parallel open discussions on two of the key themes of the symposium: Dealing with Motorization and Developing Public Transport.

There was a remarkable degree of agreement reached at the end of the symposium between domestic and international delegates on the key urban transport issues facing Chinese cities. In particular, there was general recognition that a comprehensive approach to urban transport was required which balanced transport infrastructure construction with transport policy measures. The Concluding Statement of the Symposium summarized this consensus, and set out five principles, four criteria, and eight actions to underpin the urban transport strategy for China, and to guide future assistance from IBRD and ADB. The full text of this statement is placed immediately following the Overview below.

OVERVIEW

Opening Remarks and Keynote Addresses

The opening remarks were made by leaders or representatives of some of the sponsoring institutions. They were Hou Jie (MCon), Anthony Pellegrini (IBRD), Jin Liqun (MOF), and Timothy Peterson (ADB), respectively. All their remarks touched upon the major urban

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transport issues that China's cities are currently facing and the opportunities that China has in addressing these issues.

Hou Jie, Minister of Construction, first provided an overview of China's urban transport development in recent years, and highlighted the Ninth Five-Year Plan for urban transport development and the longer-term development targets set by the Central Government. Despite considerable efforts made in recent years, he observed, urban transport infrastructure and services are still deficient, and the problem will likely become worse. The Central Government clearly has made a strong commitment aimed at major improvements in urban transport by the year 2010. Achieving this, however, as Hou pointed out, will be especially challenging, and would not be possible without further policy and management reforms in the sector.

Sustainable transport development was the central topic of Anthony Pellegrini's opening remarks. Indeed, this is also IBRD's long-standing stance toward urban transport assistance in developing countries. Noting the unprecedented pace of economic growth and the severity of adverse impacts of rapid motorization, Pellegrini stressed the need for effective policies to guide sustainable urban transport development. This, Pellegrini further emphasized, requires that urban transport policies and actions be evaluated with three complementary criteria—economic and financial sustainability, social sustainability, and environmental sustainability.

Jin Liqun's remarks touched upon the efficiency issue in urban transport investment. Achieving higher efficiency, he observed, requires careful planning, realistic implementation, and better management. He pointed out that while every effort should be made to increase urban transport investment, greater attention should also be paid to the efficient use of available funds.

Three key issues in China's urban transport—rapid motorization, the role of public transit, and the role of bicycle—were discussed in Timothy Peterson's remarks. He compared China's motorization with similar development in the Asia-Pacific region, and pointed out that the symposium was at the right time where policies and actions could be sorted out before motorization was too far advanced. He urged China to take early action to avoid repeating the errors made by other countries.

The opening remarks were followed by three keynote addresses. Li Zheng Dong, Vice Minister of Construction, focused on urban transport sector reform. He emphasized the role of the market mechanism in the efficient provision of urban transport, and sketched several reform schemes. These include competitive bidding in urban transport infrastructure project design and implementation, municipal transport management reform, fuel taxation, public transit franchising, and the separation of government ownership from the operation of transport enterprises.

In the second keynote address, Professor John Meyer put China's urban transport in both historical and economic perspectives, by comparing the process with the one experienced in the West. He discussed the complicated nature of urban transport problems and the major dilemmas that would be faced by policymakers and planners in China. He emphasized the role of pricing in the containment of negative externalities generated by rapid motorization. He also drew the Western experience of public transit decline and predicted that a major challenge for China is to develop a public transport system that can increasingly compete with improved individualized

transportation. In terms of urban transport infrastructure provision, Professor Meyer warned of the danger of "thinking too big" without sufficient prior planning.

Finally, in the third keynote address, Professor Zhou Ganshi offered a detailed assessment of the extent of current transport problems in large Chinese cities. The future growth of the vehicle fleet at the current rate and the required expansion of urban road space, he predicted, will pose serious land-use problems to large cities where the land constraint is most severe. Therefore, he called for government actions to control private cars in cities.

Theme Papers

Among the twelve theme papers, three were written by domestic authors and nine by international authors. All authors had substantial experience relating to the subjects they discussed in their papers. Most of the international authors, moreover, had extensive experience in China's urban transport and were familiar with the issues involved. During the preparation of these papers, a joint MCon, CAUPD, IBRD, and ADB sector mission, comprising most of the theme paper authors, visited five selected cities (Beijing, Shanghai, Guangzhou, Chengdu, and Jinan) and obtained useful first-hand information on the recent development of urban transport in China's large cities. The key messages from these theme papers are summarized as follows.

Motorization

Motorization in China is at an early stage but is rapidly gathering momentum. Moreover, the Central Government has recently promulgated an auto industry development policy that aims at promoting the auto industry through the promotion of the domestic market. Examining the issues associated with motorization in cities, therefore, is especially urgent at this time.

Stephen Stares and Liu Zhi dealt with the broad issues of motorization in cities, with particular attention to traffic congestion. They first reviewed the trends in motor vehicle ownership in China and predicted continuing rapid growth in the fleet in line with China's strong economic growth. They noted that considerable benefits from increasing motorization would be rapidly dissipated without proper policies to control pollution and congestion. Then, they moved on to discuss in length two broad approaches to dealing with traffic congestion: expanding street and road capacity to absorb the growth in traffic, and managing the growth in traffic to match the available capacity. Much can be done on the first approach, through improved management of the existing street system, allocation of priority road space to public transit, and construction of new streets and roads. However, this approach on its own would not be sufficient to accommodate rapid growth in demand for vehicle transport. Hence, the second approach, which includes a wide range of pricing and nonpricing options, is necessary and should be applied in Chinese cities.

To provide an international perspective, they also examined the urban transport experience in other Southeast Asian cities that have been coping with motorization for longer than China. They noted that the relative degree of success or failure in controlling traffic congestion seems to depend on the extent of control and intervention exercised by Government in the areas of land-use control, vehicle ownership and/or vehicle usage controls, and provision of good public transport services. Finally, in commenting on the auto industry development

policy, they noted that cities should be given the freedom to set limits to motor vehicle use consistent with sustainable growth, and should not be under pressure to accommodate faster growth to satisfy auto industry demands. Their analysis showed that a viable auto industry can be established on the basis of domestic demand, and controls on motor vehicle ownership in large cities will not endanger the viability of the auto industry.

Motor Vehicle Pollution

Environmental pollution is a very serious problem for China to cope with during rapid economic growth. Increasing motorization is likely to make the situation worse. Michael Walsh identified the nature of motor vehicle pollution and discussed in great detail the national and local strategies to reduce or ameliorate adverse impacts. He noted that China's motor vehicle pollution is increasingly serious in both absolute terms and relative to nonmobile sources of pollution. He further noted that China's motor vehicle fleet (including the motorcycle) has a large proportion of high-polluting vehicles using outdated engine technology, and there are few programs to detect illegal emission levels and to enforce standards. Moreover, gasoline is still almost entirely leaded, adding a particularly dangerous component to air pollution. With motorization still at an early stage in China, Walsh pointed out, there are opportunities to introduce pro-environment policies with some initial cost but with relatively high long-term benefits. He drew on international experience to show that motor vehicle pollution control strategies can be very effective. These include policies on cleaner fuels (in particular, a move to unleaded gasoline) and mandates on motor vehicle emissions.

Municipal Transport Management

Rapid economic growth is putting China's urban transport management system under pressure. The current institutional responsibilities for many urban transport functions are not clear-cut and are overlapping in many cases. Obviously, a more effective municipal transport management system is much needed for effectively tackling the growing urban transport problems. A pair of papers discussed this issue.

Wu Yong, Wang Jianqing and Yao Zukang provided an overview of urban transport institutional development in China. They first reviewed various municipal responsibilities ranging from legal framework, to policy-making, pricing, infrastructure and service management, traffic management, and financing. They noted that the current system is the legacy of the command economy and has become inefficient during the transition to a market economy. They identified the strengths and weaknesses of the existing municipal administrative frameworks, and reported on the current thinking about possibilities for reform. In particular, they stressed that municipal transport policies should be made primarily at the municipal level, and that urban transport commercial functions should be separated from government planning and regulatory functions.

Richard Meakin commented on current Chinese municipal transport management from an overseas perspective. Modern urban transport, he observed, is a complex process that requires a coordinated approach and requires institutions to implement policies that cut across the current subdivisions of the urban transport sector in most municipalities, but the current multitude of agencies has little horizontal integration and this impedes consistent transport

planning. Moreover, municipal governments in China are responsible for nearly all aspects of urban transport including planning, financing, construction, operation, and regulation, and an efficient market economy requires that the cities separate these functions and shed some of them. Appropriate roles for the municipality, Meakin suggested, are in financial planning and management, transport planning, construction management, traffic management planning and implementation, formulation of demand management policy, transport pricing policy, and transport regulation. Appropriate roles to be shed to corporatized entities, and perhaps eventually to the private sector, are transport operations, infrastructure design and construction, and perhaps infrastructure maintenance.

The Role of the Bicycle

Chinese cities are well known for bicycle use. Half of all nonwalking urban journeys in major cities use the bicycle. Amid growing motorization, however, some city managers see the bicycle as a significant cause of traffic congestion and traffic accidents, and want to discourage its use in city centers. Others see the bicycle as a cheap, readily available, and nonpolluting mode of transport that should be further encouraged. Clearly, there is an urgent need for clarifying the role of the bicycle in cities.

A.G. Welleman, C.J. Louisse and D.M. Ligtermoet used a comparative approach to examine the role of the bicycle. They first examined bicycle policies in the Netherlands and other countries. Their analysis of the revival of bicycle use in the Netherlands after a period of decline indicated strong grounds for increasing bicycle use in developed countries because of growing environmental awareness. They then reviewed development in bicycle use in Chinese cities and noted many similarities with the Netherlands. They urged that for reasons of equity and economic efficiency, the role of bicycles be retained in city transport policies. Even with rapid economic growth, bicycles will remain the only easily affordable means of transport for a large segment of the population for many years to come; it makes little sense to dismantle the currently impressive bicycle facilities in Chinese cities. Finally, they offered several recommendations to Chinese municipal governments for better bicycle policy.

Mass Rapid Transit

Currently, only a few Chinese large cities already have, or are building, metro systems, but a dozen other cities are planning them. Is metro the solution to urban transport problems? This issue was examined by Roger Allport. He first reported the recent findings on mass rapid transit in other countries and then related their applicability to the needs of Chinese cities. He noted that metros are mega-investments and are most unlikely ever to be fully viable financially, covering all costs of construction and operation, even in the largest cities. Therefore, the financial consequences of metros, both for initial capital investment and for operating budgets thereafter, must be thought through very carefully. A common mistake, Allport pointed out, is that most cities tend to take a narrow approach to planning metros with major decisions taken mostly on engineering rather than transport planning grounds, and with many key decisions made before looking for financing schemes. Metros on their own, Allport noted further, cannot be the solution, or even in most cities a major part of the solution, to mass transit needs. This is partly because the cost and complexity of the systems will postpone construction for many cities, and partly because they can serve only relatively narrow corridors. Allport then stressed that bus

transit for most cities will be the only affordable form of mass transit for many years, and it must be improved to meet immediate needs before conditions are mature enough for metro systems. Allport also examined the lower-cost alternatives to metro systems. In particular, he pointed out, busways are a viable alternative to metro and light rail, and have some key advantages over rail-based systems. An approach to providing mass transit facilities might be to install busways as a municipally-funded investment, to be replaced by rail facilities at a later date if sufficiently high demand develops.

Public Transit Reform

Recognizing the social consequences of uncontrolled motorization and the difficulties of treating bicycle traffic, public transit appears to be the obvious solution to much of the urban transport problem in China. However, many Chinese city public transit operators are experiencing declining patronage at a time when urban mobility is increasing with greater affluence. Wang Jinxia, Zhang Kuifu and Qiao Junshan provided an overview of public transit development in China, and reported on the recent development in public transit reform. They first discussed the major factors that are affecting public transit development in China. They noted that public transit is currently confronting a number of internal and external difficulties, and to overcome these, public transit reform must be continued and deepened. They also maintained that while continuing to encourage market competition, municipal governments should also continue to play an important role in public transit provision.

Bus transit reform is also a major topic in urban communities worldwide, and there is a large body of international experience in dealing with the underlying issues. The key issues relate to the management of bus operations and the appropriate role of municipal government. In presenting options of relevance to China, John Flora outlined lessons learned and experiences, both good and bad, that other countries have had in developing their bus transit systems. Bus services in many developing countries deliver a range of product types at no cost to the public sector, but bus transit does not play its due role in China for various historical reasons. There is considerable potential for revitalizing the bus industry. Bus companies should be given responsibility for operations and finance. This requires disentangling municipal bus operations from municipal bus regulation. Municipal governments will still play an important role, Flora stressed, in determining the level of standards, fares, and operational procedures most appropriate and acceptable to their communities. He further discussed steps of transition to more efficient bus operations. These include corporatization and private-sector involvement. Finally, Flora pointed out that establishing more efficient bus companies will not be sufficient, and for buses to deliver adequate service, road space and traffic priorities must be allocated to buses.

The Role of the Private Sector

The shortage of funds for transport infrastructure financing has become a common problem to most municipalities. Private-sector involvement thus provides an alternative. The private sector, mostly in the form of foreign investors, is already active in China's urban transport, particularly in bus operations and infrastructure investments. K.H. Lee discussed various facets of private-sector participation in urban transport projects, the impacts on government policies and practices, and the problems confronting the investors. He noted that private-sector investments involve a number of legal and operational issues, and Government

must set transport strategy and the project financing policy to guide the process. While private-sector involvement is a promising alternative to public funding, Lee cautioned, the private sector is unlikely to make a large contribution to urban transport infrastructure funding in the short term. However, any promising projects for private funding would likely be large in scale and would require careful definition and management.

Transport Pricing

Transport prices in Chinese cities have evolved over time and are bound up in complex systems of transport subsidy, earmarking, general municipal financing, and national taxation. Market policies and good governance require that prices be rationalized, and transport policy requirements should influence this process. In particular, there is an opportunity to introduce pricing mechanisms to help manage the demand for, and usage of, the private motor car before usage levels overwhelm city street systems. Kenneth Gwilliam's theme paper provided an primer on the role and impact of prices in urban transport. He showed how incorrect pricing leads to distortions in behavior and creates financing burdens for municipalities. He also discussed the role of pricing in managing the growth of motor vehicles and the use of scarce road space, and in infrastructure financing. These discussions offered general guidelines for the formulation of transport pricing policy. Gwilliam particularly emphasized the role of road user charges, or their proxies such as parking charges and taxation, on car ownership and use. The road user charges, Gwilliam pointed out, can help finance the provision of urban infrastructure, thus reducing financial dependence on land leasing. If the use of road infrastructure is correctly priced, moreover, bus companies can operate commercially and be totally self-financing, thus also reducing the burden on municipalities.

Urban Transport Planning

There is a widely recognized link between urban land use and transport. Most city authorities appreciate the need to consider the transport implications of land-use plans and regulations. Chinese cities formalize this in the master planning process. The master planning process, however, is currently under intense pressure to cope with rapid economic growth, the evolution of land markets, and the growing demand for better quality transport. Li Xiaojiang and Yu Li assessed the strengths and weaknesses of the current city master planning and transport planning process. They observed that the current planning process is seriously challenged by rapid urban growth, emerging land markets, the floating population, and decentralization of government decisions for transport investment. They noted that urban land use will be more and more guided by the market mechanism, but they argued that government interventions are needed to control the negative spillover effects. In finding solutions to the urban transport problem, Li and Yu noted that public transit and bicycles will continue to be the major modes of urban passenger transport for an extended period of time, and therefore, transport planning and management should give priority to them. Finally, they argued that policies for private car development should be based on objective and careful analysis. Infrastructure development should allow some room for future expansion of private car ownership, but managing demand to prevent growing congestion will be more urgent and important.

In another theme paper, Ralph Gakenheimer discussed the role of planning in transport investment and management at both the strategic and micro levels. He described in detail the

hierarchical structure and the elements of a comprehensive urban transport planning system. He emphasized that urban transport planning should be a process to achieve agreement and commitment to a consistent and affordable plan of action. All plans need to be set in the context of quantitative justification and realistic budget envelopes. For China, he suggested, the current procedures, which treat transport components as a residual of land use-oriented master planning, must be evolved further to meet the increasingly challenging urban transport planning problems.

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CONCLUDING STATEMENT OF THE SYMPOSIUM

KATHERINE SIERRA [1]

On November 8-10, 1995, a Symposium was held in Beijing on China's urban transport development strategy sponsored by the Ministry of Construction, the Ministry of Finance, the People's Bank of China, the World Bank and the Asian Development Bank. This statement closed the Symposium proceedings.

Two to three years ago, only the very largest municipalities were concerned about urban transport. Water supply and sewage disposal seemed more urgent problems. This has changed for one very clear reason: the rising number of motor vehicles—cars, trucks, taxis and motorcycles—has resulted in a sharp increase in traffic congestion. What can be done about it? Urban transport is complex. Action is needed in many areas at the same time—policy, institutions, management, prices, infrastructure construction, and other investments. It does not help to solve one problem if others are ignored. There was considerable agreement among the delegates on the general lines of actions to be taken. These have been brought together below classified under:

Five Principles
Four Criteria
Eight Actions

The *five principles* represent themes that should guide urban transport planning and operations at this time in China's development:

1. Transport is about moving people and goods, not vehicles
2. Transport prices should reflect full social costs
3. Transport reforms should be deepened to align with socialist market principles so as to increase efficiency
4. The role of government should be to guide transport development
5. The role of the private sector in providing transport services should be encouraged

[1] At the time of the symposium, Katherine Sierra was Chief, Environment and Municipal Development Operations Division, China and Mongolia Department, The World Bank; she is now Operations Advisor, Quality Assurance Group, Executive Offices, The World Bank. This statement was drafted jointly by a team from the Ministry of Construction (MCon), the World Bank (IBRD), the Asian Development Bank (ADB) and the China Academy of Urban Planning and Design (CAUPD), headed by Katherine Sierra, who also delivered the statement at the closing of the symposium. Team members included Wu Yong, Dong Li, Lu Yingfang and Lin Kai of MCon; Stephen Stares, John Flora and Liu Zhi of IBRD; Charles Melhuish of ADB; and Li Xiaojiang and Li Yaming of CAUPD.

City plans and policies for managing transport should meet *four criteria*:

1. Environmental sustainability
2. Economic viability
3. Financial affordability
4. Social acceptability

Consistent with these principals and criteria, *eight actions* are recommended:

1. Reform urban transport administration
2. Upgrade the status of traffic management
3. Prepare a strategy to mitigate motor vehicle air and noise pollution
4. Develop policies to manage traffic demand
5. Develop a strategy for mass transit
6. Reform public transport management and operations
7. Develop a financing strategy for the transport sector
8. Strengthen the framework for transport planning and capacity building

Principle 1: Transport is about Moving People and Goods, not Vehicles

Priorities for the use of road space should be allocated to transport operations according to their relative efficiency in moving people and goods. Where appropriate, this will mean giving priority to public transport, bicycles, and pedestrians.

Principle 2: Transport Prices Should Reflect Full Social Costs

Social costs represent the total costs of transport, including those costs imposed on society through transport operations, in particular:

- by environmental pollution (health, medical, productivity loss)
- by congestion

Principle 3: Transport Reforms should be Deepened to Align with Socialist Market Principles so as to Increase Efficiency

The move to the market has started in the transport sector, but the process now needs to be extended, particularly in the fields of:

- introducing competition
- the pricing of public transport services
- the ownership, operation, and regulation of public transport enterprises
- wider use of user fees

Principle 4: The Role of Government is to Guide Transport Development

This is done through:

- establishing a stable and transparent legal and regulatory framework
- setting and enforcing technical standards
- preparing transport plans and strategies
- financing strategies for infrastructure development
- setting pricing policies, including:
    - ◊ determining need for subsidies to disadvantaged sectors of society
    - ◊ imposing tolls (taxes, fees) to ensure transport prices reflect social costs
    - ◊ mitigating monopoly profits and pricing
- strengthening the role of municipal government while retaining the role of National Government in providing macroeconomic guidelines

Principle 5: The Private Sector should have a Major Role in Providing Transport Services

There is considerable scope for private sector services to supplement or replace current government operations:

- Bus service provision and operation
- Car parking provision and operation
- Consulting services including infrastructure planning and design
- Construction contracting
- Funding of major infrastructure projects

Criteria 1: Environmental Sustainability

Actions and initiatives should be included to mitigate adverse impacts on the health and welfare of citizens and the depletion of natural resources.

Criteria 2: Economic Viability

Priority should be given to projects showing the highest economic returns measured in terms of the full resource costs of inputs.

Criteria 3: Financial Affordability

Transport systems and projects should be planned only in the context of realistic financing strategies for investment and operations.

Criteria 4: Social Acceptability

The transport needs of all sectors of society should be catered for, and particular attention paid to the needs of the poor and otherwise disadvantaged members of society. Social impacts of transport initiatives should be mitigated, in particular for those whose housing and businesses must be re-located to make way for new transport construction.

Action 1: Reform Urban Transport Administration

At the National Level

- Consider the roles of each National Ministry or Bureau involved in urban transport, and their links to counterpart Municipal agencies, and the need for, and content of, enabling legislation.

At the Municipal Level

- Separate Government planning and regulatory functions from the commercial functions of municipal enterprises
- Establish working groups to coordinate the planning and implementation of transport policies and plans
- To the extent possible, open the market to the private sector

Action 2: Upgrade the Status of Traffic Management

- Establish a higher municipal authority for traffic management programs
- Integrate the functions of different agencies:
  - ◊ Initially, promote interagency coordination
  - ◊ Later, restructure the responsible agencies
- Develop a traffic management strategy
  - ◊ establish functional hierarchy of roads
  - ◊ allocate road space to priority users, including bicycles and buses
  - ◊ implement action plans
- Develop programs to enhance road safety

Action 3: Prepare a Strategy to Mitigate Motor Vehicle Air and Noise Pollution

At the National Level:

- establish a schedule to reduce or eliminate lead in gasoline
- set emission standards for new vehicles

At the Municipal Level:

- implement vehicle inspection and maintenance programs
- investigate use of alternative (cleaner) fuels
- mitigate the adverse noise and emission impacts of new transport infrastructure

Action 4: Develop Policies to Manage Traffic Demand

- Establish a strategy for the development, control and pricing of parking in city centers
- Evaluate other policies for controlling the use of motor vehicles in city centers, including quotas, access restrictions, and road use pricing.
- Based on their efficiency and effectiveness, review current restrictions on motorcycles and goods vehicles
- Establish a coherent transport pricing policy that:
  - ◊ eliminates untargeted subsidies
  - ◊ provides for cost recovery to the extent possible
  - ◊ fully reflects social costs

Action 5: Develop a Strategy for Mass Transit

- Identify corridors of high passenger demand
- Evaluate and prioritize appropriate technologies for mass transit provision considering:
    - ◊ likely costs and available financial resources
    - ◊ environmental impacts
    - ◊ staging of investments and technology levels
- Develop/implement experimental programs of busways
- Research the impacts and effectiveness of existing metros
- Integrate mass transit with the rest of the transport system

Action 6: Reform Public Transport Management and Operations

- Separate Government planning and regulatory functions from the commercial functions of municipal public transport enterprises
- Pursue the reforms of municipal-owned transport enterprises, including the franchising or concessioning of services
- Actively seek the involvement of the private sector in public transport operations
- Strengthen the regulatory role to deal with enhanced private sector involvement

Action 7: Develop a Financing Strategy for the Transport Sector

At the National level:

- Consider the development, collection and allocation of appropriate road user charges, taxes and fees, including those on fuel, vehicle purchase, and vehicle operation (including the Road Maintenance Fee).
- Improve the regulatory and legal framework for private sector investment

At the Municipal level:

- Set within the context of an overall municipal financing policy
- Determine the needs for municipal involvement in investment, operations, and maintenance
- To the extent possible, implement a program of cost recovery from each transport user
- Determine the extent to which investments can be financed from debt or current revenues
- Determine the potential scope for private sector funding, either to replace or to supplement existing municipal transport budgets, including international sources

Action 8: Strengthen the Framework for Transport Planning and Capacity Building

At the National Level:

- Establish guidelines for the transport planning process
- Expand institutions for the education and training of transport professionals and officials

At the Municipal Level:

- Coordinate land development with transport development
- Integrate transport planning with land use planning
- Reflect the special characteristics of China's urban land use and resources in formulating urban transport development strategy and plans
- Ensure rigorous evaluation of all plans and policies, based on the four criteria defined above
- Exploit the use of consultants (both domestic and foreign) to supplement municipal agencies with specialized skills.

OPENING REMARKS

HOU JIE [1]

Ladies and Gentlemen, and Friends,

The International Symposium on China's Urban Transport Development Strategy is open today. At a time when China is striding toward the twenty-first century with sustained rapid economic development, the convening of this symposium is of great importance to explore strategies for China's urban transport development, to alleviate the urban transport "bottleneck" problem under the new circumstance of a socialist market economy, and to achieve sustainable urban development. The symposium is cosponsored by the Ministry of Construction, the Ministry of Finance, the People's Bank of China, the World Bank and the Asian Development Bank. The participants include international and domestic transport experts, city mayors, and leaders of the state ministries and commissions concerned. Here, I would like, on behalf of the Ministry of Construction, to take the opportunity to extend our warmest welcome to all participants. I would also like to express our heartfelt thanks to the ministries and commissions concerned, the World Bank and the Asian Development Bank for their continuing assistance to us.

The Ministry of Construction is in charge of overall management of China's urban roads and public passenger transport, including public buses, taxis, metros, ferries, and so on. Our work focuses on the provision of policy guidelines, formulation of laws and regulations, comprehensive planning, human resource development, international cooperation, and macro control, as well as sectoral and regional balance. The Ministry is committed to China's urban development in a sustainable and coordinated way. I would like to make the following points concerning China's urban transport situation, its development goals and the related policy orientation for your reference.

The Development of China's Urban Transport and Its Challenge

Cities are the vehicle for China's social and economic development and the center for industries and population. Urban transport is considered the basis and prerequisite for urban development, an indispensable social facility for urban production and people's living, and a basic infrastructure for urban investment and living environment. It is pointed out in *A Resolution to Pace up Tertiary Industry Development*, promulgated by the Central Party Committee and the State Council in 1992, that the urban public utility sector is a basic sector that has overall and guiding impact on national economic development. The urban transport sector has been given priority for, and will continuously receive, support in the field of capital investment for the present and in the relatively longer-run period. Moreover, *China's Agenda in*

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[1] Hou Jie is Minister, Ministry of Construction.

the 21st Century outlined an ambitious blueprint for urban transport required: development of transport will be vigorously promoted in order to meet the demand for transport by the national economic development and the improvement of people's living and to contribute to sustainable social and economic development.

Since the beginning of economic reform and the opening-up policy and with the rapid development of the national economy and the dramatic improvement of people's living, materially and culturally, China's urban transport has entered a period that witnessed its most rapid construction and development in history, impressive even by world standards. Since 1990, total investment in urban infrastructure, including urban road-building, has reached Y 163.68 billion. In 1994, the total urban road length was 116,000 kilometers (km) and per capita road space reached 6.6 square meters in China's 622 cities. The implementation of the Eighth Five-Year Plan (8FYP) indicated that the increased road length during this period was 8,400 km; that is 156 percent of the planned length. By the end of 1994, about 100,000 vehicles were in operation for urban public transport, the total length of service routes was 200,000 km long, and total ridership of urban public transport was equivalent to one third of the total volume of passengers carried by civil aviation, railway and roads combined. There were nearly 400,000 taxis. On average, there were 6.1 standard bus equivalent units per 10,000 people in cities. Since 1990, the modes of urban transport and the structure of the road networks have been experiencing dramatic changes. In megacities, rapid transport facilities are starting to play a major role in urban transport and the single-level system is increasingly evolving to a multilevel system. Many cities, like Beijing, Tianjin, Shanghai, Guangzhou, Jinan, Chengdu and so on, have built and continue to improve their expressway systems. Following the operation and improvement of the metro system in Beijing, Tianjin and Shanghai, Guangzhou, Shenyang, Dalian, Chongqing, Wuhan and Qingdao also started to develop rapid rail transit system. Meanwhile, the large- and medium-size cities have formed public transport systems, in which bus and trolleybus play the primary role, and are supplemented by various other transport modes such as public minibuses and taxis.

China's urban transport development has effectively ensured urban economic development and social progress. Over the past 15 years, it has basically met the tremendously increased demand for transport, generated from rapid economic growth at a 10 percent annual average rate, continuous improvement of people's living standard and constant expansion of cities; it also has contributed to urbanization.

However, we clearly understand that we are now facing the following challenges: construction of urban transport has lagged behind; the structure of urban land use is not rational and some land for transport purposes is being taken for other uses; the urban transport system is incomplete, the function of the road transport system needs to be improved, the structure of road transport networks and that of passenger transport are irrational; the funding sources for investments are not stable; there is no clear and consistent policy support for investments with high levels of benefit spillover; and urban transport management lacks coordination and the level of management is low. Urban transport, as the artery of cities, plays a role in promoting economic development and facilitating mobility. However, traffic congestion now causes over Y 10 billion loss each year. The "bottleneck" of urban transport has become a predominant constraint on economic and social development. The development of a socialist market economy needs a healthy and well-developed urban transport system to connect socialized

production and circulation, and to establish an integrated open market. The underdevelopment of urban transport has adversely affected the establishment of a socialist market-economy system. Often, the urban transport system offers low-level services. Especially in some of the megacities, the travel duration of residents is prolonged, the operating efficiency of the road networks decreases every year, hindering effective improvement in the quality of life and environment in urban areas.

Urban Transport Development Objectives and Policy Orientation for the Ninth Five-Year Plan and Toward the Year 2010

The next five years are the last period for achieving the second-phase strategic objective of China's socialist modernization; and the years 2000 to 2010 are crucial for realizing the third-phase strategic objective. As a basic sector with overall and guiding impact on national economic development, urban transport is being given due attention when the Ninth Five-Year Plan (9FYP) and the Strategic Plan for National Economic and Social Development to the Year 2010 are prepared. In the guideline for the formulation of these plans, the Central Party Committee stated that one of the primary tasks for social development should be "to enrich consumption goods, improve the consumption structure, and particularly, solve the housing and commuting problems." *The 9FYP for Urban Construction* and *the Development Strategy to the Year 2000*, drawn up by the Ministry of Construction, reflect the main idea that during this period, the functions and quality of service of urban infrastructure and public utilities, including road transport, water supply and sanitation, residential gas and heating, environment and waste management and public green area, should meet the needs of the national economy and social development. The overall service capacity and level should approach those of a middle-income country in the 1980s. A preliminary comprehensive socialized service system would be established. Both the urban investment environment and the people's living environment would be markedly improved.

It is predicted that three urban agglomerations will be formed at their preliminary stage around Pearl River Delta, Yangtze Delta and Bohai Bay Rim by the first decade of the next century. And the pace of urbanization will accelerate. About 40 percent of the total population will live in urban areas by the year 2010. China will enter into an historical transition from an agricultural society into an urban society. The government policy for the auto industry will also induce a rapid increase in motor vehicles. In addition, the implementation of *China's Agenda for the 21st Century* will bring about a series of strategic changes in population growth and environment protection, as well as strategic reforms in urban transport planning, construction and the management system. The pace of overall development of urban transport should be slightly higher than the average growth rate of national economic and social development. The overall development strategy for urban transport should be in line with the national economic and social development strategy. By the year 2010, China's urban transport should reach or near the level of a middle-income country of the early 1990s.

During the 9FYP period, cities in China will build up urban road network systems of rational layout and structure. The megacities with a population over 1 million will form urban expressway systems step by step, of which some should gradually build up rapid rail transit facilities. In urban public transit, megacities will explore the transport modes with large carrying capacities as the major means, such as metros, buses and trolleybuses, supplemented by various

other public transport means. Medium-size and small cities will mainly depend on buses and trolleybuses. The dispatch system, station facilities and overall efficiency of urban transport need significant improvement. By the year 2010, cities will build up an integrated urban-rural road network that is mainly composed of expressways and characterized by appropriate planning and a rational structure. The integrated urban-rural public passenger transport system will be composed of rail transport, buses, trolleybuses and taxis. In this system, the high-speed and large carrying-capacity facilities will be the backbones, and the small- and medium-capacity modes will be the popular modes.

It is rather difficult to attain the objectives mentioned above. However, they can be achieved through deepening of urban transport reform, implementation of development strategies tailored to the specific situation of the country and the cities, and introduction of competition mechanisms by reforming the existing urban transport management system. Urban transport will be further developed by expanding cooperation with the outside world; improving efficiency in road construction, operation and management; establishing stable channels for investment and financing in road construction; giving priority to development of public transport means while controlling the development of cars in city areas; and strengthening the formulation and enforcement of urban transport laws and regulations.

- Under unified planning and management by the state, the Government should continue to take primary responsibility for urban transport while introducing a competition mechanism to accelerate its development. Urban transport is a basic sector whose services bring social benefits to the public. The Government therefore should be responsible for its planning, construction and management to realize optimal allocation of resources and to establish a satisfactory and comprehensive social service system. Under these principles, in order to improve the operating efficiency of transport facilities, we should first apply a bidding system to urban road construction projects; second, establish a franchise system in public transport, open the taxi and minibus market and encourage competition on an equal footing. During the 9FYP period, the task of establishing a standard financial and management system in the state-owned urban transport companies should be accomplished to improve their operating efficiency and quality of services. The legal and regulatory framework should also be set up to ensure the legal rights of the general public, as well as those of the state-owned public transport enterprises.

- To ensure the development of road transport and establishment of an integrated, highly efficient urban road transport management system, we should reform the existing urban transport management system and strengthen the ability of government, especially that of municipal government, in planning, construction and management, while effectively changing the function of government. Under guidelines of the central government, the development of urban transport and establishment of an efficient management system will mainly rely on municipal government. The municipal government's role in urban transport financing should be strengthened. Under the central government's macro guidance, the municipal government should be given sufficient autonomy to carry out its duties.

- The setup of a legal and regulatory framework in urban transport should be accelerated and urban transport management should be strengthened. The main body of the legal and regulatory framework comprises "Laws for Urban Public Utilities," "Regulations on Urban Road Management" and "Regulations on Urban Transport Management," which serve as the basis for the whole legal and regulatory system. A series of supporting codes and regulations will also be promulgated accordingly at the local level. In addition, the law and regulations should be effectively enforced to promote urban transport development.

- Priority will be given to the development of urban public transport. According to China's current level of economic development, the uncontrolled development of private transport modes, in particular, private cars, should be contained in large- and medium-size cities. The emphasis should be on the development of public transport. Therefore, it is very important to undertake timely studies on the strategy and policy for promoting public transport as a development priority and to effectively carry out this policy.

- A reliable investment and financial system for urban transport should be established and all financial channels should be explored. A user charge scheme for urban transport facilities should be gradually implemented. Meanwhile, comprehensive urban development should be vigorously promoted. Funds needed for construction of municipal infrastructure, including urban road facilities, can also be mobilized through paid term leases and transfer of state-owned land. External funds will be actively introduced through further promotion of exchange with the international community and exploration of various financial means so as to accelerate the construction of urban roads and public transport facilities.

To implement the 9FYP and materialize the long-term objectives in the year 2010 for the national economy and social development, the urban transport sector faces big challenges. Together, we have organized this International Symposium for China's Urban Transport Development to help fine-tune the 9FYP and the medium- and long-term strategies for urban transport development in a more scientific way. It is hoped that this international symposium will guide and promote the development of China's urban transport and lay solid foundations for the formulation of an overall strategy for China's urban transport development.

I thank the Chairman and every participant.

OPENING REMARKS

ANTHONY J. PELLEGRINI [1]

On behalf of the World Bank, I would like to congratulate Mr. Hou and the Ministry of Construction for arranging this important Symposium. I would also like to thank the Ministry of Finance and the People's Bank of China for their valuable sponsorship. We particularly appreciate the opportunity to work in partnership with you and the Asian Development Bank in this important emerging arena. I would also like to thank the Governments of Switzerland and the Netherlands for their assistance in making this symposium possible. Finally, we welcome the presence of city leaders from across China who are grappling with the issues that will be discussed in the next days.

China's Urban Transport Challenge

China, probably more than any country in the world, is facing enormous demands for improved urban transport. Two factors are at play at the same time. First, China's cities are growing rapidly, and second, the rate of motorization is increasing at an unprecedented pace. Many view these changes with great optimism since they are occurring in tandem with rapid economic growth and ma be seen as a consequence of increased economic wealth. The World Bank's experience, however, shows that without effective urban transport policy, and without good planning many economies have failed to realize their true potential. In fact, the quality of life, particularly for the poor, can actually become worse.

The cost of inaction is high.

With congestion, deliveries take longer, and fewer trips are made. Prices increase as a result of inefficient distribution. It is estimated that over one-third of the gross city product of Bangkok, Thailand, about $4 million per day, is lost due to inefficient urban transport in that city.

Poorly managed urban transport systems are a threat to people's health. Air pollution is reaching crisis proportions in many cities of the world. Children suffer the most. In Mexico City, schools must close some days, because it is not safe for children to play outside. The intelligence of Bangkok's children has been permanently reduced by exposure to lead.

In many cities around the world, *traffic* accounts for over 60 percent of urban air pollution. Emissions from gasoline engines are a primary source of lead in urban areas.

People's lives are affected in many other ways.

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[1] Anthony J. Pellegrini is Director, Transportation, Water and Urban Development Department, The World Bank.

Rapid motorization has brought with it an equally rapid increase in traffic accidents and deaths. In some parts of eastern Europe where there has been a rapid transition to a market economy but where there has *not* been prior traffic safety planning, the accident rate has surged over 10 times that of western Europe. Other problems: noise pollution is a growing citizen complaint. People's communities can be cut off from the life of the city when highway design is poor. And major infrastructure works can mean that more people must move from their homes than would be necessary with more careful planning.

Motorization: Not Good—Not Bad

Motorization, that is, increased use of motor vehicles, may be inevitable, but these problems are not inevitable.

We must redirect our thinking. Instead of concentrating on how best to move vehicles, we must think of how to move people and also freight.

We know from experience in many countries that a plan that is only based on building more roads will not work—cities cannot build their way to a solution. To find a solution, we must look closely at many parts of the puzzle. How can mass transit, be it an improved bus and or metro system, help? How can we maximize the use of *existing* infrastructure. Are we getting best use of existing roads? How can we plan for the best use of the bicycle? Do better pricing of transport services and improved land use planning hold important keys?

As we consider these questions, we must remember that for transport policy to be successful, it must be sustainable over the long term. The Bank has learned that the evaluation of policies and actions should consider three complementary criteria—economic and financial sustainability; social sustainability; and environmental sustainability.

Economic Sustainability

Economic and financial sustainability requires high levels of efficiency in the provision of transport services and high levels of efficiency in the use of infrastructure.

- Revenues must be collected that are sufficient to properly operate and to expand the systems.
- Pricing services so that costs are recovered is critical.

Introducing competition between modes and among service providers is also important. Transport services can be disaggregated and unbundled and some moved to the market by allowing commercialization and private sector participation through franchising and concessions. However, to get the benefits from competition, we must create regulatory institutions and performance standards that will ensure that the population in fact gains the benefits that are possible.

Social Sustainability

To achieve *social sustainability*, the population must perceive that the transport plans are *fair* and that the transport requirements of all parts of society are being addressed. The goal is to give people access to jobs, education, and social services. If subsidies are needed, efforts should be made to target the subsidies on families most in need. Subsidies should not remove incentives for efficient operation. Mechanisms should be developed that provide reliable revenues at the *local level* to finance these subsidies.

Land use planning and transportation should be integrated. Both public mass transport and nonmotorized modes of transport should be integral parts of the planning process. And pedestrian access and the appropriate role of bicycles in urban transportation should be planned for and protected according to the plan.

Environmental Sustainability

Finally, policies that seek to improve the environment so as to protect the health of people should have high priority. To combat air pollution, cleaner fuels that eliminate sulfur and lead are needed. Plans to promote safety, particularly for pedestrians and bicyclists, must be developed. And charging users for the environmental damage they cause, for the infrastructure they use and for the congestion they impose on others, would help to improve the environment.

Sustainability, Synergy, and Balance

Evaluation of alternative actions and investments within this triangle of *Economic, Social, and Environmental Sustainability* goals enables you who are responsible for urban transport policy to identify the conflicts in trying to achieve these goals and exploit synergy. This will contribute to development of a properly balanced program that supports community values and contributes to sustainable urban development.

The World Bank in Partnership with China

How can the World Bank help? Our partnership with China on urban transport issues is promoting these ideas in Shanghai where two projects are improving the operational and economic efficiency of that city's urban transport system. We have traffic improvement components in a project in Tianjin and we are also working closely with the Guangzhou municipal authorities who have completed an important strategic study that takes a comprehensive approach to urban transport development. We hope that this will lead to a project that will implement innovative solutions in the area of public transport development, environmental protection, institutional reform and traffic management. We are also cooperating with the National Environmental Protection Agency and the State Science and Technology Commission on the development of strategies for improved motor vehicle pollution control.

More broadly, our contacts with many cities in China have highlighted the growing sense of urgency on the part of city leaders as they face sharp increases in traffic congestion and environmental degradation. Our purpose in being with you at this Symposium is thus to work together: in order to understand the nature of the urban transportation problem in China; to draw insights from international experience; and to see whether there is an emerging consensus on the

directions city leaders and the national government can take to meet these challenges. We hope that these insights will provide direction for future cooperation with China.

Closing

In closing, I would again like to express the appreciation of the World Bank for the opportunity to participate in this important event. The real value of a conference such as this is the opportunity for all of us to share experiences, and to learn from one another. I look forward to the next few days with great anticipation. Thank you.

OPENING REMARKS

JIN LIQUN [1]

Honorable Guests,
Ladies, Gentlemen, and Friends,

First of all, I would like to extend, on behalf of the Ministry of Finance, my warm welcome to our friends from the World Bank, the Asian Development Bank, participants from municipalities and experts from both China and abroad. Hearty gratitude also goes to our colleagues of the Ministry of Construction who host this symposium, and colleagues from other commissions and ministries who have saved no effort in supporting this symposium.

This year is the end of the Eighth Five-Year Plan period and also the critical year for drafting the Ninth Five-Year Plan. The last five years have witnessed a matured and fruitful cooperation between China and the World Bank and the Asian Development Bank. Completion of the Shanghai Inner-Ring Road and the two Huangpu River Bridges and the ongoing preparation of the Guangzhou City Center Transport Project and the Liaoning Urban Transport Project represent a new and a more extensive cooperation in the area of urban transport.

Urban transport, as one of the major infrastructures for modern cities, is of particular strategic significance. China, which is undergoing its transition from a planned economy to a socialist market economy, needs to make the most of market mechanisms in resource allocation, and therefore should strengthen the pivotal and central role of cities in economic development and market functioning. Along with the deepening of reform, further opening-up to the outside world and rapid development of the national economy, our cities have been growing both in their numbers and in their size. Although significant improvements have been made in vehicles and urban roads, many cities find it increasingly difficult to cope with the continuing rapid traffic growth, a phenomenon closely associated with economic growth. In some areas where intercity roads have been improved, urban transport has become an enormous traffic bottleneck that hampers economic development. Many large and medium cities are experiencing increasing road congestion, travel inconvenience, and increasing pollution from auto emissions. Meanwhile, these cities are further pressured by the rapid growth of the urban population, especially the floating population. Very often, the completion of new transport projects is quickly followed by the emergence of new traffic problems. Urban residents are longing for greater improvements in urban road conditions and transport modes, especially public transit.

Approaching the twenty-first century, great changes will take place in the national economic structure and urban-rural population ratio. Modernization of the national economy and urban economy will surely stimulate modernization in urban transport. Facing the opportunities

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[1] Jin Liqun is Assistant Minister, Ministry of Finance.

and pressure of historical development, urban transport must enter a new strategic phase. We need to work out a development strategy that is scientific, realistic, and future- and people-oriented, and that fits Chinese city characteristics.

Urban transport is a key area of infrastructure investment, construction and management. It is closely linked with development of an urban economy and a national economy. By itself, it is also a precondition for development of a national economy and an urban economy. Further development of urban transport requires deepening reforms in the urban economy and in the management systems of related enterprises and institutions. Municipal governments should actively create opportunities for enterprises to operate independently. Meanwhile, urban transport development should be planned, not only in consistency with an urban master plan, but also with urban, even regional, socioeconomic development plans. The formulation of an urban transport development plan requires studies in the areas of institutional reforms, financing, management, cost saving, and efficiency improvement. Efforts also should be made to introduce advanced technology and international experience, as well as to make good use of domestic experience and lessons.

To develop urban transport, we should not only increase investments through every effort, but also emphasize investment efficiency and scientific management, and make the transition from a long-adopted singled-minded approach to a more rigorous and diversified one. To this end, we should establish the right principles for urban transport development; we should formulate on a scientific basis the development plans and implementation schemes that are tailored for each city; we should ensure design, operation and management be carried out in a scientific way; we should make good efforts to save various resources including land, labor and capital; we should properly arrange resettlement work required for land requisition; we should protect urban air from auto pollution and reduce traffic noise; we should strengthen the management of urban road transport and the management of enterprises and institutions in the urban transport sector; and we should try our best to increase the overall benefits of urban transport investment. As to investment sources, not only should we improve the management of the infrastructure construction budget, urban construction and maintenance funds as well as other related sources, but also take initiatives to attract more investments from the general public, enterprises and foreign financial institutions. This can be done through further opening to the outside world, the deepening of reforms, as well as improvement of management. According to the local capability of raising counterpart funds and the capability of repaying debts, the Central Government will, through an integrated management system of borrowing, spending and repaying that unifies obligations, rights and benefits, continue to borrow, in the amount appropriate and with high efficiency, from international financial institutions for urban transport development.

Urban transport is a key area of urban development. It requires not only the continuing efforts by government agencies within the sector, but also the support of municipal governments and agencies of other sectors. To follow the Central Government guideline for capturing development opportunity, deepening reforms, expanding openness, promoting development, and maintaining stability, all municipal governments and agencies will bear more important responsibilities. Yet, our past experience suggests that our cities will be able to achieve more in urban transport and socioeconomic development.

Please allow me to wish the symposium success in helping us develop new thinking for urban transport development strategies. Thank you.

OPENING REMARKS

A. TIMOTHY PETERSON [1]

Introduction

Honorable Minister Hou Jie, Mr. Chairman, distinguished guests, ladies and gentlemen.

The Asian Development Bank is very pleased to take part in this Symposium on Urban Transport that, for the first time in the People's Republic of China, brings together senior urban transport experts to discuss how different urban transport problems and issues can be tackled. It provides an excellent opportunity to share ideas of how other countries are addressing similar issues and how these might be applicable to the numerous cities in China.

The Asian Development Bank

Before moving on to the theme of the conference, let me give a brief background on the operations of ADB.

ADB was established in 1966 and today it has 56 members, 36 of which are developing countries in the Asia-Pacific region. In almost 29 years of operations, the Bank has provided loans totaling more than $50 billion and technical assistance grants approaching $1 billion. The Bank has become a major catalyst in promoting the economic and social development of the Asia-Pacific region.

Bank operations cover the entire spectrum of economic development—with particular emphasis on agriculture, energy, capital market development, transport and communications and social infrastructure. Its objectives are achieved through loans and equity investments to both the public and private sectors, through technical assistance grants and through policy dialogue.

The Asian Development Bank has had extensive experience in funding transport projects in China. Given the strategic importance of the sector to the development and expansion of the economy, the Bank places high priority on relieving bottlenecks that impede efficiency and hold back the development of essential services. Our involvement in China covers a wide range of sector activities and includes support for roads, railways, ports, urban transport and urban development.

Since 1986, when the People's Republic of China joined the Bank as a developing member country, ADB has made 17 loans for transport and communications infrastructure totaling more than $1.9 billion and has provided 44 technical assistance grants amounting to $17.8 million.

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[1] A. Timothy Peterson is Deputy Director, Infrastructure, Energy and Financial Sectors Department (East), Asian Development Bank.

Urban Growth in Asia

This morning I would like to say a few words on the growth of urban areas and urbanization in the Asia-Pacific region and how it is expected to change in the future.

The Asia-Pacific region has witnessed considerable economic growth over the past three decades. Consistent expansion of individual economies across the region has had a pronounced impact upon urban communities of all sizes. As economies have expanded, their structure has changed the composition of economies, moving them away from dispersed rural-based activities toward manufacturing and services. The strong growth trends have diverted economic and social activities away from rural-based operations toward those more suited to urban environments and this is reflected in the accelerated trend of urbanization across the region. Over the past 30 years, the number of people living in urban areas in developing Asia has increased almost fourfold from 270 million to 850 million people. This represents an increase in urbanization from 18 to 30 percent of total population. Furthermore, over the next 30 years the region's urban population is expected to increase to 2,250 million, representing more than 54 percent of total population. Consequent with increasing urbanization is the expansion in size of urban communities. By the end of this century there are expected to be 280 cities in developing Asia with populations greater than half a million, of which 160 will exceed 1 million and 32 exceed 4 million. The rapid pace of urbanization across the region is a major contributor to a range of urban issues including those pertaining to urban transport.

Vehicle ownership across the Asia-Pacific region is also expanding rapidly. Historically, national vehicle fleets have increased faster than economic growth and this trend is expected to continue as per capita incomes continue to rise and vehicle ownership becomes more affordable. In many countries such as in India, Malaysia and Thailand, the vehicle fleets are increasing at more than 15 percent a year. At this growth rate, the vehicle population is doubling every five years. Despite these large increases in vehicle ownership, current vehicle ownership remains low in comparison with developed countries. The continued expectation of increasing prosperity across the region is expected to result in substantial increases in vehicle fleets in the future.

The very large expected urbanization explosion across the region, coupled with increasing vehicle ownership and incomes, will combine to exert heavy pressure upon urban infrastructure. It is to be expected that this will significantly increase demand for substantial expansions in transport network capacity and services. The magnitude of the resources required to provide adequate capacity and maintain quality of services is expected to be a major problem for the majority of cities in the region.

The particular problems associated with urban transport are primarily a function of the interactive factors contributing to development. These include growing population levels and per capita income and progressive urbanization. In certain respects they are a result of achieving progress in economic and social development. Together, these factors constitute the major parameters that influence the demand for movement of both passengers and freight.

Over the past decade, the problems and constraints associated with urban transport in the region have increased rapidly in both scale and intensity; today they are widespread throughout the region. Attitudes toward supporting development of cities and towns are changing rapidly. It is

increasingly being realized that improving the efficiency of urban areas is extremely important if rates of national economic growth are to be maintained. The development of physical infrastructure and related services is of paramount importance if continued investment in industrial and commercial activities are to be sustained and employment created. It is also increasingly recognized that social conditions in urban areas, including measures to improve the environment, need to be urgently addressed. Problems associated with traffic growth, infrastructure bottlenecks and deteriorating environmental and social conditions are rapidly combining to reduce the benefits of urban living. As a result, the need to address urban issues, including urban transport, has moved up the developmental agenda from both an economic and social perspective.

With few exceptions, investment in urban transport has generally received low priority, in terms of budget allocations, in the majority of developing countries. Deferred investment is now resulting in severe transport constraints impeding the efficiency of urban areas. In several of the region's major cities, the need to tackle urban transport problems has risen to the top of the political agenda. The demand for financial resources is, and will continue to be, considerable and is expected to remain outside the range that can be provided by the majority of governments and municipal authorities. External assistance will be required to help identify urban transport needs and priorities, ascertain the most appropriate use of available resources, investigate sector policies as well as provide financial support for individual projects. The demand for resources is so high that innovative approaches to resource mobilization will be needed if the sector is to erode the escalating capital cost requirements. While provision of public sector resources will remain important, it is expected that a large proportion of resources will need to be sourced from the nongovernment sector, not only in traditional areas for the provision of services but also increasingly for the provision of infrastructure and its operation. Within the Asia-Pacific region, it is anticipated that the financial allocations to urban transport, from all sources, will increase markedly over the next decade and beyond. The role of the Asian Development Bank will not only support the goals and objectives of governments but, more importantly, act as a catalyst for the mobilization of nontraditional sources of finance through provision of technical and financial support to private sector initiatives.

The timing of this Symposium is very appropriate as the problems associated with urban transport in China's cities have only begun to emerge in the past few years. The Symposium, therefore, provides a suitable forum to discuss how various urban transport problems have been dealt with in other countries and how their experience might be of benefit to urban managers and planners in China.

I see from the agenda of the Symposium that a number of important topics are to be discussed and I would like to make reference to those that we, at ADB, consider to be most important.

The problems associated with motorization, as I have noted earlier, are widespread throughout the Asia-Pacific region. Many countries have not yet succeeded in addressing these issues and perhaps the only city that has managed to contain problems associated with motorization is Singapore. In most of the cities in the region, government and municipal authorities have only just begun to tackle the problem but because vehicle fleets have already reached unmanageable proportions many actions are characterized as being "too little, too late." The position in China is unique in that the current number of motorized vehicles is comparatively small; therefore, there is

still time to address and introduce measures to manage the problems associated with motorization before they emerge. It is important that policies designed to reduce the use of private transport, particularly in central business districts, are promoted before traffic intensities growth to an unmanageable level. Such policies will need to be enacted together with improvements in public transport as unless suitable alternatives are available reductions in private transport utilization will be impossible. I look forward to listening to your discussions on this topic as I believe that China is in a good position to be able to introduce the necessary measures to minimize the adverse impacts of motorization that have occurred in most other parts of the world.

A second topic of interest concerns the role of public transport and the possible introduction of mass transit in some cities. In the majority of cities in the region, public transport has an important role in providing the means of movement for the majority of trips purposes; more than half of the trips in regional cities use available public transport services. In many Chinese cities, modal split has very different characteristics, with public transport only accounting for a very small proportion of total trips. Within the region, many of the successful public transport services are provided wholly by private operators. They provide efficient, low-cost services that are affordable to the public and are not a burden upon municipal budgets. I believe that there are possibilities for introducing some of the experiences in the region to cities in China to enhance the provision of public transport services and reduce the burden on municipal budgets. It will also provide the framework for improving quality and reliability and also introduce services that are responsive to the demand and needs of the residents.

The introduction of mass transit in the region has been relatively slow due to the enormous costs associated with constructing such infrastructure. Very few municipal authorities have the resources to finance such schemes, which require the largest investment a city is ever likely to meet. While transit schemes can provide good economic benefits, they frequently fail to generate sufficient financial returns to cover their construction and operating costs. Most mass transit projects, therefore, require operating subsidies that can be large if a low fare policy is adopted. The introduction of mass transit is often seen by municipal authorities to be a panacea that will resolve the transport problems. Unfortunately, transport problems are complex and many investments have not achieved their stated goals: several have added to the financial burden of the city and its residents through the need to raise local taxes to pay for large operating subsidies. I look forward to listening to your discussions on the public transport and mass transit papers as these topics are critical to the provision of good accessibility in urban areas. Efficient and affordable transport services are required not only to promote economic growth and social development but also to provide urban residents, particularly low-income groups, with an improved quality of life.

Another area of particular interest relates to the future role and use of the bicycle in China. Your country has the largest bicycle fleet in the world and in many cities, there are as many bicycles as people. The bicycle is affordable and its current use is widespread. Given the relatively short trip distances currently being made, the bicycle is the preferred modal choice and is highly competitive with most public transport services. However, this might not necessarily be the case in the future as cities expand both in terms of population and area. This is likely to result in longer trip distances, particularly for journeys to work, and the bicycle will become less competitive relative to motorized modes. The role of the bicycle in the future is an important urban transport issue in China and is one that I am sure will simulate interesting discussion.

Mobilization of Resources

The Asian Development Bank has observed, with great interest, the rapid strides that China has been making in attaining its growth objectives. We are proud to have played a part in this effort in recent years, and stand ready to continue to help where we can in the future. We are encouraged by the sense of urgency we see in the country's efforts to expand and improve its basic infrastructure. And, we are pleased to see widespread appreciation of the importance of attracting private capital and foreign investment in several infrastructure sectors including urban transport.

Despite these developments, considerable scope remains for greater private-sector involvement and investment in providing infrastructure facilities. This is driven, in part, by the enormity of the challenge that faces the country—namely, to mobilize the necessary resources to provide basic infrastructure services in a rapidly growing economy. Such resources must come in large part from the private sector, as financial resources from the various levels of government, domestic banks and the international donor community are limited.

While the financing of urban transport is not a major theme of this Symposium, it will have an important, if not predominant, bearing on all decisions taken in the transport sector by municipal authorities. To meet this financing challenge, it will be necessary to examine and adjust the role of state and local government in infrastructure development, to strengthen the partnership between state and nonstate sectors, and to attract more foreign investment in municipal development. Private-sector investment can be mobilized through joint ventures, build-operate-transfer (BOT) projects and from the domestic and international markets. Recommendations from this Symposium on ways in which mobilization of resources to facilitate development of urban transport infrastructure and services would be particularly relevant.

Conclusions

Distinguished participants, the Asian Development Bank is pleased to support this Symposium on Urban Transport to discuss important urban transport issues emerging in Chinese cities. Through this Symposium we expect that a better understanding of the urban transport problems and issues will be ascertained and that the experiences of other countries in the region, as well as outside the region, will be of use to resolving transport problems in China. I look forward to your deliberations over the next three days and hope that this Symposium will provide fruitful and useful information to government and municipal authorities, which will enable them to better serve urban communities in China. I also hope that it will provide a basis for further future support by ADB to assist with the development of urban transport in China.

Thank you.

KEYNOTE ADDRESS 1: REFORMING CHINA'S URBAN TRANSPORT SECTOR

LI ZHENDONG [1]

Respected Chairman, Ladies, Gentlemen and Friends:

Along with rapid urban economic development and the deepening of economic reform in China, the urban transport industry is experiencing dramatic changes. On the one hand, the investment of urban transport infrastructure in large cities keeps growing, the share of urban transport investment in total fixed asset investment gradually increases, and urban roads and passenger transport vehicles continuously grow. On the other hand, the growth rate of motor vehicle ownership and passenger transport volume is higher than that of transport infrastructure and facilities, and thus serious problems emerge in urban public transport, such as traffic congestion and the low quality of public transport in large cities. These problems have hampered urban social and economic development, resulting in a loss of efficiency in urban transport and deterioration of people's living condition in urban areas.

Problems in China's urban transport have caused concern. The central, provincial and municipal governments are paying increasing attention to these problems. Facing a big challenge in the development of urban transport, we realize the urgency of making a comprehensive strategy for urban transport development to guide the reform and development of the urban transport sector in large cities. The International Symposium on China's Urban Transport Development Strategy will have significant impact on the formulation of urban transport development strategy in China. It will also give a strong impetus to urban transport development in China's large cities. The concerns about China's urban transport problems from international financial institutions such as the World Bank and the Asian Development Bank are very important. I hope that China's urban transport industry will get more financial and technical assistance from the World Bank and the Asian Development Bank.

The existing problems in Chinese urban transport and their causes are very complicated. Mr. Hou Jie, the Minister of Construction, has presented some important opinions concerning the current status of China's urban transport development and the policy orientation for the urban transport industry, which provides us with a general picture of China's urban transport industry. The fundamental solution to China's urban transport problems lies in reform. Therefore, I will make some comments about the reforms in China's urban transport industry.

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[1] Li Zhendong is Vice-Minister, Ministry of Construction.

The Urban Transport Industry Should Meet the Demands of a Socialist Market Economy

The socialist market economy mechanism requires that regulations, policies, institutional setup and management for every subsector of urban transport be made on the principles of a market economy. It also requires the use of economic leverage to reach an equilibrium in demand and supply and formulate a sound investment cycle mechanism in urban infrastructure and facilities, that is, investment—construction—user charge and cost recovery—investment.

In order to meet the requirement of a market economy, the commercial attribute of transport infrastructure should be recognized. It is especially important to keep this recognition in mind while we make policies influencing the provision of urban transport infrastructure. This is to say that the price of transport infrastructure should be in line with its value of providing basic social benefits to society. This principle should also be applied to urban public transport services. Although these services have strong public welfare implications, their demand and supply should be determined, to the highest possible extent, through the price mechanism.

Urban roads and parking lots take up a large share of urban lands and absorb a significant amount of construction funds. The problem at present is the lack of linkage between the use of urban roads and the sources of financing of roads and other related infrastructure. Urban infrastructure has been treated as public facilities providing social services. Their provision and usage thus do no reflect market principles. As a result, road use is either free or badly underpriced for a large number of vehicles (or road users), directly contributing to inefficient use of roads and growing road traffic congestion. It is therefore important to follow socialist market economy principles and use economic leverage to balance the relationship between construction and usage to realize sustainable and balanced development of urban transport.

Opening the market and introducing competition are the main avenue to improve internal management of the urban transport sector, increase its operating efficiency and economic return, and promote its development. The concrete measures include: the gradual opening of the construction market for urban transport projects and the public transport market; standardizing market activities through the establishment of laws and regulations; strengthening sector management; introducing competition to improve the quality of design, construction and services, reducing costs of transport infrastructure construction and services; and introducing competition to improve state-owned enterprise operation and management.

Urban land development, especially the construction of large-scale commercial centers in old town areas of large cities, and unrestricted real state development, aiming at an increase in floor-area ratio, intensify the concentration of urban transport demands, which puts enormous pressure on urban transport and causes the drastic increase in infrastructure investment and construction in certain areas by the municipal government. Therefore, it is necessary to establish an evaluation system to analyze the impact of large real state development projects on the transport system, which will be taken into consideration in project planning and approval. This practice is to ensure balanced development of land and transport infrastructure, which should complement each other.

Reforming Urban Transport Management System

Urban transport is a complex system. It includes planning, construction and maintenance of transport infrastructure; administration and ownership of transport means; provision of transport services; management of transport safety; formulation and implementation of policies in government finance, investment and pricing; land development plans; urban residents' living and working patterns; environmental protection and so forth. All these aspects of an urban transport system should be well coordinated. At present, however, there are many serious problems in Chinese big cities' transport management systems, especially the lack of coordination among different agencies of the system, overlapping of organizations and not-clearly-defined purviews and responsibilities for each organization. As a result, the following phenomena are pervasive: difficulty in reaching consensus, lack of communication, mutual restriction, and often many different policies concerning one particular issue from different government agencies. Therefore, the administration and management of transport systems have very low efficiency. We should take action and deepen the reform of the management system to correct those shortcomings and increase efficiency. The guiding principles are "simplification, effectiveness and unification."

Another important task in the reform of management system is to change the Government's management style. It requires change from the current style of mainly using administrative instruments to a combination of legal, administrative and economic means; change from direct management to indirect management; change from management by departments and ministries to management by industry sector and society; separation of ownership and management of state-owned enterprises; and separation of government functions and enterprise operation.

Building up Rational and Stable Funding Channels for Transport Infrastructure Construction

In China, financial resources for urban transport infrastructure mainly come from urban construction and maintenance funds, government budget allocation, bank loans, and surcharge on property for municipal infrastructure development. The existing system of financing has the following problems: funding channels are not stable; resources for transport investment are separated from demands for transport infrastructure; the road maintenance fees are not used for urban road construction, although 70 percent of all motor vehicles make their trips on urban roads; the existing system of tax and surcharges does not reflect the relationship between the benefits to road users and the cost of road construction.

In building rational and stable funding channels, the first task is to reform the existing system of taxation governing urban transport, and levy taxes on motor vehicle fuels, tires and usage of nonmotorized vehicles. The charge for road use should be in line with the cost. The "users pay their way" principle should be reflected in the use of infrastructure facilities. Economic leverage should be used to influence the supply to and demand for transport so as to establish rational and stable funding channels for transport infrastructure and facilities.

In line with government regulation, many municipalities allocate a lion's share of revenue from the lease and transfer of land-use rights into the construction of urban infrastructure. This practice relieves the tension between supply and demand to a certain degree.

Some municipalities have urban road construction as the forerunner of urban development and implement a comprehensive development plan, thereby solving the serious problem of insufficient funds in the renovation of transport infrastructure in old town areas. In addition, the following methods in fund-raising should be promoted and applied to a broad area in a stable fashion: using domestic and international loans on favorable terms, issuing construction bonds, and attracting foreign investment in construction and operation through the lease of operating rights.

Effectively Implementing Public Transit Priority Policy

In the light of increasingly crowded urban transport conditions in Chinese large cities, development of public transport is a rational strategy to effectively relieve the tension between supply and demand. Urban public transport is the one with the lowest social costs and highest comprehensive benefits among all means of urban transport. Not only does it offer the social benefits of urban transport, but it also provides low-price services to middle- and low-income urban households.

Taking Chinese cities' specifics, such as land, population and economic capacity, into consideration, we should let the regular bus and trolleybus play a major role among all the public transport modes including bus, trolleybus, minibus, taxi, light rail and subway. A small number of megacities may gradually develop a rapid rail transit system.

In recent years, the Ministry of Construction has formulated a series of policies encouraging the development of public transport. However, implementation of these policies has been slow and ineffective. The prioritization of public transport asks for strong government support in investment and price, including the implementation of franchising public transport operations and the efficient use of government subsidies. It also needs preferential treatment in road use, transport management, provision of facilities and equipment and so on.

In 1994, the central government launched "The Development Policy for the Automobile Industry." This policy encourages the production of automobiles, especially cars, and the private ownership of family cars. Prior to the rapid development of urban private cars, we should build up an urban public transport system offering high-quality services to enhance the attractiveness of public transit. The objective is to make China's urban transport structure more rational and efficient.

Strengthening the Reform of State-Owned Public Transport Enterprises

In China, the state-owned urban public transport is of a large scale. By 1994, the state-owned enterprises had 109,000 standard bus equivalent units. Carrying 75 percent of the total ridership, they are the major carriers in urban public transit. It is very import for the development of urban public transport to deepen state-owned enterprise reform and improve their efficiency and quality of services.

At present, the Ministry of Construction is promoting the franchising system in public transport operations and strengthening the management of the public transport sector through legal and administrative means. These policies aim at the formation of an urban passenger transport market with fair competition. In the process of establishing advanced accounting and organizational systems, the state-owned enterprises should deepen the enterprise reform,

promote scientific management and technology innovation, improve the performance of operations, reduce and eventually eliminate the operational losses. They should continue to play the major role in urban passenger transport.

Municipal governments should strengthen management of the urban public sector, rationalize the institutional framework of management and improve the system of laws and regulations. They should effectively carry out their administrative functions such as planning, coordination, inspection, supervision and so forth. Municipal governments should also help to create a conducive environment for the reform of state-owned public transport enterprises. They should delegate authority to the state-owned public transport enterprises in personnel management, finance and equipment. They should also take resolute measures to separate the government function from enterprises, the ownership rights from the rights of management and operation. The idea is to develop and improve the public transport enterprises through market competition.

Enhancing the Research and Planning of Urban Transport

The development of urban transport follows its own law. Depending on the levels of social and economic development and institutional arrangements, each country's urban transport will have different characteristics. China is now experiencing rapid urban economic development and transition of the economic system. We therefore must pay close attention to the research of urban transport theories to discover the laws and patterns of urban transport development in Chinese big cities. The research should include many fields such as social and economic development, government finance, environment, culture, administrative system, etc. Our objective is to gradually establish a system of theories, taking China's country specifics into consideration, guiding the formation of urban transport development strategies and policies, and the practice in construction, maintenance and management of urban transport.

Urban transport construction projects involve a wide spectrum of the society and entail large-scale investments. To minimize the mistakes in policy-making and investment decisions, we should strengthen and promote feasibility studies in urban transport planning and project identification, appraisal and approval, to improve the quality of and efficiency in government decision-making.

Meanwhile, we should pay close attention to fundamental theory research in transport projects to improve urban transport planning and project design. At present, the Ministry of Construction is preparing priority research projects for urban transport, which are identified in *China's Agenda in the 21st Century*, and key research projects of urban transport science and technology identified for the Ninth Five-Year Plan period. We hope that these research projects, with international cooperation, will introduce advanced technology from abroad, help in raising the technical levels of China's urban transport sector and promote fundamental theory research in urban transport.

In order to meet the demand of China's urban transport development, we should educate and foster a team of competent professionals for urban transport research and design. Up until now, the Ministry of Construction and some megacities already have a number of research and design institutes for urban transport. The preparation of the Urban Transport Engineering and Technology Research Center is now being undertaken by the Ministry of Construction. We

should deepen reform of these research and design institutes to meet the demand of economic system transition and better serve the rapid development of urban transport.

Thank you!

KEYNOTE ADDRESS 2: THE URBAN TRANSPORTATION PROBLEM IN A CONTEXT OF ECONOMIC DEVELOPMENT

JOHN R. MEYER [1]

Some centuries ago, our forefathers brought forth in this world some places called cities. On the whole, these have proven very good places to live—wealthier, more innovative, more productive than the surrounding hinterlands. Today, however, a certain blight or difficulty has settled in: urban dwellers around the world increasingly find themselves in difficulties when moving about their cities. Even when they can move, they find that the process often generates all kinds of discomforts and harm: pollution, congestion, noise, dirt, dust, and delays. Furthermore, urban transport improvements often seem self-defeating, creating as many problems as they solve; they also commonly make the city a less pleasant place to live. This pervasive phenomenon has come to be known as the "urban transportation problem." What to do about it? Can it be solved? These are the issues, with an emphasis on the special characteristics of China, to be addressed here.

But first perhaps we should ask why? What has caused this problem? The answer basically resides in urban growth processes (as several people suggest in their papers at this conference). As a city grows, it typically evolves from a centralized, high-density, compact mass into a more decentralized larger area. As this happens, the pattern of urban trip-making also changes dramatically; specifically, from a mainly radial pattern serving a centralized city to a mix of radial, circumferential and cross-city patterns serving an increasingly diffuse and decentralized city.

Obviously, as a city's population increases, the volume of total urban trips also increases. Significantly, though, commuter trips per employed worker fall as an economy develops (because of a shorter work week or abandonment of long midday lunch or rest periods, etc.). By contrast, other types of trips (for shopping, visiting friends or family, recreation, etc.) usually grow more rapidly than the economy. The total number of urban trips thus increases disproportionately with economic development, but with the commuter share of total urban trips declining as incomes rise.

Because of these disparate rates of development, utilization of the various parts of a city's transport network will also change with development. The typical network will experience "economies of fill" as trips are distributed relatively more to underutilized segments of the system. Disproportionate increases will occur in the use of facilities off-peak and at peripheral or less central locations. This overall improvement in the use of system capacity will lower the average capital or capacity costs per trip, all else equal (which of course it will rarely be!). On

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[1] John R. Meyer is Professor of Capital Formation and Economic Growth, Harvard University, United States.

the other hand, if and when there are no more underutilized segments of which to take advantage, incremental costs of added use can rise sharply: this can become a particularly vexatious problem when a society becomes relatively advanced in its development.

To a rough approximation, all this growth and change translates into a city typically progressing through three stages of transport development. These can be very broadly characterized as that of (a) animal or human power (bullock cart, ricksha, etc.); (b) mechanized public transportation (vans, buses, rail systems...); and (c) mechanized private or individualized transportation (mopeds, motorcycles, automobiles...).

The evolution from one stage to another does not imply uniform progression from bad to good to better. Each stage has its distinctive features, some advantageous and some not. Nirvana does not wait at the end of the development process—just different problems and possibilities. Some urban dwellers, I am sure, will long for the "good old days" of stages past. Others will want to hasten the inevitable processes of change. Deciding how to compromise these conflicting views will be a major challenge for political leadership.

Also, like most taxonomies of human activities, this one has its complications and definitional ambiguities. In particular, what is to be made of the bicycle, especially in its modern and increasingly "high-tech" versions? Are bicycles part of the past, Stage 1, or part of the future, Stage 3's individual transport?

Obviously, this is a question of some importance in the Chinese context. As discussed by Welleman in Theme Paper 5, the prevalence and acceptance of bicycles as a mode of transport in China's urban areas is well established. The bicycle's convenience (door-to-door service, scheduling flexibility, ability to circumvent congestion...), combined with its relatively low capital cost, has made it a dominant mode in China. By contrast, the bus is often considered an inferior mode and is used primarily by those who cannot afford the investment or otherwise do not have access to a bicycle (the very young and old, the physically handicapped, etc.). At least in part, the explanation of the bicycle's dominance probably resides in other special characteristics of the Chinese urban scene: very compact and dense cities with relatively short average trip lengths. Nevertheless, as incomes rise, demand for more sophisticated bicycles, both pedal-powered and motorized, as well as larger motorized vehicles such as mopeds, vespas and subcompact autos, will increase. On the other hand, as cities decentralize, and urban trips become longer, the bus will likely be more competitive with the bicycle for at least some trips. Bus transport may also improve its position by making service, quality and comfort improvements.

Still, the possibility cannot be ruled out that Chinese cities, to a considerable extent, may skip over much of Stage 2, going almost directly from Stage 1 to 3. This could be rather traumatic, even chaotic. The environmental damage, for example, could be sudden and extensive, as Walsh points out in Theme Paper 2. Less time would be available for adaptation. Fewer options for coping with the peculiarly difficult problems of Stage 3 would be in place. In China, where leaded fuels are still in widespread use, and most motorbikes have two-stroke engines, increased motorization could be particularly harmful to the environment. On the other hand, because of the possible continued popularity of the bicycle mode, Stage 3 may also be

more different in China than elsewhere: less polluting and environmentally more benign but more difficult to manage because of widely different modal speeds.

The substitution of individual (Stage 3) for public (Stage 2) transport is not only driven by apparent consumer preferences but also by the rising labor costs that normally accompany economic development. Importantly, any substitution of individual for public transport reduces the need for *hired* labor to operate vehicles. This can make even the automobile, let alone the motorbike or moped or "mountain bike," a relatively cost-efficient mode of transport, especially in providing the higher quality of transportation that people seek as their incomes rise. It is almost impossible for public transport, at any cost, to match the schedule convenience, flexibility (e.g., combining shopping or personal trips with commuting), privacy and comfort of the private individual modes. Noncommuter trips, especially, are often most easily (and sometimes even most efficiently) accommodated by these individual modes.

For better or worse, as incomes rise in China, urban residents will buy more and better private demand improved vehicles (mopeds, motorized bicycles, autos, etc.). For transit to compete, as Meakin points out in Theme Paper 4, ever-greater improvements in public transport services and operations will be needed. In addition, as incomes rise, the operators of the public transit vehicles will demand higher wages. Labor-intensive activities like transit tend to become relatively more expensive, and therefore less used, as an economy develops. In the worst-case scenario, these trends could undermine the underlying economics of public transport before it is even established. In at least some Chinese cities, it may simply be cheaper and easier, not to mention more convenient, to bicycle or go by moped than to ride a bus. As incomes rise in China, and consumer capital is substituted for ever more costly labor, the bicycle will be traded in for new and improved versions of two-wheel vehicles, ultimately arriving at the four-wheel variety. Consequently, China will not only face the Western world's problem of relatively poor productivity trends in public transport, but will also need to develop a public transport system that can increasingly compete with improved individual transportation on all levels.

Transit, as Flora so eloquently argues in Theme Paper 8, can best meet this competitive challenge if allowed to respond to the needs of the market. To do this, the transit system must be flexible and innovative. Experience suggests that privately-owned systems do this better than the publicly-owned. In addition, the existence of some degree of competition seems to help, suggesting that exclusive franchises for an entire urban area should be avoided.

As incomes rise and more people own motorbikes and automobiles, living outside the central urban area (where land is more available and cheaper) will also become increasingly common. Public transportation tends to be less frequent (or otherwise available) and more costly (per unit used) at the fringes of urban development. By contrast, the private automobile becomes a *relatively* more cost-efficient means of transport at low densities (though still absolutely quite expensive).

When the share of total urban trips made by motorbike, moped or automobile reaches a certain threshold, say about 50 percent, a city can be said to be well along on the transition into Stage 3. At this point, the city's population will have already sunk substantial personal capital into transport equipment. And the labor costs of operating the individualized private modes can be perceived to be low given their do-it-yourself nature. Individuals provide their own driving,

management, routing and even some maintenance services, at no explicit wage, as opposed to paying others, at increasingly higher wages, to provide those functions when using transit. Initially, too, the transition to mechanized public transport (Stage 2) may not be characterized by excessive congestion. Effective road capacity may actually increase as mechanized modes that take up less road space replace unmechanized modes. (For example, it takes a good deal less square footage of street space to accommodate 100 horsepower of diesel engine than the real thing!) However, mixing modes of different speeds may impede traffic flow, as the slower modes obstruct the movement of the more rapid; similarly, the faster modes (in attempts to circumvent the slower) may create safety hazards so that traffic, particularly pedestrian traffic, is unnecessarily endangered. Of particular importance is establishing separate rights-of-way for the different modes—powered vehicles, bicycles, pedestrians, animal-drawn carts, etc. If properly done, the immediate need and demand for more investment in road infrastructure may be relatively low since streets provided for commercial and public needs may meet emerging private mode requirements reasonably well—if not in all of China's highly dense cities, at least in many.

However, as time proceeds and auto ownership and use increase, serious bottlenecks (points of severe congestion) will appear, especially during the hours when people are commuting to and from work. In China, the volume of bicycles during peak periods already has resulted in congestion problems, especially at intersections. Although bicycles are small and require little road space in a static (at rest) sense, they are slower than motorized vehicles, requiring more time per vehicle to complete a trip and in particular to clear an intersection. Consequently, as more motorbikes are introduced and substituted for the pedal-powered, traffic flows may initially improve (because motorbikes may make better dynamic use of available street space than conventional bikes).

This "free lunch" is not likely to last long in crowded Chinese cities. It appears that urban transport development is affected not just by a city's population density, but more specifically by the relationship between road length per capita and population density. This relationship, as developed by Stares and Liu in Theme Paper 1, may provide important insights into a city's future road infrastructure needs. For example, Chinese cities have a very low ratio of roads per capita and very high population densities compared to cities in most developed countries and many developing countries. This suggests that as the cities in China continue to grow and develop, lack of road infrastructure will be a particularly aggravating and increasingly difficult problem. Stage 3 in China could be a nightmare of congestion in many cities. The increased congestion accompanying city growth and rising incomes may only increase many of the advantages of using bicycles. A transportation planning challenge in China could then be that of attracting riders away from bicycles to buses (thus more efficiently using scarce road space) by improving transit's quality and service. Eventually, though, increased trip making in mechanized private modes will lead to demands to provide more urban transport capacity. Unfortunately, eliminating bottlenecks by providing more highways or high performance public transit alternatives can be *very* expensive. That's the bad news. The good news is that there are some less expensive solutions to these problems. Furthermore, to some extent, congestion problems may be self-correcting, because of changes in urban trip patterns that occur as an economy develops. As an experienced traffic engineer once observed: "People do somehow avoid infinite queues."

While people do avoid infinite queues, they may nevertheless often find themselves in uncomfortably long traffic queues or delays as an economy develops. As Gwilliam points out in Theme Paper 10, serious urban transportation problems are usually symptoms of a larger or more basic difficulty: this is the inability of simple market mechanisms to optimize urban transportation choices. A driver, or cyclist, when considering whether or not to use a particular road, will only consider the costs that are directly perceived or charged to him (namely, all direct costs such as those for gasoline, tires, direct wear and tear on his vehicle, etc.). As long as the road's capacity is sufficient to accommodate his use without slowing or otherwise interfering with anyone else's use, no particular problems are created. Traffic, however, sometimes increases to the point where an additional user interferes with other users by creating congestion on the road. At this point (and for all traffic volumes greater), the new or additional user would underestimate the costs of his using the road because he would fail to take into account delay or congestion costs he imposes on others. In other words, since the individual driver only perceives his own congestion delays and not those he imposes on others, private costs fall below social costs. This, in turn means that too many (that is, an inefficiently large number of) travelers will use the road (because the perceived price, or cost, of usage is too low).

To rectify this situation and bring private costs back into balance with social costs, a toll should be imposed for using the congested road. In essence, where there is congestion, market forces can result in an optimal level of usage only if a toll is imposed on users.

However, it is usually not optimal to eliminate all congestion. Eliminating all congestion can be expensive, with costs exceeding benefits—say, by building highways almost *ad infinitum*. Of course, the existence of a large number of users willing to pay congestion tolls also strongly suggests that expansion of a facility may be desirable; that is, more capacity may be justified if the sum of congestion tolls exceeds the cost of expanding the facility.

The proper toll will obviously vary from place to place and by time of day. The highest tolls would be needed on the most centrally located facilities at the most congested peak commuter periods. Determining optimal tolls for all relevant times and places, and then implementing them, are not easy tasks. Full implementation would require sophisticated surveillance and recording equipment capable of logging the movements of every vehicle in the urban area. Clearly, a system of this sort could be costly, even if technologically feasible. Such a high degree of control and surveillance is also thought by many to be unacceptable on political or social grounds.

Fortunately, simpler pricing schemes will often suffice or at least greatly alleviate congestion problems. For example, when access to a congested area is limited to a few major expressways, tunnels or bridges (such as in Manhattan or Hong Kong's Victoria Island), congestion tolls can be simply and economically assessed by placing toll booths at these entry points. China, moreover, already has had some experience with charging fees for use of new urban access roads, originally built as toll roads. Furthermore, even if a congested area's entry points are not "naturally" limited, it is still possible to assess congestion costs by using an area licensing scheme, such as that developed in Singapore. By increasing the costs of automobile trips to congested areas, area restraint should encourage people to carpool and switch from auto to public transit or perhaps to bicycles or walking. In the process, air pollution and other environmental damages from auto use should also be attenuated. More generally, as Walsh

points out, more proactive pricing policies, if properly designed, could also help with environmental problems by inducing use of cleaner fuels, four-stroke engines, etc.

Several papers at this conference, that of Stares and Liu in particular, discuss not only the role of better pricing but a wide variety of other measures to reduce congestion, and often pollution as well. For example, one of the least expensive alternatives for increasing transportation capacity, and thereby relieving congestion, is improved traffic management. For example, conflicting traffic movements can be avoided or reduced by banning certain turning movements, by introducing one-way routing, and by traffic signals at intersections and pedestrian crossings. Benefits can also be derived by restricting stops along critical sections of the road network and loading and unloading of goods vehicles at certain times of the day. These measures require good enforcement as well as extensive use of traffic signs and road marking, but the costs generally will be relatively low.

Eventually, though, there may be little alternative but to provide new facilities and infrastructure, or at the very least to substantially modify those that exist. To start, substantial benefits often can be achieved by minor, low-cost improvements, such as road widening and pedestrian foot bridges. Better maintenance of existing roads also often enhances effective capacity quite inexpensively.

Of course, transit systems, like roads, can also become incapable of coping with demand. A need thus also arises to examine the options available for transit improvements and augmentation. Generally, as Allport points out, bus systems involve the lowest costs, are able to meet demands from the lowest to the highest levels and are flexible enough to meet the changing needs of a growing city. While the very highest demands (say. over 50,000 passengers per corridor per hour) may only be well met by heavy rail systems, the need for such systems is likely to arise only in the largest and densest of cities. Even then, priorities for existing public transit modes (namely, buses) should be aggressively pursued in the period before rail can be afforded or implemented.

The great danger, in fact, at the transition into Stage 3, is to "think too big" without sufficient prior planning and thought. The temptation may be strong to effect a "quick fix" by making a major investment, say in rail transit or expressways. If not carefully planned in relation to the urban area's underlying trends, however, both may prove counterproductive. The rail transit system, for instance, may see its market disappear as decentralization reduces densities and moped or auto ownership opens up other travel alternatives. The expressway solution, by its very institution, may facilitate and hasten decentralization so that it creates almost as many new traffic demands as it satisfies.

At some point, however, heavy and costly investments in transport infrastructure probably cannot be avoided. In fact, these may be so large as to require tapping into now private sector sources, as K.H. Lee suggests in Theme Paper 9. It is thus important, even if construction can be delayed, to make allowances (rights-of-way, land banking, zoning) for the physical expansion of the existing network in both short- and long-term development plans. Some foresight and planning for future construction helps to lower costs by minimizing disruption to traffic and other urban activities, unnecessary demolition of buildings, the diversion and reworking of utility services, and costly land acquisitions. In general, the increased complexity

of the urban transportation problem as development proceeds is almost certainly better handled with more rather than less prior analysis.

To summarize, solutions to the urban transportation problem vary in cost, derived benefits and ease of implementation. The types and magnitude of transport problems will vary considerably from country to country and from city to city around the world. Fundamentally, though, the problems have much the same origins in every case. The major urban transport problem in most cities is congestion, closely followed by pollution. In particular, the rapid and uncontrolled development of personal motorized transport is likely to lead to severe congestion to the detriment of urban form and amenities. Congestion is a problem that can be alleviated, but usually should not be totally eliminated. The proper policy goal is attenuation, and that goal is well within the realm of the possible. The most direct and economically efficient way to achieve that goal would be to place tolls on use of urban transport facilities so as to bring privately perceived costs into closer alignment with social costs.

Simple calculations of economic efficiency will rarely suffice, however, as a public policy for urban transportation. Because of the externalities and public good characteristics of urban transportation, governments are quite properly and inevitably involved. As Gakenheimer points out in Theme Paper 12, an important role for transport planning remains. Unfortunately, government intervention often leads to an intensification of the very worst proclivities and difficulties commonly encountered in providing urban transport services. For example, the desire to serve certain social or political purposes can lead to the introduction of government controls, which in turn induce inefficient use of resources and undermine managerial and labor incentives.

Almost universally, an important policy issue is defining and establishing the respective roles of the public and private sectors. The public sector is well suited for playing a role in situations where market imperfections exist, such as assigning and determining congestion costs or establishing environmental standards. In addition, the public sector is traditionally responsible, and usually needed, for enforcement of traffic laws, establishing and implementing traffic management measures, defining licensing and safety standards, etc. The private sector, on the other hand, has shown a greater ability than the public sector for developing and operating services efficiently, apparently because of the private sector being profit motivated and better able to react to market changes.

In short, the urban transportation problem is inherently difficult and complex. There are no simple market mechanisms that can be used in lieu of good public policy and intelligent public administration. On the other hand, the absence of any simple market solution can also lead to an overreliance on and indulgence of government "solutions" that are ephemeral or even counterproductive. The only apparent "escape" is to find some middle course—to define more precisely what can and cannot, what should and should not, what must and must not be done by the public and private sectors in solving the complexities of what has come to be known as "the urban transportation problem."

KEYNOTE ADDRESS 3: URBAN TRANSPORT PROBLEMS IN CHINESE CITIES: CAUSES, TRENDS AND OPTIONS

ZHOU GANSHI [1]

The rapid changes of urban transport in China are stimulated by rapid economic development. Since the early 1980s, most cities have increased their efforts in road construction and the size of investments is unprecedented. With continuing economic development, however, urban transport problems become more and more serious. To use an old Chinese saying, the boat goes up when the river rises.

CHARACTERISTICS AND PROBLEMS

Several characteristics are prominent in China's urban transport. They are discussed as follows.

The motor vehicle fleet has grown rapidly and bicycle ownership has reached a high level. In 1983, the total number of motor vehicles in China's cities was about 2 million, two times as many as that of 1977. The total number of urban bicycle in 1988 was about 4 million. In 1994, urban motor vehicles numbered 5 million. In the last few years, the annual growth rate of motor vehicles was above 15 percent. In some cities, the rate reached 30 percent. The total number of bicycles in all cities accounts for more than 180 million. Bicycle ownership in cities and towns reaches 198 bicycles per 100 households. The total number of motor vehicles in the cities accounts for about 50 percent of the national total; and that of bicycles, 40 percent. The last decade also has seen the doubling of private motor vehicle ownership. The total number of private cars in the country was 598,000 in 1993. In 1994, private motor vehicles accounted for 17 percent of the motor vehicle fleet in Beijing.

Road construction, though impressive, fails to keep up with the growth of vehicles. With an annual growth rate of 10.2 percent, the total length of urban roads increased from 29,485 km to 104,897 km from 1980 to 1993, a 5,800 km addition per year. The length of urban roads per 10,000 population reached 6.3 km, from a low 3.3 km. During the same period, the total road area increased to 1,075 million m^2 from 253 million m^2. The road area per capita increased from 2.8 m^2 to 6.5 m^2, which represents an impressive 11.8 percent annual average growth.

Fixed-route public transit is declining. During 1978-93, the public transit vehicle fleet and service routes in China increased 2.5 times and 2.8 times, respectively. The number of buses reached 0.6 per 1,000 population. However, the operating speed of buses reduced to 5 to 10 km/hour from 12 to 14 km/hour. Therefore, the increased capacity was largely offset by the declining efficiency. For many years, the public transit operations have had to rely upon

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government subsidies. The loss-making operations accounted for 70 percent of total public passenger transport operations in 1993; and government subsidies in Beijing and Shanghai alone amounted to Y 1.6 billion. Because of the declining operating efficiency and service quality, public transit ridership has been declining each year; bicycle ridership has increased. In Beijing, for example, the modal split between public transit and bicycle became 4:6 in the 1990s, sharply contrasting to the 6:4 ratio of the 1980s. In Tianjin, the ratio was 19:81 in the 1980s, but the share of public transit declined to less than 10 percent in the 1990s.

Taxis have grown rapidly and rail transit is starting to develop. With the increase of the urban residents' living standards, people are no longer satisfied with a single public transit mode. This is illustrated by the rapid increases in taxi services. In 1978, there were only 1,628 taxis in China. In 1993, there were 286,207 taxis, of which about 60,000 taxis operated in Beijing, 18,000 in Shanghai and 12,000 in Guangzhou. By August 1995, the number of taxis in Beijing reached 80,000, and in Shanghai, 32,000.

At present, only three cities in China have a metro system. They are Beijing (43.5 km), Tianjin (7.4 km) and Shanghai (14.6 km). The total route length accounts for 65.5 km. However, more and more cities are now planning, preparing and constructing metros. By the beginning of the twenty-first century, Guangzhou, Chongqing, Shenyang, Qingdao and some other cities will have their metro or light rail transit system. The total length of urban rail in China by then will reach about 200 km.

Traffic management is poor and the rate of traffic accidents is high. Because of various historical reasons, Chinese cities lack modern facilities for traffic management and safety. Here we compare Beijing with Tokyo to give an example. Both cities have a traffic control center, but the number of junctions under the center's control in Beijing is only 3 percent of that in Tokyo. The use of traffic marks in Beijing is only 70 percent of that in Tokyo; pedestrian crossings, 4.8 percent; pedestrian overpasses, 3.6 percent; and underpasses, 5 percent of those in Tokyo, respectively. We should point out that Beijing has the best traffic management facilities in China. It is thus easier to understand the similar problems in other Chinese cities. In recent years, a few large cities introduced some advanced traffic signal control systems from abroad. Due to the traffic's special characteristics in China, however, their implementation has been unsatisfactory.

The shortage of traffic control facilities and the low level of management skills contribute to a high rate of traffic accidents. In 1991, there were 0.52 traffic fatalities per 10,000 persons, or 31.3 fatalities per 10,000 motor vehicles. This increased to 49.4 fatalities per 10,000 motor vehicles in 1994. In the last few years, the deaths from traffic accidents in Beijing were about 500 persons per year, that is 60 fatalities per 10,000 motor vehicles, a rate higher than the national average. In contrast, the fatality rate is only 1.6 in Tokyo, 2.6 in the United States and in Australia, and 2.7 in the United Kingdom in 1985.

Urban vehicle operating speeds have been declining each year. Traffic volumes in many cities have been growing more than 20 percent per year, causing increasingly serious traffic congestion. As a result, vehicle speeds decline. On many arterial roads, vehicle speeds are only 15 to 20 km/hour. In city centers of large cities, vehicle speeds decline to 10 to 15 km/hour.

To summarize, the key problem of urban transport in China is the lack of a comprehensive transport development strategy, lack of coherent transport policies, and disorder in transport management. All these contribute to growing traffic jams, declining vehicle speeds, and low efficiency—a typical case of downward spiral and vicious cycle.

China is now in transition to a socialist market economy from a centrally planned economy. During this critical transition, potential dangers will arise that improper decision-making may lead to chronic traffic congestion for many years to come.

The first danger comes from short-sighted activities. These include overzealousness in the construction of large-scale, high-standard transport facilities, such as elaborate interchanges, viaducts, large bridges and urban ring roads. The construction of certain projects are needed to accommodate the traffic growth. But in some cases, they are the outcome of improper decision-making or absence of systematic planning and overall consideration. Some cities tend to prefer projects that are larger in size and higher in standard over those that are actually needed. Such projects may help alleviate transport problems in the short run. However, they could not solve the congestion problem. Furthermore, they even generate some new problems. It should be pointed out that urban transport is an integrated and dynamic system. Any changes at one point will affect the whole system. It is impossible to solve all transport problems with a single large project. Without a good understanding of the nature of transport problems, it is certainly impossible to tackle these problems in an efficient and effective manner.

The second danger arises from the fact that little attention is paid to public transport. What mode should be relied upon in urban transport? Should it be private transport or public transport? These questions have been debated for many years. In fact, public transit is the most efficient transport means. It has a large carrying capacity, and occupies relatively smaller road space. Many countries in the world have chosen the policy of giving public transit priority after a long, painful experience. Even the United States is not an exception. Because of the shortage of land and high density of population in China's cities, the Chinese government made the policy giving priority to the public transit development many years ago. However, because the economic benefits of public transit are largely reflected as social benefits and the modern mass rail transport is characterized by large amounts of investment and long investment cycle, the modern mass rail transport construction has been largely ignored by officials who are interested only in short-term economic benefits. The phenomenon of emphasizing road construction at the expense of slowing down rail transit development will adversely affect urban transport development in the early years of the next century.

PROSPECTS AND OBJECTIVES

Prospects

Forecast of urban person-trips. It is predicted that rapid economic development in China will sustain for at least another 15 years, and urbanization will also continue. It is estimated that by the year 2010, total urban population in China will reach 360 million. If each urban resident makes 2.7 trips per day, total annual person trips in all cities will be about 250 billion. If public transit is developed as the major mode of urban transport, buses and trolleybuses will takes 20 to 30 percent of all person-trips; rail transit, 10 to 15 percent; company vehicles and private cars, 10 to 15 percent; and bicycles and walking will take the rest.

Forecast of urban public transport vehicles. Historical trends suggest that the number of public transport vehicles will grow by 7 percent per year. By 2010, the total number of vehicles will be 281,000, which is 192,000 more than that of 1993. That is an annual increase of 10,000 vehicles. By 2010, there will be 7.7 vehicles per 10,000 persons in China's cities, which means one vehicle will serve 1,300 persons.

In recent years, the number of taxis has been increasing very fast. In some megacities, the number of taxis is near the saturation level. According to 1993 statistics, each taxi served 578 passengers on average. Using this figure, we can estimate that there will be 620,000 taxis by 2010, which is 340,000 taxis more than that of 1993 and an increase of 20,000 vehicles per year.

Road facilities. Because of urban land constraints, the growth of length and area of urban roads will not be higher than that of the previous years. According to "The Public Utilities Development Projection for the Eighth Five-Year Plan and the Ten-Year Plan," a report published by the Ministry of Construction, by the year 2000 the urban road length will be between 174,418 and 197,674 km and total area of urban roads will be 16.4 to 18.5 billion m^2. If these can be realized and the trends continue, by the year 2010, the length of urban roads will be 388,120 km and the area of urban roads will be 3.4 billion m^2. This means a total increase of 2,320 km^2 in land use for urban roads, or 136 km^2 increase per year.

The number of motor vehicles. According to "A Study of China's Household Car Development Strategy," the objective of automobile industry development is to realize two key strategic changes. The first is the change of production from truck dominance to car dominance by the year 2000 or a bit later. The second is the change of production focus from business car to household car. This will be realized by 2005 or later. Household car production will reach 0.4, 1.2, and 2.3 million by the years 2000, 2005, and 2010, respectively; private car ownership will reach 1.2, 4.6 and 13.2 million, respectively.

In 1993, private car ownership in China was 50,000. According to the automobile industry development objectives, by the year 2010, private car ownership in China will be 13.2 million. This is a tremendous change. By that time, private car ownership in China will be 15.8 per 1,000 persons. Cities are the center of the national economy. The use of cars naturally concentrates in the city, especially the large cities. The rate of car ownership in large cities therefore will be higher than that of the national average. It is estimated to be more than 50 vehicle per 1,000 persons by 2010.

According to this calculation, by 2010, Chinese large cities will have an additional 15 million cars. It is then necessary to build another 300 km^2 area of road and parking spaces. As the land has been almost used up in large cities, this is no doubt a serious problem. How cities and urban transport meet automobile development will then become the focus of the problem.

Objectives

The overall objective should be to establish a modern multilevel and comprehensive transport system in large cities. The implementation of this objective can be divided into two stages. The first stage will be completed by the end of this century. It includes the basic establishment of a road network suitable for economic and urban development, the strengthening and revitalization of public transport, appropriate development of paratransit, and the alleviation

of current serious transport problems in the large cities. The second stage will be from the 2001 to 2010. During this period, large cities will fundamentally improve the quality of their urban transport network, speed up the construction of rail transport, set up the urban transport control and guiding system, and reach equilibrium between the total supply and demand of transport.

The realization of this objective will be the turning point in China's urban transport history. By that time, the situation of the transport will be as follows:

- There will be a prototype transport structure for large cities, which will meet Chinese characteristics. Public transport will take up about 20 to 30 percent of urban total person-trips. Others will be trips of bicycles and pedestrians. Obviously, bicycle transport still accounts for quite a proportion.
- The multilevel transport network system will be implemented. The system will include a rapid road system for motor vehicles and a slow transport system for bicycles. The separation of motor vehicle transport and nonmotor vehicle transport will be implemented in most of the areas.
- A mass rail transit system will be actively developed in some large cities.
- The proportion of high-standard roads will be increased, to gradually allow the growth of household private car ownership.

After this period, with the rapid development of urban modernization, transport in China's large cities will enter a modern transport era of high efficiency and speed by the year 2030.

MEASURES AND SUGGESTIONS

It is necessary to follow the principle of "comprehensive and coordinated development" to tackle the urban transport problem, and to sustain the urban transport development trend along with economic development. With urban development and the introduction of a land leasing system, urban transport development now faces more constraints. Modern urban transport in large cities involves nearly all the departments within a city. Only with all parties' attention on urban transport, dealing with the problems comprehensively, combining resources, and supporting each other, are we able to build a modern transport system.

Developing Overall Guidelines for Urban Transport And Establishing a Transport Commission in Large Cities

The key issue is to strengthen the leadership of municipal governments in large cities, and to set up a high-level steering body—the Urban Transport Commission. The commission will formulate a unified urban transport development strategy; manage and guide the urban transport construction; and plan the fund-raising and the system reform in a unified way. It will also coordinate the existing urban transport management organizations and other related departments, such as municipal finance, planning, pricing, land and taxation to ensure the implementation of key transport policies.

Increasing the Density of the Road Network and Improving the Quality of Decision Making in Transport Construction

Because of the large amount of "unpaid debts" in urban transport infrastructure, the current state of urban transport is very poor and unable to meet the demands of rapid economic development. It is then necessary to increase the density of the road network and to maintain a high volume of roads in the coming years.

The development of the infrastructure should avoid blindness. Under the guidance of careful planning, we should speed up the construction of urban arterial and distributor roads and high-speed roads. The layouts of interchanges, pedestrian crossings, parking and bicycle lanes should be arranged in a rational way. In the redevelopment of the old cities, the construction of large interchanges occupying large land areas should be kept to a minimum. Channeling road junction traffic should be emphasized. The "bottleneck" sections of roads and the road structures should be renovated and improved. It is necessary to promote construction in a systematic way, to emphasize land saving, and to avoid the blind pursuit of high standards. By doing so, we will be able to save on the total transport cost and increase the economic efficiency of transport construction.

Adjusting Transit Fares and Reforming the Public Transport System

A low bus fare policy, in fact lower than the cost, has long been implemented in the large cities. The impact of bus fare adjustment on social stability has been considered as the fundamental principle guiding the bus fare adjustment. Because of the wide social implications, most municipal governments are not willing to adjust the bus fares as the adjustment will likely influence the residents' perception of municipal government performance. Due to a lack of economic resources, the enterprises are unable to develop, and the passengers could not have satisfactory services from public transport. They thus pay much higher fares on other transport means for better services. This situation turns out to be contrary to the intended purpose of the low fare policy. Therefore, to solve the existing urban transport problems, we first have to adjust bus fares and reform the subsidy policy. The objective is to provide satisfactory services while recovering the costs and even realizing a small profit margin.

However, we should notice that public transport enterprises do not have profit-making as their single purpose. Not only do they realize economic benefits through provision of passenger transport, but also their value is reflected in other social economic activities. It is thus necessary to have government support for transport development, including favorable tax and fuel supply policies, as well as necessary financial subsidies. In the near future, it is imperative to adjust the irrational relative prices, to include operating revenues in the domain of price management, and to improve the subsidy system for policy-induced losses. The strict separation of policy-induced losses and losses due to mismanagement should be emphasized. The existing way of giving subsidies should be changed and subsidy quotas should be introduced based on realistic norms and indices. For instance, to quantify the performance of transport enterprises, the annual ridership, number of employees, and passenger vehicles should be used for evaluation. Fulfillment of production targets will be rewarded and enterprises with unsatisfactory performance in production will be punished. The deadline for improvement should be specified. Only by doing so can the enterprises be forced into independent operation.

Adopting Traffic Restriction Measures to Guide the Development of Private Car Ownership

The development of private car ownership will mainly be managed through total transport demand control. Municipal governments can adopt direct or indirect control measures depending upon the road capacity of the city. It is important to coordinate well the development of private cars and road capacity. First, overall transport monitoring and analysis should be effectively implemented. Different adjustment and control measures should be applied to different areas; especially, car traffic should be restrained in the central city areas. At the same time, it is necessary to further reform government finance and taxation policies, to design and implement an appropriate tax system, to collect fees from automobiles for road cost recovery, and therefore enable the economic means to play the macro adjustment role. Motorcycles belong to the category of motor vehicle management. Since motorcycles bring more serious environmental pollution and transport accidents than automobiles, large cities must have a strict restraint policy for motorcycles.

Various Channels of Investment

China needs a considerable amount of investment for its urban transport construction. Besides the central and municipal government grants, it is very important to explore various financial channels to raise funds under favorable policies from governments. This practice has proved to be a feasible and effective way to raise funds for urban transport construction. At the macro level, we should first increase the ratio of investment in urban transport infrastructure over the GNP. The United Nations' Division for Social Policy and Development Social Development estimates that total investment in urban infrastructure should take 3 to 5 percent of GNP for developing countries. Based on this estimate and China's investment in the last few years, China's investment in urban road transport should take at least 1 to 2 percent of GNP each year. However, even the highest investment ratio (in 1993) was only 0.6 percent. We recommend that China's annual investment in urban transport construction be no less than 1 percent of GNP in the future.

Second, the Government should pay more attention to the reform of urban investment system. For major urban transport projects, the Government should formulate appropriate strategies and plans to raise funds, and give favorable policies to introduce foreign investments. In many countries, a certain percentage (1 to 3 percent) of a fuel surcharge is imposed and the tax revenue is used for road construction. This is a reasonable system to raise revenue for road construction. It has been implemented in Hainan Province since the beginning of 1995. Up to now, the Province has favorable opinions about this practice. We recommend this system be established in the whole country. In addition, many cities have implemented the development policy described as "road construction stimulates real estate development, and real estate development in turn supports road maintenance." The revenues from urban land transactions and real estate development are used for infrastructure construction. Urban development and road transport could progress at the same time. Although these practices are still at a preliminary stage, China has already accumulated some experience, and is capable of carrying out the gradual reform of the investment system through further studies, experiments, and careful operations.

Third, for urban infrastructure, we should allow large cities to formulate their own fee collection policies fitting their city specifics. The fees will supplement local government revenues and be used for road transport development. The central government and the related departments should improve the fee collection mechanism through fiscal and taxation instruments, which should be made into clearly defined national policies.

Strengthening Research in Science and Technology, and Improving Public Awareness of Transport

To know the directions of urban transport science and key technology development, we must strengthen research in urban transport science and educate urban residents. To attain this goal, we must successfully carry out the following six tasks:

- Emphasize research on economic policies for and frontier technology development in urban transport, and achieve economic efficiency in these researches to better serve urban transport. The newly published research proposal, "Modern Urban Road Transport: High-System-Efficiency, High-Speed and Congestion-Free Technologies," is the result of many experts' collective efforts under the auspices of the Ministry of Construction. It points out the direction for China's urban transport research in the twenty-first century. We suggest that this research proposal be incorporated into the national "Ninth Five-Year" key science research project plan.

- The Government should formulate related technical standards, regulations and laws; and strengthen the education of professionals and skilled workers, and the on-job training. The system of professional qualification certification in transport engineering and transport planning should be introduced to improve the quality of urban transport planning, design, construction and management.

- A national urban transport engineering and technology study center should be established under the guidance of the State Commission of Sciences and Technology and the Ministry of Construction. The Center will organize the fundamental theory research on urban transport, and promote the applied technical research and application.

- The Ministry of Construction should sponsor a National Urban Transport Expert Committee to guide the healthy development of the national transport science and technology, and appraise and evaluate key urban transport construction projects.

- The long-term transport plan and the short-term transport comprehensive improvement plan in large cities should be incorporated into city plans. When arranging urban transport construction projects, the planning agencies should make sure that those projects meet the purpose and requirements of the urban transport plans.

- Urban transport education should be incorporated into primary compulsory education. We should also strengthen transport safety education for workers of all sectors, enhance transport awareness of the population, and manage well urban transport with the cooperation of all urban residents.

THEME PAPER 1: MOTORIZATION IN CHINESE CITIES: ISSUES AND ACTIONS

STEPHEN STARES AND LIU ZHI [1]

A. INTRODUCTION

This paper looks at the issues connected with motorization in urban China. Section B starts with the numbers, looking at the current stage and pace of motorization, and going on to assess the likely scale of motorization in future years. Section C considers the likely consequences of motorization in urban areas, with particular emphasis on the issue of traffic congestion. Section D discusses ways of combating traffic congestion by better management and use of existing road space, and by the construction of new roads, but finally concluding that these approaches provide only a partial answer to congestion. Section E then reviews alternative approaches to combating congestion through the management of transport demand. Section F reviews and compares experience of motorization in several Southeast Asian localities. Finally, Section G summarizes the conclusions of the paper for urban transport strategy in China.

B. TRENDS AND PROJECTIONS

Recent Trends

Driven by rapid economic growth, China's motorization has been gathering momentum during recent years (Figure 1). The growth of the country's entire motor vehicle fleet (excluding motorcycles) averaged an unprecedented 15 percent per year between 1984 and 1994.[2] As in other countries at a similar stage of economic development, the passenger vehicle fleet in China has grown much more rapidly (at 20 percent per year) than the goods vehicle fleet; this led to a decline in the share of goods vehicles from 77 percent in 1984 to 62 percent in 1994.

Rapid motorization in China also bears the mark of the country's transition from a centrally planned economy to a more market-oriented one. During 1984-94, the number of privately owned motor vehicles increased by 28 percent per year, and the number of privately owned passenger vehicles increased by 64 percent per year. Private car data are not available, but available statistics for privately owned passenger vehicles[3] indicate a decline in the average

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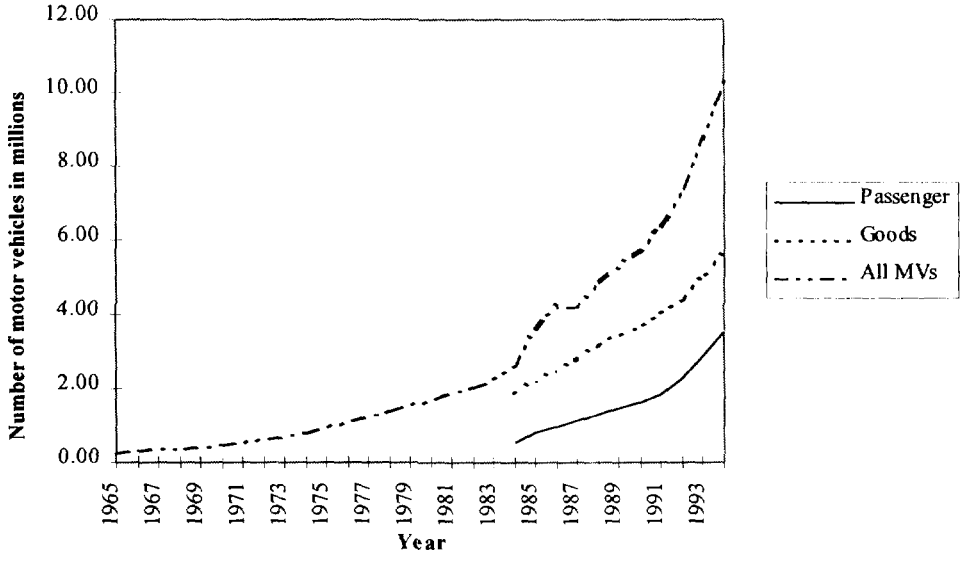
[1] Stephen Stares (deceased) was a Senior Transport Specialist, Environment and Municipal Development Operations Division, China and Mongolia Department, The World Bank. Liu Zhi is a Transport Economist in the Transport Division; Transportation, Water and Urban Development Department. Helpful comments provided by Ralph Gakenheimer, Gregory Ingram, and John Meyer are gratefully acknowledged.

[2] Motorcycle ownership data are not available at the national level. For convenience, we exclude motorcycles when using the term "motor vehicles" hereafter.

[3] Passenger vehicles in China are classified as small, medium and large, with approximately 1 to 8, 9 to 20, and over 20 seats, respectively.

passenger seats per vehicle, from 22.2 seats in 1985 to 12.9 seats in 1994. This suggests that while most of these passenger vehicles are still for commercial use, the share of private cars in the fleet is rapidly increasing.

FIGURE 1: MOTOR VEHICLE GROWTH IN CHINA



Despite impressive growth in recent years, China's per capita motor vehicle ownership remains among the lowest in the world at eight vehicles per 1,000 population, of which only one is a passenger car. China's motor vehicle ownership is not only much lower than richer countries, but also lower than countries of comparable incomes. All this suggests a very low base and therefore a huge potential for continuing rapid motorization in the years to come.

The growth of motorization in some of the more developed Chinese cities during the last several years is even more impressive. Table 1 shows that Beijing, Guangzhou, Chengdu, and Shantou have seen more rapid growth in motor vehicle ownership than the country as a whole. Even in the most densely populated city of Shanghai, where physical conditions for motor vehicle use are clearly unfavorable, annual growth has still reached 10 percent. Moreover, these cities have substantially higher levels of per capita ownership than the national average.

Another aspect of the growing motorization in urban China is the dramatic growth of motorcycle ownership. This can be illustrated by the cases of Guangzhou and Shantou, shown in Figure 2. Both cities experienced a sustained 35 to 40 percent annual growth in the number of motorcycles during the 13-year period 1980-93, a much higher rate than for passenger vehicles and goods vehicles. In response to this growth and following similar measures elsewhere, Guangzhou capped the growth rate in 1992 by imposing an annual quota on new motorcycle licenses. By 1993, motorcycle ownership per 1,000 population reached 61 units in Guangzhou and 94 units in Shantou.

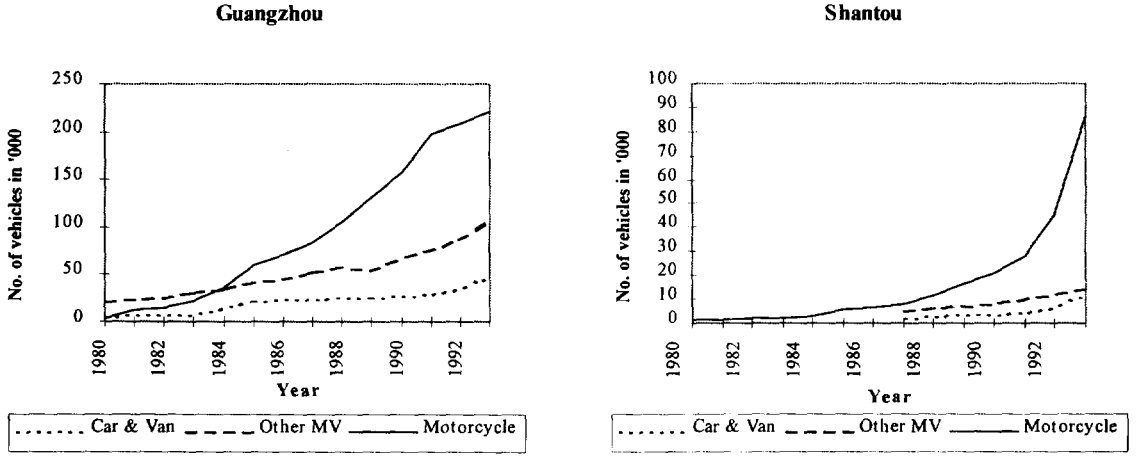
TABLE 1: GROWTH OF MOTOR VEHICLE OWNERSHIP, SELECTED CITIES

City and Statistical Area	Motor Vehicles (excl. Motorcycles) Number ('000) 1990	1993	Annual % Change	Population (millions) 1990	1993	Motor Vehicles Per 1,000 Population 1990	1993
Beijing, city proper	258	402	16	6.99	8.41	37.0	47.8
Shanghai, city proper	172	230	10	7.83	9.48	21.9	24.3
Guangzhou, city proper	94	152	17	3.58	3.70	26.2	41.0
Chengdu, municipality /a	54	124	23	9.19	9.47	5.9	13.1
Shantou, municipality	12	26	30	0.86	0.92	13.8	28.3
China	5,836	8,776	15	1,134	1,185	5.1	7.4

/a The data for Chengdu are 1990 and 1994 data.

Source: (1) Population data are from *China Statistical Yearbooks*; and (2) vehicle data are provided by local governments.

FIGURE 2: GROWTH OF MOTOR VEHICLE OWNERSHIP IN GUANGZHOU AND SHANTOU



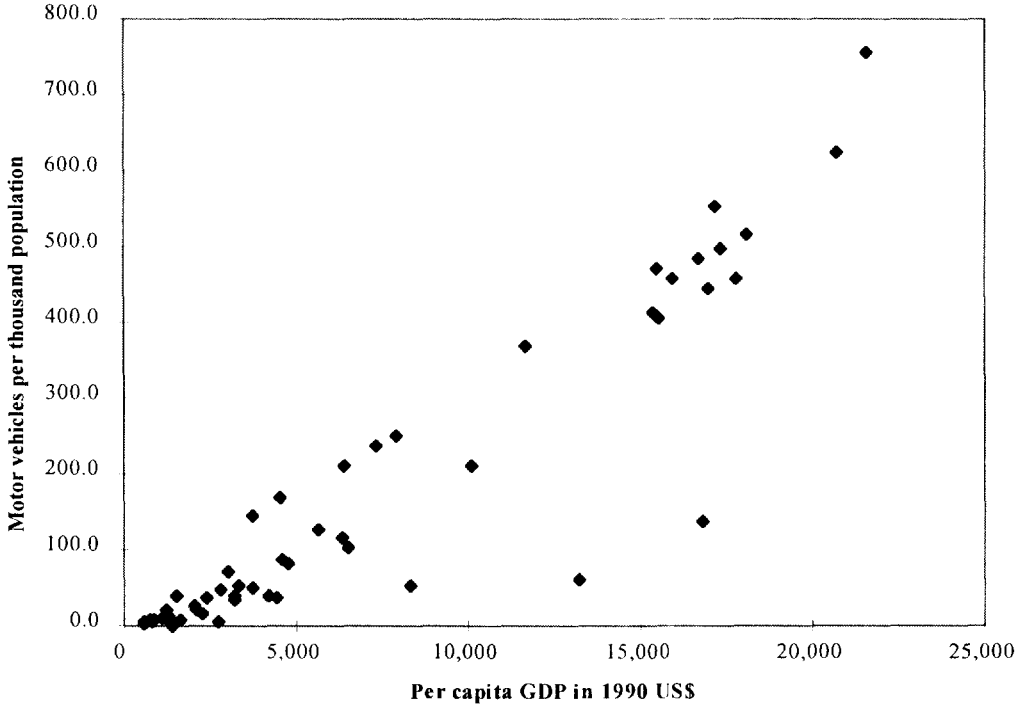
Motorization Forecasts at the National Level

There are many uncertainties associated with projections of motorization levels for China, given its low starting levels, its current high rate of growth, and the recently announced Government policy for promoting the auto industry and its domestic market. Even so, it is worthwhile to project future motorization levels, to give a sense of the possible magnitude of future growth.

International comparisons of motor vehicle growth in many countries indicate that while the levels of motorization are affected by various economic, cultural, and geographical factors, per capita income growth remains the single most important driving force for the growth of motor vehicle ownership. This causal relationship, which is clearly demonstrated in Figure 3,

has been extensively studied by economists employing cross-section or time-series regression methods to explain the variations in motor vehicle ownership between countries or cities, or within a single country or city over a period of time. Thus, a large body of consistent empirical evidence has accumulated showing a high statistical correlation between motor vehicle ownership and income growth.

FIGURE 3: PER CAPITA INCOME AND MOTOR VEHICLE OWNERSHIP IN 52 COUNTRIES OR REGIONS



Studies of the motor vehicle growth typically estimate the *income elasticity* of motor vehicle ownership, which measures the percentage change in ownership for a 1 percent change in income. Table 2 lists the income elasticity estimates reported in several representative cross-section studies.[4] These estimates range between 1.02 and 1.95, implying that a 1 percent increase in incomes would lead to 1.02 to 1.95 percent increase in vehicle ownership. It should be noted that these estimates were obtained at different times from different cross-country samples, which include both developed and developing countries, and both market and command economies. The narrow range of these estimates demonstrates that in terms of motorization these countries, rich or poor, are only at different points of the spectrum.

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4 Aubrey Silberston (1970), "Automobile Use and the Standard of Living in East and West," *Journal of Transport Economics and Policy*, Vol. 4, No. 1; William C. Wheaton (1982), "The Long-Run Structure of Transportation and Gasoline Demand," *The Bell Journal of Economics*, Vol. 13; John F. Kain (1983), "Impacts of Higher Petroleum Prices on Transportation Patterns and Urban Development," in Theodore E. Keeler (ed.), *Research in Transportation Economics*, Vol. 1, JAI Press Inc.; and John F. Kain and Liu Zhi (1994), "Efficiency and Locational Consequences of Government Transport Policies and Spending in Chile," *Harvard Project on Urbanization in Chile*, Harvard Institute for International Development.

Data in Table 2 also indicate that income elasticities of passenger cars are consistently greater than the income elasticities of commercial vehicles and total motor vehicles. This suggests that passenger cars will grow faster than other types of motor vehicles as per capita incomes grow, and recent experience in China supports this. Because passenger car ownership and use in developing countries tend to concentrate in their more developed urban areas,[5] these estimates imply that with the growth of income, urban road systems will bear more rapidly growing demands than intercity highway systems.

TABLE 2: INCOME ELASTICITIES OF MOTOR VEHICLE OWNERSHIP

Study	Sample	Vehicle Ownership
Silberston (1970)	38 free-market countries, 1965, automobiles	1.14
	38 free-market countries, 1965, total vehicles	1.09
	46 countries including USSR and East European countries, 1965, automobiles	1.21
Wheaton (1980)	25 countries, early 1970s, automobile fleet	1.38
	25 countries, early 1970s, total vehicle fleet	1.19
	42 countries, early 1970s, automobile fleet	1.43
Kain (1983)	23 OECD countries, 1958	1.95
	23 OECD countries, 1968	1.59
	98 non-Communist countries, 1977	1.30
Kain and Liu (1994)	52 countries, 1990, passenger cars	1.58
	52 countries, 1990, commercial vehicles	1.15
	52 countries, 1990, total motor vehicles	1.44
	60 world cities, 1980, passenger cars	1.02

It must be noted that other social and geographical factors are also important determinants of motor vehicle ownership, and their effects could be substantial in the short run. However, partly because these factors are difficult to quantify, their quantitative relationships with vehicle ownership are not well-established empirically. Since income is the predominant determinant of long-term vehicle ownership growth, we rely on income elasticity estimates to project the likely growth of vehicle fleet for the next 25 years.[6] It also should be noted that the use of per capita incomes to project car ownership may mask the effect of income distribution. More precisely, car ownership is highly correlated with the upper end of income distribution; this is particularly true for the early stage of motorization. However, we are not able to pursue this further due to the lack of empirical data and to the high degree of uncertainty that exists in the projection of future changes in income distribution.

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5 For more discussion on the concentration of motor vehicle ownership and use in urban areas in the developing world, see Wilfred Owen (1978), "Automobiles and Cities: Strategies for Developing Countries," in Ralph Gakenheimer (ed.), *The Automobile and the Environment: An International Perspective*, The MIT Press.

6 Methodologically, it is proper to use the income elasticity estimates obtained from cross-section data, because these estimates capture the long-run effect.

Forecasts of car, truck, and total motor vehicle ownership for China as a whole for the period 1995-2020 were prepared using income elasticities (1.58 for cars and 1.15 for trucks) estimated by Kain and Liu (1994), the most recent cross-country study that includes China in the sample.[7] In projecting the future levels of motorization, we assume that China's future per capita gross domestic product (GDP) growth rate declines *gradually* from the current rate of 10 percent per year to a sustainable 8.0 percent per year by 2000.[8] Considering that the current high growth rate of motor vehicle ownership results partly from rapidly growing incomes, and partly from "catching up" on the enormous pent-up demands caused by a tightly controlled supply of motor vehicles in the past,[9] we further assume two scenarios for the changes in vehicle ownership growth rate in the next five to ten years. In the lower-growth scenario, the current high rate of vehicle ownership growth is assumed to decline gradually to the level determined by income elasticity (that is, equal to income elasticity times the assumed income growth rate) by 2000; and in the higher-growth scenario, we assume current high rate of vehicle ownership growth continues through 1996-2000, then gradually declines to the level determined by income elasticity by 2005. The projections are summarized for several key years in Table 3.

TABLE 3: CHINA: PROJECTIONS OF VEHICLE GROWTH

	Lower Growth			Higher Growth		
Year	Car	Truck	Total/a	Car	Truck	Total/a
Vehicles per 1,000 population						
1995	2	6	9	2	6	9
2000	5	10	16	6	10	19
2010	16	24	45	25	26	57
2020	53	57	124	83	62	162
Percent growth per year						
1995-2000	16	10	10	23	11	15
2000-2010	12	9	11	15	10	12
2010-2020	13	9	9	13	9	11

/a Total motor vehicles, excluding motorcycles.

7 Kain and Liu (1994) used cross-country data to estimate regression models for passenger car, commercial vehicle, and total motor vehicle ownership. The sample included 52 countries, ranging from the very poor (such as Tanzania and Malawi) to the very rich (United States and Japan), and from some former centrally planned economies (China, Hungary and Poland) to countries that once implemented or continue to implement policies to control private motor vehicle ownership (Korea and Singapore).

8 A country study by the World Bank (1993), *China: Managing Rapid Growth and Transition*, predicted that the current very high growth rate would fall to a sustainable rate of about 8.9 percent if the Government moves swiftly and actively in its reform, or to a rate of 7.1 percent if the Government continues its reform in stop-go cycles.

9 Kain and Liu (1994) provided empirical evidence of pent-up demands for motor vehicles in China. The analysis estimated a vehicle ownership regression model, using international observations including China, to predict vehicle ownership. It was found that China's actual motor vehicle ownership was substantially lower than the predicted level. The finding suggested China's motorization level was lower than the average level for the countries of comparable incomes.

Motorization Projections at the City Level

Projecting motorization at the city level is more difficult, simply because the physical conditions for car use vary widely city by city and potential government controls on ownership and usage at the local level are very hard to foresee. Again, we turn to international experience. There are very few cross-world city studies available. A recent study by Kain and Liu (1994) provided some useful estimates that would help our projections of motorization at the city level. This analysis used data from 60 world cities to estimate cross-section regressions of passenger car ownership, and found that about 80 percent of the variance in passenger car ownership at the city level could be explained by two variables: *per capita GDP* and *city population density*. The role of *per capita GDP* in explaining levels of urban motorization is similar to the cross-country case. *City population density* is used as a proxy to reflect the impact of urban physical conditions on car ownership. The study estimated elasticities of 1.02 and -0.21 for these two variables, implying that a 1 percent increase in per capita incomes would lead to 1.02 percent increase in car ownership, and a 1 percent decrease in city population density would be accompanied by a 0.21 percent increase in car ownership.[10]

We used the elasticities for income (1.02) and density (-0.21) to forecast the future level of car ownership for a hypothetical large Chinese city prototype.[11] We focused on passenger cars only, for cars are going to be the major problem at the city level. For a 1995 base year, the city prototype was assumed to have 3 million population, with a gross population density of 20,000 persons per square kilometer—km^2 (a level that is comparable to the actual levels found in Guangzhou and Chengdu), and a passenger car ownership level of 10 per 1,000 population. A range of assumptions were made on future income growth, car ownership growth, and population density decline, as follows:

- **Income Growth.** Two possible scenarios for future per capita income growth rate, both plausibly higher than those assumed for the whole country in the earlier projections:
    - ◊ a gradual decline from the current 15 percent per year to a sustainable 9 percent per year by 2000; and
    - ◊ maintaining the current growth rate through 1996-2000, and then gradually declining to a sustainable 9 percent per year by 2005.
- **Vehicle Ownership Growth.** Corresponding to the two income growth scenarios above, two alternative scenarios for future car ownership growth were assumed:

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[10] The city car ownership regression used 1980 data from 60 large world cities (in 40 countries). Because income data at the city level were not available, the data of per capita GDP at the country level were used as a proxy. Given the greater measurement errors for the income variable used, the income elasticity estimate obtained for the regression is considerably smaller than those obtained in the cross-country regressions.

[11] There is a methodological problem here that per capita incomes and, to a lesser extent, car ownership, are also determinants of city population density. However, we consider this a miner problem on the assumption that city population densities in China will be largely determined by land use policy.

- ◊ a steady decline from the current 20 percent per year to the level determined by income elasticity by 2000; and
- ◊ continuation of the current rate through 1996-2000, and then declining steadily to the level determined by income elasticity by 2005.

- **Population Density Decline.** Most large Chinese cities currently have extraordinarily high population densities, but many are now undergoing a dedensification process. Therefore, we anticipated a decline of population density in the future, and assumed two possible scenarios for the planned population density for the year 2020 (the long-range urban master planning target year for many Chinese cities):
  - ◊ **higher density:** 15,000 persons/km^2 (comparable to Seoul in 1990, and the target density in Shanghai's long-range urban master plan); and
  - ◊ **lower density:** 10,000 persons/km^2 (comparable to Amsterdam in 1980).

Projections of car ownership based on four sets of combined assumptions for income growth and population density decline, are summarized for several key years in Table 4.

TABLE 4: CHINA: PROJECTIONS OF CAR OWNERSHIP

	Higher Density		Lower Density	
Year	Lower Income Growth	Higher Income Growth	Lower Income Growth	Higher Income Growth
Cars per 1,000 population				
1995	10	10	10	10
2000	21	25	21	25
2010	51	83	54	86
2020	127	204	138	222
Percent growth per year				
1995-2000	15.9	20.3	16.1	20.5
2000-2010	9.4	12.6	9.7	12.9
2010-2020	9.5	9.5	9.9	9.9
1995-2020	10.7	12.8	11.1	13.2

The projections show that car ownership growth in urban areas could be sustained at high rates for many years if incomes continue to grow. In addition, urban dedensification will contribute, to a lesser extent, to the increases in car ownership. The projected levels under higher income growth scenario for 2010 are similar to current Singapore levels, and for 2020, about 30 percent higher than current Seoul levels.

Hence over the next 25 years with continuing growth and expansion, Chinese cities could see the car fleet increase by some 13 to 22 times, or an average growth of 11 to 13 percent

per year. The estimates, moreover, can be regarded as conservative because we use per capita incomes, instead of upper end of income distribution, as the major determinant. As will be seen later, such rapid growth has been sustained in other SE Asian countries over past years, and is clearly attainable by China.

The Unknown: Motorcycles

The trends of motorcycle ownership in Guangzhou and Shantou shown earlier clearly indicate that motorcycles are likely to be the fastest-growing mode of urban transport in the near future, unless controls on ownership are imposed. It is not so clear, however, where the trends are heading to in the longer run. Experiences outside mainland China, as illustrated by the following cases of Italy and Taiwan (China), suggest two possible trajectories after a period of fast growth: stabilization at a moderate level or continuing rapid growth to near saturation.[12]

The historical trends of motorcycle ownership in Italy and Taiwan are shown in Figure 4. In Italy, motorcycle ownership remained higher than car ownership from 1950 until around 1963, the time when the subcompact economy cars (Fiat) became available at affordable prices. After this, car ownership continued to grow while motorcycle ownership remained at a quite stable level. By 1990, Italy had 475 cars and 96 motorcycles per 1,000 population. Taiwan (China) followed a different path. In 1972, there were 63 motorcycles (comparable to the current Guangzhou level) and 5 cars per 1,000 population; but in 1992 motorcycle ownership reached 485, still substantially higher than car ownership (146). It took merely two decades for Taiwan's motorcycle ownership to grow from a moderate level to near saturation.

Why did Italy switch to car while Taiwan continued with motorcycle? Several factors probably intervened. In the case of Italy, the motorcycle image probably deterred older candidates from this form of motorization, public transport was probably better, and cheap motorcycles (Vespas and Lambrettas) arrived not long before the affordable car and therefore had less time to get established. Very importantly, incomes in Italy were quite high in the mid-1960s (Figure 5) when the affordable car arrived, and urban densities were lower, so the switch to the car took place quite readily. In Taiwan, cheap motorcycles were available from the start of the period of rapid economic growth in the mid-1960s, and incomes did not reach the Italian mid-1960s level until 25 years later. Hence, motorcycles had a long period of dominance before the small car became widely affordable. There could be other reasons too, such as climate and cultural differences. But no matter how complicated the reasons, there is one common message from both cases: motorcycle ownership can grow rapidly if there is physically little room for passenger car use or no policy to control motorcycle ownership.

Mainland Chinese cities are typically densely developed. By all indications, motorcycle ownership growth in these cities would tend to follow the Taiwan (China) pattern instead of Italy's. Given continuing rapid growth in per capita incomes, motorcycle ownership in some cities could reach saturation level in a fairly short period of time. For example, if Guangzhou

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[12] The saturation level for motorcycle ownership is defined as 500 motorcycles per 1,000 population, which is based on Taiwan's current motorcycle ownership, the highest found in the world. Actually, whether this level can be said as saturation remains a question, as motorcycle ownership in Taiwan still grows (though at about 5 percent per year in recent years, a much lower rate than earlier years).

relaxed its cap on new motorcycle licenses, it would take only 20 years for motorcycle ownership to reach near saturation at a conservative growth rate of 10 percent per year (just one quarter of the actual growth rate before the cap was imposed). For Shantou, it would take just 16 years.

FIGURE 4: TRENDS OF CAR AND MOTORCYCLE OWNERSHIP IN ITALY AND TAIWAN (CHINA)

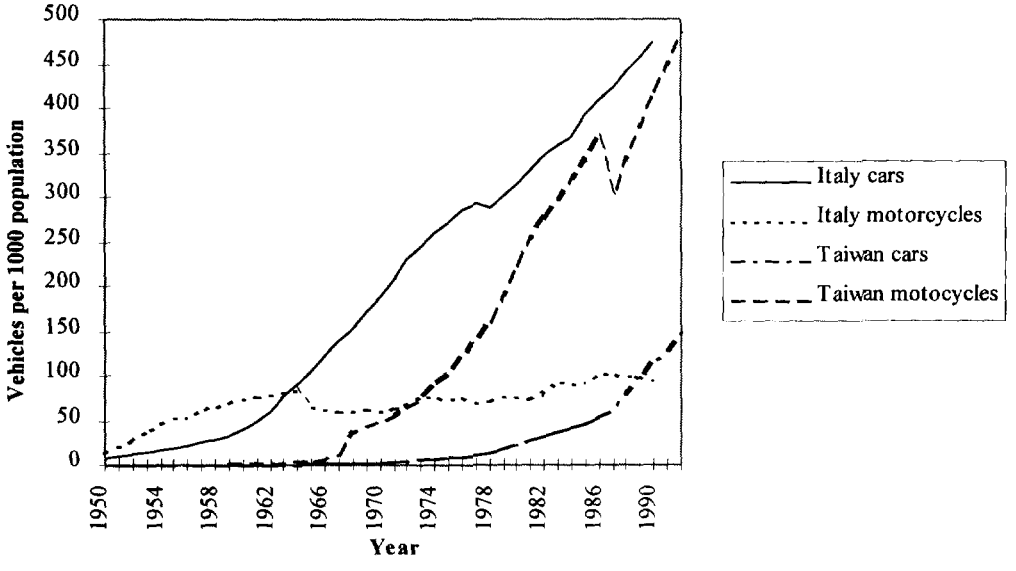
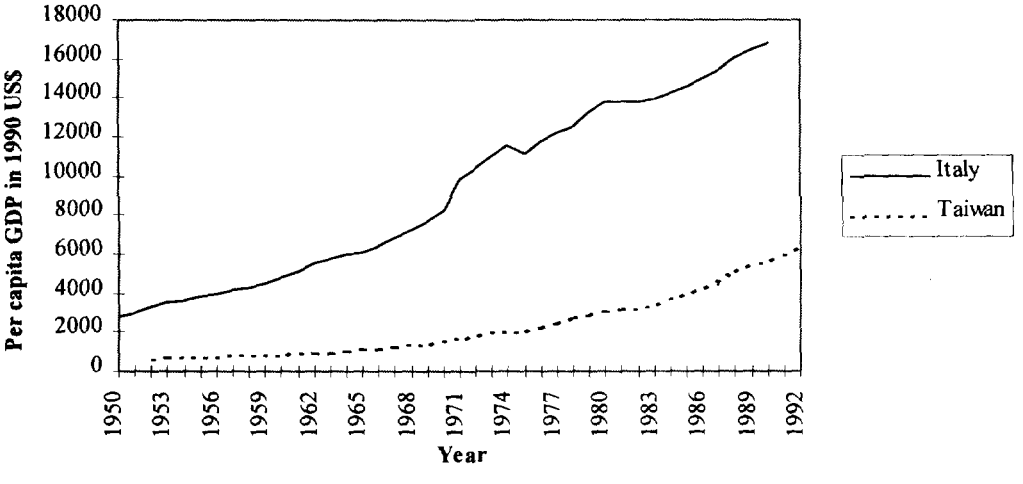


FIGURE 5: COMPARISON OF PER CAPITA GDP: ITALY VS. TAIWAN (CHINA)



Goods Vehicle Ownership in Cities

Currently, goods vehicles occupies a large share of the total motor vehicle fleet in Chinese cities. In Beijing, for example, the number of goods vehicles accounts for 59 percent of total motor vehicle fleet; in Guangzhou, 64 percent; and in Chengdu, 54 percent (in all cases excluding motorcycles). According to recent motor vehicle surveys conducted in Jinan, Fushun, Nanning, Fuzhou, and Shantou, total vehicle-kilometers traveled by goods vehicles account for roughly half of the total vehicle-kilometers by all motor vehicles.

While absolute numbers of goods vehicles will increase, their proportion in the vehicle fleet will decline, perhaps by 2020, reversing the current approximately one-third/two-thirds split in favor of goods vehicles. As discussed earlier, the passenger vehicle fleet is growing much faster than the goods vehicle fleet in urban China. This is consistent with international experience that passenger vehicle demand is more elastic to income growth than goods vehicle demand. In general, the goods vehicle fleet grows proportionally to growth in total GDP, while passenger vehicle ownership grows more than proportionally to per capita GDP growth. Although goods vehicles will continue to be a major component of total motor vehicle traffic for many years to come, it is the rapid and uncontrolled growth of car ownership in cities that will cause much of the urban transport problem in the future, and this is the main focus of this paper.

China's Motor Vehicle Industry Development Policy

The central government of China has recently promulgated an auto industry development policy[13] that aims at promoting the motor vehicle industry to lead the development of the national industrial sector. The central focus of the policy is on the formation of a domestic market, particularly a market for household cars, to ensure economies of scale for the domestic industry. The policy sets a domestic car production capacity target of 1.2 million units per year by 2000 and 3.5 million units per year by 2010, with 90 percent of the products sold domestically. The policy aims to encourages private car ownership, and calls for the elimination of government controls on vehicle purchase, for car prices to be determined by the market, and for taxes on cars to be reduced.

The foundation for this policy is an official study of China's future motor vehicle industry prepared by the Institute of Techno-Economics of the State Planning Commission (SPC-ITE). The study indicated that future car ownership in China, particularly household car ownership, depends on three key factors: (a) household affordability; (b) levels of need for car use; and (c) physical conditions for car use.[14] Household affordability is measured as the ratio of standard car prices over per capita gross national product (GNP). Based on an evaluation of international experience, the study estimated that household car ownership would break through the benchmark level of five cars per hundred households when the affordability ratio falls into the range between 1.4 and 4.0. The study suggests a likely affordability ratio of 2.0 to 3.0 for

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[13] Institute of Techno-Economics of the State Planning Commission of China (SPC-ITE): "Household Automobile Development Strategies for China," *The Economy Daily* (in Chinese), No. 4774, October 24, 1994.

[14] *Ibid.* It is the only document we obtained on projected car ownership. It does not specify how the levels of need and the physical conditions for car use are considered in the projections.

China to reach the benchmark. This implies a household with annual income of Y 50,000 would be able to afford a subcompact car that costs Y 60,000 to buy and Y 6,000 a year to operate. Based on a random household survey conducted in 14 provinces for a total of nearly 10,000 households with household income over Y 20,000 per year, the study estimated the number of households that would be able to afford, and also willing to own, a private car in future years. Based on these demand projections, the study provided the lower-bound estimates for the domestic car production capacity required. All these results and projections are summarized in Table 5.

TABLE 5: AUTO OWNERSHIP AND AUTO PRODUCTION PROJECTIONS BY SPC-ITE

Item	Projections		
	2000	2005	2010
Households able and willing to buy (million)	4.0-4.7	15.5-16.5	37.5-40.5
Annual total demands for cars (million)	1.3-1.6	2.2-2.7	3.5-4.4
of which: household demands (million)	0.4-0.6	1.2-1.6	2.3-3.0
Total car ownership (million)	6	12	22
of which: share of household cars (%)	20%	40%	60%
Cars per 1,000 population	4.7	9	15.8
Annual car production capacity (million)	1.2	2.2	3.5
of which: household car production (million)	0.4	1.2	2.3
Household car gas consumption (million ton)	0.8	2.8	6.5
Percent of national total gas consumption	2%	6%	11%
Average gas consumption (ton/household car)	0.7	0.6	0.5

Source: SPC-ITE (1994).

Reactions to this policy vary from highly skeptical to full acceptance. The skeptical view emphasizes the possible consequences on city air pollution, loss of agricultural land to road construction and low-density urban development, and traffic congestion in city centers. Those who accept the study emphasize the potentially strong role of the motor vehicle industry in leading long-term economic development, and regard growing traffic congestion as part of the price to pay for, and even as a symbol of economic growth.

It is fair to say that the policy is based on quite realistic demand forecasts. The car production capacity target does not appear to be overstated for a country with such large potential demands. There are strong reasons for China to develop its motor vehicle industry, not only from a long-term perspective of export-led development, but also from a short-term perspective: developing an internationally competitive motor vehicle industry requires economies of scale, which are not easy to achieve without a domestic market to absorb its products during the early stage.

These issues, and the implications that they might have for the development of the domestic vehicle manufacturing industry in China, are the subject of the rest of this paper. However, at this stage it can be noted that the SPC-ITE estimates of future car ownership come very close to our low-growth scenario estimates and well below our high-growth scenario. This suggests that there is a sufficiently strong base of demand to develop a viable motor vehicle industry while at the same time permitting each city to control the use of motor vehicles so that

they do not overwhelm the capacity of the city transport system. This will be returned to in the final Section G of this paper on China's future strategy.

C. CONSEQUENCES OF MOTORIZATION

Motorization is already a powerful force in the economic growth of China. The Guangdong Province Transport Study[15] (mostly completed in 1989) reviewed transport costs and operations in that province, and concluded that motorized highway transport was ripe for development, partly to reduce transport costs, and partly to remove pressure on the overburdened rail system:

> "In China as a whole, past concentrations of development strategy on heavy industry and reliance on coal as primary source of energy have been coupled with a transportation strategy focused to an unusual degree on the rail mode. There has been relatively limited exploitation of the two most important 20th Century innovations in transportation technology: modern highways and aviation systems. Consequently, the railway has played a dominant role in transportation in China, enjoying a virtual monopoly in many respects, but at the same time burdened with much traffic for which it is inherently ill-suited, and the service quality concerns of the transportation users have been largely neglected in a situation of chronic shortage of transportation services....
>
> ....Given the changing structure of the Guangdong economy, highways would be expected to play an increasingly large role in the future, even at present road transport costs, because the fastest growing segments of the Guangdong economy are industries which are typically prepared to pay premium prices for the speed and flexibility of highway transport. The magnitude of the potential reduction in highway transport costs would further expand its scope beyond the presently limited usages and extremely short haul distances. Highways could provide more economic services for short and medium distance passenger transport and small lot size or door-to-door freight up to 1,000 km haul distance, thus relieving railway congestion and improving overall service quality."

These analyses were confirmed in the 1992 Yangtze Economic Zone Study.[16] The findings of both these two studies are validated by the explosive growth in highway traffic in the past six years. In particular, the availability of, and control over, motorized transport in the form of trucks and small vans have probably been one of the keys to success of the nonstate-owned industry sector, in particular the Town and Village Enterprises (TVEs), which has been so central to the recent economic development of China (see Figure 6). Motorization of freight transport is by no means the only reason for nonstate-owned industry success, but they probably could not have succeeded so widely without it.

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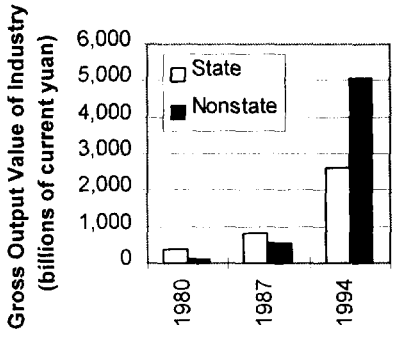
[15] *Guangdong Province Transport Study*, World Bank, June 7, 1991.

[16] *Yangtze Economic Zone Transport Study*, Yangtze Economic Zone Comprehensive Transport Study Group, April 1992.

FIGURE 6: GROWTH IN CHINESE INDUSTRY



As with freight traffic, motorized personal transport offers greatly improved mobility and expanded geographical horizons, and this has the power to radically change lifestyles. While it clearly costs more to buy and use a car than to take a bus or bicycle, timeliness, convenience, comfort, and reliability of transport are real factors that translate into personal satisfaction for individuals. Motorization in any case does not come at a fixed unit price. Individuals can choose between a new Mercedes limousine or a second-hand moped. What counts is access to mobility at an affordable price, and the fact that demand for personal motorized transport in China is soaring is proof enough that real benefits are perceived.

The freedom and flexibility of transport afforded by motorization also gives rise to its greatest problem—traffic congestion. Access to the road system is generally freely available to those with vehicles, but clearly some parts of the road system attract more traffic than others. While traffic congestion on rural roads can generally be addressed by building more road capacity, traffic congestion in cities is a much more intractable problem. The nature and treatment of urban traffic congestion now becomes the main theme of this paper.

The Nature and Costs of Traffic Congestion

Every vehicle that joins the traffic stream interferes, to some extent, with the progress of other vehicles already on the road. In light traffic this interference is negligible; in heavy traffic it is severe. Hence, as more vehicles join the traffic stream, the speed of traffic falls until it reaches crawling speed with frequent and intermittent stops—the classic traffic jam.

An obvious result of congestion is that journeys take more time to complete. Chronic traffic congestion can even result in fewer journeys being made because people are not prepared to do much more than the arduous commute to and from their workplace. Some suggest that we all have an unconscious, but more or less fixed, daily travel time budget—if this budget is used up on essential travel, there is nothing left (meaning no energy or inclination) to make additional journeys for leisure or other nonessential journeys. This can be interpreted as a reduction in the quality of life in a congested city.

Congested traffic also means higher costs for the following reasons:

- Engines are less efficient at slower speeds, and consume more fuel. For example, dropping from 20 kilometers per hour (km/h) to 15 km/h will cause an average car to consume about 25 percent more fuel for every kilometer traveled. Stop-go conditions are even less efficient, with the engine idling during stops, and with frequent speed-change cycles.

- More vehicles are required to do the same job. For example, slower traffic means that a wholesale delivery van can service less shops in a day. To deliver the same number of goods would require the distributor to invest in a larger vehicle fleet.

- Time costs money, whether this is directly in the wages of goods vehicle, bus and taxi drivers, or in the lost time of business executives, school children and shoppers caught in traffic jams. Also, congested traffic conditions means that additional time has to be allowed for journeys to allow for the greater uncertainty of travel, wasting yet more time.

An individual might weigh these costs and still decide that a journey through congested traffic is worth making for reasons of personal convenience. By doing so, however, the individual is unconsciously making travel more difficult—slower, more uncomfortable, and more costly—for everyone else already traveling. In fact, the costs and time penalties imposed on others in congested conditions can be larger than the costs incurred directly by the individual. This is particularly true for car travel which is the most inefficient user of road capacity. Some numbers are put to this Box 1.

Economists believe this to be the crux of the traffic congestion problem. Motorists choose to travel on congested roads by car because they are responsible for only their own costs, and have no liability for the additional costs they impose on others. In other words, motorists do not pay the full price of their travel and this encourages excess traffic. More generally, economists believe that congestion is, to a considerable extent, created by the systematic underpricing (namely, prices well below cost) of all modes of urban transport services. This underpricing is evidenced in several forms, ranging from free or very low-cost parking for bicycles, motorcycles or cars, subsidies to public transit, and, as discussed here, free use of highly congested streets in central parts of cities. Hence, pricing policies are likely to be a key weapon in the fight against traffic congestion, as discussed in Section E of this paper.

Impact of Traffic Congestion on Bus Services

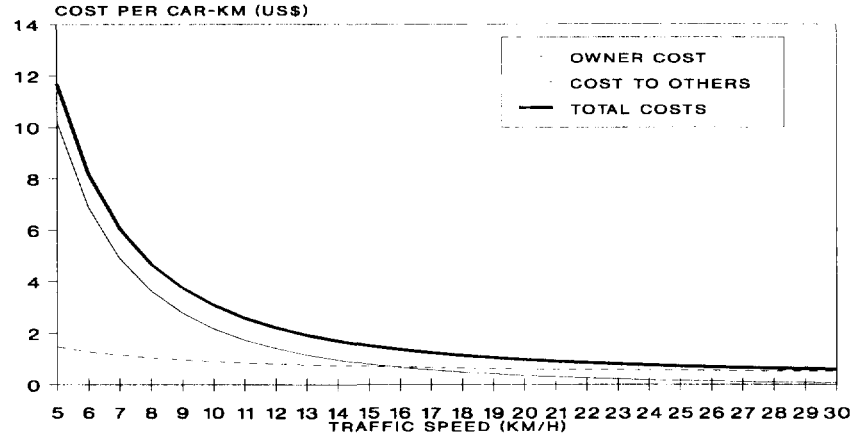
Traffic congestion affects all road users, but bus services are particularly badly affected. For example, take the case of a bus dispatcher at a terminus sending out buses on a route that takes one hour to complete. To maintain a 6-minute bus headway, 10 buses will be needed since the first bus will return in time to make the next journey along the route after the tenth bus has departed (give or take spares for fueling breaks and breakdowns). If traffic congestion increases so that it now takes half an hour longer to complete the route, the dispatcher has two choices; either send buses out less frequently —now every 9 minutes—or put more buses on the route—15 buses are now needed to maintain a 6-minute headway. The second choice does not exist in the short term but, faced with generally increasing congestion, a bus company over the longer term can acquire more buses to maintain timetables. Either way, service to passengers will deteriorate with definitely longer travel times and, if extra buses are not provided, longer waiting times. If the bus companies do buy more buses to maintain headway, these must be paid for, along with the extra drivers, extra depot space and larger maintenance staff. This means either higher bus fares for passengers or an increasing deficit financed by the municipality. While the latter appears to avoid impacts on the passengers, in the long run bus company deficits cannot be

allowed to rise forever, so that lower service or high fares will likely prevail. (See Box 2 for some estimates of the impact of traffic congestion on bus operations.)

BOX 1: MOTORIST CONGESTION COSTS

Analysis shows that in congested traffic conditions, the costs a motorist imposes on others far outweigh the costs incurred directly by the motorist. This is illustrated in the Box Figure, which shows the total cost of operating a car at different speeds, separating out the cost incurred by the car owner, and the cost imposed on other road users by the presence of that car. The computation was based on the methodology set out in the Smeed Report[1] but using road usage parameters from Hong Kong. Values are expressed in 1995 US dollars.

BOX FIGURE: TOTAL COST OF CAR OPERATIONS



At 30 km/h, which would be an excellent speed in urban conditions, a motorists incurs a cost of about $0.5/km. At the same time, the motorist is imposing a total additional cost on all other road users of about $0.08 for every kilometer traveled. At 12 km/h, which corresponds to typical congested conditions, the situation changes significantly. The costs incurred by the motorist rise by about 50 percent to $0.8/km, but the cost imposed on all other road users increases nearly 20 times to $1.4/km. In chronic congestion at 5 km/h, costs incurred by the motorist almost double from the previous level to $1.5/km, while the costs imposed on others increases another sevenfold to $10.2/km. The calculations are less reliable at lower speeds, but the graphical representation of the steep increase in costs imposed on other traffic at low speeds is generally realistic.

[1] *Road Pricing: The Economic and Technical Possibilities,* Smeed, R., et al., London, 1964.

Thus, increasing traffic congestion results in poorer service and rising fares, which in turn encourages passengers to find some other way to make their journeys, adding further to congestion. Thus develops the downward spiral of increasing congestion, rising costs, poorer service, higher fares, reduced patronage, and yet higher congestion that confronts urban bus operators the world over.

BOX 2: IMPACT ON CONGESTION ON HONG KONG BUSES

Estimates below show Hong Kong bus operations under two conditions of traffic congestion in 2001, as simulated for the 1989 Second Comprehensive Transport Study.

	Congestion Level	
	Lower	Higher
Av speed (km/h)	14.3	10.8
Daily bus-km	602,000	602,000
Daily bus-hours	42,000	55,700
Number of buses	4,120	6,160

Hence with a reduction in average operating speeds of 3.5 km/h, yet trying to maintain the same volume of bus operations measured in daily bus-km, operating hours would increase by one third and about 50 percent more buses would be required to maintain the same frequency of services. The total cost of operations would be increased by perhaps 30 percent which would have to be covered by a subsidy from Government (not accepted in Hong Kong) or an increase in fares. At the time of the study, bus and minibus transport together carried about two-thirds of all public transport passengers in Hong Kong, so the need to control traffic congestion was very apparent.

Impact on the Environment

Emissions from motor vehicle engines are a serious source of air pollution in motorized cities. Pollutants from vehicle engines include lead, carbon monoxide, nitrogen oxides, ozone, and particulates. These pollutants cause a wide range of adverse impacts on urban populations, including impaired intelligence and reduced learning ability (from lead poisoning) and a series of respiratory ailments including infections, asthma, and decreased lung efficiency. Besides adversely affecting individual welfare, these impacts impose health burdens and costs on the community that reduce the economic efficiency of urban areas.

Air pollution from motor vehicles increases under congested traffic conditions. The generally lower traffic speeds, intermittent stop-go operations and, in chronic congestion, frequent periods when vehicles are halted with idling engines, not only increases the amount of fuel consumed, but the fuel is burned less efficiently by the engines. The net result is that the quantity of emissions per unit of distance traveled is sharply increased.

In fully motorized societies, motor vehicle emissions comprise a high proportion of total urban air pollution. For example, in the countries of the European Union in 1990, motor vehicles caused 50 percent of all nitrogen oxide (NO_x) pollution and over 60 percent of all carbon monoxide (CO) pollution. But motor vehicle pollution is perhaps an even greater problem in rapidly motorizing developing countries where emission controls are less extensive and effective, and engine technology is older. In Manila, for example, the contribution of motor vehicles to total NO_x and CO emissions in 1990 was 80 percent and almost 100 percent, respectively.

While China is at an early stage of motorization, the potential course of motorized pollution is plain to see. In Beijing, one of the centers of motorization, the contribution of motor

vehicles to NO_x and CO pollution has already reached 46 percent and 30 percent, respectively. For less-developed Chinese cities, industrial and domestic emissions of pollutants are probably the dominant concern at present. However, in the next few years as industrial and domestic pollution are reduced and motorization advances, motor vehicle emissions will become a much more significant source of air pollution.

These issues are discussed in detail in Theme Paper 2 on "Motor Vehicle Pollution Control in China: An Urban Challenge." The paper also reports that one of the lessons from motorized countries is that motor vehicle emissions can be greatly reduced with an aggressive strategy for cleaner air. China currently has an opportunity to set such a motor vehicle emissions control strategy, which could significantly reduce the extent and costs of future air pollution in urban areas.

Air pollution is not the only environmental problem posed by increased motorization of cities. Other problems include motor vehicle noise, especially from concentrated high-speed traffic on urban expressways, decreased local amenities when excessive vehicle flows dominate local streets, visual intrusion from poorly designed highway structures, and reduced traffic safety due to the mixture of intrinsically incompatible vehicles, bicycles and pedestrians. All of these adverse environmental impacts can be mitigated by better design, sensitive to the function and needs of the city. However, for better design to flourish requires both a commitment from the city to improving environmental conditions, and also the development of professional skills to exploit the techniques available for improved design.

Impact on Nonmotorized Traffic

The mixture of motorized and nonmotorized vehicles is inherently hazardous under any traffic condition. The relatively higher speeds of motorized vehicles, and the unprotected nature of the bicycle, means that cyclists are highly vulnerable in accidents.

The effect of traffic congestion on bicycle traffic is complex. The competitiveness of the bicycle is generally increased when congestion slows motorized traffic to the speed of the bicycle. Also, riding conditions are possibly less hazardous, with the effects of higher volumes of motor traffic offset by the generally lower speeds in congestion. On the other hand, air quality is very much worse with greatly increased motor vehicle-generated pollution affecting cyclists more than most road users. Uncontrolled congestion also has a tendency to spread to all parts of the street network, so that motor vehicles will penetrate back lanes and side roads previously the sole domain of bicycle and pedestrian traffic. On balance, conditions for bicycles in congested traffic are probably worse, but their competitive advantage is probably increased.

It must be recognized that bicycles are substantial users of road capacity, and that the massive bicycle flows in many Chinese cities are themselves a contributor to traffic congestion, especially at intersections. Until recent times, however, the mainly bicycle flows were manageable. It is the mixture of motor vehicles and bicycles that has sparked off serious congestion. More is said on the role of the bicycle in Section D of this paper.

Impact of Motorization on Land Use and Urban Form

The evolution of residential and employment location patterns commonly seen in Western cities provides a useful reference for projections of the likely impacts of motorization on land use and urban form in China. Although the details of Western land use patterns vary city by city, they possess some fundamental similarities. These can be summarized as a concentric urban form comprising a central business district (CBD), a central city, and outlying suburbs, with a radial transport network linking the three components. Basic businesses[17] mostly cluster in the CBD, residences and population-serving businesses mainly locate in the central city and suburbs, and most manufacturing businesses locate in suburban areas with convenient road transport. Both residential and employment densities decline with distance from the CBD.

Forces for Suburbanization. Historically, Western cities were overcrowded with both population and employment located within close proximity. It has evolved into the modern form described above through decentralization or suburbanization, a process characterized by expansions of urban geographical boundaries and declines in both population and employment densities. Suburbanization is caused and affected by many socioeconomic factors, the most notable among them being (a) increasing urban populations, (b) rising real incomes, (c) falling real transport costs, and (d) the relative price of rural and urban land. Growing urban populations have direct impact on the expansion of urban boundaries. However, rising real incomes and falling real transport costs are the main driving forces for the declines of both population and employment densities, which also lead to urban spatial expansion. The pace and extent of suburbanization have been affected by the availability of cheap land as well.

It is important not to misunderstand the role of private cars in this process. Suburbanization occurs in all parts of the world, developed and underdeveloped, with and without widespread car ownership. In the United States, suburbanization did not start with the emergence of the private car, but with streetcars. It is misleading to attribute the lower-density suburban development in the United States simply to widespread ownership of private cars. The post-World War II rapid urban sprawl in the United States was the consequence of a number of factors, including the federal housing policies that encouraged single-family detached housing construction. Private cars played a role to reinforce the trends, but only a small role. The generally lower densities of US cities than many cities in other parts of the world are also explained by the fact that land is more abundant and, hence, land cost is relatively lower in the United States. When land supply is limited or land prices are relatively high, availability of private cars does not lead to such widespread suburbanization.

Motorization does play an important role in modern manufacturing business location, but it does not act alone. The suburbs provide cheaper and larger pieces of land for the single-story plants more suitable to the needs of many modern manufacturing businesses. These are most easily served by road transport, which provides cheap door-to-door services.

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[17] Urban businesses can be divided into two major categories. The so-called basic businesses are those exporting their goods and services to other areas. The "population-serving" businesses sell consumer goods and services to local households.

Motorization and Land Use. To further understand how motorization affects urban land use patterns, we should understand how businesses and households respond to changes in transport in their chosen location. The modern urban form results from a market process where land prices are determined through demands for land by businesses and households, and typically decline with distance from the CBD, reflecting the comparative advantages of location. Businesses choose their location to maximize profits. The basic businesses cluster in the CBD because, by locating there, they are able to generate sufficient revenues to cover the high land prices and still make a profit. Households choose their residential location in the outer areas where the much lower housing prices (due to lower land prices) more than offset the higher commuting costs. Population-related businesses, of course, follow the residential locations.

A transport improvement between the CBD and the suburbs lowers the cost of commuting, and makes it possible for households to move farther away from the center to enjoy larger housing. This decrease in commuting cost also allows businesses at the center to contain wages, thereby improving their position over competitors located in other areas, and maintaining the attractiveness of the CBD to new businesses as a center of employment. An increase in commuting costs on the other hand, as would be caused by increasing traffic congestion, initially has an opposite impact: centralizing residences and decentralizing jobs. As congestion continues to grow and the CBD is seen as an increasingly expensive and unattractive place to work, jobs would tend to decentralize, taking households with them. In summary, if land is not controlled, increasing motorization will likely promote decentralization of both population and employment locations, but this process will be greatly accelerated if severe congestion is allowed to dominate the city center. Clearly, decentralization caused by congestion is a very inefficient process.

Motorization and the Development of Chinese Cities. The major Chinese cities currently have quite different land use patterns from those found in Western cities. Much of the difference is the legacy of several decades of urban land development under strict government controls in the absence of a land market, especially the widespread implementation of enterprise-based provision of housing and other services. However, the rapid changes now taking place, most notably residential dedensification and large-scale addition of office buildings in the city center, lower density residential development in the city fringe areas, and relocation of manufacturing businesses from city center to suburbs, are following the evolution of urban form similar to that seen in the West. These changes are associated with three major factors: (a) the emergence of an urban land market that determines land values to reflect locational advantages, (b) income growth that makes overcrowding increasingly unsatisfactory and dedensification possible, and (c) availability of faster transport modes, including cars.

Motorization will facilitate such changes of urban form in Chinese cities. It is also probable that uncontrolled motorization would speed up the decentralization process further, but in an inefficient manner. While there are good reasons for guiding motorization to avoid excessive urban sprawl, the Government should be aware of three lessons from the Western experience:

- Car ownership is not the single factor for urban sprawl, and excessive urban sprawl would not be avoided by simply restricting private car ownership.

- The key to avoiding excessive urban sprawl is a firm land development policy; this is particularly important before the land market is fully developed to reflect the scarcity of land resource. If the Government loses control of land development, growing motorization will no doubt help lower the density of development in city fringes.

- Growing traffic congestion will likely erode the locational advantages of city centers and encourage businesses to locate in outer areas.

Impact on Economic Growth

The negative impact of traffic congestion on economic growth is self-evident. Congestion increases transport costs for both freight and commuters. Higher cost for freight transport directly translate to lower productivity; and higher commuting cost requires employers to pay higher wages that will increase production costs and thus decrease productivity.

Estimates of the scale of economic losses due to congestion are very uncertain. Most of these estimates were obtained by comparing the costs of transport in currently congested conditions with costs under assumed ideal conditions, but these ideal conditions are difficult to identify and can be quite unrealistic. After all, congestion is a consequence of more economic activities associated with economic growth. This is particularly true for urban areas, in which these activities tend to concentrate due partly to urbanization driven by economic structural change, and partly to economies of scale in production. This close proximity of activities, in location and timing, is therefore both a cause of congestion but also creates the climate for economic growth.

Studies in several cities including Seoul, Bogotá, Bangkok, and cities in northeastern India and Nigeria,[18] indicate that the city center acts as an incubator for the creation and growth of small- and medium-size businesses. They require close proximity to other similar businesses that they do not find in the suburbs. However, severely deteriorating traffic conditions in Bangkok have impeded that role of the city center, forcing medium and small businesses to move to less-productive locations. This supports the notion that mild congestion is part and parcel of urban life, but chronic congestion diminishes the economic life of a city.

Conclusions on Consequences

The benefits of motorization to China are likely to be substantial in terms of improving the quantity, quality and efficiency of transport services. The motorization process is integral to continuing national economic development. Despite some alarmist speculation, economic forces will likely control the depletion of both fuel and land resources. The best defense here is the continued move to a market-oriented economy with prices fully recognizing economic resource costs.

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[18] The results of these studies are summarized in Cavelle D. Creightney (1993), *Transport and Economic Performance, A Survey of Developing Countries*, World Bank Technical Paper Number 232.

Motorization poses two substantial threats to city life. The first is the increase in air pollution, which, if unchecked, could seriously damage health and impose significant costs on the community in the form of increased health care and loss of productivity. This subject is taken up in Theme Paper 2 on "Motor Vehicle Pollution Control in China: An Urban Challenge." The other main threat is the development of chronic congestion in cities. This would dissipate many of the expected benefits of motorization, and destroy much of the amenities and quality of city life. Techniques for dealing with traffic congestion are discussed in the next two sections.

D. Dealing with Traffic Congestion—Managing Road Space Supply

The instinctive solution to traffic congestion for most city managers is to try to supply more street traffic capacity to absorb the excess traffic demand. This can be done in two ways: by managing existing street space more efficiently to maximize available capacity, and by constructing new streets and roads to add more capacity. These two approaches are discussed in this Section.

The Street Management Solution

Available road space in most Chinese cities is not used to the limits of its capacity because this has not been necessary until relatively recently. With growing traffic pressures, cities are now in the process of developing traffic management skills to make more efficient street systems, but this will take a little time to mature. Elements of traffic management solutions comprise the following:

- A logical road hierarchy, defining the traffic function of each street;
- Improvement of street and junction layouts through placement of curbs, painting white lines, installation of proper signing;
- Segregation of major traffic classes—bicycles, buses, and others—to the extent possible by:
    - horizontally—separate lanes or streets for each class of vehicle;
    - by time—selective priorities and restrictions by time of day;
    - vertically—grade separation of key junctions;
- Extension, automation, and linking of traffic signal systems;
- Removal of hawker traffic to side streets; and
- Education and enforcement.

With the exception of traffic signals and grade separations, traffic management is essentially low-technology and low-cost. However, it requires training and skills to develop and apply appropriate solutions and, above all, organization and determination to bring all the components together into a coherent traffic management strategy. The status and importance of

traffic management in Chinese cities needs to be raised, and this could be assisted by the development of interagency teams to tackle traffic management in a comprehensive manner.[19] It is estimated that street capacity in currently congested cities, where some traffic management measures have already been applied, could be boosted by 30 to 50 percent with refined techniques. This is well worth while pursuing.

Bicycle Solutions. Since the mixture of bicycles and motor vehicles appears to exacerbate congestion, two extreme bicycle "solutions" have been proposed to make more efficient use of road space: either ban the use of bicycles altogether and rely entirely on motor vehicles (including public transport), or ban the motor vehicle and give the streets back to the cyclists. Neither is realistic.

Banning bicycle use would be immensely disruptive to urban life and the urban economy since they remain the dominant mode of transport in even the largest cities. It is possibly the most efficient mode of transport for short journeys (2 to 5 km) and this efficiency would be lost by a total ban. Even if the disruption of a ban could be accepted, it would put enormous pressure on the public transport system, and this could not be expanded overnight. Hence, the outright elimination of bicycles could not be supported. However, in the context of leveling the playing field for all modes of urban transport, there is a case for removing unreasonable subsidies to cyclists, and even imposing fees on cyclists commensurate with their use of road space (as long as all modes are treated evenhandedly).

Banning motor vehicles and giving the streets back to bicycles is equally unrealistic. The economic forces outside cities driving the motorization process are unstoppable, and motor vehicles in the form of buses, vans, taxis, trucks (especially small trucks), mopeds, motorcycles and, increasingly, cars, will have needs to penetrate city centers. They cannot realistically be relegated to the city fringe.

Bicycles and motor vehicles must learn to live together. Positive provision for cyclists through segregated facilities is likely to be a more efficient solution than either outright bans on cyclists or pursuing dreams of turning the clock back to an earlier transport age. Positive provision for the bicycle would benefit both bicycles and motor vehicles as discussed further in Theme Paper 5, "Bicycles in Cities."

The Smaller Vehicle Solution—the Role of Motorcycles. Of all *individualized* vehicles, motorcycles can be the most efficient users of road space in terms of the volume and speed of passengers transported. In urban areas, motorcycle speeds are comparable to car speeds, but a motorcycle requires only about half of the road space needed by a car. Assuming both motorcycles and cars have similar average occupancies, as is the case in Guangzhou, a road can carry twice as many travelers by motorcycle as by car. The efficiency of motorcycles relative to bicycles is not so obvious. Compared with a bicycle, motorcycles occupy more road space, but carry more passengers and travel faster. Probably bicycles are more efficient for short journeys in the city center, but the balance of efficiency would swing to the motorcycle for longer-distance trips on relatively uncongested roads.

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[19] Discussed further in Theme Paper 4, "Municipal Transport Management: Overseas Experience."

There are, of course, many disadvantages to motorcycles. They are generally much more polluting than cars in terms of noise and engine emissions. Also, the combination of higher car-like speeds with bicycle-like lack of personal protection makes motorcyclists vulnerable to traffic accidents, with adverse consequences for both individuals and the community. It is also clear from Section B earlier that the demand for motorcycles is immense and, if uncontrolled, could quickly swamp the capacity of the street systems of most cities.

Some of these issues could be dealt with by specifying higher standards for motorcycles (particularly on engine emissions and mufflers); this would alleviate (but not eliminate) some of the problems at source and, because of the higher prices associated with the higher standards, would restrict the rate of growth. Other controls on motorcycle growth might be deemed necessary, but these should be considered carefully in the light of the clear benefits that motorcycles bring to a segment of the population. They are not inherently inefficient users of urban road space, and the potential role of motorcycles should not be left to go by default.

The Larger Vehicle Solution—More Use of Public Transport. Public transport buses are potentially the most efficient users of road space per person transported, and greater use of buses in place of either bicycles or cars could improve overall road transport efficiency. In the busier corridors, removing passenger flows from roads onto metros would have even greater impact, but high expense and complexity are likely to limit metros for the foreseeable future to just a few corridors in the major cities. Development of road-based bus mass transit is a much more affordable solution for most Chinese cities. In particular, the development of bus transit along important radial routes between the city center and the suburbs could serve as a "premetro." Such schemes could both satisfy existing demand at an affordable price, and help concentrate passenger flows and strengthen the viability of subsequent upgrading to rail-based transit systems. These aspects are discussed in detail in Theme Paper 6, "Investment in Mass Rapid Transit."

For buses to be effective, they need to be protected from the impacts of road congestion by allocation of street priorities. These could include the premetro busways in major traffic corridors as discussed above, but also city-center street priorities including bus-only lanes, bus-only streets, bus "gates" (short sections of streets accessible only by buses), priority for buses at traffic signals (through automatic detection of bus arrivals), and so on. Such priority measures are in common use throughout the world, but are still rare in China. One objection heard is that dedicated bus lanes often appear lightly used relative to adjacent general-traffic lanes. While this will be true in terms of the number of vehicles, bus lanes are potentially much higher carriers of people, and this is the key measure to efficient use of street space in urban areas.

The Role of Taxis. Taxi service can also increase efficiency of city-street usage. Combined with other policies and services, taxis can substitute for the use of private cars in city centers, providing higher-quality and more timely transport for those disinclined to use public transport or bicycles. The role of taxi service needs special attention because of its close relationship with the development of public transit.

Taxi transport is a growing industry in urban China. In Guangzhou, the number of licensed taxis increased from approximately 8,000 at the end of 1991 to 12,800 in 1995, an average growth of 16 percent per year. In Beijing in 1994, the taxi fleet of nearly 50,000

vehicles carried more passengers than the subway, and accounted for 13 percent of all public transit journeys (3.9 billion passengers). By all accounts, current taxi services are financially viable. For example, Beijing taxi vans cost around Y 50,000 and are rented out by the taxicab companies to drivers for about Y 4,500 per month; drivers are reported to generate sufficient revenues to cover operating costs and provide a wage.

Although rapid growth in the taxi industry has resulted primarily from rapid income growth and the resulting demands for faster and better passenger transport services, other contributing factors should not be ignored. In particular, underdeveloped public transit systems prevalent in many Chinese cities leave many tripmakers, particularly business visitors, few choices but the taxi. In other words, poor public transit systems have provided an opportunity for taxis to penetrate the market. As a result, the number of taxis per 1,000 resident population is high in many large cities: 8.0 in Beijing; 3.4 in Shanghai; 4.2 in Guangzhou; 3.5 in Qingdao; 3.7 in Urumqi; and 3.2 in Fuzhou. This contrasts with 3.0 taxis per 1,000 population in Hong Kong, a city noted for its relatively high taxi usage.

Rapid growth in the taxi industry also appears to be a mixed blessing for at least some large Chinese cities. While taxis have met fast-growing demands for better service, large volumes of taxi traffic are adding significantly to traffic congestion. It was reported in Beijing that taxi flows comprised 60 percent of the peak-hour traffic volume in 1994, much of it due to the cheap and popular minivan taxicabs (nicknamed "yellow bread loaves" for the vehicle's shape and color) introduced in 1992. The municipal authority recently decided to restrict new registration and licensing for this type of taxi vehicle.

Given the limited data available, it is difficult to make a definitive statement on the proper role and extent of taxicab services in Chinese cities. This is worth more detailed study. Clearly, taxis have proved very popular in filling a void left by inadequate public transport services, but their massive presence in some cities is now possibly inhibiting the development of good public transport. The taxi policy should be linked with public transport policy, and relative pricing of taxi and public transport services should be a key issue. Both services should be able to cover all their costs of provision, and these costs should include the costs of congestion imposed on other traffic. Since taxis impose greater congestion costs per passenger than do buses, taxi fares should probably increase in the future relative to public transport fares. This would promote bus usage, helping to restore the balance between the two types of transport service.

Other Efficiency Options. A variety of options are available to spread peak transport demand or use road space more efficiently. The following are a few examples:

- **Staggered Working Hours.** Since the main transport problems occur in the morning and evening peak hours, widespread implementation of staggered working hours, including flextime, could improve the peak-hour commuting problem and relax the need for traffic control measures. However, such policies are not popular with employers and positive efforts are needed to gain wider acceptance.

- **Park and Ride.** Construction of bicycle and car parks at mass transit terminals and stations promotes the use of public transport for access to the city center.

- **Vehicle Sharing.** Filling cars with passengers makes them more efficient users of road space, and this can be encouraged by giving advantages to high-occupancy vehicles (HOVs). It is common practice in the United States to allow HOVs to use designated bus lanes on freeways. A common practice in South America, also followed in Washington, DC, is to promote sharing of taxis by allowing drivers to pick up additional passengers along the route. While this does lead to higher occupancy of taxis, which is more efficient for the road space used, taxis as a result tend to keep to the main corridors that are already served by public transport, which reduces benefits.

While all these methods are worth exploring, they operate at the margin and must be regarded as supplementary to other policies.

The Road-Building Solution

In response to the sharp increase in motor vehicle traffic, many cities in China are developing plans for extensive new road construction. This section looks at the background to these plans, their scope, and their likely effectiveness in dealing with road traffic congestion.

Urban Road Infrastructure Deficiencies

Many Chinese cities were developed long before the advent of the motor vehicle and their street systems now struggle to cope with modern traffic flows. Much can be done to improve the efficiency of existing streets by traffic engineering measures, as discussed above. However, many city planners also believe that Chinese cities are underprovided with roads as compared with modern city prototypes.

A much-quoted statistic in China is the percentage of the total urban area given over to roads. Low figures for China (for example, 5, 6 and 11 percent for Shanghai, Guangzhou and Beijing, respectively) are compared unfavorably with much higher figures elsewhere (for example, 18 percent for Seoul, 23 percent for Tokyo, 35 percent for London, and an incredible 45 percent for Washington, DC). With grave suspicions about the contrast between Shanghai at 5 percent and Washington, DC at 45 percent, we conducted and solicited actual measurements of selected streets in Washington DC and several Chinese cities, with the following results:[20]

City and District:	% Road Space
Washington Downtown	16-18
Central Guangzhou	8
Shanghai Downtown	17
Shanghai Luwan District	12
Shanghai Southwest Suburb	6-8
Beijing Within 2nd Ring	10-12

[20] Stephen Stares, unpublished note, February 1995.

The striking finding is that downtown Shanghai has approximately the same road space percentage as downtown Washington. This is hardly surprising because downtown Shanghai is really a European street layout, but how could the quoted statistics have diverged so much? Probably for several reasons having to do with the definition of the measurements. The earlier-quoted Washington figure of 45 percent is almost certainly not the share of road space. It is more probably the total percentage of the urban area not occupied by buildings, and so includes the wide sidewalks and possibly even the park areas of its famous Mall. It is also possible that the quoted Chinese cities' statistics include much undeveloped land in the measure of the total urban area, thereby depressing the percentage of street space. Quoting a single figure for an entire city, in any case, gives a misleading impression since considerable variation exists between districts. Whatever the reasons, such simplistic comparisons are dangerously misleading

Based on the measurements cited above, though, it can be concluded that road space in many Chinese cities probably is low, although not as low as commonly quoted. The comparative underprovision of roads is probably due to a street layout common to many Chinese cities where very large city blocks are bordered by 4- to 6-lane streets, but penetrated only by narrow alleys scarcely one vehicle wide.

How Much Road Construction Do We Need?

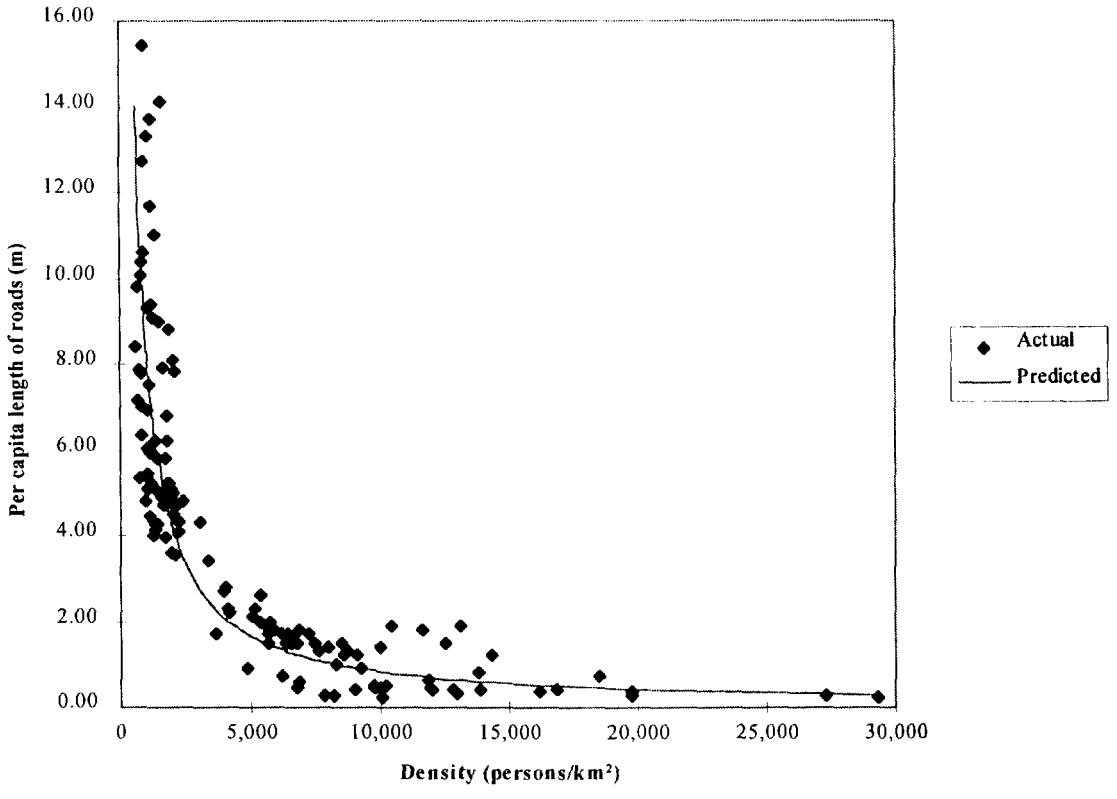
It seems clear that many major cities in China could benefit from additional road space. However, the needs for road space can be quite different among cities of similar level of motorization, because there are many other interrelated factors. These include the levels of public transit service, the spatial distribution of jobs and residences, urban topography, government policies that affect the relative prices of using different modes and allocation of urban road capacity among them, and so on. Hence, there is no single formula applicable to all cities. For a particular city, how much road space is needed and where it should be located require careful evaluation in order to gain the maximum benefit with limited financial resources.

With these cautions in mind, we have nonetheless attempted to quantify, in very broad terms, the scale of future road construction needs in typical Chinese cities. This was done by making comparisons of international data on two aspects: (a) the relationship of per capita road length vs. population density, and (b) the proportion of high-grade urban roads. These comparisons strongly suggest that there are certain regularities in the relationships, which could be helpful in assessing the needs for urban roads in Chinese cities.

Per Capita Road Length vs. Population Density. It should be acknowledged that a more precise measure of physical amount of roads is lane-kilometers of roads by functional type. These data, however, are generally unavailable. Therefore, we have to use total length of urban roads as a proxy for urban road space. This will be supplemented later with an examination of the variations in the composition of urban functional roads among different cities. Figure 7 plots per capita urban road length against population density for 65 world cities, including several Chinese cities. Some of the cities appear twice or three times in the sample because data for different years (mostly 10 years apart) are available. All plots lie fairly closely around a smooth curve similar to a hyperbola function, strongly suggesting that denser cities have lower per capita road length than less dense cities. When we fitted the two variables into a log-log function, we

obtain a striking -1.0 elasticity estimate, which could be interpreted that a 1 percent decrease in urban population density would be accompanied by roughly a 1 percent increase in per capita length of urban roads.[21]

FIGURE 7: RELATIONSHIP BETWEEN URBAN POPULATION DENSITY AND PER CAPITA LENGTH OF URBAN ROADS
(137 observations for 65 world cities)



The underlying reasons for the simple relationship between per capita road length and population density are complex, but reveal a simple fact: per capita length of urban roads is, by and large, determined by the population density. In Figure 7, several US sunbelt cities lie at the low-density extreme, while Hong Kong is at the high-density extreme. Hong Kong is much richer than many other high-density cities in the sample, but it has the lowest per capita road length due to its extremely high density. Taking this international regularity as a yardstick, it is safe for us to say that urban road development in China's major cities is unlikely to go anywhere near the level of Los Angeles or Phoenix, as long as densities in Chinese cities remain high.[22]

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[21] Liu Zhi (1996), "Urban Form and Transportation: An International Perspective," unpublished research note.

[22] Even the post-World War II US urban highway construction has been criticized for providing excessive and uneconomic capacity. The available evidence suggests that for most of the very costly centrally located facilities, the costs of added capacity exceed the incremental benefits of reduced congestion. For more discussion, see John R. Meyer and Jose A. Gomez-Ibanez (1981), *Auto, Transit, and Cities*, Harvard University Press, p. 228.

It should be indicated, moreover, that the plots for Guangzhou, Chengdu and Jinan all lie far below the curve (or the international average) and the plot for Beijing is roughly at the curve. This suggests that per capita road lengths for these cities, except Beijing, are substantially low by international standards.

Proportion of High-Grade Roads. The previous comparison of per capita road length masks the variation in composition of urban road types among world cities. The character of urban road systems is very much determined by the combination of expressways, major arterials, minor arterials, collectors and local roads, and investment requirements for different types of road are obviously different. Does urban road composition by functional type vary significantly city by city?

To answer this question, we examined the proportion of road space dedicated to urban expressways and arterial roads for 16 world cities and for 113 US urban areas.[23] The results shown in Table 6 strongly suggest that the share of road space given over to high-class roads, and particularly expressways, is quite small and varies within a narrow range. Several East Asian cities with higher levels of motorization have similar shares: 2.4 percent in Tokyo, 2.6 percent in Seoul, and 3.4 percent in Singapore. The small standard deviations for the larger US sample are striking, considering that the sample embraces a wide range of city types, from New York to Los Angeles.

TABLE 6: COMPOSITION OF URBAN ROAD FACILITIES
(Percent of total urban road length)

	16 World Cities					
	All 16 cities		12 with higher auto ownership		113 US Urban Areas in 1990	
Road Type	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Expressways	1.71%	1.65%	2.40%	1.53%	2.93%	1.15%
Arterial Roads	16.31%	7.44%	15.53%	5.88%	15.67%	4.00%
Primary Arterials	n/a	n/a	n/a	n/a	6.35%	2.13%
Secondary Arterials	n/a	n/a	n/a	n/a	9.32%	3.08%
Collectors	n/a	n/a	n/a	n/a	9.53%	2.51%
Local Access Roads	n/a	n/a	n/a	n/a	71.87%	5.39%

It is not hard to understand the small share of high-grade urban roads. These roads are provided for higher-speed motorized travels between urban districts, and any traffic using them comes from and ends up on the local street network. One should not build more high-capacity roads than the local streets can bear in various parts of the city. It should be noted, moreover, that most of the developing cities in the world still do not have high-grade urban roads such as urban expressways because of their very low levels of motor vehicle ownership and use.

[23] These 16 cities include Washington, DC, Denver, Toronto, London, Paris, West Berlin, Tokyo, Osaka, Singapore, Seoul, Kuala Lumpur, Bangkok, Jakarta, Warsaw, Krakow, and Gdansk. These cities were selected due to availability of comparable data.

Increasing motorization will require the construction of some high-grade roads to complete the urban functional road hierarchy needed to serve modern traffic.

Estimated Road Needs for Chinese City Prototypes

Based on the relationship between per capita road length and population density, and the proportion of high-grade roads, we projected the urban road needs for three large Chinese city prototypes. They were assumed to have the general characteristics of Chinese cities with population over 1 million. In general, larger Chinese cities have higher population density, lower per capita road length, and slower population growth due to government control. These three prototypes are:

- **Prototype 1.** A city of 1 million population at 100 persons/km^2, 0.39 meters (m) of roads per capita, population growth of 5 percent per year, and no change in density.
- **Prototype 2.** A city of 2.5 million population at 150 persons/km^2, 0.33 m of roads per capita, population growth of 2 percent per year, and a declining density to 100 persons/km^2 by 2020.
- **Prototype 3.** A city of 5 million population at 200 persons/km^2, 0.26 m of roads per capita, population growth of 1 percent per year, and a declining density to 150 persons/km^2 by 2020.

Based on the assumed population density for the future years, we estimated two sets of total "target" road length for each city prototype. The results are shown in Table 7. The first set of estimates, termed the "status quo" estimates, was obtained simply applying the growth rate of per capita road length determined by the -0.1 density elasticity, to the base year per capita road length. The estimates give the additional road space needed to accommodate population growth and dedensification, assuming the same character of road network (or more precisely, the road network density, that is, kilometers of roads per squared kilometer urban built-up area) is maintained as previously.

The second set of estimates, termed "toward the world average" estimates, assumed these city prototypes make extra efforts to increase per capita road length to the world average level (represented by the regression curve shown previously in Figure 7) during urban expansion and dedensification. The difference between these two sets of estimates of total road length is illustrated in Figure 8. The extra efforts would require both higher road density in the new development area and a modification of road network in the existing built-up area, particularly the crowded central area. Adding more roads in the city-center areas would require massive redevelopment that makes room for new roads, or building the expensive viaducts. But these could be done only in a small part of the center area one at a time. In other words, it is nearly impossible to upgrade per capita road length to the world average level in a few years. This would take a long time, probably half a century, to achieve. Therefore, we assumed by the year 2020, or 25 years from now, per capita road length for these prototypes achieve the mid-point level between the status-quo estimate and the world-average estimate.

We further used the mean share of urban expressways for 12 world cities with higher auto ownership (2.4 percent) to estimate the length of expressways for these Chinese city

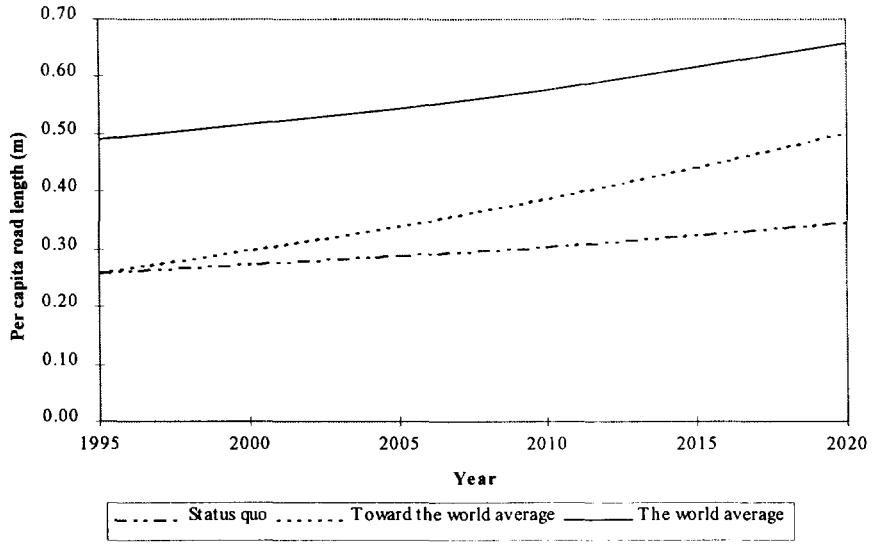
prototypes for each future year. Again, two sets of estimates were obtained. These results are also shown in Table 7.

TABLE 7: PROJECTED URBAN ROAD NEEDS FOR LARGE CITY PROTOTYPES BY SIZE

Year	Urban Population (million)	Assumed Density (persons/ km^2)	Urban Land Area (km^2)	Total Urban Roads (km)		Urban Expressways (km)	
				Status Quo	Toward the World Average	Status Quo	Toward the World Average
1.0 Million Pop.							
1995	1.0	10,000	100	390	390	8	8
2000	1.3	10,000	128	500	580	11	12
2005	1.6	10,000	163	640	830	14	18
2010	2.1	10,000	208	810	1,190	17	26
2015	2.7	10,000	265	1,040	1,680	22	36
2020	3.4	10,000	339	1,320	2,350	28	50
2.5 Million Pop.							
1995	2.5	15,000	167	810	810	17	17
2000	2.8	14,000	197	960	1,060	21	23
2005	3.1	13,000	235	1,150	1,380	25	30
2010	3.4	12,000	280	1,370	1,790	29	38
2015	3.7	11,000	337	1,650	2,330	35	50
2020	4.1	10,000	410	2,010	3,030	43	65
5.0 Million Pop.							
1995	5.0	20,000	250	1,300	1,300	28	28
2000	5.3	19,000	277	1,440	1,570	31	34
2005	5.5	18,000	307	1,600	1,880	34	40
2010	5.8	17,000	341	1,780	2,250	38	48
2015	6.1	16,000	381	1,990	2,690	43	58
2020	6.4	15,000	427	2,230	3,220	48	69

Note: The Scenario "Toward the World Average" assumes that per capita road length in large Chinese cities catch up with the world average level by 2045.

FIGURE 8: ALTERNATIVE PROJECTIONS OF PER CAPITA ROAD LENGTH



As the estimates in Table 7 indicate, total urban roads for the three city prototypes will increase dramatically during the next 25 years. The total increase in urban road length for each prototype can be decomposed into three contributing factors: (a) urban spatial expansion associated with population growth, (b) urban spatial expansion associated with dedensification, and (c) the joint effect of population growth and dedensification. In the first prototype, all new roads are required by the urban expansion due to population growth, because of the assumed fixed density. In the second prototype, 44 percent of the new roads are required by population growth, 34 percent by dedensification, and 22 percent by the joint effect. In the third prototype, 40 percent by population growth, 47 percent by dedensification, and 13 percent by the joint effect.

Clearly, many assumptions are made in obtaining the estimates shown in Table 7, and they cannot be taken as a guide to road construction in any specific city. However, they do provide a useful measure of the scale of road construction needed in Chinese cities in coming years, mostly required by the expansion and dedensification of the existing urban areas. With increased awareness of motorization needs, the designs for new road layouts, both in the existing city where sites are cleared for development as well as in the newly added urban areas, will follow modern design standards, so that the proportion of urban space allocated to roads will gradually increase.

Urban Expressway Plans

Of particular interest in Table 7 is the proportion of road length dedicated to expressway construction. If Chinese cities follow the pattern of the rest of the world, the entire expressway "allocation" for most cities might be taken up by just one ring road and one or two radial routes, with perhaps an additional ring in the largest cities. Yet, it is not uncommon now to see Chinese masterplans for major networks of high-performance urban expressways comprising two to four ring roads, linked by radial routes extended to the planned new development areas, and even networks of expressways criss-crossing the central areas within the planned Inner Ring, all superimposed on the existing urban area street network. Such plans go well beyond the scale of expressway construction in existing developed motorized cities across the world.

Why have existing motorized cities stopped short of such elaborate expressway plans? In part, it is because of the huge costs of construction of urban expressways, especially in the city centers where land is costly. It is also because the intrusion of these roads disrupts communities and builds up local resistance. Few new expressways have been built in Western city centers in recent years, largely for this reason. Both of these factors will probably contribute to a scaling back of the Chinese city expressway masterplans. In addition, though, developed cities no longer favor urban expressway systems because of increasing doubts on their efficiency to relieve traffic congestion. In other words, the notion that we can build our way out of congestion is increasingly questioned.

Can We Build out of Congestion?

Plans for extensive urban expressway networks are conceived in a determination to eliminate congestion. City leaders envisage high-speed roads passing over the old congested street system, ensuring quick and easy access to all parts of the city. Does this work? Can we

build out of congestion? If international experience of urban road construction spanning more than half a century can be any indication, the answer to these questions is a quite definite "no." Building roads is only part of the solution to the complicated urban transport problem. Even in US cities with the most advanced highway system, such as Los Angeles, traffic congestion in the city-center area and some suburban expressways is chronic and still growing.

The underlying reason for this is best stated by what is known as the Downs Law,[24] which can be summarized as follows: new highway construction along a traffic corridor reduces travel impedance, but it also induces traffic from other corridors and other modes, often resulting in a return to previous congestion levels. Moreover, latent demand created by the previous shortage of road capacity also surfaces and swamps the new highway capacity. Downs made this observation in the early 1960s and part of the reason for the phenomenon also could be attributed to the rapid growth of car ownership in the US urban areas during that time. Nonetheless, for many places to this day, his interpretation that new capacity attracts new demand still holds true, and the equilibrium between capacity and traffic is still far from reality.

Downs Law will certainly hold for many Chinese cities for an extended period of time. Even if the municipal governments substantially increase their efforts in new road construction, traffic congestion will remain as long as incomes, population, and vehicle ownership continue to grow. Under this dynamic circumstance, building more roads makes sense only in preventing traffic congestion from getting worse. Theoretically, continuing road construction would eventually satisfy all demands including those attracted by the new capacity, but achieving this goal may not be economically wise because the cost of providing roads may far exceed the benefit of eliminating congestion. This is also the reason why we have to look for other more economically viable options, such as traffic demand management.

Conclusions on Urban Road Construction

It is concluded that road construction will be an important feature in the development of Chinese cities, in part to match the expansion and dedensification of the existing urban areas, and in part to make good the current underprovision of road space. However, some of the more elaborate plans for urban expressway networks seem unrealistic, both in terms of what can be afforded (in cost and resettlement), and in terms of their impact on traffic congestion. International experience clearly shows that road construction on its own provides no solution to traffic congestion except in the very short term.

Further, the need for expressway network should be analyzed in the context of a sustainable and budgeted transport strategy. Each separate section of the network should be subject to detailed economic, technical and environmental feasibility analyses. This is further discussed in Theme Paper 12, "Shaping the Future: The Role of Urban Transport Planning."

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[24] Anthony Downs (1962), "The Law of Peak Hour Expressway Congestion," *Traffic Quarterly*, Vol. 16.

Conclusions on the Supply Management Approach

Several ways of improving the efficiency of the street system have been discussed, and the need for some new road construction identified. However, Downs Law—that the demand for transport will often exceed supply of road space under a dynamic situation—intervenes. It was introduced in the context of new highway construction, but in reality applies to all methods of improving the efficiency of the road system. The overwhelming conclusion from all experience of motorization to date is that if the road system is made more efficient, or of greater capacity, yet more motorists will be attracted to using it until congestion again intervenes. Since most transport improvements are incremental, the effect is that any new capacity gained is swallowed up immediately by new traffic, seeming to make all efforts (and particularly small-scale efforts) in vain.

Hence, the conclusion is that road transport demand will always exceed the supply of road space, no matter how well managed and how efficiently used. Therefore, municipalities have no alternative but to consider ways of controlling and managing the demand for road space. This is discussed in the next section.

E. Dealing with Traffic Congestion—Managing Transport Demand

This section looks at policies for managing the growth in transport demand. Available policies are listed in Figure 9, grouped into two main classes. One set of policies attempts to deal with the problem at source and discourages or limits the ownership of vehicles. These options are classified under Vehicle Ownership Controls. The main alternative is to permit wider vehicle ownership but then control the use made of vehicles; these policies are classified under Vehicle Use Controls. Within these two approaches, both pricing measures and regulatory measures can be contemplated.[25] Before discussing these policies in detail, a comment is made on the potential function of prices in controlling congestion.

Congestion Pricing

The price of transport, whether in the form of costs for operating a vehicle, or the fare paid to use a public carrier, profoundly affect the volume of transport demand. Higher costs and fares result in lower demand. Since the fundamental cause of traffic congestion is that drivers are responsible for only a fraction of the costs that they actually cause (see previous Box 1), thus encouraging wasteful journeys, pricing as a means of managing traffic demand has many merits. Economists argue that if drivers could be confronted with the full costs of their journey—their own costs plus the costs they impose on other vehicle operations—their decision to make the journey could well be modified. Thus has arisen the concept of a congestion tax imposed on traffic. If the tax is set at the right level, marginal journeys would be deterred while essential journeys would continue to be made.

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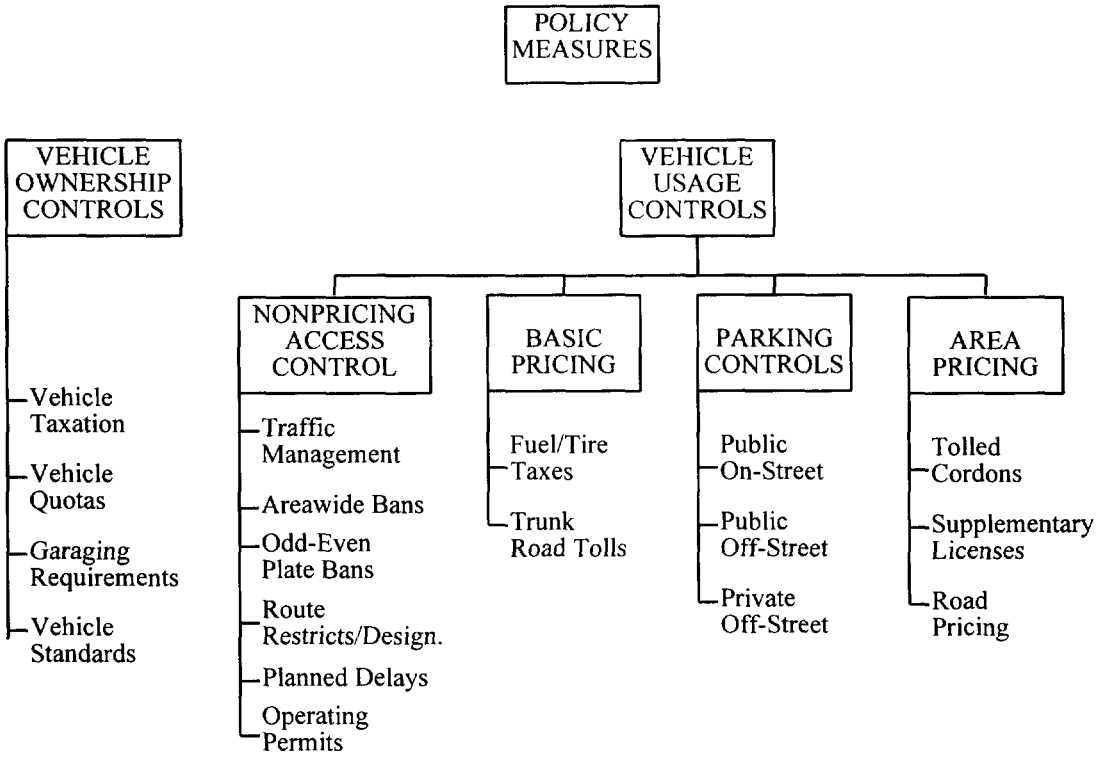
[25] Three documents were consulted in preparing this section: *Hong Kong Second Comprehensive Transport Study*, op cit.; *Methods of Traffic Limitation in Urban Areas*, J. Michael Thomson, OECD, Paris, September 1972; and *Congestion Charging Mechanisms for Roads: An Evaluation of Current Practice*, Timothy D. Hau, World Bank Transport Policy Research Working Paper WPS 1071, Washington, December 1992.

What determines whether a journey is marginal or essential? Economists argue that this must be decided by the price an individual is willing to pay. Those who are willing to pay at least the full cost of a journey—their own costs, plus the costs imposed on others—can be deemed essential. Those who are unwilling to pay the full costs must be considered marginal. In theory, it is possible to estimate a congestion tax where the resulting traffic demand is in balance with the capacity of the road system. Set too high and roads will be wastefully underutilized; set too low and roads will remain clogged with traffic.

FIGURE 9: MANAGEMENT OF TRANSPORT DEMAND



In practice, determination of such a tax is difficult. To be effective, the tax must vary by time of day—higher during the morning peak, much lower for a quiet Sunday afternoon—and by location—central business districts require a higher tax than rural areas. Only the most sophisticated transport demand management policies seek to achieve such elaborate road use pricing. However, many policies utilize pricing devices to achieve the objectives of controlling excess traffic demand, usually complementing nonpricing traffic allocation measures such as quotas or road space allocation to specific modes.

Congestion pricing is only one aspect of transport pricing. For further details, and a discussion about the relevance of pricing policies in China, see Theme Paper 10, "Shaping the Future: Getting Prices Right."

Controls On Vehicle Ownership

Vehicle ownership controls seek to limit the size of the vehicle fleet by either fiscal or regulatory means, in this way restricting the number of vehicles available to use the road system. Several approaches are possible.

Vehicle Ownership Taxation

Taxes are commonly raised on vehicles both at the time of vehicle purchase, and thereafter annually or monthly for all vehicles maintained in use. These taxes and fees are independent of the amount of usage—they apply equally to all vehicles, whether they are used every day or once a month. The principal function of the taxes is to raise Government revenue, but they also have the effect of making the ownership of vehicles more expensive, thereby putting it out of the reach of some.

Additional vehicle ownership-related purchase fees, annual licensing fees, and residential parking fees can be imposed with the objective of making the ownership of a vehicle even more expensive and thereby further restricting the total size of the vehicle fleet. This policy has been used very successfully in both Hong Kong (see Box 3) and Singapore.

Vehicle ownership taxation is a fairly crude instrument for control of congestion. While they have the effect of restricting the total number of licensed vehicles, thereby reducing overall traffic levels, those who pay the necessary ownership fees can then use the licensed vehicles when and where they like, so that congested roads are not directly targeted.

China, in common with other countries at an early stage of economic development, imposes relatively high vehicle taxes on imported vehicles to restrain the volume of imports, but quite low taxes on domestically manufactured vehicles in order to encourage local industry. There is strong pressure from the vehicle manufacturers in China to maintain this system into the future.

Vehicle Quotas

Vehicle quotas can be used to restrict the growth of the vehicle fleet to a fixed number of vehicles per year. Quotas are currently used widely in Chinese cities to control the number of motorcycles, taxis, and enterprise-owned vehicles.

Strictly enforced quotas can be effective in limiting vehicle fleet size, but some care is needed in application. There are several problem areas. First, there is the danger of restricting a particular vehicle type unjustifiably, thereby forgoing the benefits of its wider use. This is possibly the case with motorcycles, which have been restricted recently in several Chinese cities, but with little evidence of serious analysis of the costs and benefits of wider motorcycle ownership. Second, quotas applied by area can be circumvented by registering the vehicle with a friend or relative living outside the area, and might have to be supplemented by some additional usage regulations to prevent vehicles registered outside the designated area from coming in. This has its own problems as discussed later under vehicle usage controls. Third, if demand is high but the quota is low, licenses within the annual quota become very valuable. Some cities auction licenses and so gain this increase in value, but this requires an effective administrative

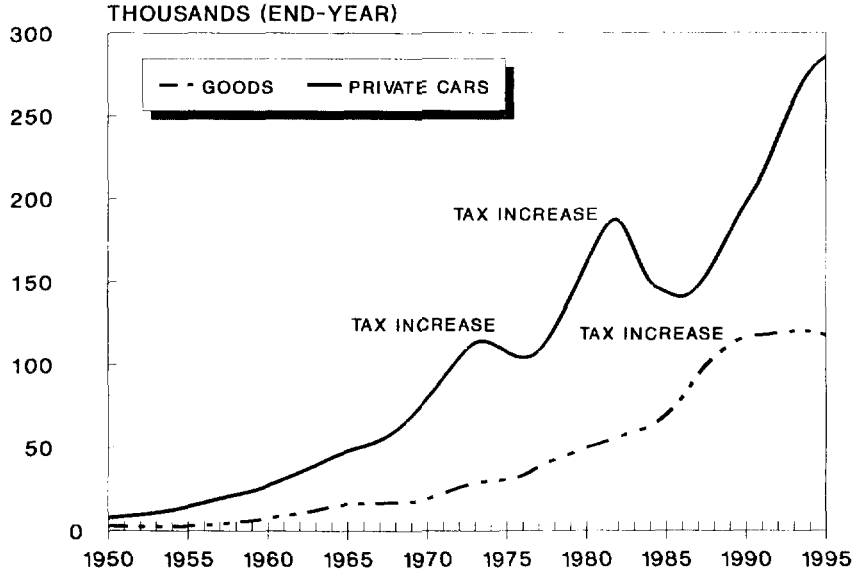
system. The alternative of allocating licenses to customers at the normal prequota prices could be quite arbitrary, with opportunities for favoritism or, worse, corruption. Almost inevitably, a black market in licenses at higher-than-official prices would become established.

Singapore successfully combines quotas and pricing to restrict the growth of the motor vehicle fleet to 3 percent per year. Purchasers of new vehicles must first obtain a Certificate of Entitlement, of which a fixed number are auctioned to the highest bidder each month. This, combined with other duties, taxes and fees, increases the cost of cars to about five times their CIF value (all are imported).

BOX 3: IMPACT OF VEHICLE TAXES ON RATE OF OWNERSHIP IN HONG KONG

The size of vehicle taxes can dramatically affect the size of the vehicle fleet, as illustrated by the history of tax changes on private cars and vans in Hong Kong shown in the Box Figure. A large increase was imposed in 1973 when vehicle growth appeared to be getting out of hand. When the effect of the increase wore off and growth resumed, even bigger increases were imposed in 1982 when the First Registration Tax (FRT, effectively the purchase tax) was doubled and annual license fees tripled. The 1982 increase started a decline in the car fleet that was reversed only in 1987. Currently, the FRT is approximately 90 to 120 percent of CIF value, and annual license fees range between HK$3,899 and HK$5,800 depending on engine size.

BOX FIGURE: VEHICLE OWNERSHIP GROWTH IN HONG KONG



One impact of the 1982 tax increases on private cars was to increase demand for personal use of light goods vehicles—vans and pickups—which were then taxed much more lightly. The growth in the light vehicle fleet was stemmed in 1991 by increasing the FRT on light goods vehicles from 15 percent of CIF value to 90 percent. Since 1987, the vehicle fleet has again grown rapidly, despite adjustments to annual license fees to keep pace with inflation. It was recently suggested that a further vehicle tax increase is now required, but the size of increase would have to be very substantial to have any significant effect, and there are concerns about its acceptability.

Garaging Requirements

A widespread practice in urban Japan, as well as in at least some Chinese cities, is to restrict vehicle ownership to those who have off-street parking places. In Japan, proof of parking place must be deposited at vehicle licensing time, consisting of maps and letters of authority. Thus, it is relatively simple for the authorities to make spot checks on such claims. The main aim of establishing garaging requirements is to ensure that residential streets are not cluttered with parked vehicles. The effective restriction on total vehicles that results is a by-product, but probably very effective in high-density city centers.

Vehicle Standards and Classification

High vehicle standards enforced by annual inspections are primarily aimed at enhancing vehicle safety and reducing motor vehicle emissions, and are practiced in many countries. However, higher vehicle standards also effectively influence vehicle ownership by raising the costs of vehicle maintenance. It was thought that the introduction of more rigorous vehicle inspections in Hong Kong in 1986 was responsible for extending for a further year the downward trend in licensed vehicles initially caused by the car taxation increases of 1982. However, in terms of overall control of the size of the vehicle fleet, this is essentially a supplementary measure.

Conclusions on Vehicle Ownership Controls

A major disadvantage of vehicle ownership controls as a means for limiting the use of motor vehicles is that it is administratively complex, perhaps impossibly so, to differentiate between urban and rural ownership. Without differentiating these ownership classes, rural vehicle ownership would have to be maintained at the same low levels necessary to prevent urban congestion, which is inefficient. For this reason, vehicle ownership restraint to limit urban congestion has been practiced only in the city states of Hong Kong and Singapore.

Extensions of vehicle ownership controls in China could form part of an overall package of measures to control the growth in vehicle usage and generate revenues for infrastructure improvement, but could not be recommended as the sole policy. Controls on vehicle use seem more appropriate for China, as discussed in the next section.

Controls on Vehicle Use

Controls on vehicle use offer the opportunity to be more discriminating in the management of traffic demand. A large number of methods are available, which vary greatly in their sophistication. For ease of discussion, they are grouped into four overall classifications: nonpricing access controls, basic pricing, parking controls, and area pricing; but in reality there are many overlaps.

Nonpricing Access Controls

A widely used method of eliminating unwanted traffic is simply to ban vehicle use. The scope of such bans varies greatly, ranging from time-based restrictions on selected vehicles on

parts of some streets, to complete and permanent areawide bans. A range of such measures are discussed below.

Traffic Management Measures. In Section D of this paper, traffic management measures were discussed in the context of making the street network more efficient and increasing vehicle throughput. It is also possible to deliberately restrict vehicle usage by, for example, narrowing junctions, creating one-way traffic schemes, widening footpaths, and even creating pedestrian precincts out of streets previously open to traffic. This might be done to protect a residential area from through traffic, or to create a more pleasant environment in a central area. Such measures are now termed traffic-calming and are complementary to the earlier efficiency-based traffic management measures considered. Used in combination, traffic can move more efficiently on improved through routes while being restricted from inappropriate areas. Of course, by allocating road space to particular users—traffic lanes or entire roads designated for bicycle or bus use—even efficiency traffic management measures can have the effect of restraining the use of other motor vehicles.

Traffic-calming schemes have been pursued vigorously in the older cities of Europe where the charm and scale of the sometimes ancient street pattern has been swamped by excessive use by cars for which they were not designed. However, they also make sense in any residential and shopping area dominated by pedestrians. One Chinese example is the set of restrictions imposed along Nanjing Road, the premier shopping street in Shanghai, where vehicle access is now physically restricted during periods of peak pedestrian activity.

Traffic restrictions of this nature are often opposed by commercial forces, which equate restrictions on traffic access with restrictions in trade, even though the opposite effect can be demonstrated. It sometimes takes an unusual event to convince people of the validity of traffic restrictions. For example, a bombing incident in the heart of the City of London in the early 1990s resulted in widespread street closures for many months; these have proved so popular that they are now being made permanent.

Areawide Bans. Bans on certain types of vehicles entering the city center during daytime hours are quite common. Many European cities impose such bans on private cars. For example, Milan in Italy bans private cars from the city center between 7:30 am and 4:30 pm. In Hong Kong, goods vehicles of any type are banned from the Mid-Levels, a major residential area, during the morning and evening peak hours when passenger vehicle flows are greatest.

In China, access to the center of large cities by heavy goods vehicles is generally restricted to nighttime hours. There has also been some discussion of restricting the use of vehicles that are not registered in the city, and this is already practiced with motorcycles in some cities. This selective approach costs more to administer, and is not particularly logical; it is by no means clear that interaction with a neighboring city should have lower priority than the free use of roads by residents. Extensive use of such discriminatory methods against nonresidents could constitute a barrier to free trade and economic growth, and could also lead to retaliatory regulations in the neighboring cities. The particular issue of goods vehicle controls is discussed in more detail later.

Odd-Even Number Plates. Several cities, including Athens, Lagos, and Mexico City, impose restrictions on the days on which selected vehicles can operate, based on the date and the number plate—vehicles with even-number plates operate on even dates, and with odd-number plates on odd dates. This system was also applied in Seoul, Korea during the period of the 1988 Olympic Games to ensure easier traffic conditions for visitors. It is currently applied in some larger Chinese cities as a means of limiting the access of light goods vehicles to the city center.

While odd-even number plate control is a simple system to set up, it is essentially arbitrary in operation and open to fraud. In Mexico City, where its effectiveness in reducing the levels of motor vehicle pollution has been studied, it was concluded that the scheme's effectiveness diminished over time.[26] As a short-term measure, such as the Seoul application, the scheme has merit, but other methods are preferable over the long term.

Route Restrictions, or Route Designation. An alternative to areawide bans is either to prohibit certain types of vehicles (such as heavy goods vehicles) from some classes of road, or to designate specific routes for such vehicles and signpost them clearly. This recognizes both the economic value of such vehicles being able to penetrate to all parts of the city, but also their unsuitability for operation on all parts of the network.

Planned Delays. Some schemes have been devised to impose regulated delays on traffic with the hoped-for advantage that some drivers would switch to public transport while others could plan journeys with more certainty. A major scheme of this nature, known as the Zones and Collar Scheme, was tried in Nottingham in the United Kingdom in the early 1970s. Traffic leaving some large housing estates, and traffic approaching the city center, were held up at traffic lights with a very low proportion of green time. Car parks were provided at the traffic-light locations on the main roads with free bus services to the city center. At all traffic-light barriers, buses could bypass the lights. The scheme did not succeed, partly because the main roads could not accommodate the long traffic queues that developed, and partly because many motorists refused to obey the long delays at traffic signals at the exit to the housing estates. The hoped-for switch to public transport did not take place and overall economic benefits were estimated to be negative.

Operating Permits. Car operating permits issued on the basis of need have been suggested for use in London, but not implemented. In reality, it is very hard to define need adequately—doctors on call and permits for the handicapped are two categories that may be accepted by most but, for the most part, it is impossible to define watertight criteria that could be generally accepted or easily administered.

More on Goods Vehicle Traffic Controls. Restricting daytime access of heavy goods vehicles to the city center is widely implemented in many Chinese cities. Because goods vehicle transport is highly associated with urban economic growth, this practice deserves careful evaluation.

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[26] *Rationing Can Backfire: The "Day Without a Car" in Mexico City*, Gunnar S. Eskeland and Tarhan Feyzioglu, World Bank Policy Research Working Paper No. 1554, Washington, DC, December 1995.

In general, there are four types of road freight movements in cities: import, export, transit, and intraurban movements.[27] Historically, most Chinese cities have long sought to minimize these freight movements through urban master planning. In particular, facilities that handle large volumes of freight, such as warehouses, heavy industrial plants, and rail marshaling yards, are required to locate at convenient locations near the city-fringe areas, with proper separation from residential and other business functions. The urban master planning principle also requires large cities to provide bypass roads for transit traffic. However, the rapid urban expansion that occurred in many large cities during the last 10 to 15 years has dramatically changed the relative locations of these facilities. Locations on the city fringe in the past are now part of the main urban area, and former bypasses now function as urban roads. Industrial relocation and new bypass construction often lag far behind the rapid growth of urban areas. As a result, large volumes of goods vehicle traffic remain in the much expanded city-center area.

The current urban land-use changes, particularly residential dedensification and relocation of manufacturing firms to the outlying areas, if continued would have substantial impact on the future pattern of freight movements. This land-use decentralization process will be further facilitated by economic reforms (specifically corporatization and privatization) in the wholesale and retail service industries, which will give firms more freedom in the choice of location. It can be expected that manufacturing firm relocation will shift more import and export freight movements to the city fringe area. Part of the intracity freight, such as those for population-serving retail services, will also decentralize with residential dedensification. The freight relating to central-area retail services may remain. In sum, as current trends in land-use change continue, urban freight movements in Chinese cities will be increasingly removed from the city-center area, but these more decentralized freight movements will require suburban road facilities that provide faster mobility and more widespread access. These trends should be recognized in urban master planning and transport strategic planning.

However, land-use changes will take a long time to be effective, so goods vehicle movements will likely remain an important part of city-center traffic for some time to come. It is understandable that many large cities currently choose to control heavy goods vehicle traffic in their central areas. However, improperly planned goods vehicle bans may do more harm than good, because goods vehicle traffic is so closely related to the functioning of urban economy.

There are some opportunities for time-based restrictions on goods vehicles, since the peak hours for passenger traffic and goods traffic are normally different. For example in Jinan, peaks for passenger vehicle traffic are during 8:00 to 9:00 am and 16:00 to 17:00 pm, while those for goods vehicle traffic are during 9:00 to 10:00 am and 14:00 to 15:00 pm. The use of urban roads by goods vehicles during the off-peak hours for passenger vehicles makes economic use of otherwise underutilized road capacity, and therefore should be encouraged. There is also a good case for confining goods vehicle to selected designated routes as discussed above. The outright ban of goods vehicle traffic during the daytime, as implemented in many large cities, should be reevaluated.

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[27] The first two types involve the carriage of freights into or out of the city. Transit movements are those intercity freights passing through on urban roads. The intraurban freight movements are those both generated from and destined to locations within the city.

Conclusions on Nonpricing Access Controls. Nonpricing access controls have their place in protecting sensitive areas, or in better allocating road space among road users. Their nonpricing nature means that they should only be imposed after careful study to be sure that all the costs and benefits are carefully weighed.

Basic Pricing

Fuel and Related Car Use Taxes. Virtually all countries impose duties and taxes on fuel as a general revenue-raising measure. Increasing these duties is an administratively simple traffic control measure, directly affecting the cost of using vehicles and thereby reducing usage. Other car consumables, such as spare parts and tires, can also be taxed for the same purpose, although parts and tire taxes can have adverse effects on vehicle safety by discouraging proper vehicle maintenance.

The disadvantage of the fuel tax as a specifically urban traffic control measure to reduce congestion is that it acts across the board, hitting off-peak motoring in uncongested areas almost as much as motoring on the busiest roads. Users of congested roads pay rather more per kilometer, since fuel consumption goes up as speeds decline with congestion, but rural and off-peak motorists would still pay at least two-thirds of the tax paid by the urban peak-hour motorist. Differential fuel taxes, higher in urban areas, lower in rural areas, remains a possibility to curb specifically urban road use, but would be difficult to administer and would almost certainly encourage uneconomic journeys from urban to rural areas simply to obtain cheaper lower-taxed fuel. As an urban traffic control measure, therefore, fuel taxes are only a little better than vehicle ownership taxes.

Higher fuel taxes tend to encourage the use of smaller, more fuel-efficient vehicles, which is useful from the resource conservation and environmental pollution standpoints. Higher taxes on gasoline can also encourage use of diesel-engine vehicles, which might not be so beneficial. This latter is an important consideration in China where diesel engines are widely used in agricultural vehicles and waterway vessels, complicating any decisions to raise diesel fuel taxes.

Overall, however, as discussed in Theme Paper 10, "Shaping the Future: Getting Prices Right," fuel taxes are very low in China compared to most other countries in the world and there are excellent arguments for increasing them from current levels. The impact of curbing excessive vehicle usage would be a useful side benefit.

Trunk Road Tolls. In many countries, including China, tolls are commonly charged on expressways, bridges and tunnels in both urban and rural areas in order to collect revenues for financing construction and maintenance. Tolls also affect traffic volumes using the tolled facilities, and can be used to control the volume of traffic demand, as discussed in Box 4.

The toll principle can be extended to cover other trunk roads in order to control the traffic levels and ensure congestion-free conditions for longer journeys. Toll systems can take two forms: open or closed. Open toll systems require toll plazas at intervals along the length of the road, with the disadvantage that traffic could bypass tolled sections by returning to the street system for sections of the journey. Closed toll systems require toll barriers at all entrances and exits to the toll road, to ensure that all users of the road pay for the full length of the journey on

the road; the disadvantage is greater land take and the generally higher cost to build and operate such a system.

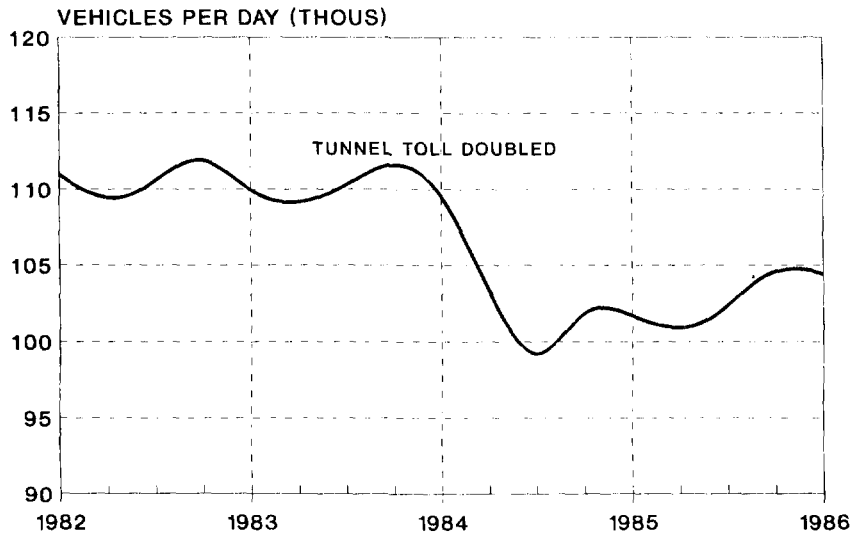
There are two major issues on urban trunk road tolling. First, land required for toll plazas in urban areas is normally very expensive, although use of prepaid tolls combined with automatic vehicle detection can greatly reduce the land required. Second, the traffic deterred by the tolls must continue to use the existing street system. To control congestion on existing streets, other traffic management policies are still required.

Tolls as a means of controlling traffic demand in urban areas are most effective when the tolled facilities cross a natural barrier with no parallel nontolled routes. The cross-harbor toll tunnels in Hong Kong and the river bridges in Guangzhou are good examples. They are less effective for overall urban traffic control purposes where there are parallel routes of significant capacity, although they remain an option for raising financing for new trunk roads. Tolls are discussed further in a later section in connection with cordon tolling.

BOX 4: IMPACT OF TOLLS ON TRAFFIC DEMAND

The use of tolls to influence traffic demand is shown in the Box Figure, which shows the impact of a doubling of tunnel tolls on the Hong Kong Cross-Harbor Tunnel in 1984 (in US prices, from about 70¢ to $1.30). Car and taxi traffic was reduced by about 15 percent and light goods vehicle traffic by about 13 percent—medium and heavy goods were almost unaffected. Traffic growth since then replaced those traffic reductions, but three years of improved operations were gained.

BOX FIGURE: CROSS-HARBOR TRAFFIC VOLUMES, HONG KONG



Guangzhou Municipality also imposed differential tolls in 1990 to adjust traffic levels between five river bridges. Two new bridges with tolls built outside the main city center in the 1980s supplemented three older bridges inside the city center that were untolled. Finding that traffic on the two new tolled bridges was very light, they imposed tolls on all five bridges, thereby shifting traffic to the new bridges. Overall, traffic on the old bridges reduced by 25 percent, and overall cross-river travel by 12 percent.

Parking Controls

The areas of highest traffic congestion tend to be major business and shopping districts. Therefore, controls on vehicle parking can be used to limit the number of trips made to these districts by car. Controls can be imposed in three main ways: by quotas on the number of parking places, by pricing the use of parking places, or by specifying rigorous criteria for parking garage provision that are difficult to meet.[28]

The three approaches all have weaknesses. Reliance on nonpriced parking quotas effectively provides a substantial subsidy to motorists, and forgoes the substantial revenues that can make parking provision self-financing. On the other hand, reliance on purely pricing controls is vulnerable to distortions in the market. This is particularly true where a true market economy is not yet fully established and where hidden subsidies could finance parking oversupply. The third method of defining and enforcing rigorous criteria for parking provision requires considerable sophistication on the part of city officials and technical officers, and could not work without this. Hence, many cities rely on a mixture of all three methods. (See Box 5 for examples.)

BOX 5: PARKING POLICIES

In Hong Kong, the quantity, location and prices for public parking provision are specified by the Government, with prices set to achieve an average 15 percent availability rate as measured in regular surveys. The quantity of private parking provision is guided by parking provision standards that vary by district and class of building. Developers of new buildings are required to demonstrate the traffic acceptability of their project by means of a detailed traffic impact statement, which considers parking provision among other things. This provides a basis for planning permission, including any departure from the parking provision standards.

Bangkok is an example of a city with chronic traffic congestion and poor public transport, where building developers have been permitted to provide for massive vehicle usage with little or no control. New buildings typically provide 8 to 10 floors of parking, greatly increasing the traffic load on surrounding streets. It is reported that simply departing the parking lot during daytime can take up to an hour.

Parking controls, as a means of limiting traffic demand, suffer from the key weakness that through traffic, which does not need to park in the targeted district, is unaffected. This has been summarized as "the inherent problem of the parking policy of attempting to control moving vehicles by charging stationary ones."

Parking controls can also induce additional circulation travel searching for an available parking place, and delivery/collection travel where a driver will enter the controlled area to drop off or pick up passengers. For these reasons, many economists compare parking controls unfavorably to more sophisticated area pricing schemes (considered below). However, area pricing still remains a largely theoretical concept, while parking controls, imperfect though they

[28] For example, Chicago did not permit parking garages to exit onto streets with flows greater than 25,000 vehicles per day, which effectively limited the number of such garages in the central area. For detail, see *Methods of Traffic Limitation in Urban Areas, op. cit.*

are, are widely understood and accepted. Also, lack of parking controls can seriously undermine other traffic control or traffic provision measures. Singapore, the only city with any history of area pricing, regards parking controls as a necessary and complementary measure to their area pricing scheme.

Public On-Street Parking. On the basis that streets are principally intended for moving traffic, on-street parking is normally restricted to short-duration visits, typically between 15 minutes and 2 hours. On-street parking bays are clearly marked and located where least intrusive on the traffic flow. Availability of parking places can vary throughout the day, with some places made unavailable during the peak traffic hours. On-street parking can be free or charged, the latter requiring either permanent attendants (as in most charged parking in China) or the installation of parking meters or parking ticket machines. Whether free or charged, on-street parking requires enforcement by traffic wardens. Generally, in developed cities with intensive demand for vehicle parking, the revenues from charged parking more than cover the costs of equipment and enforcement.

Public Off-Street Parking. Public off-street parking provides for longer-duration parking. Fees should cover at least the costs of carpark provision, operation and maintenance. In fact, parking is generally a profitable business in developed city centers; the market can bear higher prices and potential demand generally exceeds supply. Hence, an increasing number of cities leave the management, and often the provision, of public off-street parking to the private sector, and have privatized previous Government-run carpark operations. Hong Kong privatized such operations in 1984.

Many cities use the availability and price of off-street parking as the main means of controlling traffic access to the city center, applying different charging rates depending on parking duration and time of arrival to obtain a balance between long-term commuting parking, and short-term parking for other purposes (business, shopping, etc.). The Government pricing policy can still be reflected by privatized carpark operations as long as there are clear franchising agreements. New public parking provision can be accepted in places where the road system is of adequate capacity, although the necessary analysis to back up this policy is demanding.

Private Off-Street Parking. Private off-street parking is not usually charged directly; staff or clients are simply allocated the use of parking spaces at the owner's discretion. The privileged users of these spaces, therefore, park free and are unaffected by a public parking policy.

Authorities normally attempt to influence private off-street parking supply by specifying parking provision standards. In the early stages of motorization, developers of new commercial buildings are often reluctant to provide parking places, seeing this as an unprofitable use of valuable real estate. In an effort to ensure that motorists visiting such buildings do not clutter the surrounding road space with parked vehicles, authorities can insist on a minimum parking provision. This is currently the situation in most large Chinese cities, and remains the situation in Hong Kong where the private car is used for only about 15 percent of all journeys. After motorization takes hold, and especially if public transport services are not well developed or are curtailed through road congestion, building developers tend to switch, seeing provision of

parking as a key attraction for potential tenants. At this stage, many city authorities will then switch to specifying a maximum parking provision to discourage overprovision.

Goods Vehicle Parking. In developing a parking policy for both on- and off-street parking, it is necessary to consider the needs of goods vehicles. Many businesses depend on regular deliveries from several suppliers, which requires access throughout most of the day. The nature of goods deliveries requires parking at the site since heavy loads must be moved. Off-street parking is desirable, but often not available in older and smaller establishments, so that on-street parking near the premises is a necessity. This needs careful planning and regulation, but is normally possible given that the peak period for goods vehicle use in cities normally does not coincide with peak car usage.

Conclusions on Parking Controls. Control of parking, despite its imperfections, should be a key component of a policy to control vehicle usage. In China's mixed economy, pricing mechanisms need to be supplemented by public parking quotas and mandatory standards for private parking provision. There will always be pressures to relax parking provision standards in order to attract important developers to their area, but the Bangkok example demonstrates the need to place some limits. Probably the key to controlling private off-street parking is to require developers to provide traffic impact statements for all new developments to demonstrate the traffic feasibility of development proposals.

Area Pricing

Area pricing aims to charge motorists for the use of roads in selected districts, with the highest charges for the most congested districts. Frequent users of busy roads would accumulate high charges, but the more casual motorist, by careful selection of times and routes, could avoid road charges altogether. The practical effect should be less traffic on the busy roads as motorists avoid the higher-priced congested districts.

The main difficulty with area pricing is in devising a practical method for collecting charges from the motorist. Three distinct classes of schemes can be identified (although modern methods of electronic vehicle detection and charging are tending to blur the distinctions):

Tolled Cordons
Supplementary Licenses
Electronic Road Pricing

Tolled Cordons. A cordon is set up around the area to be charged with toll gates installed at all entry points. Toll charges can be varied by time of day to make peak-hour entry more expensive, and charges can be abandoned altogether at off-peak times, on weekends or on public holidays. This approach has been introduce in several cities in Norway, starting with Bergen in 1986 and followed by Oslo in 1990 and Trondheim in 1991. The systems have been designed, and accepted by the public, as a means of collecting revenues for financing transport infrastructure construction. However, in all cases, traffic has dropped, by 12 percent in Bergen with an $0.80 toll, and by 5 percent in Oslo with a $1.60 toll, the difference in traffic impact having to do with the particular characteristics of each city.

A practical disadvantage of such schemes is the land needed for toll booths. The practical problems of finding such land tends to dictate a larger controlled area than desirable for traffic control purposes, and even then would be very difficult to implement in high-density cities. A related disadvantage is that the operation of the toll barriers requires traffic to stop; resulting delays are dependent on the number of toll booths provided, and hence the size of the toll plaza. With high traffic flows, large toll plazas would be required, with up to six toll booths per high-capacity lane. As with toll roads discussed above, both these disadvantages can be reduced with prepayment of tolls combined with automatic vehicle detection technology to detect prepurchased electronic tags. Both Oslo and Trondheim use such methods, but still need to retain some manual toll booths for vehicles (perhaps from other cities) without the necessary tags.

Some cities, by accident of geography, could find such schemes more practicable. For example, it has been proposed, but not yet implemented, to control traffic entering and leaving Manhattan Island in New York, taking advantage of the fact that entry to the Island is restricted to a limited number of bridges, tunnels or ferries.

Supplementary Licenses. These schemes require cars to display a special prepurchased supplemental license to be able to enter or use roads in a designated area. Enforcement of the scheme depends a little on the criteria for vehicle use. If entry criteria are specified, checkpoints need to be set up on all entry roads. While this is similar to the tolled cordon discussed above, it differs in the key respect that it can be tightly defined around the main congested area of a city, making it more acceptable to absolutely ban all vehicles without a license. Hence, manual toll booths with their expensive land requirements can be completely eliminated. The Singapore area licensing scheme is such a scheme (see Box 6).

The Singapore scheme currently does nothing to control movements within the control area after entry. More elaborate schemes have been devised, but not implemented, using different-colored licenses for areas with different congestion levels, thus allowing more subtlety of charging for different levels of congestion in different areas. For example, a high-priced red license may be required for the most congested areas, but cheaper blue and yellow licenses could permit use of roads in other, less critical areas. Many areas would not require supplementary licenses at all. The red, blue and yellow zones would be clearly designated by maps and roadside signs. Enforcement of such a supplementary license scheme would be the main problem, although not insuperable. Such a scheme for Central London, proposed in 1974 but never implemented, estimated that 400 wardens would be required to achieve 90 percent compliance at a cost equal to 6 percent of gross revenues.

Electronic Road Pricing. This is the most sophisticated category of area pricing schemes and practical implementation is the goal of many traffic planners worldwide. Whereas previously discussed schemes levy charges by entry to, or presence within, a designated area, electronic road pricing (ERP) aims to charge for actual vehicle usage in congested areas. A key feature is its dependence on fully automatic vehicle detection and charging. By careful setting of detectors and varying charges by time of day, traffic planners could target the heaviest charges on the busiest roads, while leaving uncongested roads charge-free. By this flexibility, ERP offers the most effective way of countering traffic congestion yet conceived.

BOX 6: SINGAPORE AREA LICENSING SCHEME

The Singapore area licensing scheme introduced in June 1975 requires a special license to enter the central area during peak hours. Gantries have been set up at all entry points to the designated central area, with flashing lights to indicate times when the special license is required to pass the barrier. Traffic officers monitor the traffic stream; offenders are photographed and tape recordings are made noting time of offense. These photographs and recordings are admissible evidence in courts when offenders are prosecuted.

One very interesting aspect of the Singapore scheme is the extent to which it has been modified from time to time, based on practical operating experience. The initial scheme covered just the morning peak hours, Monday to Saturday from 7:30 am to 9:30 am, but the period was extended after two months of operation to 10:15 am to reduce problems caused by large numbers of vehicles arriving immediately after the restraint period ended. In June 1989, licenses were introduced for the evening peak, initially set from 4:30 pm to 7:00 pm, but shortened six months later to end at 6:30 pm. In January 1994, the scheme was extended to cover the entire day, 7:30 am to 6:30 pm (3:00 pm on Saturdays), but with lower charges for off-peak use. Charges for the morning peak started out in June 1975 at S$3 per car (about US$2), but were increased to S$4 after six months of operation, and then to S$5 in March 1980. When the all-day scheme took over in 1994, the all-day charge was reduced to S$3, with a S$2 part-day fee for the period 10:15 am to 4:30 pm (10:15 am to 3:00 pm on Saturdays). Some vehicles were initially exempted, including taxis, motorcycles and goods vehicles, but are now charged. High-occupancy vehicles were also initially exempt but the ingenuity of local youth, who filled car seats for a fee to enter the restricted area, defeated this. Public buses and emergency vehicles are now the only exempt vehicles. Company cars are now charged at twice the rate of private cars. The physical extent of the protected area has also been increased from about 5.5 km^2 in 1975 to about 7 km^2 today. The Singapore Government has further plans to improve the scheme, most notably by replacing the paper licenses with electronic tags for automatic detection, and might even extend to a full electronic road pricing system.

The Singapore scheme, as modified over time, has been very successful. In the simplest terms, traffic volumes in the central area have been reduced so that average speeds in the central area are around 30 km/h. However, the supplemental licensing scheme is only one element of urban transport policy in Singapore, and its success is in large part dependent upon the support of many other strong initiatives in urban transport planning—strong traffic management, good public transport including both buses and metros, effective infrastructure provision to a clear plan including bypasses around the designated area, and effective pricing policies. A further important element is the ability (both technical and legal) to identify and prosecute offenders.

All recent proposals would require vehicles traveling in the designated zone to be provided with devices that can be recognized, or accessed, by devices mounted in or near the road. Several alternative schemes are under investigation, differing in both the technology and also the approach to pricing (see Box 7). While much (but by no means all) of the technology for ERP has been demonstrated, the only actual installation to date has been the 1985 ERP pilot project in Hong Kong. This demonstrated the feasibility of the technology, but was not deemed to be acceptable politically. This was partly because of the privacy concern mentioned in Box 7, but also because the public could not be convinced of the value or necessity of the scheme. While some of the objections have been overcome, in theory at least, by improved technology, actual implementation remains a plan in Hong Kong and elsewhere.

Conclusions on Area Pricing. Singapore has demonstrated both the workability and benefits of area pricing. Singapore has also demonstrated the virtue of starting with a relatively simple scheme, and then refining and adjusting it to achieve better results. Further, what they have accomplished so far makes very little use of advanced technology, demonstrating that

technology need not be the driving force behind effective area pricing, even if it has the potential to make it more efficient. All of this would augur well for initiating area pricing schemes in China.

BOX 7: ELECTRONIC ROAD PRICING TECHNIQUES

A variety of electronic road pricing schemes have been proposed, making use of different technologies, and much experimentation is currently underway. The technical details (for example, should the link between vehicle and roadside monitoring device be by means of optical, infrared, radio, or microwave technology) need not concern us here, but will be critical in finally developing a workable system. Some differences are more crucial for public acceptability, as follows:

Off-Vehicle or On-Vehicle Metering. Off-vehicle metering monitors the progress of a vehicle through the congested zone, accumulating road-use charges in a central computer. The motorist is then sent a monthly bill for congestion charges in much the same way as for regular utility bills. This raised objections on privacy when piloted in Hong Kong in the 1980s, since it leaves the possibility for investigators unrelated to the ERP scheme to raid the central computer for information on the whereabouts of any registered vehicle. More recent schemes therefore emphasize on-vehicle metering where a prepaid meter (perhaps an electronic smartcard) mounted on the vehicle is turned on and off by the roadside devices, and must be replaced, or replenished, when completely used up.

Point Charging or Continuous Charging. The question here is whether a charge is accumulated for each passage past a fixed roadside point or whether the meter runs continuously in the charged areas with the roadside devices simply turning the meter on and off at entry and exit points. The latter method clearly could provide a better measure of actual usage but, for many motorists, would be alarmingly open ended—a bad traffic jam could be really expensive. The former method would be less rigorous in charging for congested road use, but would give the motorist a much clearer idea of the extent of financial commitment for a particular journey.

Fixed Rates or Variable Rates. Some schemes propose fixed and posted rates, varying by zone, while others seek to vary the charging rate according to the actual level of congestion as measured by average road speed measured by detectors. As with point and continuous charging, the latter is more effective but the former is likely to be more understandable and therefore more acceptable.

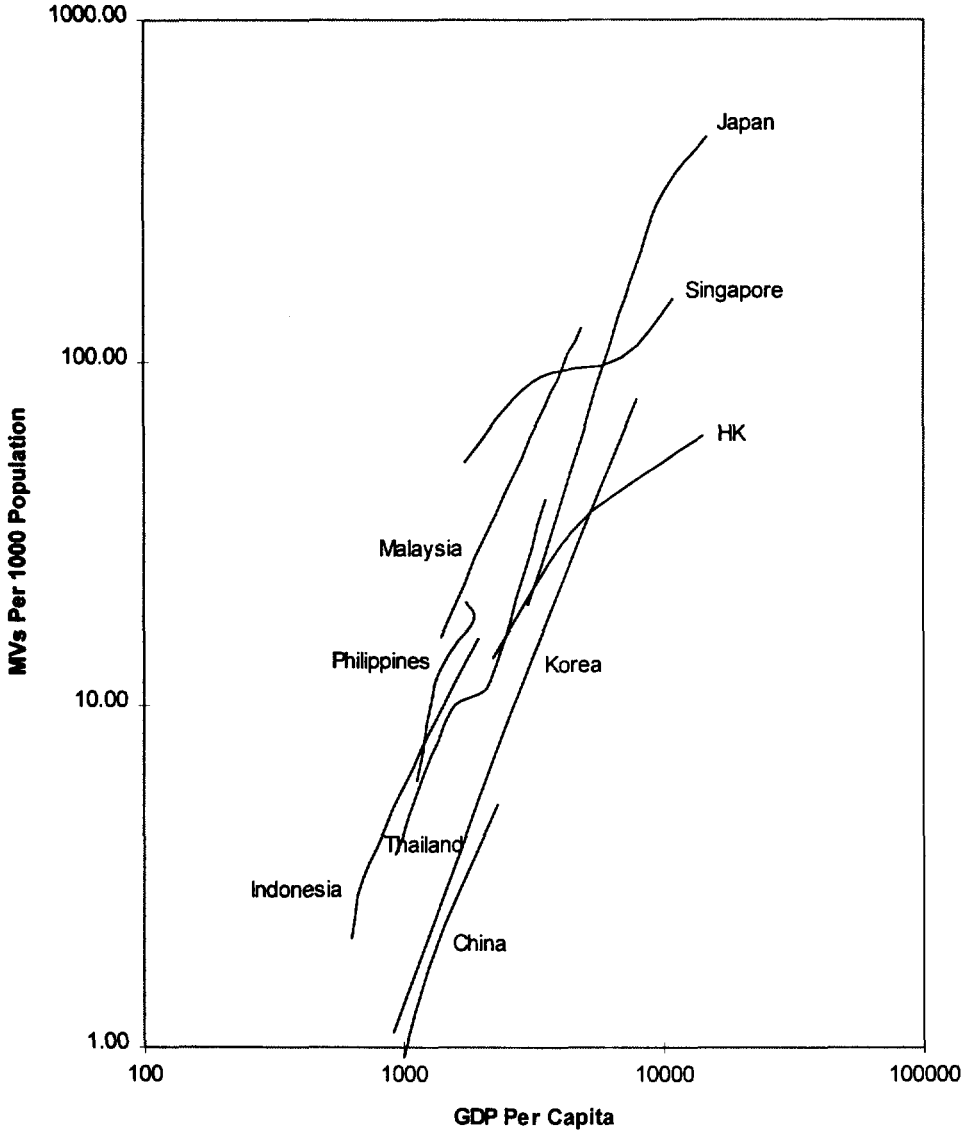
On the other hand, the Singapore scheme was established on a secure basis of strong urban transport management underpinned by a sound understanding and acceptance of market pricing principles. This framework is largely lacking in Chinese cities. In China, the relatively sudden advent of motorization and consequent lack of experience in traffic management, the current dependence on bicycle travel, the lack of efficient public transport systems (either bus or rail), and the uneven application of market pricing principles all complicate the introduction of area pricing in the short term. It remains, however, the most enticing approach to gaining control of motor vehicle congestion.

F. INTERNATIONAL EXPERIENCE OF MOTORIZATION

This section looks at the actual experience of transport developments in several Southeast Asian cities, all of which are further along in the motorization process than China. As a background to this discussion, the graph in Figure 10 presents the growth of the total vehicle fleet over the period 1960-90 for the main Southeast Asian economies. The line for each country spans the period, starting bottom left at 1960 and finishing top right at 1990. Patterns are quite consistent for the country economies, with a strong correlation between vehicle ownership levels

and per capita GDP. Korea shows that high growth can be sustained over a 30-year period, and Japan indicates that vehicle fleet growth can continue even at very high GDP per capita levels. However, the two city-states of Hong Kong and Singapore show that the pattern can be modified with high vehicle-taxation policies to restrain vehicle ownership growth.

FIGURE 10: EAST ASIA MOTORIZATION, 1960-90



The significance for China is clear. While motorization is at an early stage in China, Figure 10 indicates that China is starting to follow the East Asia pattern, supporting the projections of China motorization presented in Section B of this paper. This section, therefore, examines recent developments in transport in several major East Asian cities as they are going

through the motorization process to see what lessons they might have for Chinese cities embarking on the same process.[29]

Hong Kong

Hong Kong is a small city region of 1,070 km^2, mostly comprising steep hills and uninhabited islands. The densely developed built-up area covers just 96 km^2, much of it reclaimed from the sea. With few natural resources, Hong Kong has thrived on light industry, on financial services, and as a major regional seaport. Strong economic growth has been sustained for many years, averaging around 8 percent per year since the early 1960s. Population roughly doubled from about 3 million in 1960 to nearly 6 million today.

Facing increasing road congestion in the mid-1960s and a rapidly increasing population, Hong Kong embarked on a series of transport and land development studies, both major and minor, which continue to this day. Quantified transport and land-use planning is a hallmark of the Hong Kong planning process that has guided the massive transport infrastructure development program of the past 30 years.

Despite an intensive construction program, it was recognized early on that new roads could not keep pace with rising car ownership and that chronic traffic congestion would threaten the viability of the road-based public transport system, which carried around 85 percent of all passenger journeys in the early 1970s. Therefore, a decision was made in 1973 to deter further vehicle ownership by imposing large increases in vehicle taxation; this was reinforced by further increases in vehicle taxes in 1982. These measures were successful (see the figure in Box 3). Supported by other measures, including parking controls and increased tolls on road tunnels, and with strong traffic management to extract maximum efficiency from the available road system, peak-hour urban road speeds in 1986 were maintained at 25 to 28 km/h. However, vehicle growth resumed in 1986, and traffic congestion is again an issue. Average peak-hour speeds have now dropped to at most 22 km/h (1993 measurement).

Given high densities of urban development, much located in narrow corridors of reclamation, the early transport studies gave high priority to the construction of a rail-based mass transit system. Construction of the mostly underground Mass Transit Railway (MTR) started in the mid-1970s and three lines have been opened to date. With high ridership (2.2 million passengers/day), the MTR is considered one of the most successful metro systems in the world, and the only one with any chance of recovering all its construction and operating costs from passenger revenues. During the same period, the Kowloon-Canton Railway (KCR) expanded services to the rapidly growing towns of the New Territories located outside the main urban area by electrifying its mainline and constructing a new light rail system (for a total 1.0 million passengers/day). Both MTR and KCR are owned and operated by public corporations.

Despite the construction or upgrading of five major rail lines (about 100 km) in the past 15 years, buses, minibuses and taxis (3.5, 1.7, and 1.0 million passengers/day, respectively)

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[29] The authors were greatly assisted in preparing the city write-ups by Sock-Yong Phang (Singapore), George D. Esguerra (Manila), Rodney J. Stickland (Bangkok), Jason Brooks (Kuala Lumpur), and Bob C.L. Lee (Taipei).

continue to carry well over half of all public transport passengers. Many buses are now air-conditioned and provide good levels of service, partly protected from road congestion by bus-priority traffic management measures. Preference is given to buses, with the number of minibuses kept fixed and the few additional taxi licenses granted each year (around 170) that are auctioned to the highest bidder. Trams and ferries complete the public transport scene. All these services are provided (profitably) by private companies under Government-regulated franchises.

Hong Kong has excellent transport infrastructure and public transport services, a result of many years of intensive planning and investment. It is also a highly competitive system with services available over a range of quality and price. Road and rail construction continues, including works to serve the new airport and provide new links with China, but it is recognized that construction solutions are not sufficient on their own. The major transport challenge continues to be rising vehicle ownership and associated traffic congestion that again threaten the essential bus, minibus and taxi services. Various countermeasures are under consideration, including further increases in vehicle taxation, road pricing (piloted successfully in 1985 but not implemented), and increased tunnel tolls (although complicated by franchising agreements).

Seoul, Korea

Seoul's urban land-use/transport system has evolved into a model favored by many Chinese city planners and policymakers. A densely developed metropolis, Seoul is the home for 17 million people. The growth of its central city has been physically controlled by a strictly enforced greenbelt, with much new development taking place in high-rise satellite towns scattered outside. These satellite towns are linked to the central city by high-performance railways and highways. The central city itself is served by four metro lines (121 km) and an extensive bus network (422 routes and 8,700 buses). Yet, Seoul is now facing the biggest transport challenge in its history: rapidly growing traffic congestion.

In the early years of economic development, all cars were imported and subject to high duties, which put vehicles out of reach for most people. This changed with the development of the domestic car industry, which the Korean Government saw as an engine of the economy and a key export earner. To help establish the industry, the Government initially set low taxes for domestic vehicle purchase and reduced the fuel tax and other vehicle usage fees. Combined with growing incomes, this has produced continued rapid increases in car ownership nationwide. In Seoul, the number of passenger cars has grown by 20 percent per year since 1985. Average auto speeds declined from 33 km/h in 1989 to 20 km/h today, and peak-hour traffic jams are now a daily phenomenon.

Recognizing that the central city, with a population density of 18,000 persons per square kilometer, had little room for road capacity expansion, Seoul focused instead on expanding the metro system. However, the metro has not made any appreciable impact on road congestion. Moreover, although it carries 5 million passenger-trips daily, and is very crowded during rush hours, fare revenues do not cover operating expenses (including depreciation). With further subway extensions typically penetrating thinner and thinner markets, increasing subsidies are likely in the future. As in the past, further subway expansion is unlikely to reduce road congestion because continuing growth in road traffic will soon fill spare capacity created by any road users diverted to the metro.

The bus system has been the biggest loser to growing traffic congestion. Carrying 10 million passenger-trips per day (40 percent of total person-trips), the system is operated primarily by 90 private businesses under Government regulation of fares and routes. To date, it has not required any operating subsidies and has been regarded as very efficient by international standards. But growing traffic congestion caused serious declines in bus speeds and deterioration of service reliability, resulting in loss of ridership and revenues as passengers turned to private cars and taxis. At the same time, declining bus speeds increased both operating and capital costs. Facing ridership losses (5 percent per year) and cost increases (15 percent per year), Seoul's bus operators demanded action. In response, the Seoul Government recently implemented extensive bus-lane priorities across the central city; these are reported to have improved bus speeds substantially and shifted some car users to buses.

While Korea's successful auto industry strategy has brought substantial benefits to the country's economy and the people's well-being, road congestion caused by uncontrolled motorization in urban areas is in danger of eroding these benefits. By opting for subway development and avoiding any direct action to reduce road congestion, the Seoul Government exposed itself to increasing subsidies for metros and deteriorating quality of bus transport, which still remains the largest public transport carrier. The recent actions on bus priorities, which both helped buses and restricted car usage, have substantially improved the situation, but vigilance will be required to cement these gains.

Bangkok, Thailand

Bangkok, with a population approaching 8 million, is located on low land adjacent to the Chao Phraya River. Until the early twentieth century, its transport was based on the river, Khlongs (canals) and waterways. The development of the city has proceeded in a largely uncoordinated manner, due to the absence of any effective planning controls or strong administrative direction. The road network is characterized by very wide, multilane main roads—many constructed over or along the alignment of abandoned khlongs—and a large number of small local feeder roads (sois) that are narrow, poorly connected and indirect. Overall densities are relatively high in the inner areas, but are significantly lower in the outer areas where development is limited by the absence of an adequate road network.

There has been a tremendous increase in the vehicle fleet in Thailand in recent years. New vehicle sales have shown a sustained growth of over 15 percent per year, with a staggering 33 percent per year increase in private car sales over the last 10 years. Half of all vehicle registrations (75 percent for cars) are in Bangkok. Despite these high rates of growth, the absolute levels of vehicle ownership are still relatively low and substantial growth may be expected before saturation is reached. Fuel sales in the region have been increasing by over 9 percent annually, representing a doubling in traffic volumes every eight years.

The dominant characteristic of Bangkok's transport system is overwhelming traffic congestion. Within the inner areas, speeds average less than 10 km/h for much of the day, and conditions in the suburbs are rapidly becoming similar. The lack of alternative nonroad-based transport and the ever-sprawling suburban development results in congestion extending upward of 20 km from the center for up to 16 hours per day.

With the exception of very limited local commuter rail services and some boat services on the river and khlongs, there are no segregated public transport services in Bangkok. Those without access to cars or motorcycles are dependent on buses, minibuses, taxis and a mix of smaller public transport modes—including semilegal motorcycle taxis. Buses carry some 6 million passengers per day, but are severely affected by the high levels of traffic congestion and face increasing competition from the ever-increasing number of private cars and motorcycles.

The problems have long been recognized and studied, and many proposals for mass transit schemes and urban expressways have been promoted over the past 20 years. A series of privately funded transit schemes have been proposed, although none of the projects are close to being operational, and construction is well behind schedule on the two schemes on which work has started. Full funding has yet to be secured for these projects, which are claimed to be self-financing. Progress on the implementation of urban expressways has been more impressive and a network of tolled routes is now in operation, with more sections planned or under construction. Most have been implemented using a mix of public and private finance: considerable difficulties have been experienced in securing the finance and the associated contractual arrangements between the operator and the Government. These expressways, however, do little to solve the underlying problems and serve to funnel yet more traffic onto the overloaded central street system.

The main hope for improving travel conditions lies in the completion of the rail mass transit schemes. Restrictions on private car usage would be desirable, but are considered both impractical and unacceptable in the Thai context, with the commitment to personal liberty and individual freedom.

Singapore

Singapore is a small island city-state with a population of 3 million and a land area of 630 km^2. It has no natural resources (except for its strategic location and excellent natural harbor) and has pursued a successful industrial policy of attracting foreign direct investment to its manufacturing, financial and business services sectors. Economic growth has averaged 8 percent per year since the early 1960s.

The Government has undertaken long-term land-use and transport planning since the late 1960s. The state has been responsible for industrial park developments, as well as the construction of large high-rise public housing estates that presently house 86 percent of Singapore's households. It also leases land to the private sector for commercial, residential and recreational developments. The island is well served by adequate public transport services and excellent transport infrastructure.

Public transport operators are either owned or regulated by the Government. The two-line 66-km Mass Rapid Transit rail system, owned and managed by public corporations, was opened in stages between 1987 and 1990. The capital cost was entirely financed by the Government and passenger revenues are expected to cover operating costs only. Further expansion of the MRT is underway or planned, and the Government has also made a commitment to link additional areas to the MRT via Light Rail Transit systems. Bus services are provided by two major operators that are profitable, publicly listed companies. Buses enjoy

exclusive bus lanes as well as priority right-of-way at designated traffic junctions. Minibuses operate high-quality public transport services between certain housing estates and the downtown area during peak hours.

Road congestion became a major problem in the early 1970s. Tackling the motorization problem early, the Government implemented an Area Licensing Scheme in 1975 (see Box 6). The scheme that started as a morning-peak licensing scheme has been extended to become a whole-day scheme. Road pricing has also been introduced along an expressway and other usage charges include parking fees and fuel taxes. Usage charges are complemented by strict vehicle ownership quota policies that aim to restrict vehicle growth to 3 percent per year. Since 1990, prospective new car owners must first acquire a Certificate of Entitlement (COE) obtained at a monthly tender. The October 1995 tender price of a COE for a medium-size car (1,001 to 1,600 cc) was about US$30,000. Other duties, taxes and charges took the average price of a medium-size car to over US$90,000 in 1995, perhaps five times the CIF value. (There is no domestic automobile industry in Singapore so all cars are imported.)

The combination of quotas and pricing policies has successfully reduced road congestion in Singapore; peak-hour speeds in the restricted zone average 30 km/h. Motor vehicle charges have also proven to be highly revenue-productive, accounting for nearly one-quarter of total tax revenue in recent years, more than adequate to finance expenditure on transport infrastructure.

However, despite (or perhaps because of) Singapore's success in containing the motor car, the Government is now under great pressure to expand vehicle ownership and road facilities. A recent poll showed that young Singaporeans have two major aspirations: to live in a bungalow (currently 86 percent of the population live in high-rise apartments), and to own a car (currently just 1 in 10 own one). For the majority, these must be dreams, but Government is committed to respond. The 1996 Government White Paper, "A World-Class Land Transport System," pledges to greatly increase road construction (possibly including underground expressways in the central area), to increase car ownership to 1 in 7, but at the same time to extend vehicle usage controls to maintain free traffic flows—electronic road pricing is scheduled for implementation in 1997. Plans also include continuous improvement of the public transport system and further decentralization of employment from the central city area to four regional centers.

Metro Manila, Philippines

Metro Manila, covering an area of 636 km^2, is the country's capital region comprising eight cities and nine municipalities. With 8.9 million residents, Metro Manila accounts for about 13 percent of the national population, one-third of all urban dwellers, and about one-third of the national economic output.

With trade liberalization, the economic upturn in 1990, and Government's policy to make the price of locally-assembled cars affordable through the "People's Car Program," vehicle ownership and usage have increased rapidly. The private transport share has risen from 26 percent in 1980 to the present level of 35 percent. Out of the 80,000-unit annual sales of the domestic car industry, two-thirds are registered and used in Metro Manila. The growth in private vehicles, increasing at the rate of 12 percent per year, has outpaced growth in road capacity and

traffic congestion has spread to nearly all the arterial roads of Metro Manila. Peak-hour travel speeds are now down to 10 km/h in major traffic corridors.

Public transport services are predominantly road-based, consisting largely of privately-owned jeepneys and buses for primary and secondary routes. Short-distance bus transport forms an integral part of Metro Manila's transit system. Under the liberalized regulatory regime, public transport operators, particularly bus companies, have recently increased and modernized their fleet.

As early as the 1960s, the strategic transport development plan for Metro Manila called for the introduction of urban rail transit systems to provide trunkline services. Despite financial difficulties, a 15-km Light Rail Transit (LRT) line was constructed in 1984 to serve two of Metro Manila's most-traveled corridors. The Manila LRT system enjoys daily ridership of about 400,000 passengers. Despite the low flat fare of ₱ 6.00 ($0.22) since 1991, the fare box ratio (gross revenue divided by direct operating expenses) has remained high at 1.5, comparable to other urban rail systems in the world. Thus, revenues help offset equipment depreciation, but make little or no contribution to the original construction costs. The LRT line has helped shape the urban development of Metro Manila, triggering redevelopment of the old business districts within the City of Manila and commercialization of areas around the LRT stations.

The transport problems of Metro Manila are mainly attributed to the deficiencies in public transport services and the urban road network. The traffic situation is dominated by the sheer number of private cars and the operation of space-consuming jeepneys, with the latter now operating on traditional bus routes. Traffic management measures, despite the use of a computer-controlled signal system, have remained uncoordinated, and suffer from inconsistent traffic enforcement by a multitude of traffic authorities. The end result has been chronic congestion on most roads, which further degrades the level of service of public transport modes, particularly buses. In an attempt to combat traffic congestion, in December 1995 transport authorities adopted an odd-even number plate permit scheme on key routes during peak periods. This scheme has so far proved ineffective, so plans are being made to extend it to cover public transport vehicles, including taxis. However, the hopes of the authorities rest on implementing major road construction projects and three new LRT lines, targeted for opening by 1998.

Kuala Lumpur, Malaysia

The Federal Territory of Kuala Lumpur provides a natural focus for business and commercial activities undertaken in Malaysia. Covering an area of some 245 km^2, Kuala Lumpur has a population of some 1.3 million people and also provides a source of employment for residents of neighboring states. Population growth in Kuala Lumpur during the past decade has been rapid, largely as a result of urbanization, and economic growth has paralleled the national GDP growth rate of over 8 percent per year.

A key component of the Government industrial strategy has been the development of a national car industry (Proton), and this has greatly reduced costs of car ownership. Since the introduction of the Proton Saga in 1985, growth in passenger car ownership has been rapid, with vehicle registrations increasing at more than 8 percent per year during the past decade. Import duties remain high on all foreign cars.

The combined pressures of an increasing population and high car ownership have led to rapid growth in traffic demand within Kuala Lumpur. Traffic congestion is now pronounced within the central area of the city. Traffic police are required to man all major intersections during peak periods and the duration of traffic congestion is spreading throughout the day. Investment in road network construction has focused on the development of effective orbital road systems to relieve traffic demand in the central city areas. Much of this development has been achieved through private-sector involvement and many of the new road schemes will operate as toll roads.

Buses carrying some 1 million passengers per day provide the main public transport service in Kuala Lumpur but have long been viewed as a mode of last resort, reflecting problems of overcrowding, poor travel conditions, and unreliable journey times. The Government has recently embarked on a major reorganization intended to improve bus service standards and promote private-sector investment. They plan to rationalize the role of buses and minibuses and construct new passenger interchange facilities away from the urban center. The Government is also evaluating the potential benefits of introducing bus-priority measures within the central area of the city.

Rail facilities provided by Keretapi Tanah Melayu Bhd (KTM) have recently been upgraded, including construction of a second parallel track, track electrification, and construction of new stations. Work was completed in 1995 and has led to improved commuter rail service within the Kuala Lumpur conurbation. There has also been a long-standing commitment by the Government to implement a Light Rapid Transit (LRT) network within Kuala Lumpur. Two main routes (covering some 50 km) are currently being implemented by private-sector companies and will each provide a carrying capacity of some 16,000 passengers per hour. They are scheduled to be completed before the start of the Commonwealth Games in 1998. The implementation of an LRT system will greatly increase the overall capacity of the public transport system and reduce its sensitivity to road congestion. However, it is recognized that the full benefits of the LRT system will only be realized by integration with other rail and bus services.

Since the early 1990s, the authorities in Kuala Lumpur have acknowledged that it is not possible to accommodate the demand for personal mobility through new road construction alone. Instead, the authorities have embarked on a series of major initiatives designed to achieve a modal shift of 40 percent from private to public transport by the year 2000. The initial emphasis has been on the development of a fully integrated public transport system, as described above. However, it is also recognized that measures will likely be needed to limit the growth in motor vehicle traffic. Measures currently being considered include revised parking policies, high-occupancy vehicle lanes and the implementation of road pricing.

Taipei, Taiwan (China)

Taipei has an area of 272 km^2 and a population of 2.64 million. The city is surrounded by mountains on three sides and Tansui River in the west. Its metropolitan area has extended westwards over the river to many cities of Taipei County linked by more than 10 bridges. The Central Business District (CBD) is very dense in the middle-west area, and the residential area is located beyond.

Private vehicles play a major role in Taipei's urban transportation system, with approximately 0.9 million registered motorcycles and 0.42 million registered cars. They carry 30 percent and 25 percent, respectively, of daily passenger travel. The total number is still growing, with more than 10,000 new vehicles per month. There is currently no specific policy for limiting vehicle ownership, in part to help the domestic manufacture of cars and motorcycles. Growing incomes make it easy to own a vehicle and poor public transportation service encourages private vehicle usage. Traffic congestion is considered a serious problem in the CBD and on commuter routes. The average traffic speed is 15 km/h during the peak, 18 km/h during the off-peak.

Vehicle parking is another issue in Taipei. Demand exceeds the supply of public off-street parking places, so that roadside parking and illegal parking are very common in the city. This reduces city street capacity and exacerbates congestion. Recently, the City Government decided to provide more incentives to private development of carparks.

Buses and taxis are the two major public transportation modes in the city, accounting for about 35 percent of all passenger movements. Currently, 10 bus companies are operating with a total fleet of 3,345 buses and providing 247 service lines inside the city, which link to the neighboring cities in Taipei County. The number of taxis operating in the city is estimated to be more than 50,000, including those registered in Taipei City and neighboring cities. However, the transport capacity provided by public transportation is far below the demand, especially in peak hours, and the service quality is poor. To mitigate this problem, the City Government has drafted many schemes, for example, dedicated bus lanes, on-time bus information, comfort interior design of buses and automatic fare collection system, in an effort to attract more trips from private transportation modes.

A major goal of the City Government is to improve the service level of public transportation in order to shift more trips from private transport modes to pubic transportation. A five-line Mass Rapid Transit (MRT) system has been under construction since 1988 and is expected to be completed by 1998. The first line was scheduled to commence service in 1994 but, due to a series of construction and equipment problems, the line is still under inspection and testing. It is now expected to begin operations in 1996, at the same time as the second line. Currently, limited rail commuter services carry about 5 percent of daily passengers.

Conclusions from the Southeast Asian Experience

Table 8 below attempts to summarize the main features of transport development in the Southeast Asian cities presented in this section, and of the outcome in terms of traffic congestion.

The two extremes of city transport development in Southeast Asia are represented by Bangkok and Singapore. Bangkok suffers from chronic traffic congestion resulting from uncontrolled growth in vehicle ownership, an inadequate city street system, and little effective control of land use or public transport services. Some hoped-for improvement is offered by the rail transit schemes being planning or under construction, but these are plagued by financial, political and physical problems. Singapore, on the other hand, can be said to have solved the traffic congestion problem, using a combination of strict land-use controls, severe restraint of

vehicle ownership through draconian pricing policies, controls on vehicle usage of the busier roads, again using pricing methods, and development of an exceptional public transit system exploiting both buses and metro, where appropriate.

TABLE 8: TRANSPORT POLICY VS. OUTCOME IN SOUTHEAST ASIAN CITIES

City and Country	Land Use Controls?	Motor Industry Strategic?	Urban Rail or Metros?	Bus Priorities?	Car Restraints?	Congestion Controlled?/a
Hong Kong	√	X	√	√	√	√
Seoul, Korea	√	√	√	√	X	X
Bangkok, Thailand	X	X	(√)	X	X	XX
Singapore	√	X	√	√	√	√√
Manila, Philippines	X	X	√	X	X	XX
Kuala Lumpur, Malaysia	√	√	(√)	(√)	X	X
Taipei, Taiwan (China)	X	√	(√)	(√)	X	X

X = No, √ = Yes
(√) = In implementation or planning

/a A double mark indicates a higher degree of success or failure.

The other cities fall somewhere between these two extremes. The relative degree of success or failure in controlling congestion seems to depend on the extent of control and intervention exercised by the government in the areas of land-use control, vehicle ownership/ usage restraint, and provision of good public transport services.

The two city-states of Singapore and Hong Kong have been most active in restraining vehicle ownership, but have two key advantages that neither the other cities nor China possess: a restricted land area with no rural hinterland to consider, and no domestic motor vehicle manufacturing industry to satisfy. However, Singapore has also been extremely successful in controlling motor vehicle usage in the city center, and this owes nothing to its city-state status. On the evidence of Singapore, road usage pricing can be effective when implemented with other integrated transport policies.

All cities have identified fixed rail systems as a key element in their transport strategy. Several have successful systems in operation and all are constructing or planning new lines. There are three special features to note. First, almost all the cities are the capital city of their territory, so financing becomes a national matter rather than just a city one. Most large cities in China contemplating expensive urban rail construction would not be supported by national funds. Second, all the cities were at an advanced stage of economic development before starting on urban rail development and therefore had substantial resources to call on. Many large Chinese cities are not at this stage yet. Third, and most importantly, rail systems alone are not the answer. The successful rail-system cities are those vigorously pursuing other parallel policies to control land use and transport.

It is difficult to summarize experience from other countries in any precise way, partly because objective comparative data are hard to come by, and partly because the influence of the

particular geography, history and customs of each city is difficult to capture and yet has a profound impact on the outcome. Hence, international experience can provide some clues on likely transport policy outcomes, but specific policies for China must be developed in the local context.

G. STRATEGY CONSIDERATIONS FOR CHINA

Motorization is proceeding rapidly in China, and this process is essentially irreversible. It is mostly driven by the substantial economic benefits brought to industry, and in particular to the forms of widespread light industry which have been so crucial to China's recent economic growth. However, the problems of motorization are mostly felt in the urban areas, and traffic jams are now becoming a daily feature of major cities. This paper has reviewed the issues raised by this, and the range of possible actions that can be taken. These are discussed below in the context of current policies in China.

Road Management and New Construction

Available road space is relatively low in many Chinese cities, although not as low as sometimes quoted. This leads to the following considerations:

- Existing road space can be better managed. With the existing fragmented responsibilities for municipal transport, this could be assisted by the development of interagency teams to tackle traffic management in a comprehensive manner.

- Bus services are particularly vulnerable to traffic congestion and need protection. Bicycles do not mix well with motorized traffic, but play an essential role in city-center transport. Therefore, it makes sense to allocate existing road space among road users, segregating to the extent possible buses, bicycles (already extensively segregated) and other road vehicles. This means protecting specific roads or sections of roads for exclusive use by buses or bicycles, at least for critical periods in the day.

- In addition to the above measures, to make the existing street system perform more efficiently, special measures are needed to protect vulnerable areas where excessive vehicle use is detrimental, particularly those dominated by pedestrians, using *traffic-calming* methods.

- Considerable road construction will be required in future years, but this will mostly be part and parcel of the process of urban expansion and city-center dedensification.

- Some urban expressway construction will be useful, but many city masterplans currently in development are well in excess of world norms for urban expressway construction, will likely prove unaffordable, and are unlikely to resolve city traffic problems in the manner intended. Better evaluation and justification of high-class road networks is necessary.

- In general, new road construction on its own will not solve the traffic congestion problem—traffic will tend to fill up all available road space. New construction and road management must be combined with management of transport demand.

Management of Transport Demand

Cities need to take action to avoid chronic traffic congestion, which profoundly reduces the efficiency and quality of life in cities.

- A major cause of traffic congestion is the systematic underpricing of transport services, which both burdens the road system with excess traffic and produces financial deficits to be made up from general revenues.
    - ◊ A more consistent transport pricing policy is highly desirable, as discussed in Theme Paper 10, "Shaping the Future: Getting Prices Right."
    - ◊ In particular, higher prices for vehicles and fuel, imposed by means of supplementary taxes or fees, would provide additional municipal revenues and usefully dampen the present rapid and unmanageable growth in transport demand.
- Worldwide experience shows that the keys to controlling traffic congestion are strong policies to control the use of vehicles, particularly cars and motorcycles, in city centers at peak times:
    - ◊ Control of city-center parking by pricing and regulatory means are the most widely used policies, despite some inherent flaws in this approach.
    - ◊ More sophisticated area pricing and road pricing policies promise to be the more effective over the long term and deserve close study.
    - ◊ China currently has a window of opportunity to establish effective policies before motorization is too far advanced.
- Such measures could be supplemented by restrictions by vehicle type or by area, but measures applied to date in China appear ad-hoc, implemented as problems arise, without analysis of needs and benefits of each vehicle class and with little restriction on car usage. All nonpricing methods of restricting vehicle usage deserve very careful evaluation to ensure that they do not bring substantial economic disbenefits.

Motorcycles

Motorcycles present a special problem:

- Without controls, they are likely to grow extremely rapidly and swamp city street systems.
- Higher-quality motorcycles, with strict noise and emissions controls and priced accordingly, could improve their environmental impacts and somewhat restrict demand, but further controls would likely be necessary.

- Increasing motorcycle prices by supplementary taxes or fees would help control the growth in demand, but would unnecessarily penalize ownership and use in rural areas where they have a strong economic role.

- Until urban road pricing becomes a reality, some areawide restrictions on urban motorcycle use appear to be necessary.

Motor Vehicle Industry

Projections of the rate of motorization in China made by domestic motor industry studies are probably conservative. This suggests:

- that a viable domestic industry can be established on the basis of domestic demand;

- that it will not be necessary to "force" the pace of motorization by subsidies or financial incentives or subsidies to new owners;

- that cities can be left to set policies to control and guide the ownership and usage of motor vehicles without endangering the viability of the motor vehicle industry.

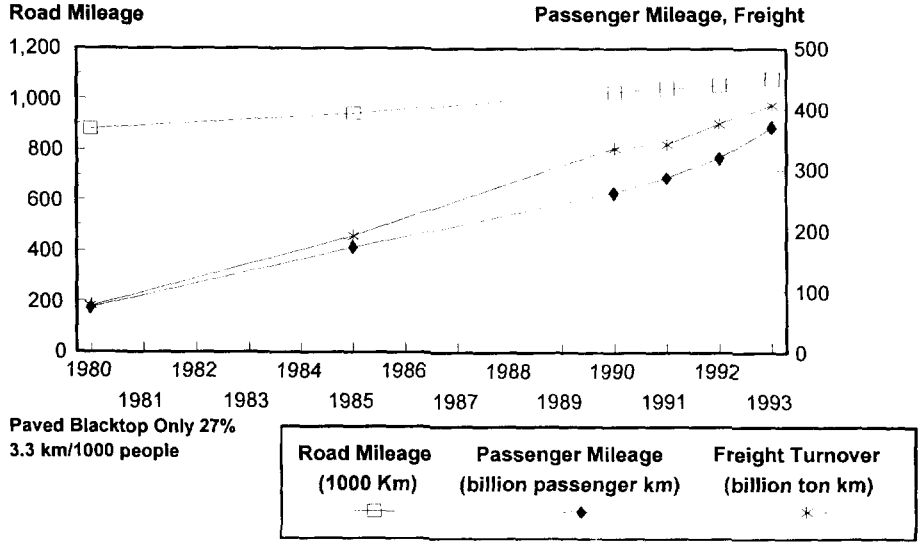
THEME PAPER 2: MOTOR VEHICLE POLLUTION CONTROL IN CHINA: AN URBAN CHALLENGE

MICHAEL P. WALSH [1]

INTRODUCTION AND BACKGROUND

Over the past one or two decades, the vehicle population has begun to grow rapidly in China. For example, in Figure 1, the total road network is growing rapidly, as is the total amount of passenger mileage and freight turnover. Further, as illustrated in Figure 2, there has been a steady shift from rail to road over this same time frame. While these vehicles have brought many advantages—increased mobility and flexibility for millions of people, more jobs, and enhanced many aspects of the quality of life—the benefits have been at least partially offset by excess pollution and the adverse effects which result.

FIGURE 1: GROWTH OF ROAD MILEAGE AND TRANSPORTATION



The purposes of this paper are to review the environmental consequences of an increase in road traffic and to summarize the strategies that could be used to ameliorate them. The next section will review the adverse effects of pollution. This will be followed by an assessment of the dominant role usually played by motor vehicles as a source of this pollution. Then, the

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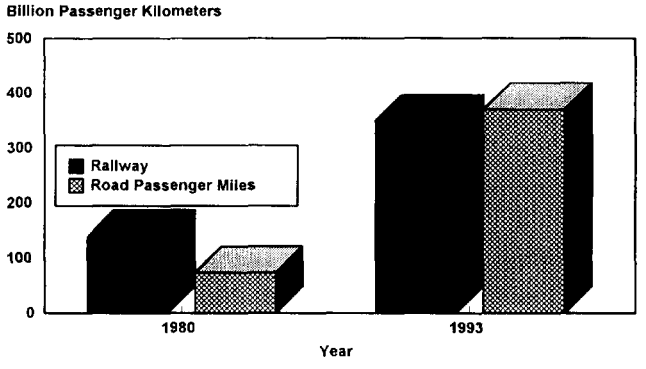
current and likely future situation in China will be evaluated, followed by a review of strategies that could reduce vehicle pollution, in general, and then specifically in China.

VEHICLE EMISSIONS AND AIR QUALITY CONCERNS

Cars, trucks, motorcycles, scooters and buses emit significant quantities of carbon monoxide, hydrocarbons, nitrogen oxides and fine particles. Where leaded gasoline is used, it is also a significant source of lead in urban air. As a result of these emissions, many major cities around the world are severely polluted. This section will review some of the consequences of these pollutants.

FIGURE 2: TRENDS IN SURFACE TRANSPORTATION



Lead

There has been an explosion of knowledge during the last two decades with regard to the adverse health impact of long-term exposures to low levels of ambient lead.[2] In response to this growing body of data, most industrialized countries and several developing countries have introduced unleaded gasoline and several have or will soon prohibit the use of leaded gasoline entirely.

The toxic properties of lead at high concentrations have been known since ancient times as lead has been mined and smelted for more than 40 centuries. Precautions in its use have been widespread for centuries, but it has only been recently that its adverse impacts at very low levels have been fully appreciated. The seminal work in this area is the 1979 report by Dr. Herbert Needleman and his colleagues, which showed that children with high levels of lead accumulated in their baby teeth experienced more behavioral problems, lower intelligence quotients (IQs) and decreased ability to concentrate.[3] More recent evidence indicates that it is not only the length and severity of exposure to lead that results in the health damage but the age at which exposure occurs. This is especially important because "Of all the persons in the community, the newborn child is the most prone to injury from overexposure to lead for several reasons, and the damage that may be caused then will have the greatest long-term social and economic consequences."[4]

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2 "Lead Exposure and Human Health: Recent Data on an Ancient Problem," Needleman, *Technology Review*, March/April 1980. "Air Quality Criteria for Lead," Office of Research and Development, US Environmental Protection Agency, Washington, DC, December 1977.

3 "Deficits in Psychological and Classroom Performance of Children with Elevated Dentine Lead Levels," Needleman, et al., *The New England Journal Of Medicine*, Vol. 300, Number 13, March 29, 1979.

4 "Exposure to Lead in Childhood: The Persisting Effects," Moore, *Nature*, Vol. 283, January 24, 1980.

Another series of health studies in the United Kingdom confirmed these findings.[5] They add further evidence that lead contributes to behavioral problems, lower IQs and decreased ability to concentrate. Even after taking up to 15 social factors into account, a 3 IQ number deficit was consistently found. While not necessarily statistically significant in any individual study (which is largely influenced by the size of the sample among other factors), the body of data consistently shows the effects.

In addition, the studies of Dr. Winneke in Germany offer further evidence that "neuropsychological effects are causally related to very low blood lead levels."[6] The effects are not necessarily the dominant ones in any particular instance but they are real, a matter of concern and preventable.

Several comprehensive studies of the health issue have been conducted and their major conclusions are summarized below:

- In 1980, the US National Academy of Sciences completed an extensive study of "Lead in The Human Environment."[7] A major finding of this study is "The evidence is convincing that exposures to levels of lead commonly encountered in urban environments constitute a significant hazard of detrimental biological effects in children, especially those less than three years old. Some small fraction of this population experiences particularly intense exposures and is at severe risk." The Academy then recommended that "A serious effort should be made to reduce the baseline level of exposure to lead for the general population of the United States."

- In August 1982, as part of its review of the existing lead program, the US Environmental Protection Agency (EPA) reanalyzed the issue and summarized the results in this way: "The majority of the comments emphatically rejected the proposition that lead was no longer a public health problem. Sixty-four comments were received from the professional health community and academia. Sixty of these opposed any loosening of the lead standard, and many suggested that tighter controls would be desirable. Thirty-two comments were received from local and state governments. All of these supported retention of the current standard to protect the citizens' health. Most of the commenters pointed to previous studies, as well as their own experiences, to demonstrate that lead has an adverse effect on people at very low dosages, and that the more the problem is studied the lower the 'acceptable level' of lead becomes. They concluded that protection of public health and welfare demands that all reasonable steps be taken to eliminate lead from the environment."[8] In October 1982, EPA decided as a result of this review to reduce the amount of lead in gasoline even further.

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5 "The Relationship between Blood Lead Concentrations, Intelligence and Attainment in a School Population: A Pilot Study," Yule, Lansdown, Millar and Urbanowicz, *Devel., Med. Child. Neurol.* 1981, 23, 567-576.

6 Comments at Conference, *Lead in Petrol*, Winneke, May 1983.

7 "Lead in the Human Environment," National Academy of Sciences, Washington, DC, 1980.

8 *Federal Register*, Vol. 47, No. 167, Friday, August 27, 1982.

- In April 1983, the US Court of Appeals completed its review of the EPA decision to lower the gasoline lead levels.[9] In its opinion the Court noted, "there is compelling evidence that gasoline lead is a major cause of lead poisoning in young children." In making this assessment, the Court found that "recent studies suggest that the recognized danger point of 30 micrograms per deciliter is too high and that lead reduces intelligence at blood lead levels as low as 10 to 15 micrograms per deciliter.... Other studies have correlated blood lead levels of 10 to 15 micrograms per deciliter with altered brain activity." The Court concluded that "the demonstrated connection between gasoline lead and blood lead, the demonstrated health effects of blood lead levels of 30 micrograms per deciliter or above, and the significant risk of adverse health effects from blood lead levels as low as 10 to 15 micrograms per deciliter, would justify EPA in banning lead from gasoline entirely."

- Finally, also in April 1983, in the United Kingdom, the Royal Commission on Environmental Pollution concluded that "the safety margin between the blood lead concentrations in the general population and those at which adverse effects have been proven is too small.... It would be prudent to take steps to increase the safety margin of the population as a whole." They continued, "that measures should be taken to reduce the anthropogenic dispersal of lead wherever possible...."[10]

Based on the growing body of data showing adverse effects from lead, in 1985 the US EPA reduced the maximum allowable lead content in leaded gasoline to 0.1 grams per gallon. As part of that rule-making, EPA uncovered evidence linking lead in the blood and high blood pressure.[11]

A subsequent study, in which 249 children were monitored from birth to two years of age, found that those with prenatal umbilical-cord blood lead levels at or above 10 micrograms per deciliter (μg/dl) consistently scored lower on standard intelligence tests than those at lower levels.[12]

Most recently, British researchers reviewed every epidemiologic study on lead and IQ published since 1979 that had over 100 children and measured IQ as a function of blood or tooth lead levels. Based on a meta-analysis of all the data, they concluded that a doubling of body lead burden from 10 to 20 μg/dl in blood levels was associated with a mean fall of about 1 to 2 IQ points.[13]

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9 United States Court of Appeals, No. 82-2282, Small Refiner Lead Phase-Down Task Force, et al. v. US EPA, April 22, 1983.

10 "Lead in the Environment," Ninth Report, Royal Commission on Environmental Pollution, April 1983.

11 Schwartz, J., H. Pitcher, R. Levin, B. Ostro, and A.L. Nichols. 1985. *Costs and Benefits of Reducing Lead in Gasoline: Final Regulatory Impact Analysis*, Report No. EPA-230-05-85-006, US EPA, Washington, DC.

12 Needleman, 1989.

13 Pocock, S.J., et al., "Environmental Lead and Children's Intelligence: A Systematic Review of the Epidemiological Evidence," BMJ 1994, November 5; 309: 1189-97.

In summary, the available evidence indicates that "there is no known physiological function served by lead in mammalian metabolism. As far as cells are concerned, each molecule of lead has the potential to disrupt the chemical basis of normal cellular function. For nerve cells, this interference is particularly destructive because communications between cells in the brain depends upon precisely controlled movements of such molecules such as calcium, sodium, potassium and chloride. Lead can interfere, on a molecule by molecule basis, with these essential elements."[14]

Lead Scavengers

When lead additives were first discovered to improve gasoline octane quality, they were also found to cause many problems with vehicles. Notable among these was a very significant buildup of deposits in the combustion chamber and on spark plugs, which caused durability problems. To relieve these problems, lead scavengers were added to gasoline at the same time as the lead to encourage greater volatility in the lead combustion by-products so they would be exhausted from the vehicle. These scavengers continue to be used today with leaded gasoline.

Ultimately, a significant portion of these additives are emitted from vehicles. This is important because, unfortunately, these lead scavengers, most notably ethylene dibromide, have been found to be carcinogenic in animals and have been identified as potential human carcinogens by the National Cancer Institute.[15] Therefore, their removal along with the removal of lead may result in significant benefits to health.

Carbon Monoxide (CO)

Carbon monoxide—an odorless, invisible gas created when fuels containing carbon are burned incompletely—poses a serious threat to human health. Persons afflicted with heart disease and fetuses are especially at risk. Because the affinity of hemoglobin in the blood is 200 times greater for carbon monoxide than for oxygen, carbon monoxide hinders oxygen transport from blood into tissues. Therefore, more blood must be pumped to deliver the same amount of oxygen. Numerous studies in humans and animals have demonstrated that those individuals with weak hearts are placed under additional strain by the presence of excess CO in the blood. In particular, clinical health studies have shown a decrease in time to onset of angina pain in those individuals suffering from angina pectoris and exposed to elevated levels of ambient CO.[16]

Nitrogen Oxides (NO_x)

As a class of compounds, the oxides of nitrogen are involved in a host of environmental concerns impacting adversely on human health and welfare. Nitrogen dioxide (NO_2) has been linked with increased susceptibility to respiratory infection, increased airway resistance in

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[14] "Lead Poisoning," Dr. Ellen Silbergeld, *Toxic Substance Control Newsletter*, Autumn 1982.

[15] "Automotive Emissions of Ethylene Dibromide," Sigsby, et al., *Society of Automotive Engineers*, #820786.

[16] "Effect of Carbon Monoxide on Exercise Performance in Chronic Obstructive Pulmonary Disease," Aronow, et al., *American Journal of Medicine*, 1977, "Health Effects of Exposure to Low Levels of Regulated Air Pollutants, A Critical Review," Ferris, *Journal of The Air Pollution Control Association*, May 1978.

asthmatics, and decreased pulmonary function.[17] It has been shown that even short-term exposures to NO_2 have resulted in a wide-ranging group of respiratory problems in school children—cough, runny nose and sore throat are among the most common.[18] Further, in France, in an ingenious experiment, Dr. Orehek has shown that asthmatics are especially sensitive to even one-hour exposures.[19] A small group of asthmatics were initially exposed to carbachol, a bronchoconstrictor representative of urban pollen, and then to NO_2; adverse effects such as increased airway resistance were experienced by some of the individuals at levels as low as 0.1 parts per million for 1 hour.

The oxides of nitrogen also participate in the formation of the family of compounds known as photochemical oxidants and in acid deposition. Finally, as a result of secondary transformations in the atmosphere, NO_x emissions are converted to nitrates, thereby increasing the accumulation of particulate in the air.[20]

Photochemical Oxidants (Ozone)

The most widespread air pollution problem in areas with temperate climates is ozone, one of the photochemical oxidants that results from the reaction of nitrogen oxides and hydrocarbons in the presence of sunlight. Motor vehicles are a major source of both of these precursor pollutants. Ozone causes eye irritation, cough and chest discomfort, headache, upper respiratory illness, increased asthma attacks and reduced pulmonary function.[21]

It has also been demonstrated in numerous studies that photochemical pollutants seriously impair the growth of certain crops. For example, the Congressional Research Service of the US Library of Congress found that "the short-run or immediate impacts of ozone are evident in annual crop yield decreases estimated at $1.9 to $4.3 billion."[22]

Particulate (PM)

A series of studies released in the last few years indicate that particulate may be the most serious urban air pollution problem. By correlating daily weather, air pollutants and mortality in six US cities, scientists have discovered that nonaccidental death rates tend to rise and fall in

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17 "Air Quality Criteria for Nitrogen Oxides," Draft, US Environmental Protection Agency, June 1980, "Health Effects of Exposure to Low Levels of Regulated Air Pollutants, A Critical Review," Ferris, *Journal of The Air Pollution Control Association*, May 1978.

18 "The University of Akron Study on Air Pollution and Human Health Effects," Mostardi et al., *Archives of Environmental Health*, September/October 1981.

19 "Effect of Short-Term, Low-Level Nitrogen Dioxide Exposure on Bronchial Sensitivity of Asthmatic Patients," Orehek, et al., *The Journal of Clinical Investigations*, Volume 57, February 1976.

20 Atmospheric nitrate is essentially secondary, formed from reactions involving oxides of nitrogen to form nitric acid.

21 "Air Quality Criteria for Ozone and Other Photochemical Oxidants," US Environmental Protection Agency, April 1978.

22 "Air Pollution Impacts on Agriculture and Forestry," Biniek, Congressional Research Service, Library of Congress, May 1982.

near lockstep with daily levels of particulates—but not with other pollutants.[23] Because the correlation held up even for very low levels—in one city to just 23 percent of the federal limit on particulates—these analyses suggested to the researchers that as many as 60,000 US residents per year may die from breathing particulates at or below legally allowed levels.[24]

More recently, another study has emerged showing a strong linkage between particulate air pollution and mortality.[25] The study is distinctive in that it used a prospective cohort design that allowed for direct control of other individual risk factors such as cigarette smoking, diet, etc. In addition, the study was larger and represented a larger geographic area than any other study to date.

Air pollution data from 151 US metropolitan areas were linked with individual risk factors in 552,138 adults who resided in these areas when they were enrolled in this study in 1982. Deaths were ascertained through 1989. Sulfates and fine particulate air pollution were associated with a difference of approximately 15 to 17 percent between mortality risks in the most polluted cities and in the least-polluted cities. Even in cities that meet the US Federal clean air standards, the risk of death is 2 to 8 percent higher than in the cleanest cities.

Certain particles appear to be especially hazardous. For example, diesel particles, because of their chemical composition and extremely small size, have raised special health and environmental concerns. Diesel particulate matter consists mostly of three components: soot formed during combustion, heavy hydrocarbons condensed or adsorbed on the soot, and sulfates. In older diesels, soot was typically 40 to 80 percent of the total particulate mass. Developments in in-cylinder emissions control have reduced the soot contribution to particulate emissions from modern emission-controlled engines considerably, however. Much of the remaining particulate mass consists of heavy hydrocarbons adsorbed or condensed on the soot. This is referred to as the soluble organic fraction of the particulate matter, or SOF. The SOF is derived partly from the lubricating oil, partly from unburned fuel, and partly from compounds formed during combustion. The relative importance of each of these sources varies from engine to engine.

A comprehensive assessment of the available health information on diesel particulate was carried out by the International Agency For Research on Cancer (IARC) in June 1988 and concluded that diesel particulate is probably *carcinogenic* to humans.[26]

Studies conducted at the Fraunhofer Institute have suggested that the diesel particle itself, stripped of the organic and other materials on the surface, may also be carcinogenic. Confirmatory studies under the auspices of the Health Effects Institute (HEI), a jointly funded Industry-Government program, recently verified this conclusion. These "results, and recent

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23 "An Association between Air Pollution and Mortality in Six US Cities," Dockery, et al., *The New England Journal of Medicine*, December 9, 1993.

24 "Air Pollution and Daily Mortality in Philadelphia," Dr. Joel Schwartz, presented at the 1991 meeting of the American Lung Association, Anaheim, CA, May 1991.

25 Pope at al, 1995.

26 The term "carcinogen" is used by IARC to denote an agent that is capable of increasing the incidence of malignant tumors.

findings from other laboratories, suggest that (1) the small respirable soot particles in diesel exhaust are primarily responsible for lung cancer developing in rats exposed to high concentrations of diesel emissions, and (2) at high particle concentrations, the mutagenic compounds adsorbed onto the soot play a lesser role, if any, in tumor development in this species."[27] This is quite significant as it indicates that it is important to control the particles themselves and not just the organic material sitting on the surface of the carbon.

In a subsequent analysis, HEI raised questions about this conclusion.[28] The authors argue that because the rats were exposed to very high concentrations over their full lifetimes, the observed effects are more likely the result of the impairment of the rat's ability to clear particles from its lungs, leading to inflammation and rapid cell proliferation. They note that similar effects did not occur in hamsters and results were mixed with mice.

While further studies are carried out to determine which element in diesel particles is most hazardous, the prudent course of action seems to be to reduce both the organics and the particulate mass.

To put the concerns with diesel NO_x and particulate into perspective, one recent study attempted to quantify the health benefits associated with reducing diesel particulate and nitrogen oxides.[29] Based on a careful review of the available health information, the authors concluded that reducing one gram per mile of particulate or NO_x, over a 100,000-mile vehicle lifetime would produce benefits of $11,432 and $1,175, respectively. Focusing specifically on the 1992 heavy-duty vehicle fleet in Los Angeles, the authors conclude that a 50 percent reduction in NO_x and PM_{10} emissions, would be worth $9,200 and $13,500 per vehicle, respectively. A 90 percent reduction would have a value of $16,600 and $24,300 per vehicle, respectively. It is important to emphasize that these amounts reflect the value of the health benefits alone. Earlier studies have indicated that the economic benefits of reduced soiling and improved visibility are also quite significant.

Physics and Chemistry of Particulate.[30] Atmospheric particles originate from a variety of sources and possess a range of morphological, chemical, physical, and thermodynamic properties. Examples include combustion-generated particles such as diesel soot or fly ash, photochemically produced particles such as those found in urban haze, salt particles formed from sea spray, and soil-like particles from resuspended dust. Some particles are liquid, some are solid; others contain a solid core surrounded by liquid. Atmospheric particles contain inorganic ions and elements, elemental carbon, organic compounds, and crustal compounds. Some atmospheric particles are hygroscopic and contain particle-bound water. The organic fraction is especially complex. Hundreds of organic compounds have been identified in atmospheric

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27 "Pulmonary Toxicity of Inhaled Diesel Exhaust and Carbon Black in Chronically Exposed Rats," Mauderly, et al., *Health Effects Institute Research Report* Number 68, October 1994.

28 HEI, 1995.

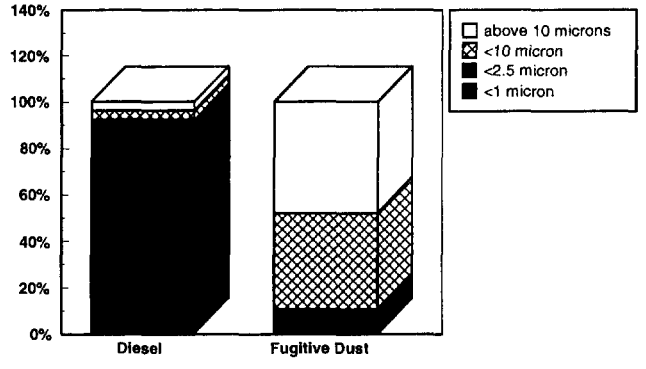
29 "On the Costs of Air Pollution from Motor Vehicles," Small, K. and Kazimi, C., Department of Economics, University of California at Irvine, forthcoming in *The Journal of Transport Economics*, January 1995.

30 Excerpted from US EPA Draft PM Criteria Document, April 1995.

aerosols, including alkanes, alkanoic and carboxylic acids, polycyclic aromatic hydrocarbons, and nitrated organic compounds.

Particle diameters span more than four orders of magnitude, from a few nanometers to 100 micrometers (μm). Combustion-generated particles, such as those from power generation, from automobiles, and in tobacco smoke, can be as small as 0.01 μm and as large as 1 μm. Particles produced in the atmosphere by photochemical processes range in diameter from 0.05 to 2 μm. Fly ash produced by coal combustion ranges from 0.1 to 50 μm or more. Wind-blown dust, pollens, plant fragments, and cement dusts are generally above 2 μm in diameter.

FIGURE 3: SIZE DISTRIBUTION OF TYPICAL PARTICLES



Recent measurements of the size distributions of primary particles confirm US EPA conclusions that most fugitive dust emissions are in particles larger than 2.5 μm and that the majority of emissions from combustion sources are in sizes smaller than 2.5 μm. Figure 3 was derived from a major characterization of different source emissions in California conducted during 1986. Hot-exhaust samples were diluted to ambient temperatures prior to sampling onto filter media through impactor inlets with 50 percent cut-points of 1, 2.5, 10, and ~30 μm. The figure shows that combustion products are nearly always less than 2.5 μm in size. In particular, they show that diesel truck emissions are almost all less than 1.0 μm in size; particles in this size range are especially hazardous because when breathed in, they are able to penetrate to the deepest part of the lung where the critical gas exchange takes place.

Sources of Suspended Particles. The ambient atmosphere contains both primary and secondary particles; the former are emitted directly by sources, and the latter are formed from gases (SO_2, NO_x, NH_3, VOCs). Fugitive dust is a primary pollutant. Major sources of particle emissions are classified as major point sources, mobile sources, and area sources; these are anthropogenic. Natural sources also contribute to ambient concentrations.

Fugitive dust is a major contribution to PM_{10} at nearly all sampling sites, although the average fugitive dust source contribution is highly variable among sampling sites within the same areas, and is highly variable between seasons.

Primary motor vehicle exhaust in the United States makes up as much as 40 percent of average PM_{10} at many sampling sites. Vegetative burning outdoors and residential wood burning are significant sources in residential areas. Fugitive dust from paved and unpaved roads, agricultural operations, construction, and soil erosion constitute around 90 percent of nationwide primary emissions in most countries. Fugitive dust consists of geological material that is suspended into the atmosphere by natural wind and by anthropogenic activities from sources

such as paved and unpaved roads, construction and demolition of buildings and roads, storage piles, wind erosion, and agricultural tilling.

Mobile sources are major emitters of primary particles, oxides of nitrogen, and volatile organic compounds. They are also minor emitters of sulfur dioxide (SO_2) and ammonia (NH_3). On-road motor vehicles using gasoline-and diesel-fueled engines are by far the largest component of mobile source emissions in most countries, and the emissions estimation methods are most highly developed for these vehicles. Motor vehicle exhaust contains high concentrations of organic and elemental carbon, but their ratios are much different from those found in wood combustion with the abundance of elemental carbon being nearly equal to the organic carbon abundance.

Exposure to Particulate Emissions. For any air pollutant, the total exposure of an individual consists of a variety of sequential exposures to a variety of microenvironments. They are typically, outdoors, indoors at-home, at-work, in-traffic, and many other indoor microenvironments. A typical particulate exposure scenario can be seen in Figure 4.

Other Toxics

The 1990 Clean Air Act (CAA) directed the US EPA to complete a study of emissions of toxic air pollutants associated with motor vehicles and motor vehicle fuels. The study found that in 1990, the aggregate risk is 720 cancer cases in the United States. For all years, 1,3-butadiene is responsible for the majority of the cancer incidence, ranging from 58 to 72 percent of the total motor vehicle toxics risk. This is due to the high unit risk of 1,3-butadiene. Gasoline and diesel particulate matter, which are considered to represent motor vehicle polycyclic organic matter (POM), are roughly equal contributors to the risk. The combined risk from gasoline and diesel particulate matter ranges from 16 to 28 percent of the total, depending on the year examined. Benzene is responsible for roughly 10 percent of the total for all years. The aldehydes, predominately formaldehyde, are responsible for roughly 4 percent of the total for all years.

A variety of studies have found that in individual metropolitan areas, mobile sources are one of the most important and possibly *the* most important source category in terms of contributions to health risks associated with air toxics. For example, according to the US EPA, mobile sources are responsible for almost 60 percent of the air pollution-related cancer cases in the United States per year.

Air Quality Standards

Because of all the above concerns, the World Health Organization (WHO) and many individual countries have adopted air quality standards to protect public health and the environment. A cross-section of such standards is summarized in Table 1.

FIGURE 4: A TYPICAL PARTICULATE EXPOSURE SCENARIO

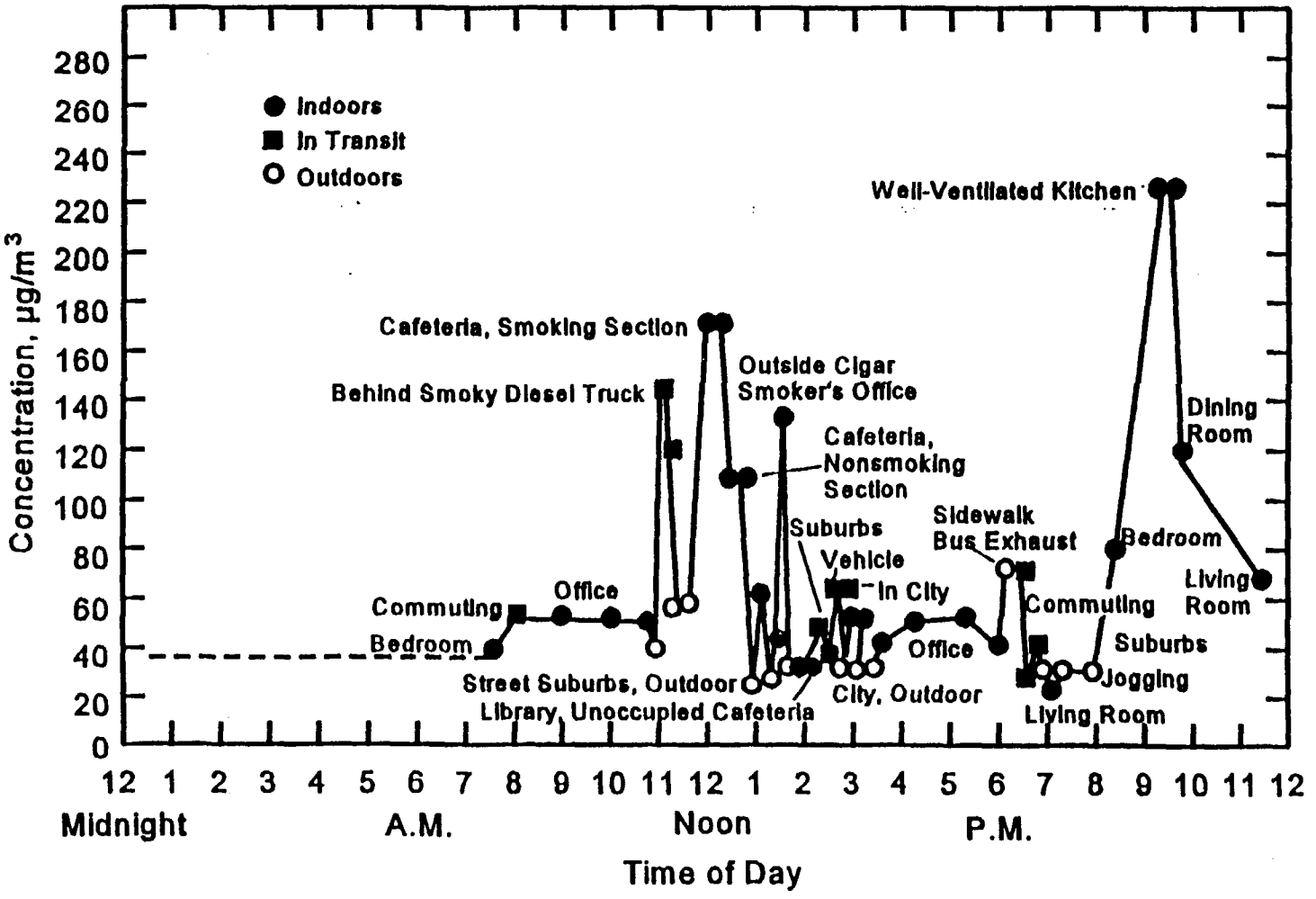


Table 1: AMBIENT AIR QUALITY STANDARDS
($\mu g/m^3$, except for CO which is in mg/m^3)

	CO		NO_2			SO_2			SPM		O_3		Pb	
	8 hr.	1 hr.	Annual	24 hr.	1 hr.	Annual	24 hr.	1 hr.	Annual	24 hr.	8 hr.	1 hr.	Annual	24 hr.
WHO	10	30		150	400	50	125	350		120	100	150	0.5	
United States	10	40	100			80	365		50/a	150*		235	1.5/b	
Japan	22.8			80			107	267		100		118		0.1
Germany		30	80		200	140		400	100				2	
Italy			50		200	40	100		40	100				
Netherlands	6	40			175		500	830		150		120	0.5	2
Canada	6	15	60	200	400	30	150	450	60	120	30	100		
Taiwan (China)		22.9		100		133	267		240					
Thailand	20	50			320	100	300		100	330				10

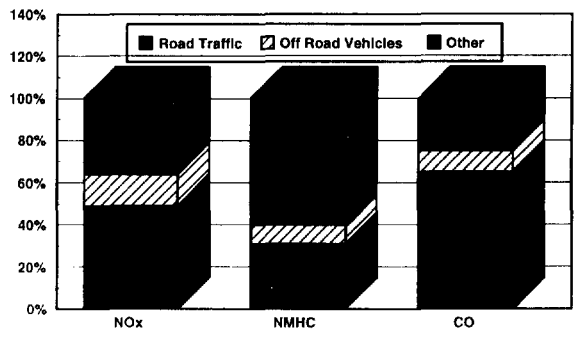
/a USA SPM standards are for PM10, others are for TSP.
/b Quarterly Average.

MOTOR VEHICLES ARE A DOMINANT POLLUTION SOURCE

Worldwide, cars, trucks, buses, and other motor vehicles continue to play a dominant role in local, regional and global air pollution. They are major sources of carbon dioxide; volatile organic compounds (VOCs) and nitrogen oxides, the precursors to both tropospheric ozone and acid rain; carbon monoxide (CO); toxic air pollutants such as diesel particulate; and chlorofluorocarbons (CFCs).

Throughout the European Union as a whole, for example, both on- and off-road vehicles are the largest source of CO, NO_x and nonmethane hydrocarbons, as illustrated in Figure 5.[31]

FIGURE 5: SOURCES OF EMISSIONS IN THE EUROPEAN UNION, 1990



In densely populated urban areas, vehicles can be a major source of particulate as well. For example, as recently noted in the United Kingdom, "currently, road vehicles account for 74 percent of nitrogen oxides and 94 percent of black smoke emissions in London. On their own, diesels account for 32 percent and 87 percent of total emissions (43 percent and 92 percent of vehicle emissions) for these two pollutants respectively."[32]

As illustrated in Figures 6 and 7, motor vehicles are also major emissions sources in the United States and Japan. In the northeastern United States where the air pollution problem is

31 "The Estimation of the Emissions of Other Mobile Sources and Machinery Subparts Off-Road Road Vehicles and Machines, Railways and Inland Waterways in the European Union," Andrias, Samaras and Zierock, September 1994.

32 "Diesel Vehicle Emissions and Urban Air Quality," Second Report of the Quality of Urban Air Review Group, prepared at the request of the Department of the Environment, December 1993.

especially severe, EPA projected that highway vehicles will account for approximately 38 percent of the total NO_x inventory and 22 percent of the total VOC inventory in 2005, in spite of the introduction of tighter motor vehicle standards in the 1990 Clean Air Act.[33]

FIGURE 6: SOURCES OF EMISSIONS IN THE UNITED STATES, 1993

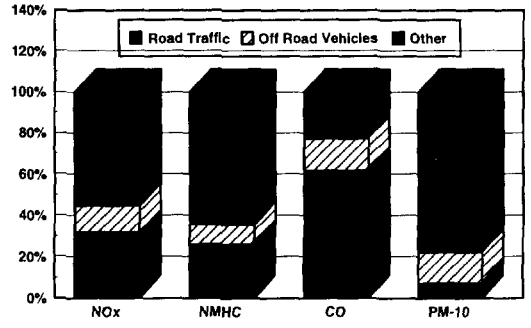
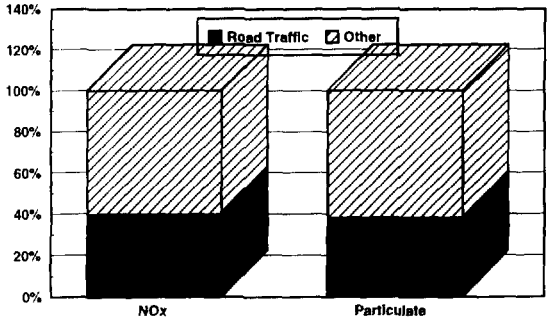


FIGURE 7: SOURCES OF EMISSIONS IN JAPAN, 1989



While not as well-documented, it is increasingly clear that motor vehicles are also the major source of many of the pollution problems that are plaguing the developing world. By way of examples, the motor vehicle contribution to air pollution problems of Manila and Korea are summarized in Figures 8 and 9.

FIGURE 8: SOURCES OF EMISSIONS IN THE REPUBLIC OF KOREA, 1991

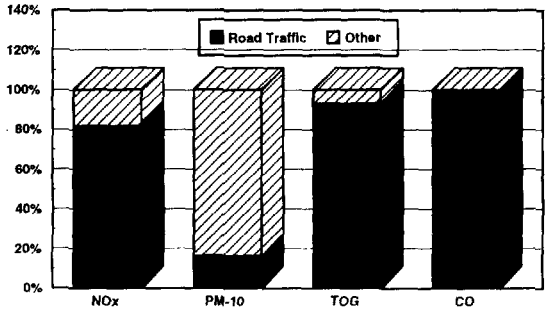
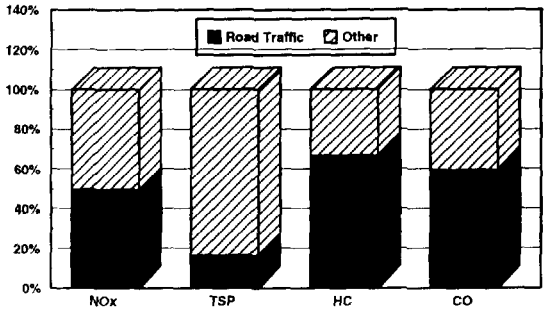


FIGURE 9: SOURCES OF EMISSIONS IN MANILA, 1990



Virtually the entire global motor vehicle fleet runs on fossil fuels, primarily oil. For every gallon of oil consumed by a motor vehicle, about 19 pounds of carbon dioxide (containing about 5.3 pounds of carbon) go directly into the atmosphere. In other words, for every 15-gallon fill-up at the service station, about 300 pounds of carbon dioxide are eventually released into the atmosphere. Globally, motor vehicles account for about a third of world oil consumption and *about 14 percent of the world's carbon dioxide emissions from fossil fuel-burning.* For the United States, motor vehicles consume about 50 percent of the oil used each year and emit about 25 percent of the carbon dioxide.

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[33] These emissions estimates are based on the most accurate data currently available. The Agency continues to analyze emissions data and modeling assumptions. Consequently, these estimates could be subject to change.

A major source of CFCs in the atmosphere is motor vehicle air conditioning, and in 1987 approximately 48 percent of all new cars, trucks, and buses manufactured worldwide were equipped with air conditioners. (CFCs also are used as a blowing agent in the production of seating and other foam products, but this is a considerably smaller vehicular use.) Annually, about 120,000 metric tons of CFCs are used in new vehicles and in servicing air-conditioners in older vehicles. In all, these uses account for about 28 percent of global demand for CFC-12. As agreed under the Montreal Protocol, CFCs are to be completely phased out of new vehicles by the turn of the century, a welcome but long overdue step. CFCs emitted over the next decade will cause damage to the planet for the next two centuries.

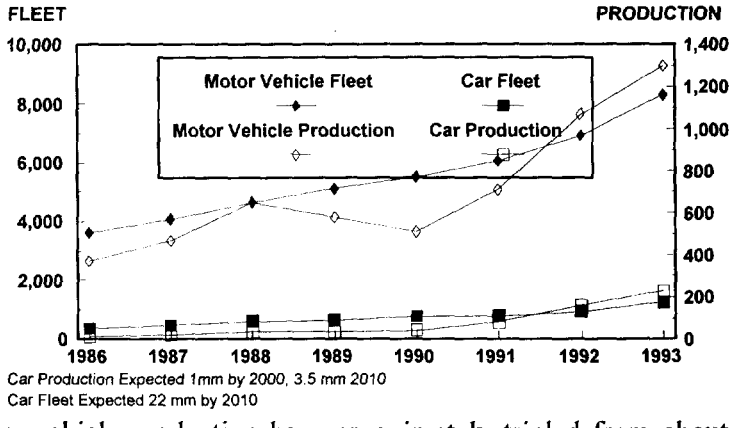
THE SITUATION IN CHINA TODAY

Background

The number of motor vehicles in China is very small compared with the developed countries—the total vehicle population is only approximately 6 million; conversely, the population of China is almost 1.2 billion, the largest in the world. Moreover, 71 percent of the vehicles are trucks, less than 23 percent are passenger cars, and only 15 percent are diesel-fueled vehicles, a much lower ratio than in virtually any other country in the world.

Nevertheless, over the past several years the annual vehicle production and registrations have begun to increase rapidly, averaging 10 and 12 to 14 percent per year, respectively, since the late 1970s and one can expect that this tendency will continue for the foreseeable future. As a result, as shown in Figure 10, the vehicle population in China has doubled from less than 4 million in 1986 to almost 8 million in 1993. At the same time, vehicle production has approximately tripled from about 400,000 to about 1.3 million vehicles per year.

FIGURE 10: PASSENGER CAR FLEET AND PRODUCTION ('000)



Not surprisingly, as has been the case in most other countries, most of the vehicles tend to be concentrated in or near urban areas. As a result, as illustrated in Figure 11 for just three cities, Guangzhou, Beijing and Shanghai, the urban vehicle population has grown even more rapidly than the national vehicle population since the early to mid-1980s.

If these trends continue at the current rate, as shown in Figure 12, the urban vehicle populations will be two to four times greater by 2010 than they are today; in fact, their rates of increase are likely to be more than linear.

FIGURE 11: VEHICLE POPULATION TRENDS IN CHINESE CITIES

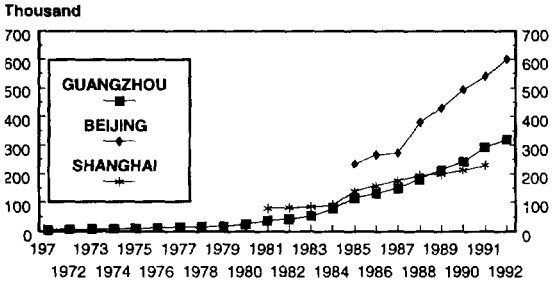
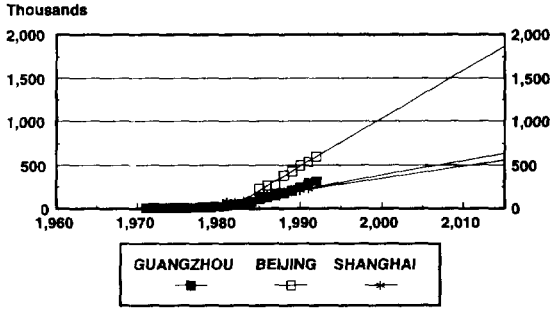


FIGURE 12: VEHICLE POPULATION TRENDS IN CHINESE CITIES



It is also important to note that the types of vehicles can differ substantially between cities. For example, as illustrated in Figure 13, almost two out of every five vehicles in Beijing is a light truck or utility vehicle; in contrast, almost two thirds of the motor vehicles in Guangzhou are motorcycles. Further, the growth rate of motorcycles in Guangzhou far exceeds that of other motor vehicle types (Figure 14). This is significant because of the high-pollution characteristics of these vehicles, especially those with two-stroke engines.

FIGURE 13: 1992 VEHICLE POPULATION IN DIFFERENT CHINESE CITIES

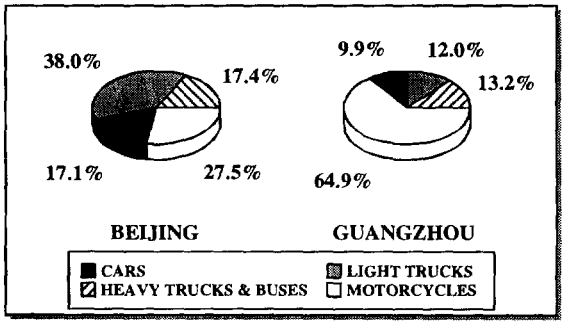
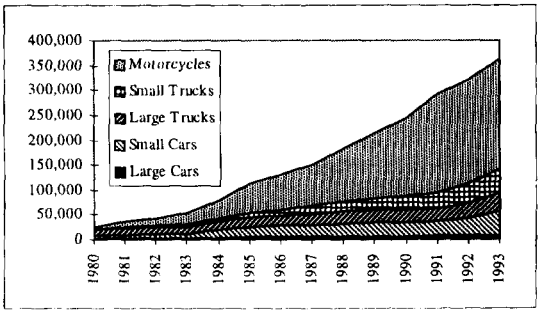


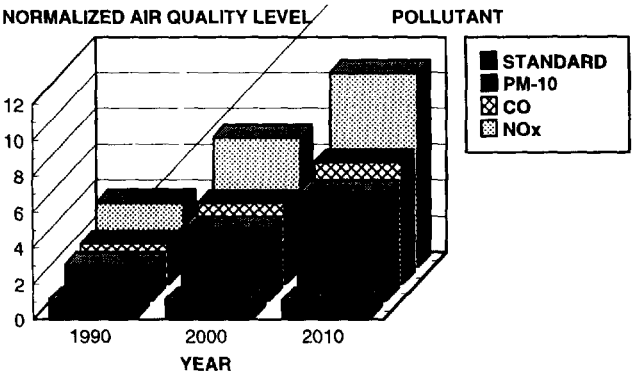
FIGURE 14: VEHICLE REGISTRATION IN GUANGZHOU (NUMBER OF VEHICLES)



Environmental Problems

In spite of the relatively low vehicle population, air pollution problems caused by motor vehicles have started to emerge in the major cities of China (Figure 15). One reason, as noted above, is that the vast majority of the vehicles in use in China are driven in major cities. In addition, while some of the vehicles in China are manufactured by joint-venture enterprises and by enterprises under the license of developed countries, another portion are designed, developed, and manufactured

FIGURE 15: LIKELY MOTOR VEHICLE-RELATED AIR QUALITY TRENDS IN CHINESE CITIES



by domestic companies using designs that are more than 20 years old. One result is that the CO and hydrocarbon (HC) emission levels in these engines are estimated to be about 10 to 20 times the levels emitted from the controlled vehicles in the United States or Japan.

Furthermore, the operating speed of motor vehicles in the major cities is quite low due to the crowded streets and mixed traffic (motor vehicle, motorcycle, bicycle, tractor, even carts); the average speed inside the third ring road of Beijing is lower than 20 km/h, which results in a high level of CO and HC emissions.

Therefore, pollution levels in the major cities of China are already unacceptably high, especially for CO and HC. CO and HC levels frequently exceed healthy levels, and their ambient concentrations parallel vehicle traffic patterns, that is, they tend to peak during the morning and evening peak traffic time. Within the city proper in Beijing, the average concentration of CO exceeds the limit prescribed by the National Ambient Air Quality Standard. Furthermore, the concentration levels in the street and in the residential areas near the street are much higher than the average values. Finally, the proportion of days exceeding the standards is increasing in parallel with the increase of motor vehicles in use.

According to an air quality survey of Beijing in the late 1980s as summarized in Table 2, motor vehicles contribute about half of the total CO, HC, and NO_x emissions coming from all pollutant sources.

TABLE 2: MOTOR VEHICLE EMISSION POLLUTANTS' CONTRIBUTION IN BEIJING URBAN AREA (WITHIN THE THIRD RING ROAD)
(Percent)

Pollutant	Winter Time	Summer Time	Annual Average
CO	26.1	60.0	39.1
HC	62.7	86.8	74.8
NO_x	38.0	54.7	46.2

Lead is another pollutant of concern in the major cities of China. Lead levels in the urban area of major cities such as Beijing are usually 1 to 1.5 $\mu g/m^3$, and even reach 14 to 25 $\mu g/m^3$ in some areas.

Overall, particulate problems caused by motor vehicles in Beijing are minimal. One reason is that driving motorcycles is restrained in many major cities of China including Beijing. In addition, the proportion of diesel-fueled vehicles is relatively small compared to other countries. Most of the diesel vehicles are heavy-duty trucks, which are not allowed to drive in urban areas. In Beijing, therefore, the only significant diesel vehicle population is buses. Serious smoke, suspended particulate matter, and SO_2 pollutants in China mainly result from the coal burned by power stations, plants, and residents.

Based on current vehicle emissions rates and the likely future growth in urban road traffic, one can foresee a tremendous growth in vehicle-related air pollution problems in the near

future along the lines illustrated below unless government policies are adopted to reverse current trends.

Motor Vehicle Emissions Controls

Rather than waiting for that to happen, and then trying to rapidly develop solutions in a crisis mode, China has already begun to address motor vehicle pollution.

All the motor vehicles driving in China are required to be registered, and equipped with a pair of registration number plates. The local vehicle management offices, subordinated to the local bureau of public security, are in charge of this registration. A domestic motor vehicle will not be registered, unless the model of this motor vehicle has been listed in the "Index of Enterprise-Produced Motor Vehicles and Their Products" issued by the China National Automotive Industry Corporation (CNAIC) and the Ministry of Public Security. Before being listed in the index, the vehicles must pass an approval test carried out by "The Type Approval Organization for New Motor Vehicle Products" authorized by CNAIC. Included in the approval test are idling emissions tests for gasoline-fueled vehicles and free-acceleration smoke tests for diesel-fueled vehicles. In addition, a full-load smoke test is required for diesel engines. During 1994, new light-duty vehicles offered for sale in Beijing were required for the first time to pass the ECE regulation 15-04 emissions standards. In addition, each motor vehicle should be checked for its idling emissions or free-acceleration smoke at one of the local inspection lanes during registration.

In the case of imported motor vehicles, the approval test, including safety and emission tests, of a sample vehicle is conducted in one of the labs authorized by the State Administration of Import and Export Commodity Inspection (SACI), which is the responsible body for motor vehicle imports and exports. Further, during registration, each imported vehicle must be checked at the inspection lane, the same as the domestic vehicles.

A periodic inspection is required once per year for every category of vehicles. It is conducted by the local vehicle management office in an inspection lane using the idling emissions or free-acceleration smoke standards.

Furthermore, idling emissions or free-accelerator smoke inspections are carried out at the end of assembly line for each gasoline or diesel-powered vehicles by the major auto manufacturers.

The National Environmental Protection Agency of China is in charge of formulating and revising the standards for controlling major vehicle emission pollutants, while the local Environmental Protection Bureaus are responsible for supervising and putting emission standards into effect. A number of additional steps are under development and will be phased in over the next few years. These include the following:

- The gasoline octane number available for trucks will be raised from 80 to 90 Research Octane Number (RON) after 1995, to increase the thermal efficiency of gasoline engines, and thus decrease their fuel consumption.

- Unleaded gasoline will begin to be distributed to major cities, provincial capitals, and economic developing zones in 1995.[34]

- In order to reduce CO and HC by 30 percent on medium- and heavy-duty gasoline-fueled vehicles, exhaust emission standards for these vehicle are being promulgated, and will be put into effect from the beginning of 1995. The test procedure will be the 9-mode used by the US EPA in the period from 1970-83.

- For the purpose of further reducing HC emissions, it is planned to require fuel evaporative emission controls. The appropriate standards are being evaluated and it is expected that they will be phased in during 1995 and 1996 for light- and heavy-duty vehicles. The limit values will be 2 g/test and 4 g/test, respectively.

- The measurement method at idle speed will include a raised idle speed, as prescribed in International Standards Organization (ISO) 3929. It is intended that emissions of in-use vehicles will be checked at two engine speeds that are used frequently in urban areas, and on the basis of these tests determine whether the carburetor should be repaired or replaced.

- For diesel smoke, the standard at free acceleration for newly produced vehicles is expected to be tightened to 4.5 units in 1995, and 4.0 units in 2000, while the values for vehicles in use will be 5.0 and 4.5, respectively.

- As for standards of smoke at full load, the test procedure and limit value to be changed are under discussion. In addition, standards for controlling exhaust emissions of medium- and heavy-duty diesel engines are to be formulated, and the test procedure will be equivalent to that of ISO.

Conclusions Regarding Current Situation

Although China has a relatively modest vehicle population compared to developed countries, it has been increasing rapidly over the past 15 years, and will continue to have a high growth rate for the foreseeable future. Some air pollution problems caused by motor vehicles have started to emerge in the major cities of China since the middle of the 1980s, especially with regard to CO and HC, and the NO_x problem has been getting worse in the past few years. Lead pollution from vehicles is also a concern, but smoke, particulate, and SO_2 are mainly emitted from other pollutant sources.

Looking at Beijing as an example, and based on the official growth rates, vehicle emissions are expected to grow substantially in the coming years in spite of the adoption of several new requirements as summarized in Figure 16. Using more likely (and somewhat higher) growth rates, Figure 17 shows that the emissions trends could be even worse.

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[34] China already produces some unleaded gasoline and actually exports some to Singapore. The remainder is mixed with leaded fuel at terminals since no segregated distribution system exists at present.

FIGURE 16: BEIJING MOTOR VEHICLE EMISSIONS TRENDS (City Plan Growth Projections, Summer Conditions)

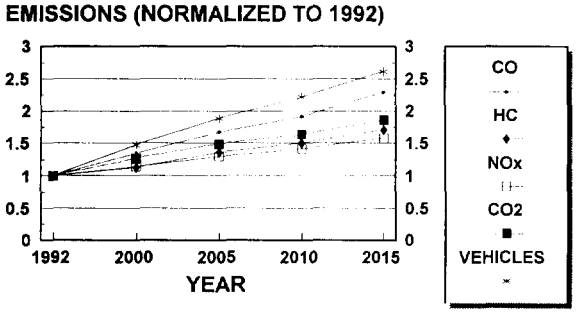
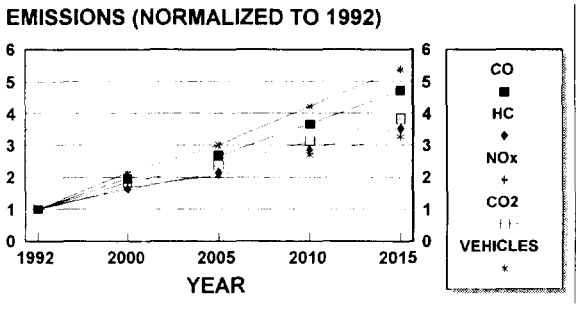


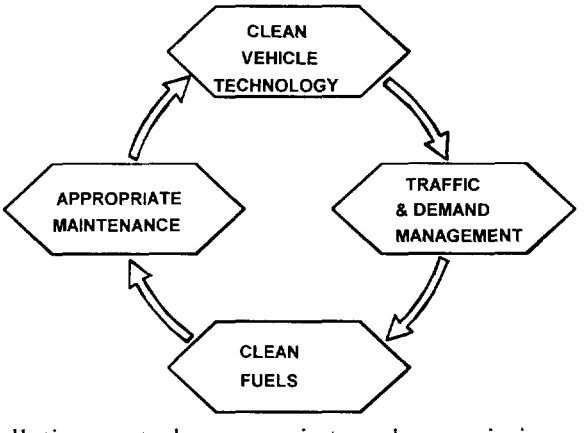
FIGURE 17: BEIJING MOTOR VEHICLE EMISSIONS TRENDS (More Likely Growth Projections, Summer Conditions)



STRATEGIES TO REDUCE MOTOR VEHICLE POLLUTION

Since a great deal has been learned about reducing emissions from vehicles, one should not conclude that higher emissions and more motor vehicle-related air pollution are inevitable. Strategies exist to both lower emissions per kilometer driven and reduce actual driving; application of both approaches can be used to ameliorate the otherwise likely future pollution increases. Many of these strategies—eliminating lead from gasoline, vehicle inspection and maintenance, vehicle demand management, etc.—are win-win strategies in that they not only lower pollution but also bring substantial economic or other benefits (Figure 18).

FIGURE 18: ELEMENTS OF A COMPREHENSIVE VEHICLE POLLUTION CONTROL STRATEGY



Generally, the goal of a motor vehicle pollution control program is to reduce emissions from motor vehicles in-use to the degree reasonably necessary to achieve healthy air quality as rapidly as possible or, failing that for reasons of impracticality, to the practical limits of effective technological, economic, and social feasibility. Achievement of this goal generally requires a comprehensive strategy encompassing emission standards for new vehicles, clean fuels, strategies designed to assure that vehicles are maintained in a manner that minimizes their emissions and traffic and demand management and constraints. These emission-reduction goals should be achieved in the least costly manner.

Standards for permissible levels of exhaust and evaporative emissions from motor vehicles should be based on a realistic assessment of costs and benefits, keeping in view the technical and administrative feasibility of proposed countermeasures. Technological approaches to achieve the desired emission standards may include fitting new vehicles with emission control devices such as catalytic converters or particulate traps or requiring such devices to be retrofitted to existing vehicles, modifying fuels or requiring the use of alternative fuels in certain vehicles,

and traffic and demand management and policy instruments. However, many of the potential benefits of these countermeasures will be squandered if they are not buttressed by regulatory and economic instruments that assure vehicle owners, manufacturers and fuel suppliers have sufficient incentives to achieve the desired goals. A key element of the overall strategy, therefore, must be effective enforcement to ensure maximum compliance with standards.

Vehicle Inspection and Maintenance Opportunities

Today's vehicles are absolutely dependent on properly functioning emission controls to keep pollution levels low. Minor malfunctions in the emission control system can increase emissions significantly. Major malfunctions in the emission control system can cause emissions to skyrocket. A relatively small number of vehicles with serious malfunctions frequently cause the majority of the vehicle-related pollution problems. Unfortunately, it is rarely obvious which vehicles fall into this category, as the emissions themselves may not be noticeable and emission control malfunctions do not necessarily affect vehicle driveability. Effective inspection and maintenance (I/M) programs, however, can identify these problem cars and assure their repair.

For countries with only minimal if any controls on vehicles, a simple I/M program can be a good pollution-control starting point as even vehicles with no pollution controls can benefit from improved maintenance. A simple idle check on CO and HC emissions from gasoline vehicles or visible-smoke check on diesel vehicles can be used to identify the highest polluters and those vehicles that would most benefit from remedial maintenance. Hong Kong, whose air quality problem is primarily excess particulates, trained a small group of smoke inspectors who then patrolled the streets, identifying vehicles with excess smoke and requiring them to be repaired or pay a fine. Such a program requires minimal capital investment and resources.

As vehicle technology advances, more sophisticated test procedures may be necessary including loaded mode tests, which use a dynamometer to simulate the work that an engine must perform in actual driving.

Substantial advances are occurring in I/M programs. For the most advanced vehicles, those equipped with electronic controls of air-fuel and spark management systems and equipped with catalytic converters to reduce CO, HC and NO_x, a transient test that includes accelerations and decelerations typical of actual driving can provide additional emissions reduction benefits.

Fuel Modifications and Alternative Fuels

Conventional vehicle fuels have undergone substantial modification in recent decades and will likely be improved even more in the future; in parallel, alternative fuels such as ethanol, methanol, natural gas and liquefied petroleum gas (LPG) continue to receive attention.

The major trend underway worldwide is the gradual replacement of lead in gasoline, both to reduce lead emissions and to facilitate the use of pollution control technologies such as the catalytic converter. Additional gasoline improvements include reduced volatility, increased oxygen content, reduced aromatics and more widespread use of detergent additives. Such fuel modifications can, if carefully introduced, substantially improve the environmental impacts of gasoline.

Conventional diesel fuel can also be improved by the reduction of sulfur and aromatic content and the use of detergent additives.

For countries that are initiating a vehicle pollution-control program, first priority with regard to fuels should be placed on improving those fuel qualities that are important for good combustion—in the case of gasoline, raising the octane number to at least 90 RON, and in the case of diesel, raising the Cetane number to at least the 40s and if possible the 50s. This will allow the use of modern engines.

Next, the focus in most countries should be on reducing the amount of lead in leaded gasoline and introducing a grade of unleaded gasoline. This involves not only producing the unleaded fuel but providing an infrastructure for its distribution. For example, China at present, produces almost 20 percent of its gasoline as unleaded and actually exports unleaded gasoline to Singapore but, because of the lack of an adequate infrastructure, distributes very little unleaded gasoline domestically.

The possibility of substituting cleaner-burning alternative fuels for conventional fuels has drawn increasing attention during the last decade. Motivations advanced for this substitution include conservation of oil products and energy security, as well as the reduction or elimination of vehicle emissions.

Alternative fuels include methanol (made from natural gas, coal or biomass); ethanol (made from grain); vegetable oils; compressed natural gas (CNG) mainly composed of methane; LPG composed of propane, butane, electricity, hydrogen; synthetic liquid fuels derived from hydrogenation of coal; and reformulated gasoline and diesel, including oxygenated blends. Additives (like lead compounds in gasoline) are introduced in small quantities to improve storage, distribution, or performance characteristics of fuel. The principal alternative fuels presently under consideration are natural gas and methanol made from natural gas, and in limited applications, LPG. Environmental assessment of alternative fuels should not be based solely on vehicle end-use emission characteristics but should account for pollutant emissions associated with the production, storage, and distribution of these fuels.

Partly in response to environmental pressures to eliminate lead in gasoline and partly in response to energy needs, increasing amounts of alcohols and ethers are being used either as high-octane blending components or as substitutes for gasoline.

Alternative fuels can make significant contribution to improved air quality and are increasingly playing a role in urban areas. Most often, these fuels are used with special groups of vehicles that can have a large impact on the environment (such as transit buses or taxicabs) and can be fueled at central location, thus minimizing the need for a widespread fueling infrastructure.

However, care must be taken when considering the use of alternative fuels to assure that the desired effect is achieved. For example, while particulate emissions and visible smoke can be reduced for a diesel vehicle by the use of alternative fuels such as CNG, emissions of other gaseous pollutants such as NO_x and aldehydes may be much higher than from diesels if they are not addressed. When CNG vehicles are equipped with the appropriate pollution controls, they can be very clean and make a significant contribution to improving air quality.

Vehicle Emission Control Technology Measures

Technology has been developed and introduced on millions of gasoline-fueled vehicles worldwide that has demonstrated the ability to lower CO, HC and NO_x emissions by approximately an order of magnitude compared to vehicles without controls. The backbone of these systems is the catalytic converter and similar approaches are now being gradually phased into the two-wheeled vehicle market.

As the world community increasingly embraces today's state-of-the-art controls on these vehicles, advanced controls are emerging, which will likely become increasingly widespread throughout the next decade.

Development of diesel control technologies beyond crude smoke controls started later but is now advancing rapidly. By the mid-1990s it is expected that exhaust aftertreatment systems will be increasingly available; in the interim, engine modifications are readily available.

Vehicle Demand Management

Cleaner vehicles and fuels alone will not solve the air pollution problem in many large cities unless accompanied by strategies designed to reduce the growth in the number of vehicle miles traveled (VMT). VMT has steadily increased over time in most areas of the world. Such increases offset a significant portion of the emission reductions potential associated with the introduction of cleaner vehicles and fuels into the motor vehicle fleet.

To avoid a similar scenario in the future, air quality and transportation planners must develop more effective strategies for reducing the amount of discretionary automobile travel, especially in single-occupant vehicles. Strategies to reduce VMT may include a host of diverse measures including the segregation of high-occupancy vehicle lanes designed to encourage multiple-occupant vehicle commuting; promoting mass transit development and expansion projects; the imposition of parking freezes and other programs to restrict vehicle use in congested urban areas; parking fees or other types of vehicle use taxes; vehicle-free zones; fringe and transportation corridor parking facilities; ride-sharing/van-pooling programs; bicycle lanes and storage facilities; flextime programs to reduce office commuting during peak-hour periods; and land use controls to promote more efficient development.

The Role of Enforcement

Advances in automotive technologies have made it possible to dramatically lower emissions from motor vehicles. Initial crankcase HC controls were first introduced in the early 1960s followed by exhaust CO and HC standards later that decade. By the mid-1970s, most major industrial countries had initiated programs to control motor vehicle emissions. Today, it is well established that use of the existing state-of-the-art emission control technologies based on catalytic converters can substantially lower emissions from gasoline-fueled vehicles. Diesel particulate standards and control technologies have tended to lag but are starting to advance rapidly.

Taking full advantage of these advances requires a carefully thought-out compliance program. For countries with no vehicle manufacturing industry, it can be mandated that vehicles

being imported into the country have received a type approval certificate from their country of origin certifying that they achieve whatever limits are being imposed. In this case, no testing burden is placed on the country receiving the vehicles.

At the other extreme, in countries with a developed vehicle manufacturing sector (such as Malaysia) that exports to highly industrialized countries, it would be possible to introduce a comprehensive compliance program. It should assure that attention to emission standards is paid at the vehicle design stage before mass production begins. It should also ensure quality assurance on the assembly line. And through an enforceable warranty and recall system, it should deter manufacture of nonconforming vehicles. Furthermore, vehicle owners should be encouraged to carry out maintenance on emission control devices as required by the manufacturer, and the service industry regulated to perform this maintenance properly.

The cornerstone of an effective compliance program in most countries will be its vehicle I/M. I/M programs can improve emissions from vehicles equipped with virtually no pollution controls as well as from the most advanced systems. To put I/M in perspective, it is important to understand that today's cars are absolutely dependent on properly functioning emission controls to keep pollution levels low. Minor malfunctions in the emission control system can increase emissions significantly, and, as noted earlier, major malfunctions in the emission control system can cause emissions to skyrocket. By assuring good maintenance practices and discouraging tampering and misfueling, I/M remains the best demonstrated means for protecting a national investment in emission control technology and achieving the air quality gains that are needed.

As a general matter, maximum I/M effectiveness occurs with centralized I/M systems using loaded mode tests. These programs are also much lower cost overall and more convenient to the public. However, as noted earlier, even simple idle tests can be helpful for older vehicles with limited or no vehicle pollution controls. Smoke checks of diesel vehicles on the road can also be very beneficial.

VEHICLE COMPLIANCE AND ENFORCEMENT STRATEGIES

Various enforcement tools are available to address each stage of a vehicle's life cycle. **The certification or type approval process** that requires testing of prototype cars prior to production can impact on vehicle design at low mileage and, to a limited degree, on the durability of emission controls. It can also impact on vehicle maintenance to the degree that review of manufacturer-proposed maintenance schedules can constrain the manufacturer from requiring excessive maintenance and thereby reduce the potential effectiveness of recall and warranty and from requiring less maintenance than was performed on his certification prototype. Some prototype maintenance, nevertheless, is not required to be recommended to the consumer. Its major advantage, that it impacts on vehicle design early in the design process before actual production begins, is also its major weakness, that it inherently deals with somewhat artificial, prototype cars in an artificial environment. By its very nature, therefore, it cannot address production problems nor deterioration due to age or real world driving and ambient extremes nor the amount and quality of maintenance that will actually be performed in-use.

Assembly Line Testing requires testing of new production vehicles and is the only technique that can be used to assure before sale that vehicles when built are in fact meeting

emission standards; however, its impact on durability of design depends on requiring allowances for deterioration that are derived from other programs, such as certification or in-use testing. Further, like certification, it cannot impact on the amount or quality of maintenance performed in-use.

The recall and warranty programs can provide some incentive to individuals to properly maintain their vehicles and are the only programs that can directly affect the actual in-use durability of vehicles. These programs are subject to the limitations of dealing only with properly maintained vehicles and a generally less-than-perfect response on the part of individual vehicle owners, and they would appear only to impact on vehicles, which have been polluting to an excessive degree, already in use and to be, therefore, remedies after the fact. Further, much of their potential effectiveness is lost after vehicles are in use more than one or two years. However, the major impact of these manufacturer-directed in-use programs is a significant deterrent to the design and/or manufacture of vehicles that will fail to comply initially or as a result of deterioration from actual use.

Inspection and Maintenance (I/M) is the only compliance technique that assures that in-use vehicles are properly maintained. By requiring that vehicles pass a retest, it impacts directly on the quantity and quality of maintenance and also impacts on design through the warranty and recall programs that use I/M as a surveillance tool.

I/M is probably the most effective "antitampering" program because of the intensive surveillance built into the periodic inspection. Such surveillance is particularly helpful in addressing vehicle maladjustments that cause vehicles to exceed standards. However, where I/M is not in effect, gross tampering by dealers may be substantially deterred by an aggressive program.

The benefits of I/M, however, are limited by the adequacy of the short test used, the ability of the service industry to make proper repairs and the potential tampering that could occur following the test to allow the vehicle to emit high emissions throughout the year.

It seems clear, therefore, that the ideal program must include all of the above elements.

INSTITUTIONAL REQUIREMENTS

While technical and policy solutions are available to dramatically lower emissions from vehicles, the greatest challenge is frequently to develop a workable institutional arrangement that blends a variety of government agencies and ministries at the local, regional and national levels while providing adequate opportunity for input from fuel suppliers and vehicle manufacturers, on the one hand, and nongovernmental organizations (NGOs) on the other.

There can be no set formula as a practical arrangement must utilize the existing legal and governmental structure and shape it to address the problems. Key ingredients in any arrangement, however, would seem to be clear lines of authority and responsibility and a public decision-making process that provides opportunity for public input. Frequently, national authorities will assume the responsibility for setting appropriate air pollution targets or goals based on local studies, as well as information available from WHO among others. Either the Environment or Public Health Ministries or their equivalent are appropriate organizations to

perform this role. In addition, national authorities will usually adopt minimum emissions standards for new vehicles and fuel quality; again environment ministries could perform this role although, in many countries, the vehicle standard setting is left to Transportation Ministries (with policy input from the Environment Ministry) and the fuel quality is defined by the Energy Ministry.

Local governments usually have the authority to go beyond the national requirements depending on the air pollution levels in a given city. Strategies such as I/M and clean fuels are especially well-suited to a local focus. Transportation planning and land use control usually best lend themselves to regional approaches.

A STRATEGY FOR PROGRESS IN CHINA

The potential for reducing emissions and improving air quality must start with an assessment of existing vehicle emissions. Many factors affect the total inventory of motor vehicle emissions. Understanding these factors helps one to better structure a total inventory of these emissions and to determine optimal programs for their control. Having inventories that accurately reflect different control measures allows one to track the effectiveness of a given regulatory program. Some of the more important factors follow:

- **Emission Factors For New Vehicles.** These emission factors can ideally be determined from the emission standards for new vehicles subject to regulation or from emission data available for similar vehicles (such as similar vehicle design, control technologies) used in other countries.

- **Deterioration of Vehicle Emissions With Vehicle Age and Mileage.** Estimating how vehicle emissions deteriorate with time and mileage is critical in assessing in-use emissions. Different types of vehicles with different technologies (noncatalyst gasoline-fueled vehicles, catalyst-equipped, diesel-fueled, etc.) deteriorate differently with increased mileage and time. This type of information has been determined from testing of in-use vehicles carried out by several different countries.

- **Tampering Effects.** This adjustment accounts for vehicle owners or drivers intentionally altering or disabling an emission control system. Examples are disconnecting air pumps, catalysts, evaporative emission control systems, exhaust-gas recirculating systems, and ignition timing. These vehicles are sometimes tampered with in the mistaken belief that vehicle performance, fuel economy or other factors (such as maintenance time or costs) will be improved. The effects of tampering on vehicle emissions can be obtained from data obtained from various countries. However, the incidence of vehicle tampering should be estimated for the particular country where the inventory is being developed.

- **Vehicle Maintenance.** If a vehicle (with or without emission controls) is not maintained according to the manufacturer's recommendations (namely, tune-ups, replacement of spark plugs or emission control components, carburetor adjustments), the vehicle will have significantly higher emissions (that is, greater deterioration) than one properly maintained. These higher emissions must be accounted for. Some

initial estimates can be made based on similar information available from in-use vehicle emission levels measured in other countries.

- **Inspection and Maintenance and Antitampering Checks.** The presence of an effective I/M program that identifies high-emitting vehicles and assures that they are repaired (or emission control systems replaced/repaired if tampered with) can help eliminate excess emissions resulting from the previous two factors. Estimates of the benefits of such programs are available from tests conducted in different countries.

- **Technology Mix.** The fraction of vehicles using different technologies (such as diesel, noncatalyst, oxidation catalyst, three-way catalyst, etc.) is critical in estimating total vehicle emissions. The fraction of technologies used in a given country (and their appropriate emission factors) must be known or estimated.

- **Vehicle Age.** The number of vehicles of a given age is important to know since older and/or higher-mileage vehicles usually have higher deterioration. This type of data is generally available from vehicle registration data obtained by most governments.

- **Number of Vehicles.** The total number of vehicles of a given model year in a given area is generally obtained from vehicle registration data and must be known to calculate an inventory. A critical element is to make accurate projections for future years.

- **Vehicle Miles Traveled Per Vehicle Per Year.** The number of miles a given type of vehicle travels per year must be known. This number usually varies with vehicle age, with older vehicles traveling fewer miles annually. The number of miles traveled will be different from one country to another.

- **Vehicle Misfueling.** If both leaded and unleaded gasolines are sold in an area where some vehicles require the use of unleaded fuel to protect the catalytic converter, the fraction of catalyst vehicles that misfuel with leaded gasoline must be determined.

- **Fuel Characteristics.** Fuel volatility can be an important determinant of vehicle evaporative emissions (which can account for as much as half of the total hydrocarbon emissions). Other fuel characteristics such as sulfur content, distillation characteristics, and oxygen content may also be important.

- **Ambient Temperature.** The average daily temperature (generally maximum and minimum) must be known to predict vehicle emissions. Generally, separate inventories are calculated for warm-weather conditions (when ozone levels are at their peak) and cold-weather (when carbon monoxide levels are high).

A typical breakdown of emissions for major urban areas in the Asia Pacific region would usually indicate that motorcycles are a major contributor to both hydrocarbons and organic particulate and a significant source of carbon monoxide and lead. Diesel vehicles are the major source of sulfate and a significant source of carbonaceous particulate. Passenger cars dominate the carbon monoxide and lead problems and contribute significantly to nitrogen oxides and

hydrocarbons. Therefore, different vehicle categories must be the focus of attention to address different aspects of the overall vehicle pollution problem.

The major elements of an overall vehicle pollution control strategy were summarized earlier. In short, one must both reduce emissions per kilometer driven while simultaneously reducing the amount of driving. Emissions per kilometer driven can also be lowered by altering some aspects of the driving itself—average speed, degree of acceleration, etc. A natural and consistent tension exists between altering driving characteristics and reducing driving since frequently strategies designed to increase average speed by improving traffic flow actually enable a given roadway network to carry more vehicles per hour and effectively increase overall vehicle emissions.

First priority, of course, should be directed at restraining future vehicle growth rates. Economic measures, physical restrictions and selective policies will, of course, each play a role. However, even if overall vehicle growth could be constrained to only 5 percent per year, well beyond the current average in many countries in the Region, vehicle emissions would explode over the next 15 years. In addition to growth restraint, therefore, a series of additional strategies are necessary.

Inspection and Maintenance

I/M programs have been demonstrated to lower emissions from existing vehicles in two ways:

- By lowering emissions from vehicles that fail the test and are required to be repaired.
- By encouraging owners of vehicles to take proper care of them and to avoid the potential costs of repairing vehicles that have been tampered with or misfueled.

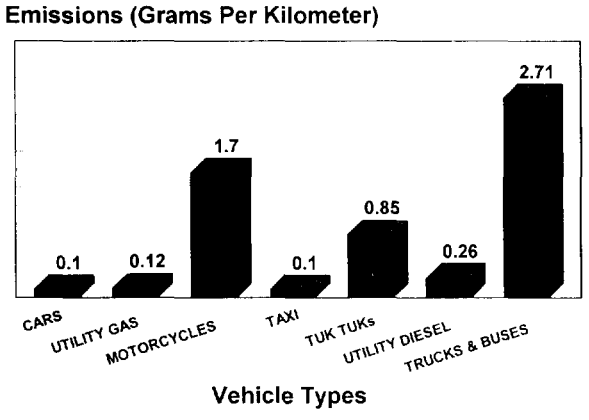
Based on all the data available, it is estimated that a well-run I/M program is capable of very significant emissions reductions, on the order of 25 percent for HC and CO and about 10 percent for NO_x. The less significant NO_x reductions reflect solely the lower tampering rates from I/M and antitampering programs since, at present, there has been no focused effort to specifically design I/M programs to identify and correct NO_x problems.

It is also important to note that the reductions start out slowly and gradually increase over time because I/M programs tend to lower the overall rate of fleet emissions deterioration. Maximum I/M benefits are thereby achieved by adopting the program as early as possible.

Stringent Motorcycle Standards

Two-stroke motorcycles are a major source of white smoke, hydrocarbons and particulate emissions. For example, as illustrated in Figure 19, in Bangkok two-stroke-powered motorcycles are estimated to emit almost as much particulate per kilometer driven as heavy duty diesel trucks and buses.

FIGURE 19: ORGANIC PARTICULATE



Technologies available to control emissions from two- and three-wheeled vehicles are similar to those available for other Otto cycle-powered engines. Reducing the content of lubricating oil in the fuel is one possible approach. Refining the fairly simple type of carburetors used would help significantly reduce HC, CO, and smoke emissions. Even catalytic converters are technologically feasible for these engines.[35]

Many modern engines use a separated lubrication system, which brings about overall leaner fuel/oil ratios and is therefore favorable for smoke reduction. Since 1986 mopeds with catalysts have been available in Switzerland and in Austria, and since 1992 motorcycles in Taiwan (China) have been similarly equipped.

It is a fair conclusion to state today that the historical problems of high smoke and unburned hydrocarbons from two-stroke technology are no longer technologically necessary. New technology promises to resolve these concerns. As examples, direct cylinder electronic fuel injection, electronic computer control, and catalytic exhaust conversion are now commonplace solutions. In addition, modern, advanced two-stroke engines such as those under development from the Orbital company indicate that these engines can even be cleaner and more fuel-efficient than four strokes.

Improved Fuel Quality

Gasoline

Throughout much of the industrialized world, unleaded fuel has been the norm for more than a decade. Japan has actually been the world leader in this regard, with more than 90 percent of the gasoline in that country being unleaded for almost two decades. In 1994, it is estimated that approximately two-thirds of all gasoline sold in the world was unleaded.

Even when leaded fuel is used, the lead content should be reduced to no more than 0.15 grams per liter.

Beyond the reduction or elimination of lead, it is possible to make additional modifications to gasoline, to "reformulate" it to reduce both regulated and unregulated emissions of concern. As part of a comprehensive policy to reduce vehicle emissions, fuel reformulation has the potential not only to offset any increased risks associated with the introduction of unleaded gasoline but to complement the elimination of lead health risks with an overall reduction of the toxic and ozone-forming potential of gasoline and gasoline vehicle emissions.

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[35] OECD [1988a]. *Transport and Environment*, Paris.

The potential for "reformulating" gasoline to reduce pollutant emissions attracted considerable attention in the United States as pressure to shift to alternative fuels increased during the mid- to late-1980s. One result was a major cooperative research program between the oil and auto industries. During the early 1990s, this was followed by a similar effort in Europe. The result is that a great deal has been learned about the potential for modifying gasolines in a manner that can significantly improve air quality. An additional advantage of fuel reformulation is that it can reduce emissions from all vehicles on the road in much the same way that reducing lead in gasoline can reduce lead emissions from all vehicles.

The most significant potential emission reductions that have been identified for gasoline "reformulation" have been through reducing volatility (to reduce evaporative emissions), reducing sulfur (to improve catalyst efficiency), and adding oxygenated blend stocks (with a corresponding reduction in the high-octane aromatic hydrocarbons that might otherwise be required). The potential benefits of improving various fuel parameters are summarized below.

Lowering Volatility. Fuel volatility, as measured by Reid vapor pressure (RVP) has a marked effect on evaporative emissions from gasoline vehicles both with and without evaporative emission controls. Tests on vehicles without evaporative emission controls showed that increasing the fuel RVP from 9 pounds per square inch (psi) (62 kilipascals—kPa) to approximately 12 psi (82 kPa) roughly doubled evaporative emissions.[36] The percentage effect is even greater in controlled vehicles. In going from 9 psi (62 kPa) to 12 (81 kPa) RVP fuel, the US EPA found that average diurnal emissions in vehicles with evaporative controls increased by more than five times, and average hot-soak emissions by 25 to 100 percent.[37] The large increase in diurnal emissions from controlled vehicles is due to saturation of the charcoal canister, which allows subsequent vapors to escape to the air.

Vehicle refueling emissions are also strongly affected by fuel volatility. In a comparative test on the same vehicle, fuel with 11.5 psi (79 kPa) RVP produced 30 percent greater refueling emissions than gasoline with 10 psi (64 kPa) RVP (1.45 vs. 1.89 g/liter dispensed).[38] In response to data such as these, the US EPA has established nationwide summertime RVP limits for gasoline.

An important advantage of gasoline volatility controls is that they can affect emissions from vehicles already produced and in-use and from the gasoline distribution system. Unlike new-vehicle emissions standards, it is not necessary to wait for the fleet to turn over before they take effect. The emissions benefits and cost-effectiveness of lower volatility are greatest where few of the vehicles in use are equipped with evaporative controls. Even where evaporative

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[36] McArragher, J.S. et al. 1988. *Evaporative Emissions from Modern European Vehicles and their Control.* SAE Paper No. 880315. SAE International, Warrendale, Pennsylvania.

[37] US EPA. 1987. *Draft Regulatory Impact Analysis: Control of Gasoline Volatility and Evaporative Hydrocarbon Emissions From New Motor Vehicles*, Office of Mobile Sources, United Sates Environmental Protection Agency, Washington, DC.

[38] Braddock, J.N. 1988. "Factors Influencing the Composition and Quantity of Passenger Car Refueling Emissions—Part II." SAE Paper No. 880712. SAE International, Warrendale, Pennsylvania.

controls are in common use, as in the United States, control of volatility may still be beneficial to prevent in-use volatility levels from exceeding those for which the controls were designed.

In its analysis of the RVP regulation, the US EPA (1987) estimated that the long-term refining costs of meeting a 9 psi (62 kPa) RVP limit throughout the United States would be approximately $0.0038 per liter, assuming crude oil at $20 per barrel. These costs were largely offset by credits for improved fuel economy and reduced fuel loss through evaporation, so that the net cost to the consumer was estimated at only $0.0012 per liter.

Oxygenates. As noted earlier, blending small percentages of oxygenated compounds such as ethanol, methanol, tertiary butyl alcohol (TBA) and methyl tertiary butyl ether (MTBE) with gasoline has the effect of reducing volumetric energy content of the fuel, while improving the antiknock performance and thus making possible a potential reduction in lead and/or harmful aromatic compounds. Assuming no change in the settings of the fuel metering system, lowering the volumetric energy content will result in a leaner air-fuel mixture, thus helping to reduce exhaust CO and HC emissions.

Impact of Oxygenate Used: MTBE. It appears that MTBE can be added to gasoline up to 2.7 percent without any increase in NO_x. There are two opposing effects taking place with the addition of oxygenates: enleanment, which tends to raise NO_x, and lower flame temperatures, which tend to reduce NO_x. With MTBE levels above 2.7 percent, the lower flame temperature effect seems to prevail.

Impact of Oxygenate Used: Ethanol. Available data indicate that ethanol can be added to gasoline at levels as high as 2.1 percent oxygen without significantly increasing NO_x levels but above that point levels could increase significantly. For example, EPA test data on over 100 cars indicates that oxygen levels of 2.7 percent or more could increase NO_x emissions by 3 to 4 percent.[39] The auto/oil study concluded that there was a statistically significant increase in NO_x of about 5 percent with the addition of 10 percent ethanol (3.5 percent O_2).

Impact of Oxygenate Used: ETBE. Ethyl Tertiary Butyl Ether appears to be an attractive source of oxygenates but, unfortunately, to date, too little data exist regarding its NO_x impact to make a reasonable judgment as to its impact. The auto/oil study found about a 6 percent increase in NO_x but the results were not statistically significant.

Other Fuel Variables: Sulfur. Lowering sulfur in gasoline lowers emissions of CO, HC and NO_x from catalyst-equipped cars. As noted by the auto-oil study, "The regression analysis showed that the sulfur effect (lowered emissions) was significant for HC on all ten cars, for CO on five cars, and for NO_x on eight cars. There were no instances of a statistically significant increase in emissions."[40] To the extent that oxygenates are sulfur-free, their addition would tend to traditionally lower gasoline sulfur levels. Based on the auto/oil study, it appears that NO_x would go down about 3 percent per 100 parts per million sulfur reduction.

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[39] Personal Communication.

[40] Auto/Oil Air Quality Improvement Research Program, Technical Bulletin No. 2, "Effects of Fuel Sulfur Levels on Mass Exhaust Emissions," February 1991.

Other Fuel Variables: Other. According to the auto/oil study, "NO_x emissions were lowered by reducing olefins, raised when T_{90} was reduced, and only marginally increased when aromatics were lowered."[41] In general, reducing aromatics and T_{90} caused statistically significant reductions in exhaust mass NMHC and CO emissions. Reducing olefins increases exhaust mass NMHC emissions; however, "the ozone forming potential" of the total vehicle emissions was reduced.[42]

With regard to toxics, the reduction of aromatics from 45 percent to 20 percent caused a 42 percent reduction in benzene but a 23 percent increase in formaldehyde, a 20 percent increase in acetaldehyde and about a 10 percent increase in 1,3-Butadiene. Reducing olefins from 20 percent to 5 percent brought about a 31 percent reduction in 1,3-Butadiene but had insignificant impacts on other toxics. Lowering the T_{90} from 360 to 280F resulted in statistically significant reductions in benzene, 1,3-Butadiene (37 percent), formaldehyde (27 percent) and acetaldehyde (23 percent).

Cost Effectiveness. It is difficult to estimate the costs and the cost effectiveness of fuel modifications because refiners differ widely in terms of the characteristics of the fuels they produce. Individual fuel component control costs and the effects of changes in one fuel component on the other fuel components are integral parts in the determination of the cost effectiveness. In the US EPA's analysis, these two integral parts were estimated from the results of refinery modeling performed by Turner, Mason and Company (for the Auto-Oil Economics group) and Bonner & Moore Management Science (for EPA) and on survey results presented by the California Air Resources Board (CARB).

The total cost (or manufacturing cost) of producing a reformulated gasoline is the sum of the capital recovery cost and the operating cost. An example of the individual fuel component costs and the associated incremental percent reduction in VOC emissions are shown in Table 3.

EPA proposed a range of VOC standards and NO_x standards based on particular combinations of fuel component controls that reduce VOC (and VOC plus NO_x) emissions at a cost of less than $5,000 and less than $10,000 per ton, respectively. EPA believes that these ranges represent the upper limit of costs that will be incurred by many ozone nonattainment areas in achieving attainment.

Estimates of the costs and cost effectiveness of California RFG continue to come down. At the time it developed its regulations, CARB estimated the costs to be $0.12 to $0.17 per gallon. Recently, an EPA analysis placed the costs at $0.08 to $0.11 per gallon. This analysis estimated the cost effectiveness of the California RFG to be $4,100 to $5,100 per ton of VOC and NO_x control; Federal phase 1 RFG was estimated to cost $3,100 per ton of VOC control.[43]

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41 Auto/Oil Air Quality Improvement Research Program, Technical Bulletin No. 1, "Initial Mass Exhaust Emissions Results from Reformulated Gasolines," December 1990.

42 "Auto/Oil Air Quality Improvement Research Program—What Is It and What Has It Learned?", Colucci and Wise, June 7, 1992, Presented at XXIV Fisita Congress, London, England.

43 "The Case for California Reformulated Gasoline—Adoption by the Northeast," Dr. R. Dwight Atkinson, May 1993.

Table 3: COMPONENT CONTROL COSTS AND VOC EMISSION REDUCTIONS

Component	Control Level	Incremental Cost (c/gal)	Cumulative VOC Reduction (%)
Oxygen	2.0 Wt%	1.67-3.36/a	9.0
Benzene	1.0 vol%	0.69	9.0
RVP	8.1 psi	0.57	17.6
RVP	7.4 psi	1.67	25.3
Sulfur	160 ppm	0.35-0.57	26.4
Oxygen	2.7 Wt%	0.59-1.18/a	28.5
Olefins	5.0 vol%	1.81-2.44	30.2
Sulfur	50 ppm	1.45-1.86	31.2
Aromatics	20 vol%	0.61-0.98	31.4

/a Based on MTBE.

Diesel Fuel

Modifications to diesel fuel composition have now also drawn considerable attention as a quick and cost-effective means of reducing emissions from existing vehicles. The two modifications that show the most promise are a reduction in sulfur content, and in the fraction of aromatic hydrocarbons in the fuel.

Sulfur Content. In addition to a direct reduction in emissions of SO_2 and sulfate particles, reducing the sulfur content of diesel fuel reduces the indirect formation of sulfate particles from SO_2 in the atmosphere. In Los Angeles, it is estimated that each pound of SO_2 emitted results in roughly one pound of fine particulate matter in the atmosphere. In this case, therefore, the indirect particulate emissions due to SO_2 from diesel vehicles are roughly as great as their direct particulate emissions. SO_2 conversion to particulate matter is highly dependent on local meteorological conditions, however, so the effects could be greater or less in other cities.

Aromatic Hydrocarbons. A reduction in the aromatic hydrocarbon content of diesel fuel may also help to reduce emissions, especially where fuel aromatic levels are high. For existing diesel engines, a reduction in aromatics from 35 percent to 20 percent by volume would be expected to reduce transient particulate emissions by 10 to 15 percent and NO_x emissions by 5 to 10 percent. HC emissions, and possibly the mutagenic activity of the particulate soluble organic fraction (SOF), would also be reduced. Modeling studies of the refining industry have shown that aromatic reductions of this magnitude can often be obtained through alterations in diesel fuel production and blending strategy, without a need for major new investments in additional processing capacity.

Reduced diesel fuel aromatic content would have other environmental and economic benefits. The reduced aromatic content would improve the fuel's ignition quality, improving cold starting and idling performance and reducing engine noise. The reduction in the use of catalytically cracked blending stocks should also have a beneficial effect on deposit-forming tendencies in the fuel injectors, reducing maintenance costs. On the negative side, however, the

reduced aromatics might result in some impairment of cold flow properties, due to the increased paraffin content of the fuel.

Fuel Additives. A number of well-controlled studies have demonstrated the ability of detergent additives in diesel fuel to prevent and remove injector-tip deposits, thus reducing smoke levels. The reduced smoke probably results in reduced particulate emissions as well, but this has not been demonstrated as clearly, due to the great expense of particulate emissions tests on in-use vehicles. Cetane-improving additives are also likely to result in some reduction in HC and particulate emissions in marginal fuels.

Alternative Fuels For Buses

The possibility of substituting cleaner-burning alternative fuels for diesel fuel has drawn increasing attention during the last decade. Motivations advanced for this substitution include conservation of oil products and energy security, as well as the reduction or elimination of particulate emissions and visible smoke.

The principal alternative fuels presently under consideration are natural gas and methanol made from natural gas, and in limited applications, LPG. Whether to use alternative fuels and if so which fuel requires a detailed study of the costs of implementing and sustaining the fuel supply system in a given location.

More Stringent Car and Truck Standards

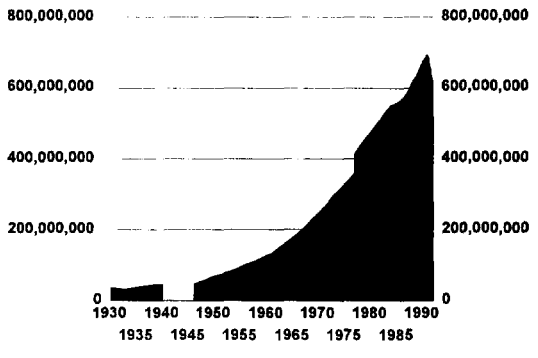
Advances in automotive technologies have made it possible to dramatically lower emissions from new motor vehicles. Increasingly, countries around the world have been taking advantage of them. Once good I/M programs and unleaded gasoline are introduced, state-of-the-art pollution controls should be pursued.

WORLDWIDE OVERVIEW

Historic Patterns of Vehicle Production and Use

In 1950, there were about 53 million cars on the world's roads; only four decades later, the global automobile fleet is over 456 million, almost a tenfold increase. On average, the fleet has grown by about 9.5 million automobiles per year over this period. Simultaneously, as illustrated in Figure 20, the truck and bus fleet has been growing by about 3.6 million vehicles per year. While the growth rate has slowed in the highly industrialized countries, population growth and increased urbanization and industrialization are

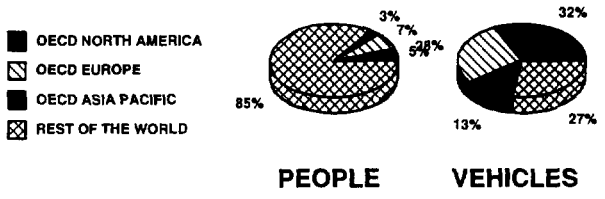
FIGURE 20: GLOBAL TRENDS IN VEHICLE REGISTRATIONS



accelerating the use of motor vehicles elsewhere. If the approximately 100 million two-wheeled vehicles around the world are included (growing at about 4 million vehicles per year over the last decade), the global motor vehicle fleet is now approaching 700 million.

Europe (including Eastern Europe and the former USSR) and North America each have about 30 percent of the world's motor vehicle population. The remainder is divided among Asia, South America, Africa, and Oceania (Australia, New Zealand and Guam), in that order. North America has about 40 percent of the world's trucks and buses, followed closely by Asia and then Europe. In terms of per capita motor vehicle registration for various regions, the United States, Japan, and Europe also account for the lion's share of the ownership and use of motor vehicles. Indeed, as shown in Figure 21, the non-OECD countries of Africa, Asia (excluding Japan) and Latin America are home to more than four-fifths of the world's population, yet account for only one-fourth of world motor vehicle registrations!

FIGURE 21: DIVISION OF VEHICLES AND PEOPLE AROUND THE WORLD



Government Responses To The Problem

Gasoline-Fueled Vehicles. Vehicle pollution control efforts reflect an approximately 30-year effort to date. Initial crankcase HC controls were first introduced in the early 1960s followed by exhaust CO and HC standards later that decade. By the early to mid-1970s, most major industrial countries had initiated some level of vehicle pollution control program (Figures 22-25).

FIGURE 22: LIGHT-DUTY VEHICLE STANDARDS (HC Plus NO_x Combined)

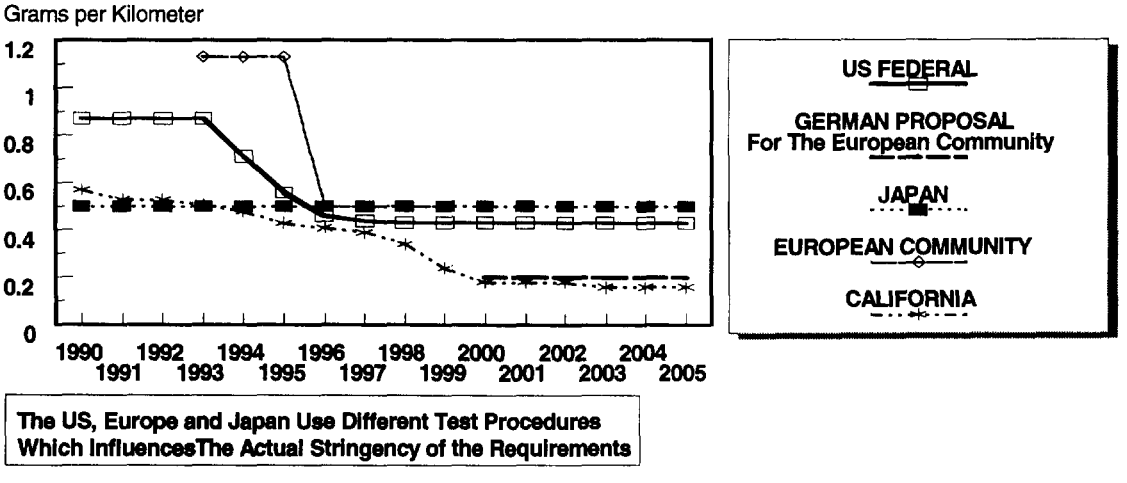
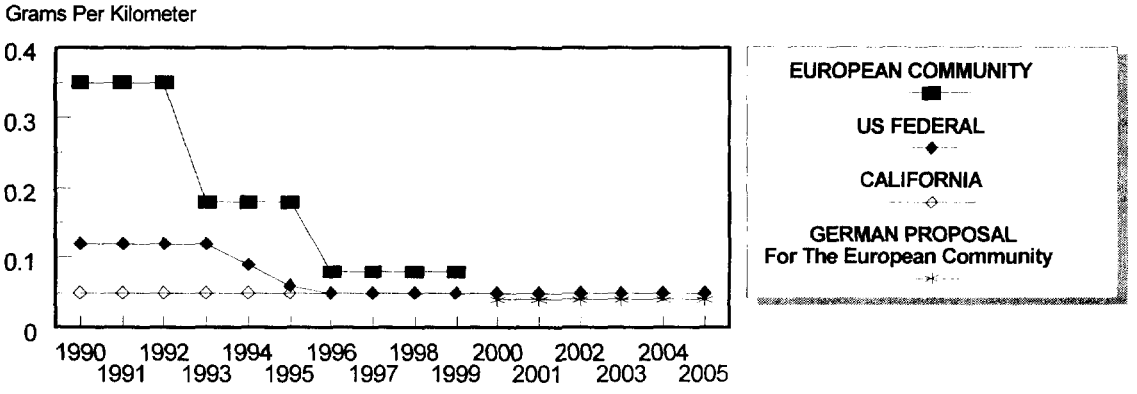
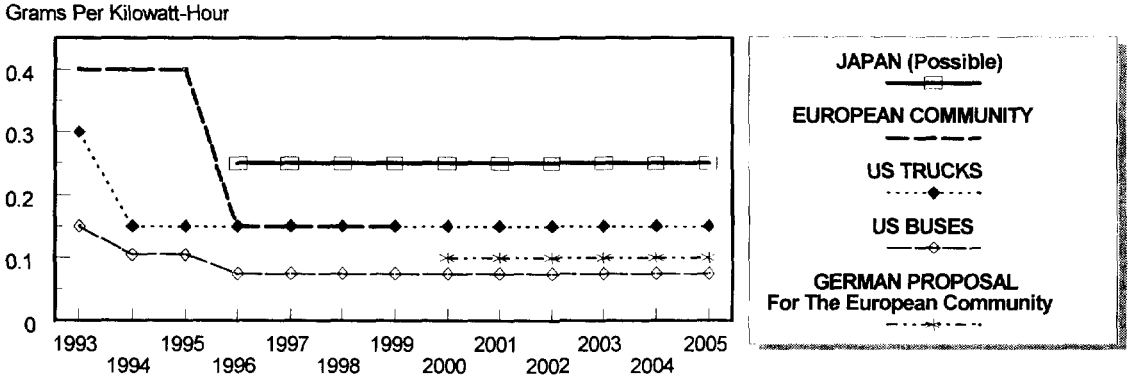


FIGURE 23: PASSENGER CAR EMISSION STANDARDS (Diesel Particulate)



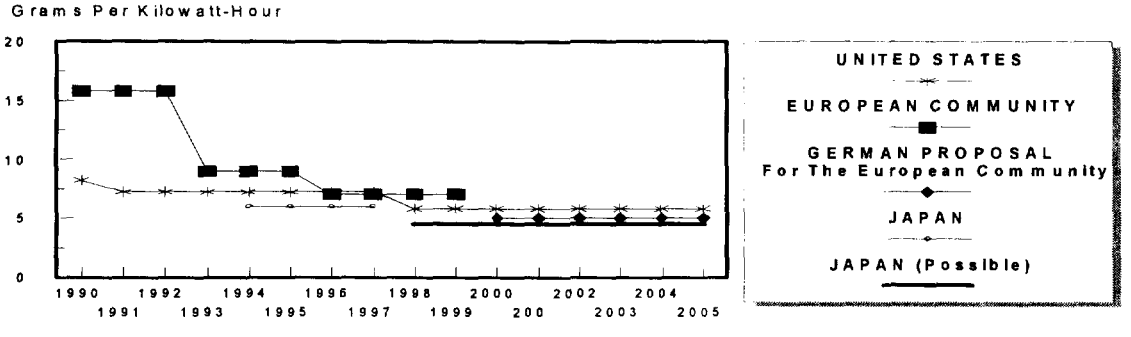
The US and Europe Use Different Test Procedures Which Influences The Actual Stringency of the Requirements

FIGURE 24: HEAVY TRUCK EMISSION STANDARDS (Diesel Particulate)



The US, Europe and Japan Use Different Test Procedures Which Influences The Actual Stringency of the Requirements

FIGURE 25: HEAVY TRUCK AND BUS EMISSION STANDARDS (Nitrogen Oxides)



The US, Europe and Japan Use Different Test Procedures Which Can Influence The Actual Stringency of the Requirements

During the mid- to late-1970s, advanced catalytic aftertreatment technologies were introduced on most new cars in the United States and Japan. During the mid-1980s, Austria, the Netherlands and the Federal Republic of Germany adopted innovative economic incentive approaches to encourage purchase of low-pollution vehicles. Australia, Canada, Finland, Austria, Norway, Sweden, Denmark and Switzerland all decided to adopt mandatory requirements. Even rapidly industrializing, developing countries or regions such as Brazil, Chile, Taiwan (China), Hong Kong, Mexico, Thailand, Singapore and Korea have adopted stringent emissions regulations.

In 1990, the European Union decided to require all new light-duty vehicles sold within the European Community by 1992/93 to meet emission standards roughly equivalent to US 1987 levels. Further, in 1994, they voted to require a second step to go into effect by 1996.

Just as Europe was moving toward parity with US standards, the United States and, to a much greater extent, California embarked on a course that could prove just as momentous to the 1990s as the 1970 Clean Air Act was to the 1970s and 1980s. With passage of the Clean Air Act amendments of 1990, the US Congress adopted requirements that will double the durability of passenger car emission control systems, tighten emissions standards, require cleaner conventional and alternative fuels, add cold-temperature standards and reduce toxic emissions.

Simultaneously, to further reduce motor vehicle emissions, the California Air Resources Board (CARB) has established stringent new vehicle exhaust emission standards, the so-called Low-Emission Vehicle or LEV program. Compliance with these standards will be achieved through a combination of advanced vehicle emission control technology and clean-burning fuels.

Diesel Vehicles and Engines. Not surprisingly, in view of the already serious health concerns and the continued growth in the use of diesel vehicles, many countries are pushing equally hard to reduce diesel emissions as gasoline vehicle emissions. The United States, Europe and Japan have all now adopted NO_x and particulate standards that will require significant technological progress during the 1990s.

Just as the 1970s represents the period when advanced gasoline vehicle technologies passed from the laboratory to the marketplace, the 1990s promises to be a similar era for diesels.

Motorcycles. Stringent motorcycle standards were adopted in the United States several years ago but as the motorcycle population declined, especially those using two-stroke engines, concern with these vehicles has waned. Motorcycles were largely ignored in the European Union as well. However, in 1988 the Swiss government broke the logjam by deciding to set new emission standards for motorcycles to go into effect by October 1990. Shortly thereafter, on July 1, 1991, the motorcycle standards in Taiwan were tightened to 4.5 grams per kilometer for CO (from 8.8), and 3.0 for HC and NO_x combined (from 6.5), based on the ECE R40 test procedure. With introduction of these requirements, Taiwan had the most stringent motorcycle control in the world, requiring use of catalytic-converter controls on all new two-stroke motorcycles. As these tight standards begin to spread during the 1990s, Taiwan will very likely institute even more stringent requirements in a few years. Zero-emissions motorcycle standards have been proposed in Taiwan for a limited portion of 1998 motorcycles.

SUBSTANTIAL PROGRESS HAS OCCURRED IN MANY COUNTRIES

Since 1970, the United States has had an aggressive effort underway to reduce emissions from cars and improve air quality. This program has combined many elements including the introduction of leaded gasoline, tight standards for new vehicles, in-use vehicle inspection and maintenance efforts, and most recently the use of reformulated and low-volatility gasoline. As a result, over the course of the past 25 years, the emission rate for on-highway cars in the United States has declined dramatically. As newer vehicles equipped with advanced emissions controls have replaced older, higher-polluting ones, there has been a clear downward trend in emissions of all three pollutants. This is especially encouraging in light of the continued rapid growth in vehicles and vehicle miles traveled by cars during this same period; in 1990 there were 50 million more cars on US highways than there were in 1970. Had emissions per mile not been reduced, passenger cars in 1990 would have emitted 65 percent more CO, HC and NO_x than they did in 1970. In other words, as illustrated in Table 4, instead of passenger car CO having been reduced from 68 million metric tons to 27, these emissions would have climbed to 112 tons.

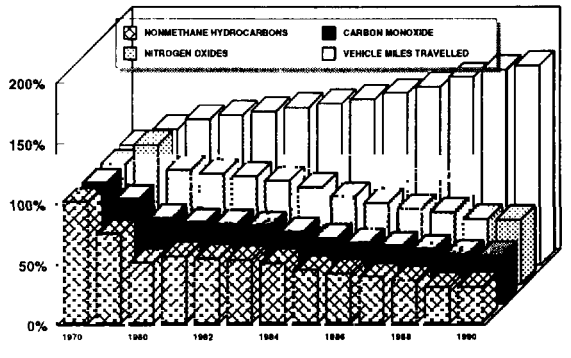
Table 4: EMISSIONS TRENDS IN THE UNITED STATES (1970-90), PASSENGER CARS
(Tons per year)

	Carbon monoxide	Hydrocarbons	Nitrogen oxides
1970 Actual	67.9	8.87	4.36
1990 Actual	26.9	2.65	2.34
1990 Potential /a	112.0	14.6	7.2

/a What would have occurred had pollution controls not been put on cars over this period.

Figure 26 illustrates the auto emissions reductions to date, 60 percent for CO, 70 percent for HC and 46 percent for NO_x. Lead emissions from all highway vehicles have also been reduced dramatically; between 1970 and 1993, highway vehicle lead emissions declined from 171,960 short tons to 1,380.

FIGURE 26: TRENDS IN EMISSIONS FROM US CARS (Normalized to 1970 Levels)



The point of this example is to show that adoption of a strong motor vehicle pollution control program can be very effective in reducing vehicle emissions.

Another example is the experience in Southern California's Los Angeles Basin, which has had the most aggressive motor vehicle pollution control program in the world over the past 40 years.[44] From 1955 to 1993, peak ozone

[44] "The Automobile, Air Pollution Regulation and the Economy of Southern California, 1965-1990," Jane Hall et al., Institute for Economic and Environmental Studies, California State University, April 1995.

concentrations were cut in half. The number of days on which federal ozone standards are exceeded fell by 50 percent from the 1976-78 timeframe to the 1991-93 interval. Further, the average annual number of days above the federal carbon monoxide standard fell from 30 to 4.3 during this same period and lead levels are now 98 percent lower than in the early 1970s. Most remarkably, this achievement occurred while the regional economy outpaced the national economy in total job growth, manufacturing job growth, wage levels and average household income. In short, a strong focus on environmental protection is not only not incompatible with strong economic development, they seem to be mutually reinforcing.

VEHICLE POLLUTION CONTROL EFFORTS UNDERWAY IN ASIA

In recent years, the most rapidly growing area of the world has been Asia. Not surprising, therefore, it already has a serious air pollution problem in many of its major cities. This review will summarize the air pollution situation, as well as the steps being adopted by several countries in the region. Several developing countries of Asia have made progress with some or all elements of these strategies; specific examples illustrating these efforts will be summarized below.

Bangkok, Thailand

Based on a review of available air quality data, it is estimated that roadside emissions of particulate, carbon monoxide and lead must be reduced by 85, 47 and 13 percent, respectively, if acceptable air quality is to be achieved in Bangkok. Recent data indicate that ozone levels downwind of the city may also be approaching unhealthy levels; therefore, it seems prudent to adopt measures which will reduce HC and NO_x emissions, the ozone precursors, as well.

In response to the serious air pollution threat, Thailand's current Seventh Plan has placed a high priority on improving air quality and definite targets have been set to control the amount of suspended particulate matter, carbon monoxide and lead on Bangkok's major streets.

Current Program. A number of measures have been adopted to mitigate air pollution problems, particularly those caused by the transport sector. They are aimed not only at exhaust-gas emission controls but also at the improvement of fuel and engine specifications, implementation of in-use vehicle inspection and maintenance program, public transport improvement through mass transit systems, and the improvement of traffic conditions through better traffic management. Measures directed toward reducing vehicle emissions include:

- Introduction of unleaded gasoline at prices below that of leaded gasoline (introduced in May 1991).
- Reduction of the maximum allowable lead in gasoline from 0.4 to 0.15 grams per liter (effective as of January 1, 1992).
- A plan to phase out leaded gasoline by 1996 (some companies have already eliminated sales of leaded gasoline).
- Reduction of the sulfur content of diesel fuel from 1.0 to 0.5 percent as of April 1992 in the Bangkok Metropolitan Area and after September 1992 throughout the whole

country; the use of low-sulfur diesel fuel has been mandatory in Bangkok since September 1993.

- Reduction of the 90 percent distillation temperature of diesel fuel from 370°C to 357°C as of April 1992 in the Bangkok Metropolitan Area and after September 1992 throughout the whole country.
- Required all new cars with engines larger than 1600 cc to meet the ECE R83 standards after January 1993; all cars were required to comply after September 1, 1993.
- Taxis and Tuk-Tuks have already been largely converted to operate on LPG.
- ECE R40 requirements for motorcycles were introduced in August 1993 and followed soon afterward by ECE R40.01; the Government has decided on a third step of control, which will be phased in this year.
- ECE R49.01 standards for heavy-duty diesel-engine vehicles are now in effect.
- The Government has decided to reduce the sulfur level in diesel fuel from the current 0.5 Wt. percent to 0.25 by 1996 and 0.05 by the year 2000.

Currently, noise and emission testing are required and are conducted under the Land Transport Department's general vehicle inspection program. All new vehicles are subject to such inspection. For in-use vehicles, only those registered under the Land Transport Act (buses and heavy-duty trucks) and commercial vehicles registered under the Motor Vehicles Act (taxis, Tuk-Tuks and rental vehicles) are subject to inspection during annual registration renewals. It is expected that Land Transport Department (LTD) will require all in-use vehicles to be inspected soon. Vehicles in use for 10 or more years are subjected to an annual inspection while the newer vehicles will be subjected to inspection at different time periods. This will be determined by LTD. Private inspection centers are being licensed.

Future Plans. Further investigations are underway to introduce more stringent standards for motorcycles as well as light and heavy trucks, and to purchase 200 CNG buses to reduce the smoke problem.

A comprehensive motor vehicle pollution control strategy is being designed for Bangkok. The most critical data needs appear to be those related to motorcycle and diesel-vehicle particulate emissions factors. Unfortunately, it appears that locally generated data in this area is at least a year away. Further, better characterization of the particulate would be very helpful. In addition, as the new air quality monitoring network gets deployed, it will be critical to periodically update the air quality targets.

Conclusions. Bangkok, like many other megacities in the world, has serious problems associated with the use of energy in transport sector. Several factors, including population growth and rapid economic expansion, etc., are fundamental factors needed to be considered for long-term planning. Rapid industrialization and urbanization, coupled with the lack of land use planing in the past, has contributed to the atmospheric pollution associated with the transport

sector. This problem has been intensified by the inadequate road infrastructures to absorb the rapidly growing vehicle population, which in turn causes congestion, and by the lack of mass transport system to offer good substitutes for private vehicles. These two factors encourage people to rely more on their private vehicles and hence have further contributed to the congestion problem.

It is recognized that this problem can be alleviated through several means including the following measures: source reduction through improvement of fuel quality, I/M program, vehicle standards, and traffic and demand management (such as having a good mass rapid transit system). A great deal of work remains to be done, especially in the policy arena to control travel demand (demand-side management).

Singapore

In Singapore, motor vehicle emissions are a significant source of air pollution. The vehicle population has been steadily increasing over the past decade as a consequence of rapid urbanization and economic growth. At the beginning of 1993, the vehicle population stood at approximately 550,000.

Land Transport Policy. Singapore's land transport policy strives to provide free-flowing traffic within the constraint of limited land. A four-pronged approach has been adopted to achieve this. First, the need to travel is minimized through systematic town planning. Second, an extensive and comprehensive network of roads and expressways, augmented by traffic management measures, has been built to provide quick accessibility to all parts of Singapore. Third, a viable and efficient public transport system that integrates both the Mass Rapid Transit (MRT) and bus services, is promoted. Finally, the growth and usage of vehicles are managed to prevent congestion on the road.

Mobile Source Controls. Singapore's strategy for reducing pollution from motor vehicles is two-pronged: improving the engines and fuel quality to reduce emissions and using traffic management measures to control the growth of vehicle population and fuel consumption. The Pollution Control Department works closely with the Registry of Vehicles to implement the two-pronged strategy.

- Between 1981 and 1987, the lead content in leaded gasoline was gradually reduced from 0.8 to 0.15 grams per liter. The use of unleaded gasoline was promoted in February 1990 through a differential tax system that made unleaded gasoline 10 cents per liter cheaper than leaded gasoline at the pump. All gasoline-driven vehicles registered for use in Singapore after July 1, 1991 must be able to use unleaded gasoline. These measures have resulted in the greater use of unleaded gasoline. About 57 percent of all gasoline sold in Singapore at the end of 1993 was unleaded. The sulfur content in diesel is currently limited to 0.5 percent by weight and will be reduced to 0.3 percent by weight from July 1, 1996 onwards.

- The emission standards for gasoline vehicles have been progressively tightened since 1984 and the standards currently in force are the European Union Consolidated Emissions Directive 91/441 and the Japanese emission standards (Article 31 of Safety Regulations for Road Vehicles).

- Since October 1992, motorcycles and scooters have been required to comply with the emission standards stipulated in the US Code of Federal Regulation 86.410-80 before they can be registered for use in Singapore.

- Since January 1991, all diesel vehicles have been required to comply with smoke standards stipulated in the UN/ECE Regulation No. 24.03 before they can be registered for use in Singapore.

- All in-use vehicles are required to undergo periodic inspections to check their roadworthiness and exhaust emissions while idling. Vehicles that fail the inspections are not allowed to renew their road tax.

Traffic Management Measures. The situation in Singapore is a unique one. Singapore is essentially a city-state with a large population living on a small land mass. Urbanization, industrialization and infrastructural development are still progressing in earnest, fueled by a growing economy. With such a combination of factors, it is easy to see that there is a potential for serious environmental problems from both stationary and mobile sources if the sources are not managed or controlled properly. In the case of motor vehicles, the need to control their impact on traffic flow and the environment has given rise to a unique set of traffic management measures.

(a) Vehicle Registration and Licensing, The expense of owning and operating a vehicle in Singapore has served as a dampener to the growth in the vehicle population. Car owners wishing to register their cars must pay a 45 percent import duty on the car's open-market value (OMV), a registration fee of $1,000 for a private car ($5,000 for a company-registered car) and an Additional Registration Fee (ARF) of 150 percent of the OMV.

In addition, car owners pay annual road taxes based on the engine capacity of their vehicle. The road tax of company-registered cars is twice as high as for individuals. For diesel vehicles, a diesel tax that is six times the road tax of an equivalent gasoline vehicle is payable.

To encourage people to replace their old cars with newer, more efficient models, a Preferential Additional Registration Fee (PARF) system was introduced in 1975. Private car owners who replace their cars within 10 years are given PARF benefits that they can use to offset the registration fees they have to pay for their new cars. For cars registered on or after November 1, 1990, the PARF benefits would vary according to the age of the vehicle at deregistration. For cars registered before November 1, 1990, a fixed PARF benefit would be given upon deregistration based on the engine capacity of the car. To provide a higher PARF benefit to car owners who deregister their cars before 10 years, all PARF-eligible cars registered on or after November 1, 1990 receive higher fees if the vehicle is newer.

(b) Vehicle Quota System. As high taxes alone would not ensure that the vehicle population grow at an acceptable rate, a vehicle quota system was introduced to achieve that objective. Since May 1, 1990, any person who wishes to register a vehicle must first obtain a vehicle entitlement in the appropriate vehicle class, through bidding. Tender for specified number of vehicle entitlements is conducted monthly. Successful bidders pay the lowest successful bid price of the respective category in which they bid. A vehicle entitlement is valid for 10 years from the date of registration of the vehicle. On expiration of the vehicle entitlement,

if the owner wishes to continue using the vehicle, he needs to revalidate the entitlement for another five or ten years by paying a revalidation fee (pegged at the 50 percent or 100 percent of the prevailing quota premium, respectively).

(c) Weekend Car Scheme. The weekend car scheme was introduced on May 1, 1991 to allow more people to own private cars without adding to traffic congestion during peak hours. Cars registered under the scheme enjoy substantial tax concessions that include a 70 percent reduction in road tax and a tax rebate of up to a maximum of $15,000 on registration. Weekend cars are identifiable by their red license plates, fixed in place with a tamper-evident seal. They can only be driven between 7 pm and 7 am during the week, after 3 pm on Saturdays and all day on Sundays and public holidays. Weekend cars can be driven outside those hours but owners must display a special day license. Each weekend car owner is given five free day licenses per year and can buy additional ones at $20 each.

(d) Area Licensing Scheme. The Area Licensing Scheme (ALS) was introduced in June 1975 to reduce traffic congestion in the city area during the peak hours. Only passenger cars were affected then. The scheme has gradually been modified to include all vehicles except ambulances, fire engines, policy vehicles and public buses.

(e) Public Transportation. Public transport in Singapore is widely available and includes a mass rapid transit (MRT) system, a comprehensive bus network and over 13,000 taxis.

Conclusions. Besides technical control measures (controls on engines and fuel quality), the use of traffic control measures has significantly contributed to the protection of the air quality in Singapore. Although the present measures appear to be adequate, Singapore will continue to look ahead for ways to improve them further. Pilot studies of three electronic road pricing systems are being carried out in Singapore and the most suitable system will be selected for implementation in 1997.

Hong Kong

Hong Kong's vehicle pollution control effort continues to focus on diesel particulate control because particulate is the most serious pollution problem at present in Hong Kong, and motor vehicles are estimated to be responsible for approximately 50 percent of the PM-10 emissions.

Current Program.

- With regard to diesel fuel, as of April 1, 1995, the sulfur level was reduced to 0.2 percent and it is planned to lower it to 0.05 percent by 1997 or 1998.

- Diesel vehicle emissions standards were also tightened on April 1, 1995. All new passenger cars and taxis after that date must comply with either the US 1990 standards (PM=0.12 grams per kilometer, NO_x=0.63) or the European Union Step 1 standards (93/59/EEC PM=0.14, HC+NO_x=0.97) or the Japanese standards (PM=0.34, NO_x=0.72 for vehicles weighing less than 1.265 ton or 0.84 for those above). Similar requirements will apply to all light and medium goods vehicles and light buses. For goods vehicles and buses with a design weight of 3.5 tons or more,

either the 1990 US (PM=0.80 g/kWh, NO_x 8.04) or the EURO 1 standards (PM=0.61 for engines producing less than 85 kW or 0.36 for engines producing more; NO_x=8.0 for all engines) will apply.

- In use smoke limits based on the EEC free acceleration test (72/306/EEC) will be lowered to 50 Hartridge Smoke Units (HSU); in certification, the limits will be 40 HSU.

- Encouraged by a price differential of HK$1 per liter price reduction for unleaded gasoline compared to leaded, unleaded gasoline is now responsible for 71 percent of total gasoline sales. Notably, the benzene content of the unleaded gasoline is only 3.44 percent, virtually the same as leaded gasoline.

Future Plans. An analysis of the motor vehicle related urban particulate problem indicates that 17 percent comes from buses, 63 percent from goods vehicles and the remainder from all vehicles under 5.5 tons.

- As a matter of policy, Hong Kong is still trying to convert all light duty diesel vehicles including taxis to gasoline. Analyses are also being carried out regarding the possibility of converting some or all taxicabs to either CNG or electric.

- With regard to I/M, the Government still has plans to introduce a mandatory program by May 1996.

- Hong Kong also remains interested in the possibility of retrofitting buses with either catalysts or diesel particulate filters. They have submitted a proposal to the Asia-US partnership to fund such an effort and have also initiated discussions with potential suppliers in Europe.

Korea

A series of recent amendments in the Air Quality Control Law will gradually tighten Korea's vehicle emissions standards as summarized in Tables 5 and 6.

The sulfur level in diesel fuel was reduced to a maximum of 0.4 Wt. percent during the period from February 2, 1991 through December 31, 1992; to 0.2 during the period from January 1, 1993 through December 31, 1995; and 0.1 thereafter.

Korea is also investigating possible improvements to their I/M program including the possible addition of I/M240.

Research remains active in the use of diesel particulate filters. Three types of approaches are under investigation—burner systems that are seen as prime candidates for large vehicles; electrically heated systems that are seen as prime candidates for medium-size vehicles, and Cerium fuel-additive systems that are seen as the prime candidates for smaller vehicles.

Research is also underway in Korea on electrically heated catalysts, CNG engines, two-stroke engines and lean NO_x catalysts.

TABLE 5: EMISSION STANDARDS FOR NEW GASOLINE AND LPG VEHICLES

Vehicle Type	Date of Implementation	Test	CO	NO_x	Exhaust HC	Evap HC (g/test)
Small Size Car /a	1987 7/1	CVS-75 g/km	8.0	1.5	2.1	4.0
"	2000 7/1	CVS-75	2.11	0.62	0.25	2.0
Passenger Car	1980 1/1	10-Mode	26.0	3.0	3.8	-
"	1984 7/1	10-Mode	18.0	2.5	2.8	-
"	1987 7/1	CVS-75	2.11	0.62	0.25	2.0
"	2000 1/1	CVS-75	2.11	0.25	0.16	2.0
Light Duty Truck /b	1987 7/1	CVS-75	6.21	1.43	0.50	2.0
"	2000 1/1	CVS-75 /c	2.11	0.62	0.25	2.0
"	2000 1/1	CVS-75 /d	6.21	1.43	0.50	2.0
Heavy Duty Vehicle	1980 1/1	6-Mode	1.6%	2,200 ppm	520 ppm	
"	1987 7/1	US Transient	15.5	10.7	1.3	4.0
"	1991 2/1	13 Mode	33.5	11.4	1.3	-
"	2000 2/1	13 Mode	33.5	5.5	1.4	-

/a Less than 800 cc of engine displacement.
/b Gross vehicle weight of <3 tons.
/c Gross vehicle weight of <2 tons.
/d Gross vehicle weight of between 2 and 3 tons.

TABLE 6: EMISSIONS STANDARDS FOR NEW DIESEL VEHICLES

Vehicle Type	Date of Implementation	Test	CO	NO_x	HC	PM	Smoke
Passenger Car	1980 1/1	Full Load	-	-	-	-	50%
"	1984 7/1	6-Mode	980 ppm	1,000/590/a	670	-	50%
"	1988 1/1	6-Mode	980	850/450	670	-	50%
"	1993 1/1	CVS-75	2.11	0.62	0.25	0.12	-
"	1996 1/1	CVS-75	2.11	0.62	0.25	0.08	-
"	2000 1/1	CVS-75	2.11	0.62	0.25	0.05	-
Light Duty Truck	1980 1/1	Full Load	-	-	-	-	50%
"	1984 7/1	6-Mode	980	1000/590	670	-	50%
"	1988 1/1	6-Mode	980	850/460	670	-	50%
"	1993 1/1	6-Mode	980	750/350	670	-	40%
"	1996 1/1	CVS-75	6.21	1.43	0.5	0.31 (0.16)/b	-
Light Duty Truck <2 Tons	2000 1/1	CVS-75	2.11	0.75	0.25	0.12	-
All Other Light Duty Trucks	2000 1/1	CVS-75	6.21	1.00	0.5	0.16	-
Heavy Duty Vehicle	1980 1/1	Full Load	-	-	-	-	50%
"	1984 7/1	6-Mode	980	1000/590	670	-	50%
"	1988 1/1	6-Mode	980	850/450	670	-	50%
"	1993 1/1	6-Mode	980	750/350	670	-	40%
"	1996 1/1	13-Mode	4.9	11.0	1.2	0.9	35%
"	2000 1/1	13 Mode	4.9	6.0	1.2	0.25 0.1/c	25%

/a Direct injection/indirect injection.
/b Gross vehicle weight <2 tons.
/c City bus only.

Taiwan (China)

The Taiwan EPA has developed a comprehensive approach to motor vehicle pollution control. Building on its early adoption of US 1983 standards for light-duty vehicles (starting July 1, 1990) it recently moved to US 1987 requirements, which include the 0.2 gram per mile particulate standard, as of July 1, 1995. Heavy-duty diesel particulate standards almost as stringent as US 1990, 6.0 grams per brake horsepower hour NO_x and 0.7 particulate, using the US transient test procedure, went into effect on July 1, 1993. It is intended that US 1994 standards, 5.0 NO_x and 0.25 particulate, will be adopted soon, probably for introduction by July 1, 1997.

Diesel fuel currently contains 0.3 weight percent sulfur. A proposal to reduce levels to 0.05 percent by 1997 is currently under consideration.

The Executive Yuan on December 10, 1992 approved increases of up to 1,700 percent for the amount of fines to be levied against motorists who violate the Air Pollution Control Act. The new fine schedule raises the former maximum fine for motor vehicle pollution from $138 to $2,357. All forms of motorized transportation are included in the new fine schedule, including airplanes, boats, and power water skis. The new fines took effect in early 1993 after official public notice.

Clearly, the most distinctive feature of the Taiwan program, however, is its motorcycle control effort, reflecting the fact that motorcycles dominate the vehicle fleet and are a substantial source of emissions.

- The first standards for new motorcycles were imposed in 1984; 8.8 grams per kilometer for CO and 6.5 grams per kilometer for HC plus NO_x, combined, using the ECE R40 test procedure.

- In 1991, the limits were reduced to 4.5 grams per kilometer for CO, and 3.0 for HC and NO_x combined. These requirements were phased in over two years and by July 1, 1993 were applied to all new motorcycles sold in Taiwan. As a result of these requirements, the engines of four-stroke motorcycles have been redesigned to use secondary air injection. All new two-stroke motorcycles are fitted with catalytic converters.

- Since 1992, electric motorcycles have been available in the market but sales have been modest.

- Motorcycle durability requirements have been imposed since 1991. All new motorcycles tested since that time are required to demonstrate that they can meet emissions standards for a minimum of 6,000 kilometers.

- Since 1991, all new motorcycles must be equipped with evaporative controls.

- In order to reduce the pollution from in-use motorcycles, EPA is actively promoting a motorcycle I/M system. In the first phase, from February through May 1993, EPA tested approximately 113,000 motorcycles in Taipei City. Of these, 49 percent were

given a blue card indicating that they were clean, 21 percent a yellow card indicating that their emissions were marginal, and 30 percent were failed.

- Between December 1993 and May 1994, approximately 142,000 motorcycles were inspected, with 55 percent receiving blue cards, up 6 percent from the earlier program, and 27 percent failed, a drop of 3 percent. The major repair for failing motorcycles was replacement of the air filter at an average cost of $20.

- In continuing regulations for the control of motorcycle emissions, EPA has adopted the Third-Stage Emission Regulation to be implemented from 1998. The new standards will lower CO to 3.5 grams per kilometer, and HC plus NO_x to 2. In addition, the durability requirement will be increased to 20,000 kilometers. Finally, the market share for electric-powered motorcycles will be mandated at 5 percent. In addition, EPA will extend the periodic motorcycle I/M program.

Conclusions

As the above examples illustrate, substantial efforts have been and continue to be underway throughout many Asian countries to address their motor vehicle pollution problems. Several conclusions can be drawn from these efforts:

- Several comprehensive motor vehicle pollution control programs have been developed in the region.

- A wide variety of strategies are being implemented, tailored to the particular problems and capabilities in a particular country or city—one size does not fit all.

- In virtually every serious effort to reduce motor vehicle pollution, cleaner fuels—especially unleaded gasoline and lower-sulfur diesel fuel—play a critical role.

CONCLUSIONS

The development of petroleum-powered motor vehicles has truly revolutionized society over the past century. The benefits of increased personal mobility and access to goods and services previously beyond the grasp of individuals cannot be denied. And, yet, the relentless growth in motor vehicle use has a dark downside that many have been slow to acknowledge, including a broad array of adverse public health and environmental impacts.

The environmental damages caused by motor vehicle emissions are no longer debatable, and on a global basis they are increasing. The cars, trucks, and buses that make life better in so many ways emit more than 800 million tons of carbon per year. From their tailpipes come virtually all of the carbon monoxide in the air of our cities. Less directly, they cause much of the ozone and smog. And motor vehicles play a significant role in stratospheric ozone depletion. All of these pollutants contribute directly or indirectly to global warming.

Over the last 40 years, the global vehicle fleet has grown from under 50 million to more than 500 million, and there is every indication that this growth will continue. Over the next 20 years, the global fleet could double to 1 billion. Unless transportation technology and planning are fundamentally transformed, emissions of greenhouse and other polluting gases from these

vehicles will continue to increase, many relatively clean environments will deteriorate, and the few areas that have made progress will see some of their gains eroded.

The worldwide challenges that these problems pose for motor vehicle manufacturers and policymakers are unprecedented. Nothing less than a revolution in technology and thinking at least as profound as the initial mechanization of transportation is needed. Manufacturers will come under increasing pressures to produce petroleum-powered vehicles that are ever cleaner, safer, more reliable, and more fuel-efficient. At the same time, they will need to develop new kinds of vehicles that will emit no pollution whatever. The amount of capital needed to accomplish these goals will be large and, making matters even more difficult, the pressures for these changes will arise not so much from traditional market forces but from public policies adopted in response to climate and other threats.

While development of appropriate policies and technologies develops, countries can benefit from adoption of currently available policies and technologies. Various steps can be taken to reduce air pollution emissions from motor vehicles. These include incentives to remove older, higher-polluting vehicles from the road; tightening new vehicle emission standards for nitrogen oxides, volatile organic compounds, and carbon monoxide; developing and using cleaner fuels with lower volatility and fewer toxic components; enhancing inspection and maintenance (I&M) programs, including inspections of antitampering emission-control equipment; and extending the useful life for pollution-control equipment to 10 years or 100,000 miles rather than the current 5 years or 50,000 miles. The potential overall impacts of tighter standards, enhanced I&M, and extended useful life are especially significant because they help ensure that the benefits of clean-air technology will persist for the vehicle's full life.

Additional reductions in vehicular emissions can be achieved by reducing dependence on individual cars and trucks and by making greater use of van and car pools, buses, trolleys, and trains. Improving urban traffic management by installing synchronized traffic lights, reducing on-street parking, switching to "smart" roads, banning truck unloading during the day, and so forth can also improve transportation system efficiency.

Providing efficient, convenient, and affordable public transportation alternatives worldwide would produce multiple benefits. For every 40 persons who get out of their cars and onto a bus for a 10-mile trip to work, some 50 to 75 pounds of carbon are not emitted to the air. Greater use of public transportation would reduce congestion, cut fatalities and injuries from traffic accidents, and greatly improve air quality. Fortunately, such transportation improvements can be phased in over time. For example, roadways initially dedicated to bus traffic can later be upgraded to light rail or heavy rail if circumstances warrant.

THEME PAPER 3: MUNICIPAL TRANSPORT MANAGEMENT: A DOMESTIC VIEW

WU YONG, WANG JIANQING, AND YAO ZUKANG [1]

Transport is one of the basic demands of our daily life. With the growth of urbanization, all social activities, such as industry, commerce, technology, culture, education, public health and so forth, are increasingly concentrated in the urban area. Urban transport thus becomes one of the basic demands of modern society. It has two distinctive characteristics. First, demand for transport is desired by every member of a society. Second, it is only a derivative of other demands. Transport in its own right is not a final product for consumption but primarily a means to link the consumers and producers of goods and services together. Because of these characteristics, urban transportation is one of the areas of heavy government intervention around the world. Governments intervene to solve urban transportation problems and to meet the increasing demand. Their efforts aim at achieving efficiency in resources allocation, increasing productivity of the society, improving quality of living in urban residential areas and enhancing social equality. The form, degree and instruments of government intervention significantly influence the scale and level of urban public transportation development and the quality of urban transport services provided to different social sectors and residents; in particular, the low-income residents.

Through many years practice and efforts, Chinese government has accumulated some experience in urban transport planning, construction, management, and regulation and policy-making. As China is now in transition from a centrally-planned-economy to a market economy, many changes have been taken place in the economic mechanism, sector structure and people's daily life. Accordingly, the structure and practice of urban transport management, formalized in the long period of the planned economy, are also in the process of transformation. They have to be reestablished based upon market principles. In the meantime, China's GNP has been growing at a 10 percent annual average rate since the reform and opening to the outside world. The living standard of city residents has been rising rapidly. In addition, the urbanization in China reached 22 percent in 1994 from a low 8.3 percent in 1978. Next only to India, China has now the second largest urban population in the world. Those factors contribute to a sharp rise in demand for urban transport. The volume of urban public passenger-transit increased from 13.2 billion passengers in 1978 to 29.2 billion passengers in 1994. The number of motor vehicles in urban areas increased from 9.5 million in 1978 to 5.6 billion in 1994. The rapid growth of economy and society, together with the reform and the open-door policy, pose a new challenge to the urban transport sector and provide an excellent opportunity for speeding up the urban

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transportation development as well. It is therefore very important to establish an urban transport management system fitting into China's development stage and country specifics, and to learn from other countries. Only by doing so will China be able to meet its increasing demand for urban transport to a reasonable degree and to ensure a healthy development of urban economy and society.

This paper first gives a brief introduction to the existing urban transport management system in China; then it accesses the role of government in and its policy impact on urban transportation. Finally, it discusses the reform of urban transport management system.

THE EXISTING URBAN TRANSPORT MANAGEMENT SYSTEM

Urban transport is an integrated part of our society and economy. It can be further divided into two subsectors: intracity transport and intercity transport. This paper focuses on intracity transport.

Intracity transport consists of three parts:

- Infrastructure, including roads, rails, bridges and so on.
- Urban transport operation systems. They include: (a) passenger transport by means of bus, trolleybus, taxi, ferry, rail and subway; privately owned motorcycles and bicycles; and (b) urban freight transport.
- Urban traffic control system. They comprise traffic lights and signs; collection, transfer and analysis of transport data; and traffic control system.

The setups of the institutional framework and the corresponding administrative purviews of each institution in urban transport sector are basically based on the divisions mentioned above. The urban transport administrative management is shared between the Ministry of Construction and the Ministry of Public Security and their subordinates at the provincial and municipal levels. The Ministry of Construction is mainly in charge of road construction and urban public transport; and the Ministry of Public Security is primarily concerned with the traffic control system.

Evolution of the Urban Transport Management System

China's urban transport management system is closely related to the whole economic management system. Its development can be divided into three periods: the planned economy period, the planned commodity economy period and the socialist market economy period.

The Planned Economy Period, 1949-78. During the planned economy, namely from the founding of the People's Republic of China in 1949 to the beginning of the reform and the open-door policy in 1978, China's urban transport management system was constructed upon the model of a centrally planned economy. Therefore, the urban transport management system was highly centralized and the municipal government had very little autonomy. Major issues, such as selection of investment projects, financing of construction projects, making of annual plans, price policy and taxation of the transport sector, were all under the control of the central

government. In addition, governments were directly involved in the operation of public transport operations. Municipal governments were in charge of the urban transport enterprises, including transport design institutes, road construction companies, maintenance companies and public transport companies. They also directly controlled the revenue and the expenditure of these enterprises. This system had led to the sluggish growth of the urban transport sector in China because (a) the lack of autonomy discouraged the local government from taking initiatives; (b) heavy government intervention at the enterprise level prevented the urban transport sector from operating as an independent commercial entity, leading to gross inefficiency. From 1952 to 1978, while the number of motor vehicles in urban areas increased 20 times, bicycles increased over 100 times, the volume of public passenger transport rose 5.4 times, and urban population increased 1.9 times, the road area per capita only increased 1.7 percent, and the number of buses per 10,000 people only increased 2.9 times. As a result, the urban areas are now facing the problem of serious traffic congestion, increasing traffic accidents and decreasing efficiency of public transport.

The Planned Commodity Economy Period, 1978-93. Since 1978, China has adopted the reform and open door policy. This period can be divided into two. First, the planned commodity economy was from 1978 to 1993. During this time, reform of the urban management system was mainly based on the principles of a planned market economy. To solve the problem of mixed government and enterprise functions, and to break the monopoly of state-owned enterprises in the urban transport industry, China formulated a policy based on the principle of "unified planning and unified management," and various forms of operation with state-owned enterprises playing the dominant role, complemented by collective and privately owned enterprises. The policy of separating the Government from construction and maintenance companies in financial matters was also implemented in urban road development. As a result, government intervention was gradually reduced during this period. And the enterprises had been left alone, to a large degree, to operate by themselves. The central and provincial governments had also gradually granted more autonomy to the municipalities, such as decisions for investments and establishment of institutions. In addition, with reforms in public finance and taxation, a new tax on urban construction and maintenance was imposed. The tax revenue, collected by the municipal government, was earmarked for urban public facilities including urban transport. The People's Congress also granted local governments (provincial governments and some large cities) power to make local laws and policies. This enabled the local governments, who had a better knowledge of their communities, to make laws, in line with the national laws and policies, and to regulate the financing of transport projects and management of the transport system. To sum up, during this period of time, urban transport as mainly the municipality's responsibility had become a widely held view, and accordingly the municipality gained more autonomy. And many reforms of investment and management systems took place. Together they effectively promoted the urban transport development. From 1978 to 1992, the total investment in urban transport reached Y 42 billion, which was 12 times of the total investment between 1952 and 1978.

The Socialist Market Economy Period, 1994 to date. In the document of "Decision on the Establishment of a Socialist Market Economy System, 1993," the Central Committee of Chinese Communist Party gave out directives about a socialist market economy in China. The Government has since embarked on a series of reforms in administration, public finance, taxation, price system and so on. The administrative institution reform is based on the directives

given by the Eighth People's Congress. The main idea is to separate the function of the government from that of the enterprise, streamline the administration and enterprises, and increase efficiency to meet the demand of estabishing a socialist market economy. Following those principles, governments at all levles have engaged in administrative institution reform. The same things are happening in the urban transport management system.

The Existing Management System

The Functions of Central and Provincial Government in Urban Transport. Since institutional reform in 1994, the Ministry of Construction and the Ministry of Public Security have been the two central government agents in charge of urban transport. Their subordinates, the Construction Commissions and Public Security Bureaus, hold these responsibilities at the provincial level, respectively. Dictated by the State Council, their main purviews and prior responsibilities are as follows:

- The Ministry of Construction is mainly responsible for urban road infrastructure and public transport operations including buses, trolleybuses, taxis, subways and ferries. It is in charge of making policies and strategies for the development of urban transport, making the long-term and mid-term plans and drafting a reform plan and related laws, regulations, technical norms and standards and technical policies.

- The Ministry of Public Security is responsible for road safety and traffic control. It is in charge of drafting laws and regulations on road safety and making related long-term and mid-term plans and policies.

The same division of purviews and responsibilities applies to their subordinate institutions at the provincial level; that is, the Construction Commission and the Public Security Bureau.

The Ministry of Finance and the State Planning Commission are involved in tax legislation and price policy related to urban transport, as well as the identification and approval of large-scale transport projects.

The Functions of the Municipal Government in Urban Transport. The municipal government has two administrative bodies in charge of the urban transport, the construction system and the public security system.

(a) **Construction System.** There are two different institutional setups of the construction department in urban transport management. The size of city dictates which framework will be used.

The first institutional framework consists of a two-level management system: the Construction Commission is mainly in charge of coordination; and the tasks of urban transportation management are carried out by the related bureaus. This model applies to more than 80 cities. They are the three central-government-directly-administrated cities (Beijing, Shanghai and Tianjin), all provincial capital cities, cities with more than 1 million population and another 16 cities singled out for planning purposes. The respective functions of the Construction Commission and its affiliated bureaus are as follows:

- As part of the municipal government, the Construction Commission is mainly in charge of macrocontrol and coordination. It is directly responsible for making strategies, policies and plans for the development of urban transport of the city, drafting the annual plan and land use plan; allocating funds, identifying construction projects, making financial plans (budgeting and funds raising) for those projects, organizing the implementation of large- and medium-scale projects, checking and supervising the work of related bureaus, licensing and verifying the qualification of transport design institutes and construction companies. It coordinates related administrative organizations such as the Planning Commission, the Bureau of Finance, the Bureau of Public Security, the Bureau of Land Management and the Environment Protection Bureau in matters of pricing and fee setting, traffic control, land use and environment protection. It also coordinates and aligns some overlapped works in planning, construction and management among its subordinate agencies, namely the Urban Planning Bureau, the Public Utility Bureau and the Urban Civil Engineering Bureau.

- Usually the Urban Planning Bureau, the Public Utility Bureau and the Urban Civil Engineering Bureau are the main organizations under the Construction Commission. However in some cities, the Public Utility and the Civil Engineering Bureaus are streamlined into one single body called the Bureau of Urban Construction.

- **The Urban Planning Bureau**. Its main responsibilities are drafting the overall plan for the urban transport system, which includes the passenger transport, freight transport and road system plans; the land use plan for transport, technical norms, the plan for plane roads and the plan for elevated roads. It issues the license for land use, urban planning and construction design of transport projects in order to ensure efficiency in land use and rationality in the layout of urban transport system.

- **The Urban Civil Engineering Bureau**. It is in charge of the construction and management of urban road system, which include drafting the long-term, mid-term and annual plans for the road construction and maintenance, implementing those plans, making the related policies and regulations. Acting as the designated owner of the urban road system for the state, it collects fees such as toll fees from bridges and advertisements; issuing license for special use of road space, managing the road construction and maintenance companies.

- **The Public Utility Bureau**. It is responsible for the construction and the management of urban passenger transport system, including taxis, buses, trolleybuses, rail transit and ferries. Its main tasks are: making related policies, long-term and mid-term plans; organizing the construction of related projects; managing the urban passenger transport market; accessing and verifying the qualification of the urban passenger transport enterprises and operators; granting the operation license; supervising the quality of the

service and dealing with the complaints from passengers; managing the related public transport companies such as the bus company, the trolleybus company, the subway company and the ferry company.

The second institutional framework only has one-level management. It applies to the small- and medium-size cities. In this framework, only one institution, either the Construction Commission or the Construction Bureau, takes all the responsibilities mentioned above.

(b) **The Public Security System.** Each city has a Public Security Bureau. It is responsible for traffic control and administration of motor vehicles. Its main tasks consist of : traffic control; enforcement of urban transportation laws and regulation, organizing and implementation of any overall improvement plans for the traffic control system; construction and maintenance of the traffic control facilities; administration of driver license and traffic accidents, registration of motor vehicles and inspection of motor vehicle safety.

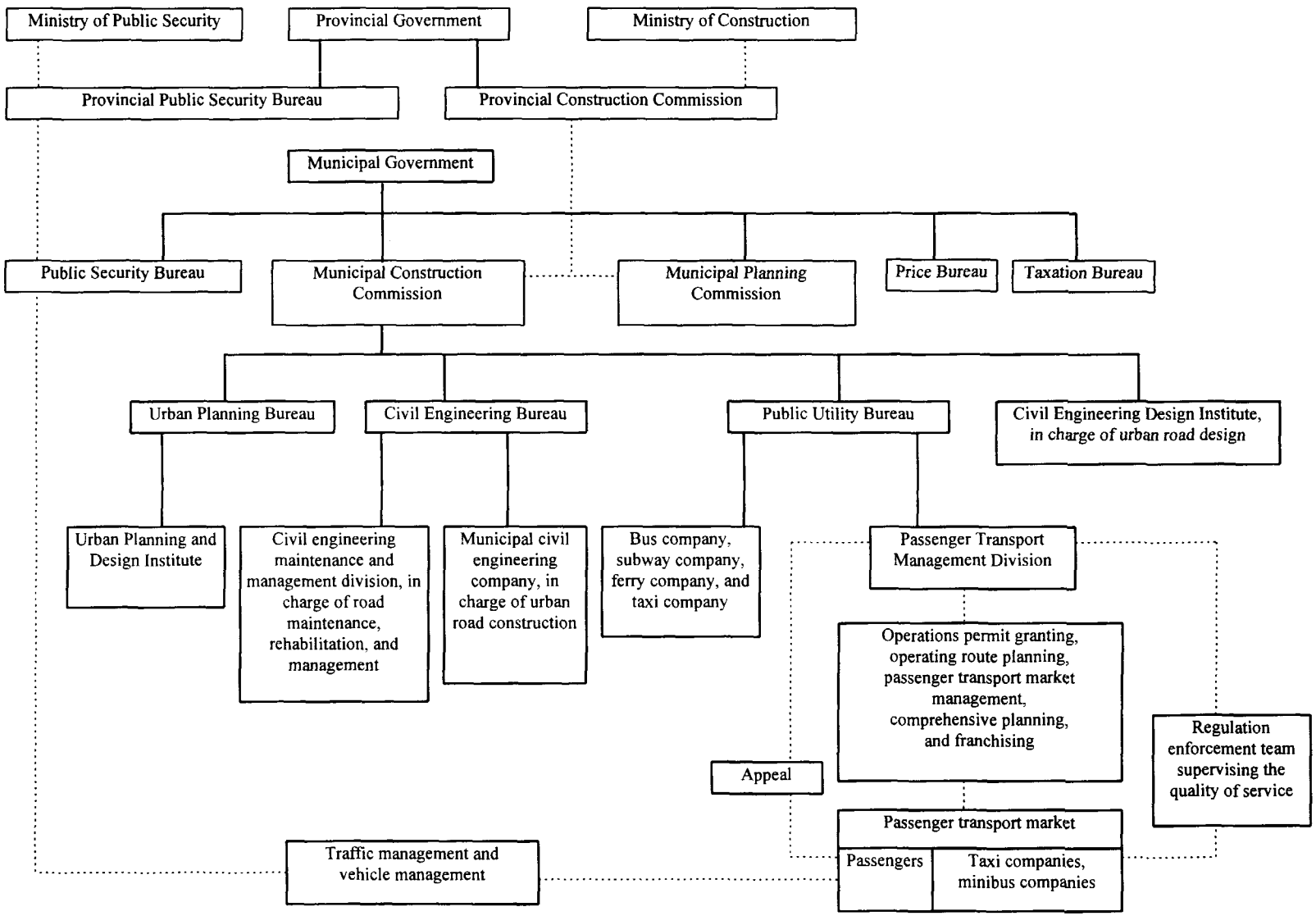
The Respective Purviews and Functions of the Central Government, the Provincial Government and the Municipal Government. According to the existing Chinese transport management system, the central government is mainly responsible for making development strategies, long-term and mid-term plans, laws and regulations, industry policies, technical norms, tax laws and tax rates. The operation of the urban transport system is the main responsibility of the municipal government. Two exceptions are the identification and approval of large- and medium-size projects and the use of foreign capital as they are closely related to the nation's development and financial ability, therefore involving the central government in the decision-making. A typical administrative institution system in urban transport for cities with more than 1 million population is shown in Figure 1.

THE CHARACTERISTICS AND EVALUATION OF THE EXISTING MANAGEMENT SYSTEM

Characteristics of the Existing Management System

China's urban transport is controlled by the central government at the macro level and directly managed by municipal governments. While allowing the central government to direct the development of urban transport through macrocontrols and incentives, this system gives the reins to municipal governments. It enables a municipal government to make development plans for its urban transport based on the city's specific economic and social development level, demand for the urban transport and financial ability. Because intracity transport is the major component of urban transport, and the factors affecting its development are quite different for each city, such as the economic development stage of the city, the financial ability of the municipal government, the geographic layout of the municipality, the structure of its industry and the income level of its residents and their consumption patterns, it is therefore very difficult, as well as inefficient, for the central government to control the local development plans and all the investment programs, and be financially responsible for those projects. It is rational to have municipal governments play the major role, to grant municipalities sufficient autonomy in urban transport development, and to have the central and provincial government concentrate on the macro control and balance issues.

FIGURE 1: INSTITUTIONAL ARRANGEMENT FOR URBAN TRANSPORT ADMINISTRATION AND OPERATIONS
(Cities with more than 1 million population)



Based on the principle of multiagency participation and balanced development, the strategy-making and its implementation in China's urban transport development are the result of coordination and participation of various parties from different levels, which help to avoid making major mistakes in development strategy. Here we can have a better understanding through a case in point, the implementation of *The Integrated Improvement Plan of Urban Transport*. This plan aims at increasing transport efficiency, reducing traffic accidents and alleviating environment pollution. The central government only requires that all municipalities implement this plan and give out directives in principle through regulations and policies. The detailed plan is made by the municipal government according to each city's specific situation. First the detailed plan is proposed by the joint working team comprising experts in urban planning, economics, sociology, engineering and transport. Next the city government organizes different agencies and departments to discuss the draft. Then the draft is sent to the municipal government for final review. After the approval of the municipality, it is formulated as an official plan for the Public Security Bureau, Construction Commission and other related bureaus under the Commission to carry out. Plans made through this process not only follow the principles of the integrated improvement policy, but also incorporate city specifics and balance the interests of the parties. As a result, they achieve higher economic efficiency and better social benefits.

The urban transport system is currently in the process of reform based upon socialist market economy principles. In this long period of transition, the institutional framework will improve through learning by doing and absorbing foreign experience. At present, government institutions in urban transport focus on their restructure to improve efficiency through streamlining and simplifying. The government functions and intervention instruments are also in transition. Instead of the giving out administrative orders, the emphasis now is on legislation, administrative and economic incentives. The change is seen from direct intervention to indirect intervention and from management by administrative ministries to management by the industry sector and community. The reform poses a challenge to all levels of government, in particular, the municipal government. The reason is that urban transport system reform at the municipal level involves reforming a large number of municipal-government-directly-controlled enterprises: the design institutions, the construction and the transit companies.

Assessment of the Current System

The major problem of the current system is the interweaving and overlapping of government functions and enterprise operations, which is typical of the planned economy in the past.

First, we look at the municipal government. It has three bureaus in charge of the urban transport: the Urban Construction Bureau, the Civil Engineering Bureau and the Public Utility Bureau. These organizations have two identities under the current system and therefore have two different objectives. On one hand, as the social planner and regulator, their objective is to maximize the social welfare through provision of transport services and regulation of market; on the other hand, as the owner of the transportation enterprise, they have to seek either maximum profit or growth in revenue. However, those two objectives are not always compatible with each other. Often they are in direct conflict.

This conflict is first clearly illustrated through the huge loss-operation of the government-owned transport enterprises. China's urban passenger transport is dominated by the state-owned enterprises with 75 percent of market share (in passenger volume). To date, Chinese cities have 90,000 buses (running along 180,000 route-kilometers with 28 billion passengers per year) and 400,000 taxis. Of this total, the government-owned enterprises have 58,000 buses (running along 65,000 route-kilometers with 21 billion passengers per year) and 10 percent of the total taxis. To achieve the social welfare objective, that is to offer low price services to residents, especially the low-income groups, the Government often sacrifices the financial health of government-owned enterprises, who are obligated to offer services at prices much lower than the cost. As a result, the state-owned enterprises produce huge financial losses. Their survival crucially depends on government subsidies. In 1993, 70 percent of enterprises were loss-makers whose loss amounted to Y 1.7 billion. In contrast, those nongovernment-owned transport companies fully operate along market principles; for instance, their buses do not run along routes without many passengers, and therefore most of them make money. This is one of the reasons that nongovernment-owned enterprises have more advantages over the state-owned enterprise in competition. However, under the current system, even if the nonstate enterprises operate in the unprofitable market in the place of the state-owned enterprises, they will not be eligible for the same subsidies from the government. In addition, the easiest way to achieve the social goal of the government in urban transport is through the state-owned companies, which makes it more difficult to leave those enterprises to the market.

The second example of conflicting interests is in road construction, where the government as the regulator of market impairs competition when it puts its interest as a competitor first. In recent years, municipal governments together invested about Y 20 billion for road construction annually, which accounts for 2 percent of the total investment for fixed assets of the country. All these construction projects were contracted to the municipal government-owned construction companies without bidding. Because every municipality has a road construction company that can get contracts directly from the government, the lack of competition and the seasonal fluctuations in job demand result in the inefficiency of those companies.

Second, we evaluate the urban transport system from the point of view of optimal control. The administrative setups of urban transport institutions follow the division of the urban transport sector; that is, road, passenger transport and traffic management. However, much decision-making is in the hands of different ministries and their departments, for instance, project financing, license issuance, identification and approval of projects are in the hands of different administrative bodies. This system is characterized by the interweaving and overlapping of organizational purviews and responsibilities. It leads to situations where for one administrative decision made, there are multiple agencies having the right to veto. Because each administrative body has its own focal point, it is sometimes very difficult to reach consensus; this greatly decreases the efficiency of the management system.

The fares for public transport give an example. In China the prices of public transit services are under the government's supervision and the level of public transit prices is an important component of the consumer price index. Urban public transport has been considered as an important social welfare for residents, and the fares have been kept low for several decades. This practice results in serious chronic loss for state-owned transit enterprises, which

becomes a great financial burden to the city government. For instance, Beijing municipality subsidized Y 800 million for public transport in 1994. The subsidies for buses and trolleybuses reached Y 520 million in 1993 for Shanghai municipality. The loss-making is caused by policy as well as by mismanagement. However, too often the policy-induced loss is used as a cover for mismanagement. Mismanagement and low quality of services are closely related to government-enterprise monopoly and thus a lack of competition. It is therefore critical to introduce competition. Accordingly, the Ministry of Construction promulgated a directive in May 1994, "On the Reform of the Management of Buses and Trolleybuses." The focal point of this directive is to introduce competition by establishing a rational price system. It allows an enterprise to sign a contract with the government letting the company operate by itself at a predetermined price level, which is estimated to be reasonable and enables the enterprise to realize a certain rate of benefit. In unforeseen circumstances, if the price is found to be responsible for profit loss, it will be compensated by the government, or readjustment of price will be made. Now the door to a better system is open; however, the implementation of this policy has to be carried out by each municipality. More than willing to implement the policy, the Construction Commission in each city made an action plan accordingly, but finally failed to reach a consensus among the Price Bureau, the Finance Bureau and the Planning Commission. The Price Bureau is concerned with the policy's impact on the price index; the Finance Bureau worries about the possibility of increasing the subsidy in case the price could not be raised after the contract is signed. This reform was finally aborted just because it is very difficult to get agreement among so many departments, although its implementation will bring great benefit to the economy and society as a whole.

The central and provincial governments are responsible for macro control in urban transport management. The macro control has two main tasks: providing guidelines in the urban transport development and balancing the regional development. The latter focuses mainly on support for development in the poor cities. However, the lack of policy instruments, in particular the lack of financial resources, makes it difficult to accomplish these tasks fully.

The insignificant impact of the central government's directives on urban road construction gives an example of the ineffectiveness of the central government's macro control. In the past 10 years, with rapid urbanization, the roads have increasingly been crowded. The low efficiency of urban transport, largely caused by road congestion, becomes a bottleneck in the development of the national economy. To solve this problem, the State Council designates urban transport infrastructure as one of its key support areas in the nation's infrastructure construction sector from now to a certain time in the future and requires the related ministries to draft action plans. This industry policy is elaborated in a 1989 State Council document, "The Current Sector Policy and the Key Sectors." Following the State Council's directives, the Ministry of Construction promulgated "The Action Plan for Implementation of the Sector Policy for Urban Road System." It specifies the mid-term and long-term targets for urban road development and six measures to ensure its achievement. These measures are: making laws and regulations; enhancing administration; increasing investment; accelerating land development; introducing advanced technologies and increasing the vitality of the enterprises. These measures have to be carried out by the municipalities. However, the central government does not have any policy instruments, either economic or administrative, to ensure the implementation of these measures. As a result, they have not been carried out effectively.

It is obvious that the level of development in urban transport is much higher in affluent municipalities than in poor ones. Although this difference is caused, to a large extent, by the difference in their economic development, the central and provincial governments have done little to assist poor municipalities because of a lack of financial resources. The result is an increasing gap in urban transport development between those two groups of municipalities, which makes it even hard to achieve balanced national development.

LEGISLATION AND ENFORCEMENT OF LAW AND ESTABLISHMENT AND IMPLEMENTATIONS OF A POLICY SYSTEM IN URBAN TRANSPORT

Urban transport management, from the macro point of view, depends on the establishment and amplification of the system of law and the system of related government policies. At the micro level, it is influenced by the strength of administrative bodies and law enforcement agencies, as well as the rationale and effectiveness of procedures in practice. In addition, a key factor is the work efficiency of each government agency concerned and the effective coordination of various government departments. This is especially important under current circumstances where the system of law is still in a preliminary development stage.

System of Laws and Regulations

The system of laws and regulations includes all laws, regulations and articles of government departments. At the present, the system of laws and regulations in urban transport management in China is not well developed. A response to the rapid economic and social development of the nation, "the Urban Planning Law," passed by the National People's Congress in December 1989, is the first law governing the urban development plan and defining the scale and nature of municipalities in the development of the national economy. The law specifies that urban planning should meet the needs of urban transport management, and a comprehensive urban transport system plan is an important element of urban planning. The law clearly states the guiding principles for urban road construction and urban transport planning in the context of a city's comprehensive development. However, its effective implementation still depends on the related laws and regulations, as well as the law enforcement agencies and administrative institutions.

Road transport includes the construction, operation and management of roads and other related facilities. It involves several government departments, such as Urban Construction and Public Security. The government promulgated "Regulations on Road and Transport Management" in 1988, which is made at the second level of the law system. To maintain order and public safety in transportation, the regulation formulated rules governing traffic signs, signals, conducts of drivers and pedestrians, as well as the administration of vehicle safety. In addition, it specifies measures to ensure the operating capacity of roads. Up until now, the Law and the Regulation mentioned above are the only laws and regulations in the law system governing road transport.

This underdeveloped law system cannot meet the needs of road and transport management, which is enormously broad and complex. First the existing system of laws and regulations results in many cases where law enforcement agencies and judges have no related law or regulation to follow. Second, the sharp rise in transportation volume and the change in

transportation structure, closely related to the transition from a planned economy to a market economy and rapid economic development, creates enormous demand for transport management. Especially, with the unprecedented social and economic growth in the urban area in recent years, many new problems emerge, challenging road transportation management. The system of laws and regulations at present is simply not adequate to meet this demand. Third, since the promulgation of the Three Decisions by the State Council regarding the restructuring of the ministries, the institutional framework has gone through some reforms. As a result, some changes have occurred in the division of responsibilities among administrative departments and law enforcement agencies. It is therefore necessary to clarify the judicial power, the executive power as well as the administrative and enforcement procedures of laws and regulations, keeping up with the changes in road transport management and keeping the government policy in line with the system of laws and regulations.

The less-than-ideal performance of law enforcement has also adversely affected road transport management. First, most municipalities have no detailed action plans for effectively carrying out existing laws and regulations enacted by the Congress or the central government. The management of road transport usually follows local administrative orders, directives and policies, which have no legal authority and are thus not effective. Second, the lack of financial resources, as a result of the existing government fiscal structure, and the less-than-satisfactory quality of law enforcement agencies contribute to some corruption cases and offenders receiving lighter-than-commensurate punishment.

In sum, China's urban transport management is still far from a satisfactory development stage. At present, the Chinese government is resolute to learn from other countries, in particular, Singapore's advanced management experience. Every effort in this field will be made to establish a sound and adequate system of laws and regulations for road transport in China.

Establishment of a Policy System

With an underdeveloped system of laws and regulations, it is important to establish and amplify the policy system and enhance its implementation to manage the urban road transport effectively. The current policy system comprises three levels.

- **The State**. The central government formulates a comprehensive guideline for road transport development. This guideline focuses on coordination of the relationships between the road transport sector and other related departments, keeping development of the road transport sector in line with overall social and economic development of the country.

- **The Ministries, Mainly Public Security and Transport, and Urban Construction**. Each of the related administrative departments of government formulates sector development policy and plans according to its administrative responsibilities.

- **Implementation of the Policy**. The second and the third levels are closely related to each other.

The National Macrodevelopment Policy. After the Third Plenary Session of the Eleventh Central Party Committee, China embarked on economic reform in rural areas, which accelerated urbanization. However, underdevelopment of the urban infrastructure, of which road transport is an important component, becomes a serious setback for urban social and economic development. Increasing attention from the government has been brought into this area.

In 1987, the State Council promulgated "The Directive on Strengthening Urban Construction Work." It recognizes that infrastructure is a prerequisite for national economic development and its opening to the world, a foundation for production and a basic need of daily life. It therefore requires that urban construction follow the reform and open-door policy guidelines. It demands the integration of urban infrastructure projects into the municipality's annual, mid- and long-term development plans, in which roads, bridges, and public transport infrastructure projects should be managed in a harmonized manner. The directive also specifies the road transport system as the focal point in urban construction, demanding that every effort be made to develop public transport and to alleviate urban traffic congestion. It encourages big cities to gradually develop light rail mass transit if circumstances permit. Finally, it classifies planning, construction and management of a municipality as the major responsibilities of municipal government.

In "The Decisions on the Key Points of the Current Sector Policy of 1989," the State Council formulated policies regarding adjustment of the industrial structure. It serves to facilitate the macro control of the national economy and to maintain stable economic development in the long run. The Decision also stresses public utilities, including the sewage system, pollution control and urban public transport, as one of the primary areas in the development of infrastructure in large- and medium-size municipalities, which significantly affects production and people's daily life in the urban area.

"The Suggestions on the Formulation of a Ten-Year Plan for the Development of the National Economy and Society and Eighth Five-Year Plan, December 23, 1989," passed by the Tenth Plenary Session of the Thirteenth Central Party Committee, points out that national economic development should focus on adjustment of the existing economic structure, development of the agriculture sector, basic industry sectors and infrastructure. Urban development and infrastructure development are emphasized in its industry policy. It states clearly that "the availability of public facilities should be improved. Synchronizing with the urban residential development, a comprehensive development plan should be in place, which includes commercial network and educational, medical, cultural and sports facilities. The development of infrastructure should be strengthened, including water supply, sewage system, heating supply, road, transport and telephone. Therefore, people's daily life will have more conveniences and the economy development will reach a Xiao Kang level in the 1990s (Xiao Kang mainly refers to a living standard with adequate food, housing and other basic necessities)."

"Resolutions on Speeding up the Development of Tertiary Industry," promulgated by the Central Party Committee and the State Council on January 16, 1992, gives a renewed importance to the tertiary industry, of which urban public facilities and utilities are important components. It indicates that socialized services and people's living standard are very important to "Xiao Kang." And development of the tertiary industry is a significant criterion in measuring the stage

of social and economic development. It recognizes that development of the tertiary industry gives a strong stimulus to development of the national economy. It points out that one of the objectives in the development of a tertiary industry is to develop a comprehensive socialized services sector, which includes urban public facilities and utilities. Because not only is the latter a basic subsector of the tertiary industry affecting every sector of the economy, but also it is a prerequisite, as well as an impetus to, overall economic development.

In "The Basic Ideas on the Tertiary Industry Development Plan, 1993," the State Council points out that "the development of municipal public utilities and facilities plays a very important role in mitigating the shortage problem in transportation, improving urban investment as well as living environment, and promoting urbanization." It sets the development objective as "to gradually establish a network of urban arterial roads and a fairly complete system of public transport facilities and urban public utilities; and in the large cities, to establish gradually high-speed rail transport and high-speed road system."

In 1994, in "The State Industrial Policy Principles in the 1990s," the State Council emphasizes that the development of urban public utilities and services should be accelerated. The guidelines are "an integrated way in planning, rational layout of location, adroit application to local specifics, comprehensive development and consolidated construction."

Together, all of these policies provide a basis for the planning, construction and management of urban transport.

Pricing Policy of Urban Transport. The pricing policy system of urban transport is formulated jointly by the public security department and urban construction department and ratified by the municipal government. Generally, the system includes freight transport pricing, passenger transport pricing (public transport pricing) and other pricing systems. From the management point of view, the transport pricing policy is used as an instrument to influence the demand and supply of the urban transport volume and to mitigate the problems in urban transport.

(a) The Pricing Policy of Freight Transport. Chinese cities had gone through a development stage as the industrial production base. Now they have reached a stage to develop as multifunctional cities. Along with this transformation come fundamental changes in urban industrial structure. The share of freight transport in urban transport has been declining. At present, a significant part of freight transport in cities is transit transport. The management of freight transport basically relies on administrative measures, such as the timing and usage of roads, rather than on pricing policy, for two reasons.

First, the pricing policy of any particular city is not effective in managing its urban freight transport. The reason is that freight transport opens up to the whole country, the volume as well as the mode of freight transport do not depend much on the pricing policy of one city. They are rather influenced mainly by overall national economic development and strength of the market mechanism in the whole economic system. So freight transport management for any particular city depends heavily on administrative controls, and the effect of price adjustment is very limited.

Second, in the freight transport system, the role of value has a small influence on the adjustment of freight transport for intracity freight transport. Intracity freight transport is not a highly socialized sector. It has its own internal service system and is basically at a stage of self-reliance and self-sufficiency. In view of the volume, freight transport only represents a small share of total transport in large- and medium-size cities. This is because the industrial structure in the large and medium cities is basically rational in relative terms, and passenger transport dominates transport flow arising from economic and social development. In the smaller-than-medium-size cities, especially the small cities, freight transport accounts for a large share of total transport volume and the passenger transport (mainly public transport) system is incomplete. The reason is that the smaller-than-medium-size cities usually have an underdeveloped service sector as the primary and secondary industries dominate the economy, and the small cities have yet to totally break away from the agricultural economic model. However, the traffic problems are not very serious in these cities, and at the low level of their economic development, their economies are of self-reliance and self-sufficiency; it is thus not urgent to formulate a transport pricing policy.

Taking feasibility and reality into consideration, the pricing policy of freight transport, at present, is placed secondary in China's urban road transport policy system.

(b) The Pricing Policy of Passenger Transport. The pricing policy of passenger transport is an important part of urban transport management. It consists of public transport and private transport. Public transport plays a very important role in the whole urban transport system. Therefore, the formulation and adjustment of pricing policy for public transport directly affect a city's traffic conditions. For a given traffic flow, changes in transport structure depend on the price level and service quality of different transport modes. It is therefore important to adjust public transport prices rationally in alleviating the traffic congestion.

Urban infrastructure facilities have always been taken as a public welfare sector because of its great social benefits. Though offering services to people's living as well as production, the fact that it is an input to production and itself a production unit is generally ignored. As a result, it is not subject to the adjustment of market mechanism. In China's every pricing system reform, public transport price is always listed under the government's control. It is therefore very difficult to make price adjustment policies in the sector. The process of formulating a price adjustment policy is as follows: the adjustment of public transport price is initiated by public transport enterprises and submitted to the pricing department. After the approval of the pricing department, the plan is submitted to the municipal government for review and ratification. In addition, the municipal government also decides the level of subsidy if price is not adjusted in a timely manner. Further, in some special cities, for instance Beijing, the municipal government has no right of ratification. Those cities have to submit the matter to the State Council for permission to implement through the state pricing department. In many cities, public transport prices have not changed for years. The low ticket pricing policy is the norm, which constitutes the fundamental principle guiding the pricing policy for public transport.

This low pricing policy is rooted on the inadequate understanding about public transport and, more importantly, on political considerations. In the adjustment of public transport price, considerations of social and economic stability always take precedence over economic and financial considerations, such as the financial position of public transport enterprises,

development level of the economy and inflation, etc. Therefore, it is more difficult to adjust public transport prices in times of high inflation. However, price adjustment based on the consideration of social stability can hardly reflect the real changes in demand for and supply by the public transport. Every incumbent municipal government is reluctant to touch the sensitive matter of price adjustment because of the implications for a broad social spectrum and its concern for the public's judgment of its administration. These considerations constitute the fundamental principle and basis for formulating and adjusting public transport price. By the same token, they are the root cause for the difficulty in adjusting public transport prices. Although in China, as well as around the world, public transport , as an enterprise of the public sector, often depends on government subsidies, it is rare to see a case of similar extent as China's, where an enormous gap between the ticket price and its real cost exists.

(c) Other Transport Pricing Policy. Other transport prices mainly refer to prices for static transport, namely, parking charges, etc. Besides dynamic transport, disordered parking contributes significantly to urban traffic congestion. Disordered parking is not only the result of a serious shortage of parking lots in the city, but also the result of lack of effective implementation of a price mechanism. In countries with outstanding performance of road transport management, there are strict regulations governing parking and fees. On the contrary, China has not formed an effective management mechanism for imposing and collecting parking fees and road use charges. Most cities in China have no restrictions on parking time and road parking areas, and free parking is the standard practice, contributing to the decline of effective carrying capacity of road. Under the situation where the construction of parking lots can hardly keep up with the demand, implementation of a paid parking policy is an effective way to mitigate problems in road transport. And many municipal governments are starting to utilize the price mechanism to improve the situation.

Bicycle transport takes up a fairly large share in urban transport. However, it is even more difficult to manage bicycle transport. On the one hand, every city gives its residents bicycle subsidies and the bicycle price is relatively low compared with an average resident's earning; on the other hand, bicycle parking and the parking fee scheme are a big defect in bicycle transport management. The parking charge is low. Disordered parking is a pervasive phenomenon and it is common to see bicycles occupying urban roads at discretion. These two factors encourage the development of bicycle ownership. Along with the development of bicycle ownership come the problems in bicycle transport common to many cities. Under the current situation in urban public transport and according to the characteristics of bicycles, it is difficult to contain the development of bicycle ownership using the pricing policy. The emphasis is still on the administrative management and its strengthening.

In sum, the market mechanism has not yet played its due role in the urban road transport management to date.

The Urban Transport Management Policy. In 1986, the Chinese government reformed the management system of road transport. The transport management departments under the public security system are designated to take charge of both intercity and intracity road transport management. Two government bodies are involved in urban transport. The urban construction system is mainly in charge of planning and construction of urban road transport facilities as well as road administration. The Public Security Bureau's transport division is

mainly responsible for maintaining the order of urban transport movement. This comprises the administration of driver licenses (including the qualification exam, license issuance, and annual review); inspection and registration of vehicles at purchase and at year-end; production, installation and maintenance of road transport management facilities; treatment of transport accident; organization, planning and implementation of intracity transport control programs, and the management of road use; and the daily administration of traffic or parking rules for motor vehicles and nonmotorized vehicles.

The urban transport management policies and measures have been adopted in two major areas: total transport volume control and traffic flow composition control. The measures adopted by many cities to control the total volume of traffic include the following:

- Priority is given to public passenger transport. Among all modes of urban passenger transport, public transport is the most effective one. It has large passenger carrying capacity and uses less roads. Therefore, prioritization of public transport development has been taken as the most important policy to relieve problems in urban transport both at home and abroad. This priority is first reflected in the industrial policy where public transport is taken as the basic key sector to be developed. In terms of transport administration, it gives priority to public transport in roads, signals and signs, etc. Although it is difficult for cities to implement public-transport-vehicle-only roads or lanes because of the many problems in road areas, structure, layout and network, every effort has been made to facilitate the public transport operation. In China, the priority policy for public transport mainly comprises the following measures: specifying areas forbidding the parking of nonpublic transport vehicles, giving preferential policies by the public security bureau's transport division to the opening of public transport operation roads and the setup of bus stations; buses can operate in both directions on one-way roads and have the right to make left turns at intersections without a left-turn penalty. All these measures are conducive to public transport development and help to relieve traffic tension.

- The second policy aims at lowering transit traffic volume and limiting the number of vehicles entering the city. Cities in general restrict the transit traffic to their peripheries. Passengers changing trains or buses as well as the exchange of freight transport are conducted outside the inner city; long-distance passenger transport and freight transport are planned to be gradually moved out of the cities in the ongoing amendment for urban planning. Freight transport that has to pass through city is facing restrictions in time and areas; for instance, freight vehicles are only allowed to pass through the inner city during nighttime. Shanghai's traffic control policy is a typical example. Its traffic control policy and regulation led to the formation of a traffic pattern in which the peak time occurs at night.

- The third policy is to contain the growth of motorcycle ownership. The fast growth of motorcycles becomes a main traffic problem in the taking off period of economic development in many cities. A motorcycle is a transport means categorized between the motor vehicle and bicycle. On the one hand, it is subject to the regulation and management of motor vehicles; on the other hand, it has the advantages of a bicycle.

It is thus difficult to manage motorcycle transport. In addition, motorcycles contribute more than their share to pollution and accidents. In fact, motorcycle ownership grows at a much higher rate than any other vehicles in every city that does not have official policies restricting its growth. Therefore, how to control the growth of motorcycles is an inevitable issue facing every municipal government in solving existing traffic problems and preventing serious traffic problems from occurring in the future. In cities that have suffered from a rushed development of motorcycles, strict controls are now in place. Guangzhou, Chengdu and some other cities have set a control target for the growth of motorcycles each year.

Measures are also adopted to reach a more reasonable traffic flow composition. The structure of traffic flow has two aspects. One refers to the composition of transport means, such as motor vehicles, nonmotorized vehicles and pedestrians. The structure adjustment in the composition of transport means is closely associated with the adjustment of total traffic volume, for instance, giving priority to public transport development and limiting the growth of motorcycles. Evenly distributing the traffic flow involves another aspect of structure adjustment, namely, the adjustment of traffic flow patterns in time and space.

Urban road transport is an integrated dynamic system. Any adjustment will directly affect the state of urban transport. Therefore, cities increasingly pay more attention to development of an urban road transport network. On the one hand, transport authorities actively introduce the use of advanced science and technology and install traffic signal control systems to collect data on the distribution of urban traffic flows. These help better distribute traffic flows over time, relieving traffic congestion of certain roads, and evenly distributing traffic flows in the road system. On the other hand, transport authorities encourage the construction of main roads and ring roads to absorb transport flow, and to balance area distribution of traffic. In addition, many other measures have been introduced, for instance, flexible work schedules to avoid the morning and evening rush hours, one-way streets, and restrictions on left turns. They are all effective measures to alleviate traffic congestion through adjusting transport flow structures across time and in space.

Urban Public Transport Policies. Many countries in the world give priority to the development of public transport, which is regarded as an important way to solve problems in urban road transport. In China's industrial policy, public transport is one of the key basic industries supported by the state. In line with the industry policy of the State Council and the implementation plan of the State Planning Commission, the Ministry of Construction promulgated an "Action Plan for the Implementation of Sector Policy for Urban Public Transport" in 1990, which is the guiding principle for the development of public transport.

Chinese government's industrial policy for public transport follows the guideline in "The Urban Planning Law." It clearly requires the formation and improvement of urban public transport plans and the integration of the transport plan into the comprehensive development plan of municipality. The development of public transport must keep pace with the redevelopment of old cities, development of new industrial and residential areas, and any large urban public facilities. Land planning and development should include plans for depots, parking yards, stations, transfer terminals, and ferry docks. To ensure effective implementation, urban public transport plans are required to be integrated into the urban economic and social development

plans, the comprehensive development plans of transport at all levels of government, and the investment plans of fixed assets. In capital construction of public transport, major support is given to buses, trolleybuses, ferries, parking yards, stations, and other related facilities. Governments should help to maintain a balance between the major capital construction programs and the annexed facilities. Thorough consideration should be given to the location and construction of stations and transfer centers to facilitate the change of transport carriers for passengers and the allocation of passenger flows. Finally, the construction of high-speed rail transit should be promoted.

Public transport offers services to production as well as to people's daily life. Its benefits are reflected as part of the economic gains of productive industries and commerce. Therefore, the social benefits of public transport usually outweigh its own economic benefits. Even so, it is still necessary to maintain a healthy economic performance to sustain the operation and development of public transport in the presence of its social benefits. Taking into consideration its social benefits, the Government has adopted a clearly-defined supportive policy for public transport. Generally speaking, in the short run (during the period of the Eighth Five-Year Plan), this policy comprises many protective measures. Its objective is to mitigate the current problems in public transport and its current state of backwardness. In the longer run (by the year 2000), a management and operation mechanism based on market economy principles will be gradually introduced, a rational pricing policy will be formulated and the quality of service will be dramatically improved. The concrete policies and measures are discussed as follows.

- The supply of rationed essential raw materials and energy, such as fuels, lubricants, electricity and those for maintenance should be secured. The supply quotas at controlled prices should be adjusted in a timely manner, along with the increase of vehicles in operation. When the prices of raw oil and refined oil were open to market adjustment in 1994, the Ministry of Construction, the State Planning Commission, the State Economic and Trade Commission and the China Petroleum Corporation jointly promulgated the "Directives on Supply of Fuel to the Major Enterprises in Urban Public Transport" to ensure the normal operation of public transport enterprises, which was also approved by the Administration Office of the State Council. The directive requires that the supply of fuel to major urban public transport enterprises be secured effectively. The municipal government must integrate the supply of fuel to the major urban public transport enterprises into the local supply plan of refined oil. Local fuel companies should also give them priority in supply. The fuels should be sold to them directly at wholesale prices to the maximum extent possible. These measures have facilitated the development of public transport enterprises.

- The responsible authorities, mainly the construction commission and the finance bureau, should jointly make a new policy authorizing the upward adjustment of fixed asset depreciation rates in the presence of inflation and thus the higher replacement cost, therefore alleviating the problem of insufficient capital funds for renovation and replacement of fixed assets in urban public transport enterprises. In addition, the rationed circulating capital funds should be integrated into the banking system's credit plan in line with state regulations.

- Every economic and budget measure should be taken to adjust fares rationally and subsidies should be provided to loss-making enterprises for losses caused by government policies. The urban public transport sector should also be exempted from the levy of fees for transport funds and adjustment funds.

- A tilted investment policy in favor of the urban public transport sector should be adopted. In addition to the central government's planned investment funds for urban public transport development, the urban construction and maintenance tax and urban public utilities fees, various methods should be encouraged to raise funds, including the active use of foreign capital, to promote the urban public transport development. In the long run, the establishment of an urban public transport fund should be studied and thus implemented in order to build up stable financing channels.

- Policy for public transport development has another important component: sector management. Sector management comprises institutional strengthening and the making of sector policy. First, the sector administrative institutions should be simplified and integrated to effectively carry out their responsibilities, including sector planning, supervision and inspection. Second, an effective and clearly-defined sector policy should be in place. In the development of the public transport sector, we should give priority to state-owned buses and trolleybuses; encourage the development of minibuses to an appropriate degree; develop actively taxis in the large and tourist cities, ferries in river and bay cities; gradually build up high-speed rail transport in cities if conditions permit; contain the development of rickshas, three-wheeler motor vehicles and motorcycles in megacities; and attract long-distance bicycle users to public transport.

In the recent government industry policy, more detailed policy measures have been put forward regarding the development of public transport (see the section on "establishment of a policy system"). There are two subjects in the policies of public transport development all along. One is to pay close attention to the role of the state-owned enterprises in urban public transport. Another is to adhere to unified management and strengthen management while utilizing society's funds to develop public transport through various channels and by different ways. Both of them are important for strengthening sector management and sustaining development of public transport. Especially after the gradual establishment of market economic mechanisms and the emergence of various economic forces entering the public transport industry, how to strengthen the macrocontrol and sustain the smooth development of urban public passenger transport market becomes a focus of many municipal governments.

In 1993, the Ministry of Construction promulgated "Resolutions on Lease and Transfer of Operation Rights of Urban Public Passenger Transport." It allows the Government, as the owner, to lease out for a certain period of time the operation rights of urban public transport through negotiations and bidding. Leaseholders are also allowed to transfer the operation rights to others under certain conditions. The lease and transfer of the operation rights have two characteristics. One is that the operators must have qualified experience and capital as required by the municipal government. Another is that the Construction Commission is the agency in charge of making and implementing the plans for the lease and transfer of the operation rights. This is the core of the Resolutions. It aims at strengthening management of the public passenger

transport market and setting up rules for the market to standardize the market participants' behavior and to provide urban residents transport services of convenience, speed and quality.

In 1994, the Ministry of Construction promulgated "Directives on the Franchising of Urban Bus and Trolleybus Services." Its objective is to better meet the conditions for establishing a market mechanism, to strengthen the leading and dominant position of state-owned enterprises in urban public passenger transport while inducing competition, to mobilize all economic forces to promote the development of urban public transport while adhering to the principle of unified planning and management, and to give priority to urban public transport development. The Directive states that under the law and regulations, qualified enterprises, which are chosen through lawful procedures (such as bidding or appointing) and approved by the municipal government as well as the executive municipal departments, can operate passenger transport in the designated roads or areas according to contracts. Government protects the legal operation rights and legal interests of the enterprises and supervise the enterprises to provide passengers with safe, convenient, fast, punctual, comfortable services.

Because of the special characteristics of urban public transport and the development trend of the public transport market, many policies of public transport are still in the research stage at present. The urban public transport policy system as a whole needs to improve gradually.

Urban Road Policy. The urban road network constitutes the backbone of a city. It provides the basic physical setting for the existence and development of urban transport. After a painful experience in road management that was characterized by digging-restoring-digging again-restoring again (or "zipper roads" as called by urban residents), municipal governments have now started to pay close attention to the planning, construction and management of urban roads. And this brings hope to the improvement of urban road transport. "The Action Plan for Implementing the Sector Policy of Urban Public Transport" of 1990 stated that "the construction of urban roads and ferry docks should be put in the first place." Then "The Implementation Program for the Current Sector Policy of Urban Roads" was promulgated in 1992, providing the guiding principle for road construction and management. The Program defines the basic principle and the needed measures for the development of urban road sector in China. This policy points out three directions for road development: strengthening the planning of the road system, broadening the financial channels to increase investment in road construction and technical innovation, and improving road maintenance. It also formulated detailed policies and measures to facilitate development of the road sector.

Urban road planning should be based on the plan for the national economy development. It should follow the city master plan. The road construction plan and its ratio of investment to other sectors of the economy should be rationalized. The annual and the five-year plan for urban road construction should be an integrated part of the long-term plan. And close attention should be paid to improving road network system planning, high-speed road system planning and intersection traffic channeling. Large and medium cities should also make plans for nonmotorized vehicle transport. The focal point is to speed up the construction of urban arterial roads (primary as well as secondary) and high-speed roads, to plan properly interchanges, pedestrian crossings, parking lots and bicycle lanes, and to improve road networks, especially their bottleneck segments. In the process of urban construction, new area development and old

city redevelopment, comprehensive development of urban roads should be promoted. The main point is the practice of land leasing. Revenues from land transaction should be earmarked for construction of urban roads and other infrastructure facilities. It is a great breakthrough in urban construction in recent years to have road construction lead the way for urban infrastructure and municipal development. It solves the problem of inadequate funds for urban road construction as well as gives an impetus to overall municipal development.

Insufficient road maintenance is a common problem in developing countries. For example, available funds for maintenance of roads and bridges in Chengdu meet only 64 percent of what is normally needed. With poor maintenance, roads are unable to operate to their designed capacity. As a result, the very low efficiency in road utilization parallels with large-scale government investment in new road construction, leading to low return of capital. China's road sector policy takes notice of this situation. In the relationship between new construction and maintenance, the policy stresses that the maintenance of road facilities is a key factor. It emphasizes improvement of maintenance quality to ensure roads operate to their potential. Only on this basis, the construction of new roads, the increase in the share of paved roads and the improvement of road quality can effectively be promoted.

Strengthening the administrative institutions and management of urban roads is very important to the development of an urban road system. In "The Implementation Program for the Current Industrial Policy for Urban Roads," strengthening administrative management in line with the law is emphasized. It clarifies that the Ministry of Construction is responsible for the urban road administration of the country. It also asks for the improvement of the administrative functions in the management of road construction and maintenance. In recent years, many activities have occurred that violate the regulations, such as occupying roads illegally, excavating urban roads without authorization, using road space for purposes other than transportation, and damaging road facilities. In some cities, the rate of roads being occupied by nontransport functions is even faster than that of road construction. As a result, the efficiency of road utilization declines significantly. To solve these problems, the Ministry of Construction and the Ministry of Public Security made a "Report on Strengthening the Management of Road Transport" in 1992, which was approved by the Administration Office of the State Council.

The report requires that the urban construction commission and public security bureau effectively take charge of road management, strengthening the supervision and inspection of road utilization and eliminating the unauthorized use of roads. There should be a unified authorization for road planning. The authorization for use and digging of roads should be at the hands of the responsible agencies at municipal level (the construction department) and the public security bureau, not to be scattered and transferred to lower levels. Strict rules should apply to temporary use or digging of roads. Meanwhile, with the development of a market economy, land use by the tertiary industry (services) should receive more attention. Pedestrian roads, parking lots and shopping centers should be included in the urban development plan. Their development should be accelerated, gradually reaching a stage where "all cars park in the parking lot and all vendors' stands are moved into buildings."

In 1993, the Ministry of Construction formulated "Policies on the Use and Excavation of Roads and Fees." It restricts the use and excavation of roads through economic means. Despite the presence of a set of policies governing the use and excavation of roads, there are still lots of

problems in urban road construction and management due to the lack of an integrated policy system, the ineffective implementation of policy and the weakness in administration and law enforcement.

THE INVESTMENT SYSTEM OF URBAN TRANSPORT

Because urban road transport infrastructure facilities, like other urban infrastructure facilities, have a long investment cycle and low rate of direct economic return, their planning, construction, and management are left behind those of other sectors. Particularly in developing countries, shortage of funds is a serious problem hindering the development of urban public transport. How to effectively raise funds for infrastructure construction to meet the needs is one of the main challenges facing the Chinese municipal governments in the economic reform.

Resources for Construction and Maintenance of Urban Transport Infrastructure

The construction and maintenance of transport infrastructure are government functions. Therefore, all fund-raising activities are marked by government intervention. At present, the resources for construction and maintenance of urban road infrastructure in China mainly come from two channels: the old, but relatively stable channel and the new channel created after reform.

The Relatively Stable Resources. According to statistics in 1994, revenues from urban construction and maintenance funds and operating revenues amounted to Y 67.5 billion. Expenditures for urban maintenance and construction were Y 65.8 billion. The sources of the revenues are:

- The urban construction and maintenance tax and the public utilities surcharges totaled Y 15.8 billion, which were the main resources for urban construction.
- Government budget for urban infrastructure construction; and appropriations from the central and local governments (special assistance funds and rationed subsidies) for special projects. They totaled Y 8.1 billion, constituting another channel of stable resources.
- The water resource fee amounted to Y 470 million, which is earmarked for expenditure on water supply.
- Domestic and foreign loans totaled Y 6 billion.
- The operating revenues of enterprises within the urban construction system were Y 5.6 billion, including housing rent and revenues from parks and sanitation services.
- Other resources totaled Y 31.6 billion.

Except for a few revenue items earmarked for special expenditures, the revenues from the above-mentioned resources are controlled by the municipal government for urban construction. The municipal government is responsible for the allocation of funds among

different departments and infrastructure of different sectors. Usually 6 to 8 percent is used for roads. As the market economy develops, the structure of the revenue sources has changed. The government budget and grants for special projects from the central government and local governments decrease each year as loans and funds raise through the market. With reform in the urban construction investment system, the financing of urban transport is now in gradual transition to a multichannel financing system.

New Resources Since the Reform. Since the municipalities are responsible for urban construction, funds needed have to be raised mainly by the municipal governments themselves. Under guidance from the central government's policy and reflecting on its local specifics, each municipal government has initiated many effective ways in fund-raising, which contribute also to the investment system reform as well as road construction.

Along with the country's economic reform as a whole and synchronizing with reform of the urban construction investment system, a lot of progress has been made in the urban transport investment system to alleviate the serious shortage of funds for urban transport due to the limited financial ability of the governments. First, in line with the city's overall development plan, the municipal government can raise funds through comprehensive land development. The revenues come mainly from land lease and transactions. Housing projects also contribute to road construction. The construction of road infrastructure is integrated into the redevelopment of old city areas and the development of new city areas. The recommended practice is "to use road construction to spur housing development and to support road construction and maintenance through housing development." This policy helps alleviate the funds shortage problem in road construction. More importantly, it produces a healthy investment cycle system and serves as the best model for improving the current state of road transport.

Second, municipal governments impose civil construction fees and infrastructure service user charges. Although the collection of civil construction fees has yet to become an official policy of the central government, the municipalities justify their practice on the grounds that it is necessary to collect such fees to finance the supply of infrastructure in order to meet demands. On the one hand, the municipal governments are responsible for the construction and financing of road transport infrastructure; on the other hand, the financial resources from the municipal government budget is far from sufficient to finance such huge investment projects, especially as the demand for road transport infrastructure grows rapidly thanks to rapid economic growth and urbanization. In fact, this practice is quite widespread and it contributes to the development of urban infrastructure. The user charge scheme is a natural result of the market economy development. The traditional view regards urban transport, especially urban roads, as social benefits to the general public and ignores its function as a producer and the importance of its financial return. As a result, users were free of charge. During the development of a market economy, the road transport sector and its enterprises are increasingly being regarded as production entities and their sound development asks for a balanced policy regarding social benefit provision and a healthy financial position. In addition, the latter will also enable the transport sector to provide better services to urban residents. At present, the user charge is an effective way to realize those objectives. In spite of the fact that the user charge scheme is still in its initial stage of development, its positive contribution to the operation of road transport is significant. The user charges are further promoted by practices such as paid lease and transfer of public transit operation rights, franchising, and parking charges, etc. As the economic reform

deepens, the users-pay principle will be employed more thoroughly and urban transport will become more market-oriented over time.

Decision-Making in Urban Transport Projects

Based on the characteristics of road transport, the planning, construction and management of urban road transport are defined as the government's responsibility in China. The municipal government strictly controls those activities. This practice is based on the fact that the performance of road transport directly affects economic development and social stability. The government plays a key role in every step of the project cycle, including project initiation, appraisal, approval and implementation. In general , an initial project plan is drafted by the relevant municipal construction executing bureaus and/or the public transport enterprises based on the overall urban plan and the five-year, the mid- and long-term development plans of the municipal government. Then, the Construction Commission, the Planning Commission and the Finance Bureau will organize the appraisal, determine the scope and scale of the project, and submit their recommendations to the municipal government. The municipal government does the final review and decides whether to give its approval. The approved project then is implemented by the executing bureaus or the public transport enterprises.

There is a marked change in municipal governments' view regarding infrastructure facilities, including roads. Governments at all levels now have a better understanding of their role in social and economic development, in particular, thanks to the exemplary effect of coastal cities where urban infrastructure including road transport not only supports but also gives a strong impetus to economic development. As a result, governments at all levels give priority to the development of infrastructure including road transport. Especially after the government designated the public utility sector as the basic and forerunner sector, infrastructure construction including road construction has risen rapidly. In the redevelopment of old city areas and new area development, road construction projects are listed as the key projects in urban construction because of their immediate effect on people's living conditions. Municipal governments give priority to road transport construction in funds allocation and support the use of various channels to raise funds as well. In the last few years, projects for road transport infrastructure have taken a large share in all urban development projects. With the support of municipal governments, municipalities also have accumulated some experience and exploited many channels for fund-raising.

Reform of the Investment System

Along with the deepening of economic reform, the Chinese government has gradually reduced its degree of intervention. Now, the government concentrates its activities on setting guidelines, exercising macrocontrol of the economy, building a sound administrative and managerial framework, establishing a market-oriented operation and management system, completing the system of laws and regulations, and helping induce incentives to enterprises for healthy business development. As for the road transport sector, the Government makes all efforts to form a sound investment policy that is in line with the general policy orientation for the overall economy and also reflects the sector specifics.

Government financing both at the central and local levels continues to play a major role in the investment system for construction of road transport infrastructure. The funding sources include civil construction fees, public utilities surcharges, revenues from land leasing and transactions, revenues from the added value of real estate, urban land use tax, urban maintenance and construction tax, user charges for public services, the central and local governments' grants, and special taxes and earmarked fees.

In this investment system, the municipal governments are authorized to levy public utilities surcharges. During the appraisal and approval of capital construction and renovation projects, associated public utilities projects should be planned as well to avoid the problem of unbalanced development. In case the government is unable to finance those associated projects, the developer or the investor should be financially responsible for the construction of related road transport infrastructure to meet the requirement of a comprehensive development. The rapid increase in revenues from urban land leasing and transactions, added value of real estate and urban land use tax are largely due to the success in China's land use reform, which has ended the long-time practice of free land use. The government policy has clearly declared that the revenues from the land use will be mainly used by the local government for infrastructure construction, which thus alleviates the problem of fund shortage. Especially in recent years, enormous progress has been made in investment system reform through comprehensive urban development and road construction in the redevelopment of old city areas.

In this new investment system, the weight of government direct investment in road construction and other infrastructure facilities as well as in overall infrastructure investment is gradually decreasing. However, this does not imply that government finance is no longer the main financial channel for these investments. The connotation of "government playing the major role in investment" has changed. The major role is no longer reflected through the government taking the lion's share of total investment, rather it is realized through the important catalytic effect a small amount of government startup funds has on inducing and channeling available funds from society into road transport investments. What we need to do now is strengthen the management of these resources.

It is also very important to gradually establish a users-pay system for usage of urban public infrastructure and facilities to recover cost. This system will ensure the normal operation of existing facilities and provide socialized service of quality for our daily life and production. The user charge schemes include, for instance, the paid lease and transfer of operation rights of public transport, charges for the usage of parking, and toll of roads. The cost recovery system based on market principles constitutes a sound investment cycle mechanism, that is investment-construction-maintenance-investment cost recovery. Its implementation is necessary for the construction and operation of road transport infrastructure and facilities to meet the increasing demand of a growing market economy.

Price reform of public utilities is very important in development of a market economy. It will directly affect development of the public utilities sector, as well as the quality of services provided to the public. Therefore, price reform of public utilities is an important task in urban development in recent years. Price reform in urban transport has, in relative terms, great difficulty due to its special functions and position. However, price reform is irreversible. An important task in policy-making for governments at all levels is how to set prices at rational

levels within the government-controlled limits. Provided that the social benefits are taken into careful consideration, reform now focuses on how to manage and operate urban road transport using the law of value. Some subsectors or enterprises with mature conditions should be allowed to operate entirely on market principles and directly subject to market competition. The focal points of price reform in public utilities are: making the price more rational to increase revenue; improving the subsidy policy by separating policy-induced loss and operating loss from mismanagement; and exploring various models of operation. The following principles must be preserved in practice: the price adjustment must be well within the government-controlled limits; prices should be set at rational levels; and the separation of enterprise from the management of functional government bodies. Enterprise reform should be speeded up to ease the burden on government.

IDEAS ABOUT INSTITUTIONAL REFORM IN URBAN TRANSPORT

Enhancing the Urban Transport Management System at the Municipal Level

Since the reform and opening to the outside world, the rapid development of urban transport in the last 15 years is a clear indication of the success in urban transport administration and management at the municipal level. Therefore, we should continue to strengthen this system. The municipal administration and management system in urban transport constitutes the main body of the overall system. This characteristic is reflected in two aspects: the main institutional body is within the municipal government's institutional framework and the authority in urban transport management mainly resides in the municipal government.

The city-based institutional setup has two implications. First, the central government and the provincial government should delegate enough authority to municipal governments, allowing them to set up their own institutional system accommodating each city's specifics, transport structure and facilities capability and to chose its model for operation. Second, it involves municipal governments. Municipal governments should realize the importance of transport for economic development; understand that the development of urban transport is the municipal government's responsibility and obligation, and one of their major tasks after the transition of municipal government functions. The focus should be on strengthening the transport management institutions. In the process, attention should be paid to city specifics such as the size of the city and the stage of economic development. In the large cities, there is a two-tier management system for urban transport planning, passenger transport and roads, namely the construction commission and the executing bureaus. The former is mainly responsible for coordination and the latter is in charge of concrete management functions. In practice, there are problems such as the interwoven and overlapped functions and not-clearly-defined responsibilities among the commission and bureaus. However, the existing institutional setup in transport does work smoothly against the background of China's overall administration framework. Especially it is effective in coordinating and balancing the working relationship among the urban transport management agencies, and the relationship between these agencies and the functional agencies such as the public security bureau, the finance bureau, the land management bureau and the planning commission, etc. The one-tier management model in medium and small size cities is also effective.

One thing that should receive due attention is that during China's institutional reform, it is necessary to simplify and streamline the administration in order to increase efficiency. The

municipal governments and all urban transport administration and management agencies have to undertake the same reform.

The government institutional reform is necessary for a successful transition from a planned economy to a socialist market economy. In the process, certain government functions should be weakened, for instance, government direct involvement in enterprise management and operation. However, certain government institutions and functions should be enhanced. The urban transport institutions and their functions belong to this category.

The municipal governments take major responsibility for urban transport development. They thus should have the authority commensurate with their responsibilities to carry out their duties in urban transport. In the current system of law and the division of power among the central, provincial and municipal governments, large city governments are already allowed to enact laws; and others are authorized to make administrative regulations. The municipal governments are in charge of the planning and administration of urban transport, including the establishment and management of transport market; project initiation, appraisal and approval; traffic control; investment budgeting; and formulation of the annual, mid- and long-term plans. However, the function of municipal governments in fund-raising and price setting is not strong.

The next step of reform is to strengthen the municipal governments' function in fund-raising and price management. The objective is to give the municipal governments sufficient autonomy in the collection of fees, fund-raising and price adjustment under national laws and regulations. This reform will enable the municipal governments to develop their own transport strategy according to their economy, population growth and other city specifics.

Deepening Reform of Government Functions to Accelerate the Development of Urban Transport and to Meet the Requirement of a Socialist Market Economy Mechanism

Strengthening the industry and sector management function of the government. In road administration and traffic control, the government function is, to a large degree, clearly defined. The focus now is on standardization and enhancement of administration based on laws. In passenger transport management, the government is responsible for establishing as well as regulating the market. The objective is to establish a fair and orderly market with a rational structure so as to meet the people's demand for transport. During the transition from a planning economy to a market economy, competition should be introduced from the beginning and the franchise system in operation should be promoted so as to establish smoothly an orderly managed mechanism supporting fair competition.

Government activities and enterprise activities should be clearly separated. The separation of government function from enterprise function is mainly a task for the state-owned urban passenger enterprises, and the state-owned design institutes and construction companies for urban infrastructure and facilities. The completion of this task will take time and needs to be done gradually. The important thing is to follow the government policy and regulation guidelines and make thorough preparations and planning.

The state-owned public transport enterprises are, and will continue to be, the backbone of our urban transport. Following the State Council's directives and regulations, the executing government agencies should grant the state-owned enterprises autonomy to operate, help them

adopt the advanced organizational and financial principles, and gradually put them into the market to compete with others. In this process, the function of government as owner and the function of government as administrator should be gradually separated to ensure the neutral position and thus the fairness of government in carrying out its administrative and managerial responsibilities. The ownership by the government should be handled by state assets management departments or the departments specified by laws. The commercial rights should be within the purview of urban transport administration departments. Meanwhile, the government should enhance its supervision on the quality of services and the prices.

The design institutes should be transformed from a government functional body into enterprises. Together with the road construction companies, they should gradually become independent of their supervision government departments. The municipal governments should open the design and construction market and introduce a bidding system in project design and construction, thereby exposing the state-owned design institutes and construction companies to full competition.

The problem of overlapping responsibilities between different departments and agencies needs to be solved through enactment of laws and legislation to clarify the responsibilities of each organization. We will look at other countries' experience and introduce their sound practices. Every effort will be made to ensure the decision-making, especial those concerning important issues in transport in a democratic, scientific and efficient way.

Central Government must have Proper Instruments to Carry out its Responsibility in Macrocontrol of Urban Transport and Support for Urban Transport Development of Poor Areas

Those instruments can be summed up into two categories: administrative and economic. The central government already has the first category of instruments at its disposal; however, the second category of instruments is not readily available. The reform orientation is to equip the central and provincial governments with both instruments through reform of the urban transport investment mechanism. It should be noticed that the economic instruments are very effective in influencing urban development at the national and provincial levels.

The following practice could be introduced: (a) imposing surcharges (or fees) on motor vehicle fuel, which will be shared among the central, provincial and municipal governments with the first two keeping less than 15 percent of the total revenue; or (b) the central and provincial governments taking less than 10 percent of the revenue from the urban construction and maintenance tax (this tax is to be reformed in the near future); revenues from either of these two resources then will be used as macrocontrol funds available to the central and provincial governments. The central government's funds can be diverted into two areas. One part can be used as urban transport development funds that must be repaid. The major recipients will be large- and medium-size backbone municipalities for their urban transport projects. The other part can be used to help the implementation of macrocontrol policies and to subsidize the poor cities' urban transport development.

THEME PAPER 4: MUNICIPAL TRANSPORT MANAGEMENT: OVERSEAS EXPERIENCE

RICHARD MEAKIN [1]

INTRODUCTION

The fast pace of economic reform is putting China's urban transport planning and supervisory institutions under pressure. Migration and increasing motorization will soon pose a serious threat to mobility and the quality of the urban environment. There is a need to develop and implement a framework of urban transport policy that will balance the rising aspirations of the people of China's cities for more and higher quality transport against the restraints imposed by the availability of financial and other resources, and the need to preserve the city's form and environment. Meeting this challenge will place considerable demands on China's municipal governments. A complex process of evaluation of options will be needed, difficult choices made and integrated plans prepared.

China is fortunate to be able to review the experience of other major cities overseas that have faced similar issues of how far to meet, and how far to manage, demand. The more progressive cities of Europe and North America are now committed to restraining access to cities by car and have invested heavily in public transport. Generally, that public transport is in some form of municipal ownership and requires substantial subsidy to remain attractive as an alternative to the car. But there is continuing concern that municipally owned transit is not as cost effective nor responsive to the needs of users as it could be and a variety of measures have been developed to introduce, or to simulate, private sector incentives to efficiency and meeting demand.

Asia's major cities have rates of recent population and economic growth that are similar to those now being experienced in China. Those cities that have successfully contained the pressures to cater for full motorization and diverted demand to well-developed public transport systems are generally those with stable and efficient political and administrative structures. Other cities have failed to contain car use or develop public transport—with catastrophic effects on the urban environment and economy.

A municipal administrative structure under stable government, within which responsibilities are clearly demarcated, both between functional areas and in internal ranking, and which has the capability to coordinate policies and programs across institutional boundaries

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at all levels provides the best basis for successful policy implementation. China's municipal governments are close to meeting these conditions.

The key to containing pressures for motorization is efficient and demand responsive public transport. International experience shows, first, that public transport that is subject to market forces is more cost effective, and much more responsive to the needs of users than when in public ownership, and second, that public ownership is strongly correlated with low rates of cost recovery from fares. China's public transport systems, including the new mass transit railways, have the potential to fully cover operating costs and, provided social obligations can be covered, the potential to be entrusted, at least in part, to the private sector. However, the private sector will only invest with confidence if a regulatory framework is in place that is impartial, transparent and confers protection from arbitrary administrative action. Meeting these requirements will place considerable demands on China's municipal administration.

THE TIERS OF GOVERNMENT

The distribution of transport responsibilities between the hierarchical tiers of government and between the departments at each level of government will vary widely between countries. Nevertheless, some principles can be recommended:

National Government

In all but the smallest countries and "city states" that effectively have a single layer of government, transport functions are divided between national and local levels of government. National government's transport responsibilities normally concern national policies and programs, matters where there is a need to standardize regulations, practices and specifications, or which concern national or international networks of roads, railways and air services. There is also a role for national government in standardizing, monitoring and collating national data and in raising national taxes and disbursing grants and subsidies. Research and development is also most efficiently organized centrally.

Control over local government is exercised through instruments, national legislation, standards, grants and loans. Typically, for transport services central government will set basic user rules, vehicle standards, and the principles governing industry structure, regulation and market access. It will also, to a degree, influence the operating environment through national standards of urban and regional planning.

Central government must also ensure that the structure and boundaries of regional and municipal administrations are appropriate and that local authorities have the necessary legal powers to discharge their functions while deterrents exist to prevent them from exceeding their powers and departing from national policies. Municipal government is usually dependent on central government for part of its funding, which allows a degree of control and supervision, and discretion in the award of supplementary funds.

Regional Government

The responsibilities vested in the intermediate level of state or provincial government depend on the degree of legal and administrative autonomy the states or provinces enjoy. They

will at least have some responsibility for the administration of regional roads and railways. In China, provincial government exercises wide powers of administration, although in those provinces whose economy and population are dominated by a major city, that city often enjoys a high degree of fiscal and administrative autonomy from provincial government and may be effectively directed by central government.

Municipal Government

Municipal or metropolitan government will have responsibility for urban management within its boundaries, within national or provincial policy and resource constraints. Within municipal government, responsibilities will be divided functionally between departments and hierarchically within them. There is a dilemma. In general, transport responsibilities at the higher administrative levels responsible for policy and program development need to be integrated, and therefore consolidated into as few departments as possible. The need to keep departments within a manageable size and range of disciplines imposes a constraint on the degree of consolidation possible. Some departmental division, based on a rational grouping of responsibilities and skills, is necessary.

Five main functional areas can be identified as a basis for grouping:

land use planning
transport infrastructure, road & rail, planning
management of roads and road use
public transport development and management
financing and investment

THE ORGANIZATION OF TRANSPORT FUNCTIONS IN MUNICIPAL GOVERNMENTS

Levels of administrative responsibility for transport may be graded in a hierarchy, which is likely to be reflected in the internal structure of policy agencies and functional departments. The functions, structure and staffing of administrative organizations at each level are described below.

POLICY AND STRATEGIC PLANNING AGENCIES

Functions

At this level, the basic transport policy framework and strategic infrastructure program is determined, including land use plans and standards, modal split targets, major road and rail infrastructure, the role to be vested in the private sector, cost recovery and regulatory policy. Decisions at this level have a high political content, and will reflect national programs and priorities. It is essential that transport policies and plans are integrated at this level, either by vesting responsibilities in a single land use/transport agency or by maintaining an effective coordination mechanism. There is also a need to ensure that transport sector policies are coordinated with environmental objectives and wider economic and social programs. A

statement of policy must be compiled, together with constituent plans and programs, which should be regularly reviewed and revised in the light of performance of the transport sector, resource constraints and wider economic and political trends.

Public sector funding for investment in infrastructure and transport capacity needs to be prioritized and coordinated into a long-term program that will specify, at least, the estimated timing and cost of current and new projects planned for the next five years. The program will be reviewed and "rolled over" annually. It will be coordinated with the program of private sector investment. Together, these programs will reflect the priorities in the transport policy framework. They will be implemented and managed by "professional" executive departments.

Structure

The two main criteria that determine the most appropriate structure will be:

- **that executive departments are grouped under policy agencies in a rational structure.**

This requires that the policy agency has, as far as possible, a complete purview of its policy area. For example, agencies responsible for the direction of transport policy will need to supervise departments executing road and rail infrastructure programs, traffic management, and public transport management and development. Transport policies must also be closely coordinated with land use and housing policies, but these will usually be supervised by a different policy agency. The structure of the recently established Singapore Land Transport Agency is described in the section on "Models of Institutional Organization." The LTA Board has assumed responsibility for road, traffic and public transport development, including the mass transit system, under the overall direction of the Ministry of Communications. Its jurisdiction does not extend to land use development control. The LTA has absorbed the respective executive departments including the Mass Rapid Transit Corporation.

- **that the municipal transport policy agency is responsive to political and community influences.**

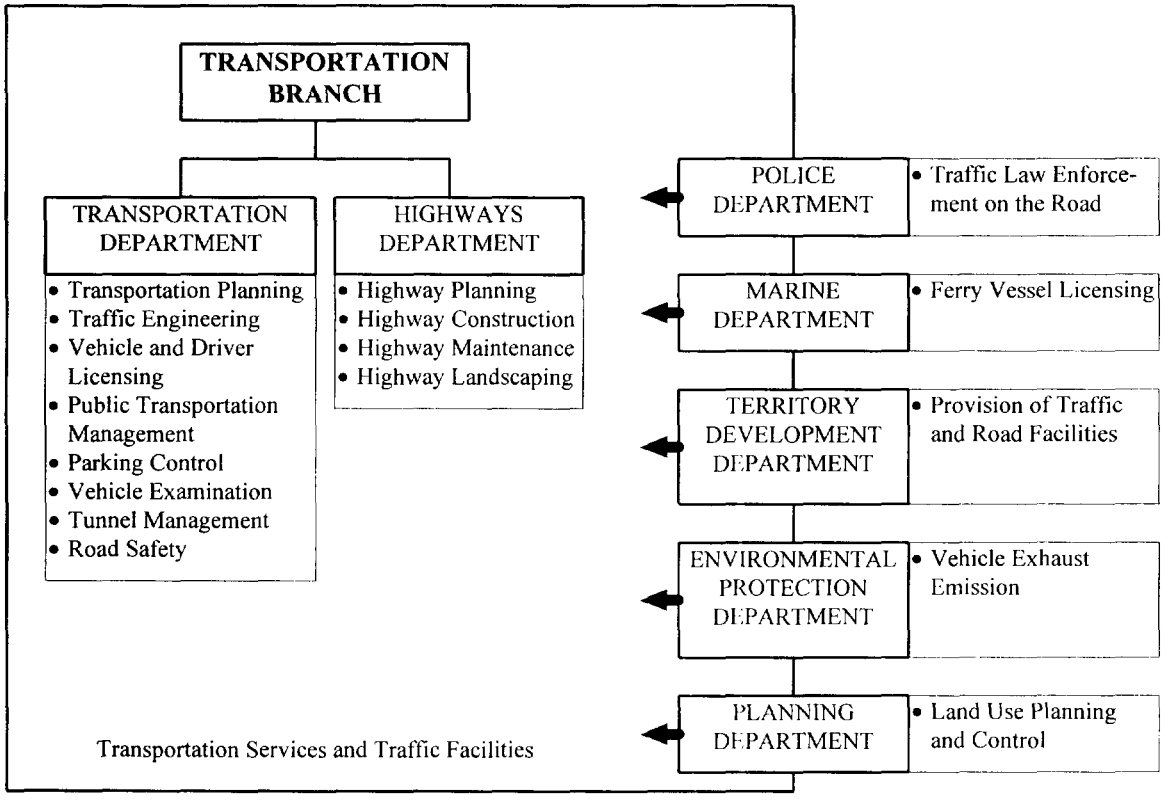
National government policies will normally be imposed through a range of political, budgetary and legislative controls, but conflicts can arise when the municipality is under the control of a different political party from national government. Such a conflict arose in the United Kingdom in 1984. The socialist-controlled Greater London Council adopted a "social" approach and permitted lower levels of cost recovery and lower fares from bus and rail services it controlled through the London Transport Executive (LTE). This was in conflict with the Conservative central government's "commercial" approach. The conflict was resolved by central government dissolving the LTE and reconstituting it as London Regional Transport directly under state control.

There are various means to ensure that the municipal policy agency is responsive, even if not accountable, to the needs of local users, interest groups and community preferences. Due to the highly political nature of transport policy decisions and the wide community interest, it is common for the administration to create an appointed body to advise it on transport policy. This might be a permanent body, or ad hoc, to review a specific issue. The advisory body may

comprise community leaders drawn from politics, business and academic circles. Their role is to act as a conduit for opinions and expert advice. They are unlikely to have statutory powers, since this will preempt the role of elected officials.

The structure of Hong Kong's transport institutions is shown in Figure 1. Executive departments are grouped under the Transport Branch of the Central Government Secretariat, which provides policy leadership and is advised by the appointed Transport Advisory Committee.

FIGURE 1: DISTRIBUTION OF RESPONSIBILITY IN THE TRANSPORTATION ADMINISTRATION OF HONG KONG



Source: Ernest Shu Wing Lee, "Traffic and Transportation Facilities in Hong Kong: An Overview," *Chinese Environment and Development*, Fall 1994/Vol. 5, No. 3

Bangkok is well known as a city that has failed to implement an effective urban transport management policy. The main restraint lies in Thailand's political structure. Government comprises an unstable multiparty coalition that cannot assume it will survive a full term. The focus of policy is thus on short-term expediency and avoidance of any measures that might generate objection such as restraints on the use of private vehicles. Control of the main policy ministries has been distributed among the parties of the coalition. Responsibility for Bangkok's transport policy is currently divided between two parties: one controls the agency responsible for transport in the inner city, while another controls the outer districts. This makes it difficult to

achieve a consensus on policy measures. Although both parties are members of the government coalition, neither has an interest in the other gaining credit.

The unstable and fragmented political system also has effects on institutional structure. A reaction to institutions' inability to reach consensus on policy has been the creation of additional tiers of high-level coordinating bodies within government. This has added further complexity to the administrative structure. The structure of transport administration in the Thai government is shown in Figure 2.

Staffing

At the highest levels of almost all government functions, the administration (the permanent civil service) is concerned with policy-making and strategic planning, being responsive to the requirements of national government and to the municipal political process. The skills required are those of the administrator: an understanding of the political process, ability to manage the resource allocation system and an overview of the transport sector and its relationship with other sectors of the economy. The administrator does not need specific experience or a detailed technical knowledge of transport; indeed, some would claim that this is a disadvantage since his particular background may produce bias. He will rely on his expert subordinates to advise him on technical issues and he will interpret and weigh their advice in the light of the resource and political constraints.

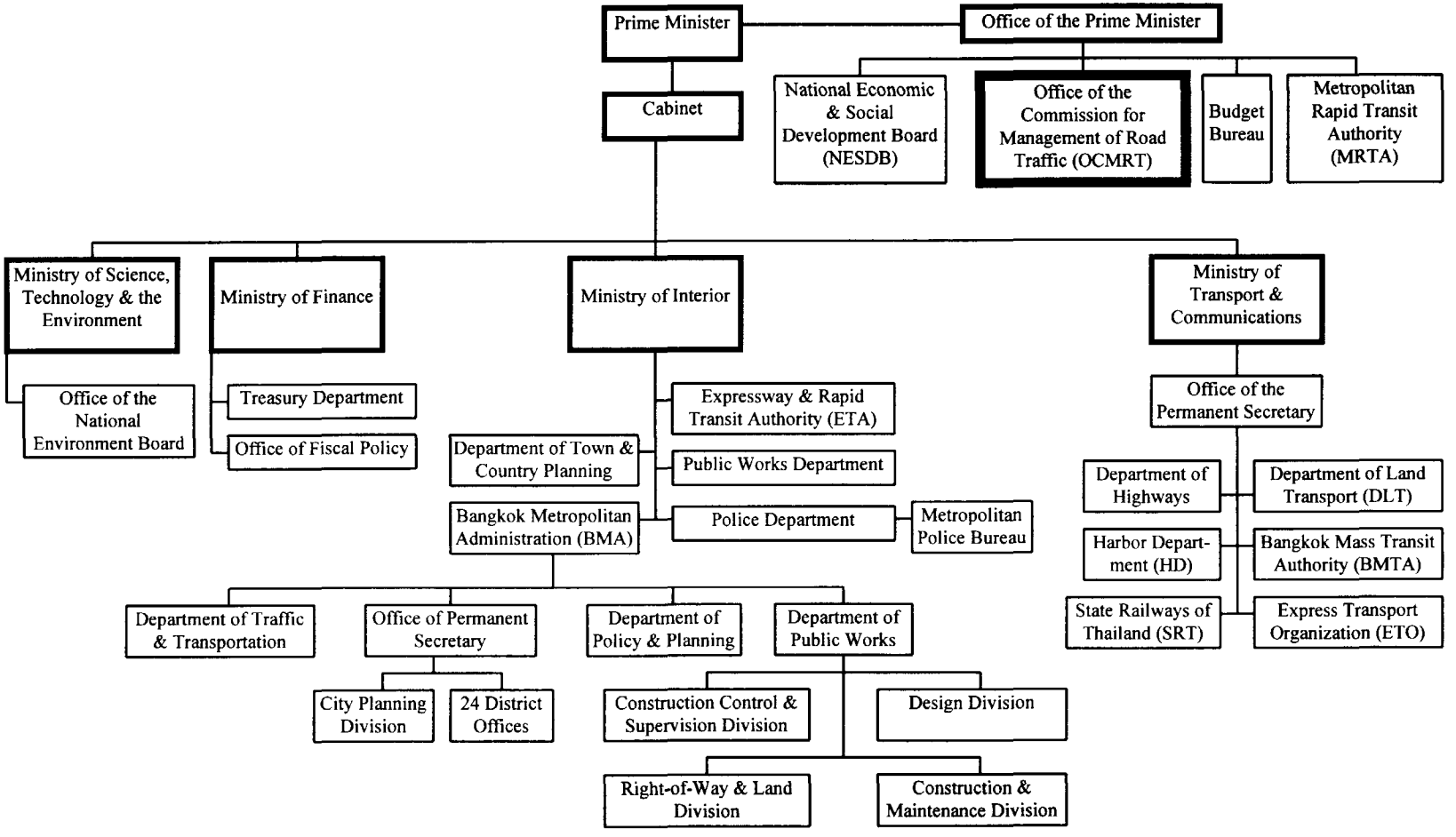
Policy-level officials will be salaried members of the civil service. They may be promoted either from the professional ranks or from a cadre of "generalist" professional administrators. Alternatively, they may be appointed from outside the civil service, from the political arena, from business or academia. A candidate may be appointed with a particular brief, perhaps to introduce reforms. A successful record of reform in another area may be his essential qualification. The appointee may be a permanent civil servant, or may serve a term under contract.

EXECUTIVE DEPARTMENTS

Functions

This is the departmental level of municipal government, where policies are translated into action programs by professional staff in technical agencies. Infrastructure projects are designed in detail for construction by government, or prepared for implementation by the private sector. Public transport policy is translated into targets, plans and investment programs for government's transport enterprises, or into regulations, franchises and standards for private operators. Traffic management standards and measures are designed and implemented. Policy proposals may be initiated and information on performance generated for submission to the higher level.

FIGURE 2: THE ORGANIZATION OF TRANSPORT FUNCTIONS IN THE BANGKOK METROPOLITAN REGION, THAILAND



Structure

The departmental structure of municipal government must ensure that there is technical coordination between the plans and programs of different departments. Coordination may be imposed by the policy-level agency provided the division between policy agencies is rational, but efficiency requires that departments cooperate at working level. For instance, transport planners must interact with land use planners and the traffic engineering unit must coordinate its programs with both the public transport unit and the enforcement agency. If effective coordination does not occur for political or structural reasons, there is a tendency for matters to be passed up to the policy level for resolution.

The more departments that exist, the more institutional boundaries and the more complex and formal must be the coordination arrangements. Coordination may be achieved by grouping departments contributing to transport programs under a common policy agency (as in Hong Kong) or a board of directors (as in Singapore), or by standing committees comprising departmental representatives of the appropriate level. It is important that ranks and levels of authority are established on a scale that it consistent between departments. This simplifies coordination, because departments need delegate only representatives at the appropriate rank. In the absence of common rankings, departments may delegate more senior representatives than necessary to ensure their interests are taken into consideration, or more junior in order to avoid commitment, or several delegates to ensure that the range of appropriate levels is included.

Staffing

The departments of municipal government may be headed by administrators or by professionals. Their structures will include divisions that carry out administrative functions and others that are essentially technical. Technical skills in the transport professions may broadly be divided between "the science" of engineering and its related fields and the "art" of policy and planning where the skills of the economist, social scientist and geographer are important. Transport administration requires a wide range of skills and it is important that opportunities are created for staff to acquire and update skills.

REGULATION AND ENFORCEMENT AGENCIES

Functions

Institutions in this category include the Traffic Police and regulatory and licensing authorities for public and private vehicles. These agencies supervise and monitor operations and ensure that plans, standards and regulations are complied with and may check the extent to which demand is being met. This may be measured by surveys and checks, and also by feedback through political channels or from users in the form of complaints and proposals for change. Where a system of regulation of transport services is in effect, licenses and franchises may be issued and negotiated. Even where services are not regulated, the authority will issue "quality" licenses to ensure the competence of operators and drivers. Operational data will be gathered and analyzed.

The extent to which the private sector is to be regulated will be a major determinant of the size and mix of skills in a regulatory department. A regulatory department, supervising bus,

taxi and minibus undertakings wholly or largely under municipal ownership as in Chinese cities, will essentially be a planning and standards body whose main role will be translating service objectives adopted by municipal government into operational plans and performance parameters. Such a body will not conduct intensive checks to assess operational performance, nor is it likely to invoke powers of compulsion or sanctions against its "sister" municipal operating organizations. It will not need extensive or carefully defined powers of direction.

By contrast, a department vested with the responsibility for regulating private sector operators will be very different in composition and character since it must maintain a fine balance of incentives and sanctions to assure a reasonable rate of return to the operators while ensuring an adequate and efficient service to users. The freedoms and service obligations of operators will be defined in a variety of formal instruments including legislation, licenses, franchises and contracts as well as informal rules, practices and precedents. Staff of the regulatory agency must maintain a balance between the adherence to rules and procedures and the exercise of their professional judgment in the public interest.

The regulatory task will vary with the mode being regulated. Buses and minibuses operating in a regulated environment will often be subject to a high degree of "positive regulation" where each operator's routes, fares, basic timetables, and vehicle type are specified by the authority, leaving the operator little discretion.

Taxis require a different regulatory regime. Supply and demand for services need to be kept in balance. The adjustment mechanisms are increases in the supply of taxis by increasing the fleet, and reduction of demand through fare increases. The regulator cannot fix levels of availability by time or location so regulation tends to be "negative." Operators have freedom of routes and times, but are subject to regulation of operating practices and fares, often through metering. Most of the regulation is aimed at curbing malpractice by which the operator can increase his income by selection of passengers or destinations. Enforcing malpractice is difficult, especially where a high proportion of operators are owner-drivers with strong incentives to maximize their income. Users are often willing participants, such as in cases of carriage of multiple passengers at fixed fares.

Minibuses and other paratransit modes, especially when in individual, entrepreneurial ownership, present similar difficulties in supervision. Operators are entrepreneurial and will seek the greatest revenue returns, even by breaching license conditions and regulations where these are not rigorously enforced. These incentives also make paratransit and deregulated modes very responsive to changes in demand. However, where the authority does not regulate comprehensively, route-based paratransit is vulnerable to control by criminal organizations. Operators' access to lucrative routes may be controlled, and fees charged by "regulators" at termini and heavy loading places, often with threats of intimidation. By their nature, such rackets are very difficult to expose and prosecute.

For modes that are effectively deregulated, the authority needs only monitor operations and exercise powers to ensure quality and safety and that market forces are not being constrained.

Structure

The extent to which the private sector is relied upon to provide transport services and infrastructure that might otherwise be provided by municipal government has a very basic influence on the size and structure of government.

First, the fewer services provided directly by municipal government, the smaller will be its direct workload and the financial and human resources it needs. Conversely, the more services entrusted to the private sector, the more developed government's regulatory functions must be. The task of awarding and regulating private sector contracts, franchises and concessions, and monitoring performance and market conditions requires a sophisticated legal and administrative framework.

Regulatory functions should be clearly separated from those of system operations. For example, where a municipal government has a transport undertaking, that agency should not also act as a regulator of private operators. In Bangkok the municipal Bangkok Mass Transit Authority is the major urban bus operator. By virtue of its monopoly right, it awards licenses for operation of its routes to private operators, and also sells them its obsolete buses. Regulatory independence can be achieved through organizational separation (such as independent regulatory agencies) or by delegation through contracts.

Staffing

Regulatory functions may be exercised by a branch of the police force, or a specialist unit within the authority that comprises a team of inspectors or checkers, and some administrative personnel for collating data and preparing and prosecuting infringements. There is a boundary between offenses for which sanctions may be imposed administratively, such as by the issue of a warning letter or suspension of a license, and more serious offenses that are in breach of the road traffic laws and dealt with by criminal procedures. It is more effective for the regulatory agency to have some capacity to identify offenses and impose sanctions within its own resources so that it can have some influence on deterrent policies and strategies. The police are likely to have different priorities for the use of manpower and may be unable or unwilling to prosecute breaches of license conditions or other technical offenses.

Regulating the Private Sector—Balancing Service Obligations and Commercial Incentives

The private sector can play a variety of roles in municipal government's transport functions including planning and design, infrastructure and system ownership, regulation, financing, investment, operation and maintenance (O&M), management and enforcement. The respective forms of public and private organization can be seen as a continuum ranging through government department, public corporation, service contract, management contract, lease contract, concession, build-operate-transfer (BOT) contract, cooperative and private entrepreneurship. The choice of organization for a particular activity will depend on the objectives or benefits sought from involving the private sector. These may include:

- skilled and independent management,
- operating efficiency,
- innovation,

- improved service quality through accountability to customers, and
- financial autonomy including access to private capital

Some improvements in management and operating efficiency can be gained from introducing commercial practices (such as by transferring operation from a government department to a public corporation) or from a degree of private sector participation such as contracting out specific services or management of operations.

Arrangements such as lease contracts, which give the private sector operator full managerial autonomy and full commercial risk together with responsibility for both operation and investment (such as concessions), are likely to produce stronger and more long-lasting benefits than more limited forms of private sector participation such as service contracts and management contracts. BOTs and full transfer to private ownership may also, depending on the specific agreements, mobilize new sources of funding and further reduce government's risk.

Service and management contracts may have potential as part of a progressive strategy of transition toward greater privatization. As public and private sector partners gain experience with these partnerships, they can lead to progressive expansion of private sector participation through leases and concessions and ultimately to private ownership.

The role of municipal government is to ensure adequate transport services and facilities for its population. The primary motive for an investor in the public transport business is to produce profits. To do so, he must identify and meet users' expectations and compete with other service providers in his fares and level of service. In a competitive environment, these incentives result in a service more attuned to users' needs and produced at lower cost than if produced by a publicly owned body. Meeting the "network" and social aspects of public transport that may be required by municipal government, such as affordable access by disadvantaged groups, integration of modes, comprehensive geographical coverage, maintenance of service on unremunerative routes and periods, are not consistent with maximizing returns. A balance has usually to be maintained between commercial incentives and public service obligations and these are embodied in a regulatory framework that has legal effect. Regulation is administered at the municipal level, although its objectives and basic principles may be imposed by national government. Since urban transport must be very sensitive to local needs, the municipal government may make a political judgment as to where it will set the balance between service and commercial aspects.

To design an appropriate regulatory framework, it is necessary to identify clearly the rationale for government intervention and the specific objectives sought. A basic prerequisite for regulation is a stable and predictable legal framework that can be enforced, especially in respect of property rights and contracts. Regulatory procedures must be transparent, easy to administer and enforced promptly. The scope for regulators' discretion should be clearly defined in order to create confidence in the stability and objectivity of the process. Where regulation of fares is necessary, methods should lead to simple automatic adjustments and enable operators to benefit from efficiency improvements. It is necessary that regulators have direct access to information about the quality of service and user satisfaction with mechanisms for consulting the users.

For municipal governments such as those in China without a strong tradition of formal regulation, the practice of contracting for operations may provide a learning process, with the regulatory function embodied in the design and monitoring of the contract. This may be a more practical approach than creating a new regulatory agency at the outset or by the current experimentation with a variety of forms of franchise.

Social obligations such as ensuring adequate transport services to low-income areas should be financed through explicit budgetary subsidies to the provider for these purposes only or, where feasible, paid directly to the needy population. Such transfers must be clearly specified at the outset in any contract.

MODELS OF INSTITUTIONAL ORGANIZATION

Hong Kong and Singapore

Hong Kong and Singapore provide models of institutional structures for public transport networks that are operated entirely on commercial principles, with road and ferry services provided by private sector companies, the railways by autonomous public corporations and taxis and minibuses (in Hong Kong only) in private ownership.

In both cities, sustained economic growth has generated growing demand for the use of private cars and both are committed to a framework of policy that rests on the three objectives of:

- development of transport infrastructure,
- development of a comprehensive public transport system,
- managing demand for the use of roadspace, giving priority to efficient modes and restraining less efficient modes, especially private cars.

The effectiveness of planning and regulatory institutions is critical to the realization of the second and third policy objectives, which require continuous upgrading of the quality and capacity of public transport systems.

Both Hong Kong and Singapore have had the advantage of strong stable government so that consistent policies have been maintained and developed over many years without changes of political direction. The small size of these territories also confers the advantage of single-tier government. The national and municipal levels of planning and supervision of urban services are effectively combined.

It is an element of policy in both cities that the mass transit railways are the core of the public transport system and maximizing their use to realize the greatest benefit from the massive public investment in the systems is a key strategy. Bus services are coordinated with, and subjugated to, the railways even though this compromises the viability of the private bus and other operators. In Hong Kong, mass transit ridership has risen to the point where parallel operation and an enhanced degree of competition can be permitted between bus and mass transit services. The incentive of competition with the railway has resulted in the rapid development of premium, air-conditioned bus services. Conversely, the competition from air-conditioned buses along some of the railway's corridors has resulted in lower rail fares.

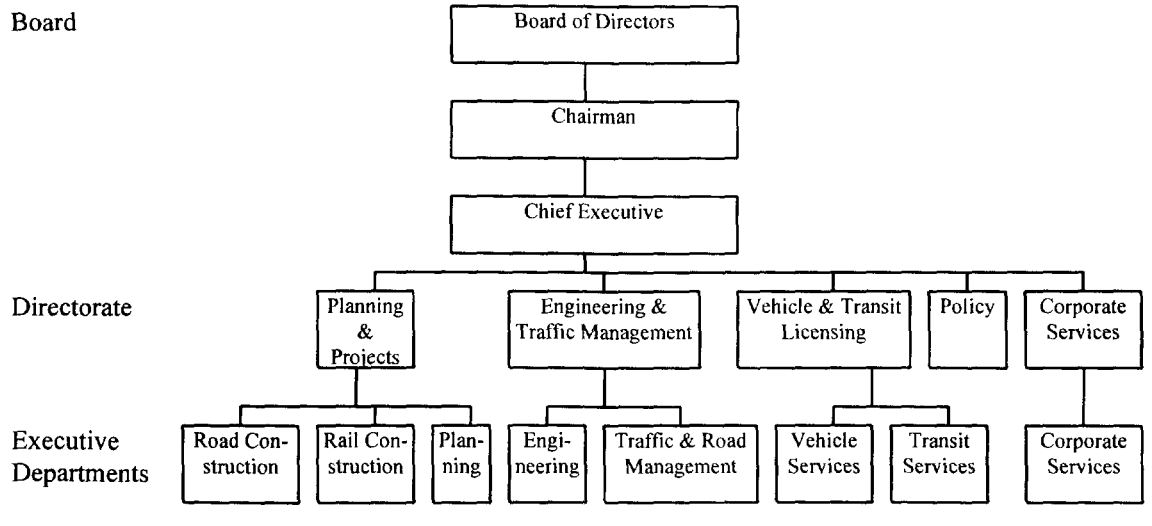
Due to the favorable operating environment (high population density, restraints on private car use, travel patterns well dispersed in time and location), the costs of the social and network obligations can be met by the operators from internal cross-subsidy without a need for external subsidy or complicated schemes to subsidize needy users.

In both Hong Kong and Singapore, the relatively high level of government direction of the transport network, and the legacies of a former system of regional monopoly bus franchises, has reduced the scope for competition between operators. Whether the bus and rail systems are as efficient and cost effective as they could be is a constant concern of government and its advisory bodies. Regulatory frameworks such as those in Hong Kong and Singapore that place constraints on competition in the interests of stability and coordination must incorporate other means to ensure efficiency.

A variety of devices, often using formulae as yardsticks, has been adopted to check and promote efficiency. International experience suggests that the further a private sector undertaking falls below cost recovery, the more specific and administratively complex the regulatory framework must be, and the lower the likelihood that it will be effective in promoting efficiency. Complex regulations administered by government tend to become bureaucratic while the operator's attempts to satisfy the formulae, rather than the market forces for which it is a surrogate, can generate undesirable side effects. Defining and administering surrogate incentives to meet demand is a perennial problem for any regime that is not fully deregulated. There are very few bus systems in private ownership that are not very close to full cost recovery. Once the profit incentive is replaced by dependence on subsidy, the public agency providing the subsidy will assume powers of direction, and the operator will be exposed to political direction and be vulnerable to nationalization.

While Hong Kong's strategy for the future development of bus and rail services is through regulation tempered by controlled competition, Singapore is moving to greater coordination, increasing government's powers of planning and integration of transport and vesting them in a Land Transport Authority (LTA). The structure of the LTA is shown in Figure 3.

FIGURE 3: THE ORGANIZATIONAL STRUCTURE OF THE SINGAPORE LAND TRANSPORT AUTHORITY



The Singapore Land Transport Authority. The Authority's mission statement is to:

> "provide a quality, integrated and efficient land transport system that meets the needs and expectations of Singaporeans, supports economic and environmental goals, and provides value for money."

Essentially a merger of four government agencies (Registry of Vehicles, Road and Transport Division of the Public Works Department, Mass Rapid Transit Corporation, Land Division Ministry of Communications), LTA responsibilities extend to the planning, design, development and management of all land transport infrastructure and policies including road building and maintenance, the design, building and operation of the mass rapid transit (MRT) and any future rail systems, vehicle ownership and demand management policies. The authority integrates all government functions relevant to land transport except land use planning within one agency. It may be distinguished from the Transport Authorities on the United Kingdom and United States models described in the section on "Forms of Municipal Ownership of Transport Systems" since, although it will regulate the operation the MRT, bus and taxi services by license and legislative powers, it will not assume ownership of the systems. They will continue to have a degree of managerial independence as corporations or limited companies. The powers vested in LTA by its Act are largely derived from the legislative powers of its constituent bodies, although these have been augmented to remove the administrative boundaries between road, rail and the various forms of land transport to promote the maximum degree of integration and cohesion. The Authority is directed by an appointed Board comprising 13 representatives of business, academia, the professions, labor and community organizations.

POWERS OF THE SINGAPORE LAND TRANSPORT AUTHORITY

Empowering Legislation	Powers Conferred on LTA
Street Works Act	To plan design construct and maintain roads, pedestrian walkways, bus stops, shelters, interchanges and terminals, taxi stands. Maintain, operate and improve road traffic signs and signals, traffic control and road lighting equipment.
Parking Places Act	To provide, license and regulate the use of motor vehicle parking places.
Rapid Transit Systems Act	To plan, design, build, operate and maintain rapid transit systems including the MRT system, and to regulate the operation of these systems.
Road Traffic Act	Powers for the registration and licensing of motor vehicles and collection of fees and charges. Licensing procedures and systems for road transport.
Other Responsibilities	To grant permits for land transport purposes. Traffic management strategies and practices. To promote land transport policies and programs. To excavate, resume or close any road. To compulsorily acquire land for building roads and railways.

MUNICIPAL GOVERNMENTS AS TRANSPORT OPERATORS

HISTORICAL FACTORS

In most American and European cities, organized urban public transport operations commenced in the latter part of the last century and were originally operated predominantly by the private sector. Their transfer to the public sector took place by the following process.

As cities grew, bus, tram and rail networks were extended to provide comprehensive coverage. Increasing motorization began to abstract passengers from public transport, and a growing proportion of routes became uneconomic but were maintained for social and network reasons. Traffic congestion, by reducing the productivity and reliability of bus and tram services, further lowered levels of cost recovery. Keeping fares within the means of lower-income groups and, later, below the perceived cost of using a car required increasing levels of subsidy. As the amount of subsidy grew, political pressures for government to assume more direct control over expenditure by taking over the operation of services prevailed.

The transfer of transport operations to the public sector is thus strongly identified with the erosion of commercial viability. In most European and all North American cities, public transport has remained in public ownership while increasing emphasis has been placed on the social aspects of public transport—ensuring a comprehensive network of services, and assuring access to disadvantaged groups so that in some cities, subsidy levels have risen to more than two-thirds of operating costs. Latterly, the social objectives of increasing transit ridership have been reinforced by increasing concerns of the negative impact on environmental quality and city form of attempts to cater for ever-increasing volumes of private vehicles.

This interventionist role of government still prevails in China. However, in the last 15 years, in many countries this "social approach" has been replaced by a market approach in which the quantity and, to a great extent, the quality of services are determined by market forces. The reasons for this fundamental change are partly ideological and partly financial—the burden of ever-increasing levels of subsidy. Some countries have responded by moving to a fully deregulated system (such as the United Kingdom), some to competitive regulation (such as Sweden), while some have maintained a fully regulated system based on the full integration of bus, tram, light rail and rail services(such as Germany).

FORMS OF MUNICIPAL OWNERSHIP OF TRANSPORT SYSTEMS

Much attention has been given in Europe and the United States to creating forms of public ownership that simulate competitive incentives, or at least provide yardsticks of efficiency while allowing social objectives to be met.

Company

A municipal government firm may be registered as a limited liability company under the corporate laws applicable to private firms. Corporate policy is decided by a Board of Directors, which responds independently to market conditions to maximize profits just as a private company. The difference is that directors are appointed by government, which receives the profits.

The laws of incorporation generally prescribe forms of organization, financing and supervision that are not appropriate to a public institution. The chief advantages of a private company—limited liability, pooling of investment, transferability of securities, perpetual existence and shareholder supremacy—have little relevance to a government entity. Since it is independent of government, with profit maximization as a motive, it may compromise service objectives and may not be susceptible to policy control.

Government Department

This is the form of organization of urban bus, trolleybus and tram services now prevalent in China's cities, usually provided by one, two three, or more municipal undertakings. The fact that a high proportion, in some cities 100 percent, of costs are recovered from fares is a measure of the viability of bus operations due to the favorable operating environment characterized by captive ridership, very low car use, high population densities and rising disposable incomes. However, management autonomy is very restricted and poor levels of service and falling ridership in some cities is, in part, an indication of the failure of services to respond to demand.

Operation by a department of government may be direct, through wholly owned companies or through separately constituted companies. Services may be "bought in" under contract. In this form of organization management responsibility is vested in the director of the municipal department, and ultimately in the head of government. Personnel are subject to civil service rules. The enterprise is funded by annual appropriations and is subject to government's budget, accounting and audit controls.

Such organizations are likely to be insensitive to market conditions, slow, procedural and bureaucratic. Managerial discretion is limited by fixed budget and rigid rules on accounting, purchasing and personnel. Funds cannot be borrowed to increase capital quickly. There is no true regulatory framework as the owner, municipal government, cannot effectively regulate itself, although it may set operational and performance objectives. Some limits on municipal governments' discretion may be imposed by central government. Direction of the municipal operator is ultimately by elected officials who, although they may lack transport expertise, should be aware of community needs. They have little time or expertise to comprehend complex issues and the operator is very vulnerable to political pressures. In these circumstances, it is likely that the operating department's objectives, especially the balance between social obligations and the commercial approach, have been ill-defined. International experience strongly suggests that the lack of clearly defined objectives tends to result in both social and commercial objectives being compromised.

Public transport operation by a municipal government department is now obsolete in the United Kingdom (UK). The Transport Act of 1985 that deregulated the UK bus industry required all municipal bus enterprises and those operated by the Passenger Transport Executives in the major conurbations to be incorporated under the companies legislation prior to disposal to the private sector. The municipality's transitional role is that of shareholder pending sale. After disposal of their operating enterprises, the UK municipalities will exercise only a regulatory role. The 1985 Act that deregulated the UK bus industry provides that any person may operate a nonsubsidized route subject only to registration. On routes supported by subsidy, the municipal government is bound to secure the best value for money. Operators compete by tender on the

basis of the lowest level of subsidy. Controlling the award of tenders puts the local authority in the position of a regulator in respect of services "bought in."

Public Corporations

Many variations of the public corporation exist. By definition, it has a degree of managerial autonomy from the government that owns it. It will have its own board of directors, accounts and is able to sue and be sued in its own name. Except for appropriations to provide capital or cover losses, a public corporation is usually independently financed and not subject to budget, accounting and audit systems of government. It may be established by specific legislation and subject to government control as provided by its statute. Its autonomy from government allows market responsiveness. There are many variations in form, ranging between bodies with many characteristics of the government department to those with similarities to private companies.

Metro Corporations

The capital requirements of metro systems preclude their development solely by the private sector, even under the most favorable operating conditions. The creation of a metro corporation confers some financial and managerial autonomy while government bears the commercial risk. Virtually all the investment in a metro is required several years before the first revenues are generated; there are substantial benefits for nonusers that cannot be captured. It is impossible to generate competition. For these reasons, metros are universally in public ownership, although it is common to vest them in a corporation with some cost recovery and service objectives. A degree of autonomy confers some freedom from the political and resource constraints of government, but to be preserved, this needs to be protected by legislation. The corporation model has been adopted for new metros in China, which also enables construction to proceed outside the complex bureaucracy of municipal government.

Both Singapore and Hong Kong's mass transit railways are constituted as public corporations. Hong Kong's MTRC enjoys commercial autonomy under the direction of an appointed board and, as a protection from government intervention, is entitled by its statute to be compensated for any obligations imposed on it by its sole shareholder, the Hong Kong government. Government provided the initial equity for MTRC, and a subsequent top-up but it now covers its capital, operating, depreciation and repayment of loans from revenue. The sale of shares in the corporation will be considered as the capital debt reduces. The railway is commercially innovative and highly successful, but the issue remains as to whether it is as cost-effective as it could be.

The Singapore MRT Corporation was the authority for the construction of the MRT. Subsequently a license was granted to SMRT Ltd. to operate it on commercial lines. Ownership of the infrastructure and track was thus separated from the operation of services, which allows the management of operations to be a financially autonomous activity. Future sale of shares in SMRT Ltd. is proposed. Nonrenewal of the contract and the possibility of replacement serve as the main incentives to efficiency. The MRTC has now been absorbed into the Land Transport Authority.

Transit Authorities—the US Model

In the United States, the transfer of public transport operations to the public sector took place quite quickly. In 1949, of the 117 largest American cities, 107 had privately owned systems. By 1979 only 11 cities had any major private sector carrier.

The vesting of responsibility for organizing and coordinating public transport in a regional authority embracing a number of municipal operating departments is common in Western Europe and the United States. Both private and municipal operations were consolidated into transit authorities. These were constituted in a variety of ways. Some systems were vested in municipal departments, funded from the municipal budget, with ultimate authority for budget, routes and fares resting in the mayor. Most American cities have utilized enabling legislation to establish separate transit authorities. In the larger cities, regional transit authorities were created, extending beyond the city boundary into surrounding counties. Usually these bodies embrace rail and road modes with the objective of achieving a high degree of integration. Creating an authority confers on the transit system a status independent of the local jurisdiction, but it can be regarded as an additional layer of government.

Not all services are operated by the authority. Some authorities, while retaining ultimate authority for budgets, routes, fares and services, subcontract operation to nonprofit corporations or commercial organizations. Many authorities employ contract executive management selected competitively, thus introducing the private sector into some areas of activity.

The constitution of US transit authorities varies; some are subject to close political and bureaucratic control over policy and operations, while others follow a "corporate" model with significant management autonomy. Typically, the authority is governed by a board of directors to which elected officials are appointed to represent constituent municipalities in proportion to population or contribution to subsidy. There is usually a professional coordinating agency. The authority usually reflects a central government policy where social and network aspects of public transport are given priority over a commercial approach. Authorities generally have low cost recovery objectives, typically half or less of operating costs being met from revenue. The balance is provided by local and central government subsidies and sometimes by specific taxes. Coordination precludes competition between operators and surrogates have to be devised to provide incentives to efficiency.

There is growing political pressure in the United States to curb the rate at which federal transit subsidies to municipal authorities are increasing. An initiative is now before Congress to cut the federal subsidy, leaving municipal governments to finance a much larger share of transit deficits. If passed, this will put pressure on municipalities to cut services and to improve cost effectiveness, although deregulation on the UK model is not proposed. Political resistance to increasing transit subsidies can be seen as a stage in the "regulatory cycle" described in Figure 4.

Verkehrsverbund—The German Model

In Germany, state governments make transport policy, while the largest cities and conurbations have joint transport authorities (Verkeshrsverbund), which plan and integrate services, coordinate a common fares tariff and investment on behalf of the participating municipal operators. The Rhein-Ruhr VVR coordinates the operation of services by 19

participating municipal operators and the national railway. The Munich MVV coordinates municipal bus, tram and metro services, the suburban services of DB, the national railway, and the suburban bus services of almost 50 operators. The organization of transport in London is not dissimilar. Responsibility for bus and underground railway operations is devolved to numerous operating companies, each adhering to service patterns and a fare structure determined by London Transport. Bus services are awarded by tender for three-year tenure. The threat of replacement provides the incentive to efficiency.

Passenger Transport Executives—the UK Model

The American trend of loss of viability of transport, consolidation and nationalization was also reflected in the United Kingdom. Partly in reaction to the dangers of uncontrolled competition between bus operators, in 1933 regulatory functions were transferred from municipal governments to the Traffic Commissioners, and competition between operators was effectively eliminated. The loss of competitive incentives and increasing motorisation soon eroded profits further and the bus industry followed the railway industry into public ownership after World War II. The London Passenger Transport Board, a public authority that acquired control of 11 municipal undertakings, was created in 1933.

Municipal public transport operations in the other large UK conurbations were consolidated and transferred to Passenger Transport Executives (PTE) in 1968. The PTEs were governed by Passenger Transport Authorities (PTA) composed of elected representatives of the constituent municipalities. The PTAs were empowered to precept the municipalities to meet the deficits of the PTE. The integration of conurbation transport services was a major objective of the creation of PTEs and they took over not only bus services, but also the control of (and responsibility for subsidizing) the local services of the national railway. The creation of separate transport authorities to undertake public transport functions marked a retreat by local government from a direct role in the provision of transport services to an indirect role.

THE DISADVANTAGES OF THE TRANSIT AUTHORITY MODEL

Since the loss, or lack, of a viable level of cost recovery has been a factor in the creation of transit authorities, they are almost invariably dependent on subsidy to cover a large proportion of cost. This makes them very vulnerable to political intervention and consequent lack of definition of management objectives by a politically motivated board of directors.

The very large scale of operations makes transit authorities insensitive to local demand. The costs of gathering data on local conditions and long channels of feedback from customers and operational staff means that information on local market conditions is poor, which may mean levels of service are not well matched to demand. This can be partly compensated by decentralizing certain management functions, especially planning and marketing, to local level.

The minimum optimum scale of bus companies is sufficiently large to lead to tight oligopoly or monopoly of supply. There may also be artificial regulatory constraints to allow profit for cross-subsidy. Any introduction of the private sector by a franchise bidding scheme must have large demand for potential operators so that unsuccessful firms can bid for future renewals. This is also true of rail operations, which are natural monopolies.

The dependence of transit authorities on subsidies from central government permit the imposition of central policy objectives. The Urban Mass Transit Administration, a bureau of the US Department of Transportation responsible for administering the federal transit aid program, has "a broad and inexplicit mandate." Its recent initiatives on universal accessibility to buses by the handicapped and performance indicators are regarded by many as insensitive to local needs.

Efforts to create forms of public ownership that restore commercial incentives, or at least provide yardsticks of efficiency while allowing social objectives to be met, have generally not been successful. As the costs of operation have risen, the proportion of cost recovery from fares has continued to fall. In most US and European cities, these subsidies have been accepted as a cost of the social, environmental and other benefits of increased use of public transport.

The key questions with respect to the efficiency of a public corporation or transit authority are:

- how is it governed,
- what mechanism exists for the definition of policy and operating objectives, and
- how is efficiency defined and assured?

The day-to-day administration should be independent of the executive and legislature except the matters of public policy and efficiency. It is difficult to supervise efficiency without restricting management freedom. f the enabling legislation is broadly stated, the corporation may in effect interpret transport policy. The main instrument of accountability is the power to appoint and remove directors. In addition, civil servants may be appointed as "ex-officio" directors, but this might lead to political interference and inhibit management. The most difficult issue in the absence of competition is how to create incentives or other means to assure efficiency. Audits, break-even budgets, power of appointment and financial autonomy are not fully effective. Clear corporate objectives, management autonomy and competition are the most effective means to ensure efficiency.

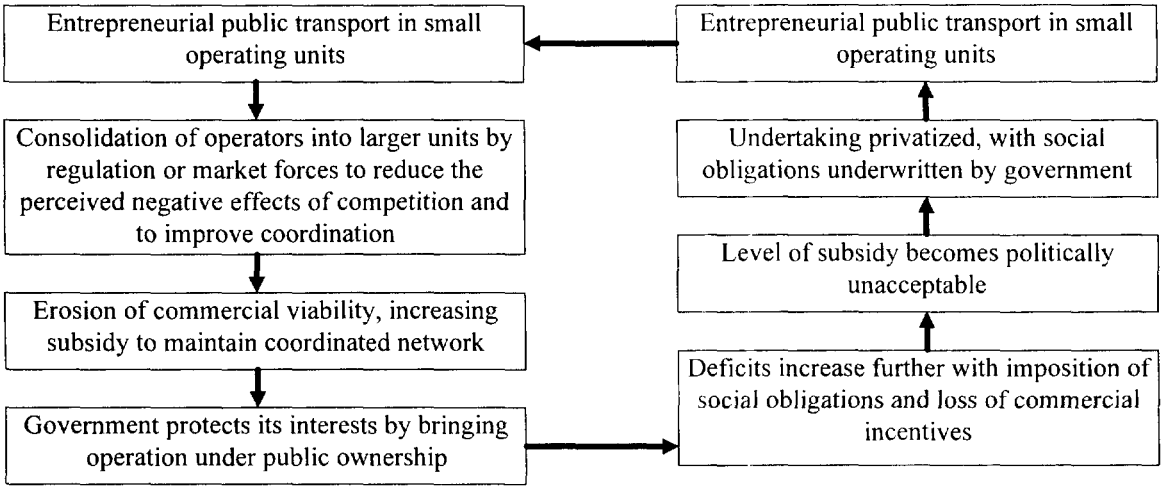
PRIVATIZATION—THE REGULATORY CYCLE

The problems of ensuring efficiency, and of meeting ever-increasing transit subsidies, have led to a move toward a restoring private sector incentives in many countries. In the United Kingdom, the increasing costs of maintaining bus services falling on local authorities were not regarded as justified by the Conservative government of the 1980s. The 1985 Transport Act required the sale to the private sector of all publicly owned bus companies and the sweeping away of all restrictions on routes and fares. The sale of the provincial bus companies of the former government-owned National Bus Company is now almost complete. Municipal bus operations and those of the Passenger Transport Executives of the large conurbations have been reformed as Passenger Transport Companies under company legislation in preparation for their sale to the private sector. The sale of these undertakings is continuing.

Thus, in the United Kingdom, the processes of consolidation and public ownership of buses that had continued for 30 years have been reversed. The bus industry has turned a full cycle from its origins in private entrepreneurial ownership in a deregulated, competitive environment, through a process of regulation to restrain competition, loss of commercial viability, public ownership, and back to entrepreneurial private ownership in a deregulated

environment. Sri Lanka has also just completed the same cycle with the privatization of the loss-making Central Transport Board and its transformation into 104 private bus companies. The stages in the regulatory cycle are illustrated in Figure 4.

Figure 4: THE STAGES OF THE REGULATORY CYCLE



Many other cities have traversed part of the cycle, ending in the public ownership stage. A few cities, such as Hong Kong, Singapore, Seoul have avoided the cycle. having profitable bus operations that have always been in the private sector.

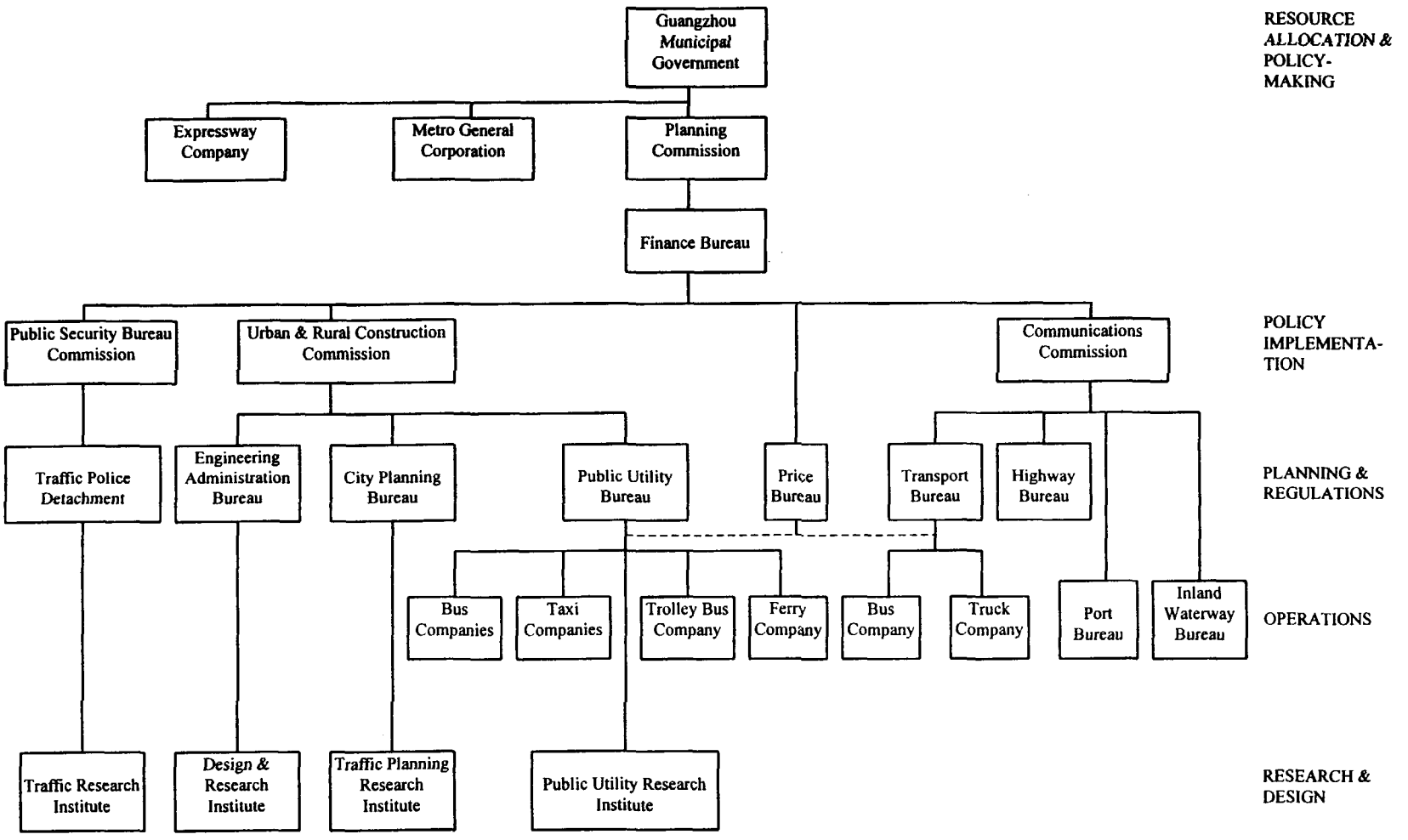
MUNICIPAL TRANSPORT ADMINISTRATION IN CHINESE CITIES

THE STRUCTURE OF GOVERNMENT IN CHINA

The administration of transport by municipal governments in China must be seen in the wider context of the structure of government. Government in China has a unitary structure. The division of responsibilities between ministries at the national level is broadly reflected in the division at the provincial and municipal levels. The national ministries have corresponding bureaus and commissions at the municipal level. At each level, People's Congresses provide consultative machinery. This structure was developed to meet the needs of a planned economy and strong central political direction from the national level to the provincial and municipal levels. However, the transition to a market economy is creating new demands on government, which it is not yet adapted to meet. The number of tiers in government makes administration cumbersome, while the constraint of a uniform structure at each level inhibits change.

The unitary structure gives municipal government a strongly vertical orientation under the administrative authority of the Mayor. Each Commission exercises a high degree of autonomy for its affairs and is not very susceptible to influences from organizations in other structures. Matters affecting the interests of a number of organizations tend to be resolved by upward referral within the hierarchical structure, often to the level of the Mayor's Office, rather than by horizontal coordination. The organizational structure of the Guangzhou Municipal Government is depicted in Figure 5.

FIGURE 5: THE ORGANIZATION OF TRANSPORT FUNCTIONS IN THE GUANGZHOU MUNICIPAL GOVERNMENT



Institutional Boundaries

The autonomy of the Commissions has encouraged them to spread horizontally, extending their administrative responsibilities across a range of activities, and vertically, through a hierarchy of executive departments, planning and regulatory agencies, research institutes and enterprises. This gives the Commissions a degree of administrative self-containment and some sources of finance outside the municipal budget, but it creates overlaps between the responsibilities and activities of different organizations and creates vested interests in protecting and expanding assets and sources of revenue. The current mix of administrative bodies, regulatory agencies and enterprises within the same organizational structure creates conflicts of interest which will intensify in the future when government enterprises will find themselves increasingly in competition with private enterprises over whom they exercise regulatory powers.

The relative ranking and authority of subsidiary bureaus and departments at similar levels under different Commissions is not clearly defined, and is often a matter of contention. Coordination of policy-making and administrative action between subsidiary organizations is therefore inhibited, which reinforces the need for directions to be imposed from above.

Transport policies tend to be multidisciplinary and involve resource, planning, regulatory, operational and political aspects. If a major initiative is required, a "campaign" approach directed from a level as high as the Mayor's Office may be employed to ensure that all agencies involved are committed to common objectives. Such initiatives tend to involve large numbers of delegates from several levels in each organization, a wide range of organizations, as well as the political elements from the Communist Party and the People's Congresses. Such initiatives are difficult to sustain. Delegation and organization of follow-up action is complex, and is not done systematically, being complicated by unclear rankings and overlapping functional responsibilities, as well as the variety of vested interests.

Geographical Boundaries

Organizational responsibilities are also divided geographically. A provincial government agency is responsible for highway planning and maintenance and transport service licensing outside the municipal boundary.

An administrative distinction is also made between local transport systems and local parts of national systems. The railways are administered by provincial railway administrations. Municipal government usually has no jurisdiction over the services provided or the management or development of facilities. This tends to subjugate local interests in rail services to national interests. Port and airport responsibilities are similarly vested at the national or provincial level.

There are also differences between national and local regulations governing road traffic. Three tiers of regulations exist, at state, provincial and municipal levels. These are not fully consistent in their provisions.

Administrative reform is recognized to be necessary to enable government to be more responsive and to cope with increasing complexity as economic reform continues, but there are many constraints and progress is slow.

Strengths of the Current System

The existing systems of municipal transport administration in China, even though developed to meet different needs, have many strengths that will provide a sound basis for progressive reform:

- authoritative government at national, provincial and municipal levels which is capable of taking resolute action, for instance to restrain growth in car use and to fund and execute major infrastructure schemes such as urban roads and railways,

- a strong tradition of centralized, coordinated planning, with administrative machinery in place,
- a hierarchy of consultative People's Congresses at every level,
- well-developed institutions,
- availability of technical and administrative skills,
- a commitment and some experience in allowing the private sector to participate in the provision of urban transport services.

OPTIONS FOR REFORM

A number of principles drawn from international experience are identified below, which may guide the evolution of municipal transport administration in China to meet future conditions. The process should preserve as far as possible the strengths of the current administrative structure while improving the definition of organizations and coordination of administrative processes. This may require structural changes.

The Role of Government to be Defined

The role of government must change as economic reform proceeds and more activities are entrusted to the private sector. Government's role in the economy should progressively retreat from commercial operations, which do not make optimum use of resources and which are not liable to the final discipline of bankruptcy, and move toward that of strategic planning, setting standards, installing appropriate regulatory regimes and generally establishing the parameters within which economic activities take place.

Structural Changes to Municipal Government

International experience suggests that the following principles are conducive to efficient administration and should be considered as objectives in the process of reform of the institutional structure of municipal government:

- the separation of enterprises from administrative and regulatory agencies,
- the rationalization of internal structures of bureaus/commissions,

- the systematic resolution of relative rankings of bureaus/commissions and their subsidiary organizations at all levels,
- the rationalization and clarification of functional boundaries between organizations,
- conferring power on municipal authorities to manage local networks and facilities of national transport systems, with particular reference to the railway network.

There is a particular need for the consolidation of municipal transport responsibilities into fewer bureaus, but the unitary structure common to all levels of Chinese government, and vested interests in enterprises are among the constraints on rationalization. As an interim measure arrangements for the coordination of policies and programs in the transport sector should be improved.

The original role of the police in many countries extended beyond enforcement to traffic management. China is one of the few countries where the police retain a major role in designing and implementing traffic management schemes. It involves a difficult demarcation of responsibilities with municipal engineering departments and should be critically reviewed. There is a case for separating design and enforcement functions and for consolidating all traffic management design functions in a specialist professional department, with the police contributing in an advisory role.

Public Sector Enterprises to be Accountable for Performance

It is current policy to encourage private, including foreign, investment in transport services and infrastructure. This will expose state-owned enterprises more to market forces and they should be given some freedom to respond to these changes. It is recommended that they be given more commercial autonomy, and that they be freed from, or compensated for, the social welfare obligations that they carry such as life-long employment, housing and welfare obligations to staff and the cost of transport services for those groups who enjoy concessionary fares or free travel. It is important that the performance of those public transport operators that remain in the public sector should be measured against industry norms. To achieve this, they must be self-accounting, with subsidies and welfare obligations taken fully into account.

Rationalize Geographical Boundaries

An administrative boundary may exist between the inner urban counties and the outer suburban counties of a metropolitan area. Different authorities license road public transport services and plan and manage road (and other infrastructure) construction and maintenance projects on different sides of the boundary. There is evidence of boundary problems in both public transport service licensing and roads and it is recommended that, in the short term, common policies and practices be adopted by both authorities and that in the longer term transport planning and licensing boundaries be adjusted to embrace the whole metropolitan area.

LESSONS FOR CHINA'S CITIES FROM INTERNATIONAL EXPERIENCE

The way that transport administration is organized in any country reflects the politics, culture and history of that country and that is demonstrably true of China. International

experience demonstrates a wide range of structures for the administration and provision of transport services within municipal government. Systems vary between countries and different systems may coexist in the same country or even in a single city. They fall into two broad groups: those where government is the planner and regulator (or in a deregulated system, the facilitator), and those where government is both the planner and the provider as in Chinese cities. Many hybrid systems also exist.

The most appropriate institutional structure for transport administration in Chinese cities will be influenced by the broad transport policy objectives to be achieved, including the role to be played by the private sector.

The three elements that have formed the basis of transport policies in Singapore and Hong Kong for nearly two decades, and many other cities are also appropriate to China's cities at this stage of their development:

- development of transport infrastructure,
- development of a comprehensive public transport system, making public transport an attractive alternative to the car and motorcycle,
- managing demand for the use of urban roadspace, giving priority to efficient modes and restraining less efficient modes, especially private cars.

The coordination of measures toward these objectives requires the urban transport system to be planned and managed as a whole, and an institutional structure that will integrate the processes of infrastructure development, traffic management and public transport planning. Public transport must be of high quality and capacity and responsive to community needs. A hierarchy of service quality is needed, to cater for groups with different value of time and comfort and to be responsive to users' rising aspirations over time.

International experience shows that high-quality, cost-effective public transport can be most effectively achieved through introduction of the private sector using competition as the incentive, moderated by a regulatory framework,

Experience overseas demonstrates that private ownership alone does not give any incentive to efficiency. A monopoly operator in private ownership will not necessarily be more efficient than a monopoly in public ownership. Efficiency requires an industry structure that generates competition. An important conclusion from international experience is that surrogate incentives, such as targets, norms and audits imposed administratively are less effective than competition in promoting efficiency and are very inferior in promoting demand responsiveness.

Another lesson from international experience is that the discipline of cost recovery forms a very important threshold. Once revenues fall below the level of cost recovery, and the operation needs to be supported by government subsidy, it becomes subject to the political and administrative controls that exist to ensure that government expenditure serves social and other policy goals. Once cost recovery has ceased to be a constraint, other policy objectives take precedence and cost recovery falls further. This is the experience from France, Germany, and the United States where cost recovery levels are between 30 and 60 percent and municipal

transport policy objectives emphasize social and environmental benefits. Deficits are recovered from local and central government grants and specific taxes. Government organizations are not sensitive to market trends and opportunities and cannot direct a transport operation along lines that will meet demand.

Indications are that urban bus operations in the large Chinese cities are potentially fully cost recovering (including financing and fleet replacement) and that mass transit railways are able to cover operating costs providing infrastructure costs have been met by government. There are persuasive arguments that municipal government should maintain cost recovery as an objective for bus and mass transit services and that competition be used as an incentive to cost efficiency and demand responsiveness.

This suggests that part of the public transport industry, not necessarily all, should be in private ownership. There will be competition within the private component of the industry to meet demand, and this will provide a comparison, and a yardstick of efficiency, for enterprises remaining in public ownership. The lack of such a yardstick of efficiency has been a the major concern in the supervision of publicly owned systems in Europe and the United States.

REGULATORY REFORM FOR PUBLIC TRANSPORT

China's municipal public transport enterprises suffer from excessive bureaucratic control, lack of investment, ill-defined cost recovery and level of service obligations and obsolete fleets and infrastructure. They are tied to the domestic bus manufacturing industry that is only beginning to produce buses with modern standards of comfort and performance. It is established policy to encourage the private sector to invest in transport infrastructure and services.

The current policy for public transport in Chinese cities is to introduce the private sector gradually, but there are political constraints. Transfer of the entire urban public transport industry to the private sector is not acknowledged as a current transport policy objective. Public transport is still regarded as a basic social service, which has long been subsidized and which policymakers feel should not be fully exposed to market forces. Private taxi and minibus services have been operating for some years under a variety of local enterprises including local/overseas joint ventures. More recently, several cities have negotiated joint ventures between their municipal bus companies and overseas investors for the operation of air-conditioned premium bus services, which are superimposed on the network of basic services run by the municipal enterprise. Passengers are thus offered a choice. Progressively, the capacity and market share of the private premium services will increase. The private sector is developing the premium end of the transport market, a sector that municipal enterprises have been very slow to identify and serve. This is a pragmatic and effective way to achieve the objectives of encouraging private investment, importing expertise and raising the quality of urban bus services in an environment where the benefits of economic reform have not yet been distributed equally. It is recommended that this strategy forms the basis for the future development of bus services in through the stages set out in the last section.

Municipal government has a vital role in facilitating this process. The importance of a carefully designed regulatory framework has been emphasized in this paper. There is still no

standard form or national policy on franchising in China and private investment is so far limited to joint ventures where the joint venture partner is a municipal enterprise. Many joint ventures have resulted from private initiatives and the subsequent negotiations have resulted in a variety of ad hoc franchising terms that are in essence contracts.

An appropriate regulatory regime will need to be developed for each mode—bus, taxi, minibus and ferry services—to promote the development of an integrated system of public transport services, to provide operators the right mix of commercial rights and public service obligations, to assure reasonable rates of return and to create incentives to efficiency. This involves a very subtle and changing balance requiring knowledge not only of commercial conditions within the public transport industry but wider transport policy objectives. Draft regulations are under discussion but they do not adequately define the rights and obligations of the operator, nor the powers of the regulatory agency. In particular, the operator's protection from arbitrary administrative action needs to be assured. At present, the regulatory agency is often a subsidiary of the Public Security Bureau, as are the municipal bus, taxi and minibus operators. In private sector joint ventures, the domestic partner is usually the municipal transport enterprise. Private operators can find themselves being regulated by a body that has an interest in both their own and in competing services. Regulatory functions must be vested in an authority that is independent of any interest in transport operation. Impartiality of the regulatory authority will be of fundamental importance if private companies are to invest with confidence in public transport. The current practice whereby senior officials of the municipal bus enterprises and the regulatory agency rotate posts also compromises regulatory independence.

However, the potential for successfully privatizing bus services in Chinese cities is very high as dense demand, a high proportion of captive users and increasing disposable incomes makes public transport potentially commercially viable. The biggest impediment to full cost recovery at present is the imposition of constraints on fare levels for social or political reasons. The sensitivity of increases in factors in the cost of living is acknowledged, but the social objective of ensuring access to services by low-income and disadvantaged groups can be met by specific targeted subsidies by municipal government or from cross-subsidy, which would not detract from the commercial incentives on the operators.

A Progressive Strategy for Reform of Municipal Transport Organizations

A progressive strategy follows from the conclusions above. The starting point is the current public transport industry structure in the major Chinese cities:

Stage 1—Status Quo

- Basic bus services are provided by municipally owned enterprises;
- Premium bus services are provided by joint venture companies including the municipal enterprises;
- Minibus and taxi services provided by a variety of private and public enterprises on fully commercial lines;

- The regulatory framework allows the introduction of private joint venture operators and a low degree of controlled competition;
- The regulatory agency is a department of the municipal Public Utility Bureau, which is also responsible for operation of the municipal transport enterprises;
- The mass transit systems are being developed by corporations, funded by allocations from municipal government budget and specific taxes.

Stage 2—Establish an Industry Structure of Autonomous Units

- The municipal bus enterprise to be divided into several district networks, each to be financially self-accounting, with a cost recovery objective;
- Private sector bus and minibus services to be developed into premium services and more operators licensed and larger fleets. Premium bus capacity to rise to match increasing demand as incomes and aspirations rise, and as central area private vehicle restraint measures introduced;
- The regulatory framework to be carefully designed reflect policy objectives and to provide a balance between commercial incentives and service obligations;
- The municipal Public Transport Management Department made independent of any interests in municipal transport operation and its analytical and planning capacity reinforced to enable it to develop and administer the regulatory framework and integrate and steer the development of the public transport system;
- An autonomous corporation be created to operate the metro with an obligation to recover operating and maintenance costs.

Stage 3—Limited Competition within a Regulated Framework

- The regulatory framework develops system and introduces contestability of bus and minibus services, awarding route packages with limited tenure and renewal by tender. Some joint ventures running in main corridors encourages competition between private operators, and between them and the municipal corporations;
- The municipal corporations also compete with private operators for market in premium services. They may lose market share as demand moves up-market to private buses;
- Continued development of the regulatory framework, including arrangements for funding concessionary fares and unremunerative but socially desirable services through cross-subsidy or targeted subsidy to users.

Stage 4—Increased Reliance on the Private Sector

- Municipal operating corporations reconstituted as companies; shares sold. Compete on equal terms with private operators;

- Number of private operators rises to 6 to 10 in the largest cities to enhance contestability and competition;
- Regulatory agency functions develop further extending to:
    - planning and forecasting: steering the development of the industry,
    - advising metropolitan engineering agencies of infrastructure needed for public transport,
    - coordinating metro, bus, ferry and minibus services,
    - monitoring and fine tuning the regulatory framework to ensure integrity of the regulatory system and effective competition,
    - monitoring operators performance standards against industry norms;
- Metro Corporations invite private capital through the sale of shares once viability is established.

THEME PAPER 5: BICYCLES IN CITIES

ANTON G. WELLEMAN, CEES J. LOUISSE AND DIRK M. LIGTERMOET [1]

SECTION 1: CONTEXT

THE IMPORTANCE OF BICYCLE TRANSPORT POLICY

On a worldwide basis, the bicycle is a means of transport that in number far exceeds the passenger car (1994: 850 million bicycles, 470 million cars; annual production of bicycles 93 million, of cars 34 million). This division already existed 100 years ago, and will probably continue for a long time. Why?

The Past

There is a simple explanation why, 100 years ago, there were more bicycles on the road than cars: the bicycle was developed earlier than the car. The first bicycle with peddles dates back to 1853. By 1880, the so-called safety bicycle was introduced, the predecessor of the modern bicycle. In 1896, 2.3 million bicycles were produced worldwide, of which 1 million in the United States. It was not until 1870 that the first steam car was built in France, followed by the first working car running on petroleum-based fuel in Germany in 1886.

The Recent Past

In many Western countries, the bicycle has made a substantial contribution to economic development. During the first phases of this development, large groups of the working population were able to travel quickly and safely by bicycle. As a result of this same economic development, increasingly more people were able to afford their own car. In most countries, the bicycle was subsequently relegated to a secondary role as a means of transport for lower-income groups, for women and students, and for leisure use. Within transport policies, attention increasingly focused on accidents involving cyclists and on the hindrance that bicycle traffic causes for car traffic.

Outside the Western world, many countries have shown the same development of bicycle and car use over the past decades as earlier in the Western world. Bicycle ownership and

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use grew rapidly, with economically relevant applications: commuter traffic, commercial traffic, and also goods transport. Car ownership is now growing but still lags the widespread use of bicycles.

The Present

Despite strong increases in car ownership and use, the bicycle has remained popular in European countries such as Denmark and the Netherlands. In many other Western countries the bicycle's popularity is growing again. On a global basis, the bicycle proves to be an efficient means of transport in many countries. In addition, cycling is increasingly seen as a form of physical exercise that is beneficial to people's health. At the same time, the cyclist provides a personal contribution to reducing threats to the environment.

What happened earlier in the Western world can now also be seen in many other countries including China: the rise of mass motorization is leading to conflicts with nonmotorized modes of transport. Such conflicts make it necessary to make choices, especially in cities with rapid economic development. Mainly due to high population densities, the adverse consequences of the motor car are becoming evident in cities of the developing world even while car ownership and use are still at a low level.

The Future

The bicycle has a good future and its use could still increase significantly. In the West, the increase in bicycle use will mean *regaining* attention, space, and budgets. Outside the Western world, in many cases it may still be possible to *prevent* one-sided attention, space, and budgets for the car. From a traffic science point of view, the bicycle's role can be summarized as follows:

- The value of the bicycle as a means of transport is mainly due to its functionality in door-to-door transport across small distances. The increasing focus in the Western world on this value over the past few years is mainly due to the negative effects of mass motorization. It has been shown that traffic congestion in cities cannot be remedied simply by expanding road system capacity.

- The accessibility of and the quality of life in cities is seen as increasingly important. In trying to find alternatives for the car, attention usually focuses on rail systems and flexible bus systems. These are indeed perfectly suitable for handling large concentrated flows of passengers, but they are often expensive for the community due to infrastructure investments, the space they occupy, and financial operating subsidies. In addition, many trips are not well served by public transport. Here lies the opportunity for the bicycle.

- The combination of public transport and the bicycle as a feeder can offer a solution for the areas that can only, to a limited extent, be served by public transport lines. The same combination of public transport and bicycle would then form a transport chain that would also offer an alternative to the car in the case of long-distance journeys. In addition, this combination of public transport and bicycle can offer a solution when very large numbers of parked bicycles lead to bottlenecks. Public

transport can then enter into or come near the busiest areas, and bicycles will take the passengers to and from the bus stops outside those areas.

Even on a political level, there is a growing realization in many countries that the bicycle, either independently or in combination with public transport, can provide a substantial contribution to the proper functioning of urban transport systems. The World Bank too has these past years shown an increased interest in Nonmotorized Transport. The Bank firmly believes that cities in developed and developing countries should exploit nonmotorized vehicles more.

SCOPE OF THE PAPER: BICYCLE POLICY AS AN INHERENT PART OF THE TOTAL TRANSPORT POLICY

This paper was written from a Dutch perspective. It is the result of an intensive professional involvement in bicycle policy and bicycle traffic in the Netherlands. Providing information on this subject to interested people from many different countries has resulted in gathering some knowledge about what is happening in this field in the rest of the world. During a short but intensive sector mission visiting five major Chinese cities in the spring of 1995, impressions were gathered of the traffic in those cities and the role of the bicycle within that traffic.

Section 2 discusses bicycle development in the Netherlands. In terms of bicycle use, the Netherlands has perhaps the highest intensity of bicycle use in the Western world. At the same time, the Netherlands has one of the highest intensities of car ownership per square kilometer. The Dutch government is aware of the advantages as well as the disadvantages of both cars and bicycles, and has therefore—since 1990—followed an active policy of promoting bicycle use and improving traffic safety of cyclists.

Section 3 describes bicycle use in China. This part of the paper may be considered as a Dutch mirror in which Chinese cities can see themselves and each other.

Section 4 pays attention to the bicycle in a number of countries in the Asia region. This sketch, which is based on only a limited number of published sources, provides an impression of bicycle transport in Asian cities that—in terms of size—can be compared to the major Chinese cities.

Section 5 discusses possible directions for future bicycle policy in China.

SECTION 2: BICYCLE DEVELOPMENT IN THE NETHERLANDS

The Netherlands is a small country (37,400 km^2 land area), situated on the North Sea in the flat delta of the rivers Rhine, Maas and Scheldt. This location has, to a large extent, determined the history of the Netherlands. On the one hand, there was the continuous battle against the water; on the other hand, this location offered excellent trade opportunities. Rotterdam, one of the largest harbors in the world, has been able to benefit most from this, also because the rivers have historically formed an excellent connection with the densely-populated European hinterland.

The Netherlands is a densely populated country (1994: 455 inhabitants/km^2 of land). For a long time, the population was spread among many relatively small towns and villages. Gradually, a dense road system came into being. The Netherlands has never had a significant passenger car manufacturing industry, but it does have its own truck and bicycle industries.

This section will first describe the historical development of traffic in the Netherlands until 1950. Subsequently, developments to the 1990s will be discussed, including the circumstances that determined and explain traffic development. The paper will then discuss traffic policy since 1990, and current expectations in the Netherlands on the future role of bicycles. The section ends with a limited number of conclusions, aimed at comparisons with the Chinese situation.

THE HISTORY OF BICYCLE USE UNTIL 1950 (Ref. 13 and Ref. 14)

Until 1890, the bicycle, which had been introduced around 1860, remained a luxury item. The price of a secondhand bicycle was approximately 40 guilders (f.), while the spendable income of a skilled laborer in the large cities was some f. 1.83 per week. Cycling therefore remained the privilege of a small, affluent group, which mainly consisted of young men.

By 1899 the situation had changed considerably. In this year the number of bicycles was 94,370 (1 per 53 inhabitants), while in 1906 there were as many as 324,750 (1 per 17 inhabitants). The bicycle was more and more used for commuter traffic and commercial use. Around 1910, manufacturers introduced cheaper models, targeted at workers and middle-class people. A good bicycle then cost between f. 55 and f. 70, while a skilled laborer earned between f. 750 and f. 1,000 per year. This development meant that the bicycle became affordable for increasingly more people. By 1912, bicycle ownership had risen to 1 per 10 inhabitants. The first traffic census in the Netherlands (in 1908) showed that 62 percent of all vehicles on the road consisted of bicycles. By 1916, this percentage had gone up to 75 percent.

In the period between the two world wars, road traffic made its definitive breakthrough in the Netherlands. Starting in the mid-1920s, when increasing mass production caused car prices to go down, car traffic in the Netherlands strongly increased. As a result of the economic crisis in the 1930s, the growth of motorized traffic stagnated. The bicycle, however, continued to rise in numbers from some 1.8 million in 1924 to some 4 million in 1940 (on a population of 8 million inhabitants). Between 1913 and 1938, the annual number of train passengers fell by 8 million to 47.8 million. Transport by bus, in particular, had become a competitor. An average of one bicycle for every two inhabitants meant that the bicycle's exclusive character had disappeared completely.

The streets had meanwhile become busier: between 1916 and 1938, the average traffic intensity in the Netherlands (excluding pedestrians) had multiplied by six. The speeds and quantities of the different categories of traffic gradually grew further apart. This became evident from a considerable rise in the number of traffic accidents. In 1934 there were 744 traffic fatalities, of which one third were cyclists. For comparison, the figures for 1994 were: 1,298 traffic fatalities, of which 269 were cyclists.

TABLE 1: NUMBER OF VEHICLES IN THE NETHERLANDS, 1930 AND 1937 *(Ref. 14)*

Number of vehicles	1930	1937
Passenger cars	67,845	90,839
Motorcycles	31,314	54,084
Buses	3,526	3,800
Trucks	41,227	48,000
Bicycles	2,700,000	3,500,000

During the German occupation (1940-45), bicycle use strongly diminished, mainly as a result of an increasing shortage of bicycles and spare parts. Figures are not available. For the first few years after the Second World War figures are available only to a limited extent. A census of 1947 shows that 52.4 percent of all commuters traveled by bicycle, 5 percent by car, while the remainder traveled by public transport. The term "commuters" at that time indicated professional population working relatively far from their place of residence. The figures therefore refer to longer commuter trips.

DEVELOPMENTS IN MOBILITY; THE 1950-90 PERIOD (Ref. 13)

The 1950-90 period is, in many ways, characterized by turbulent developments. In view of their close connection with the development of mobility, it is important to pay attention to the various demographic, spatial planning and social developments.

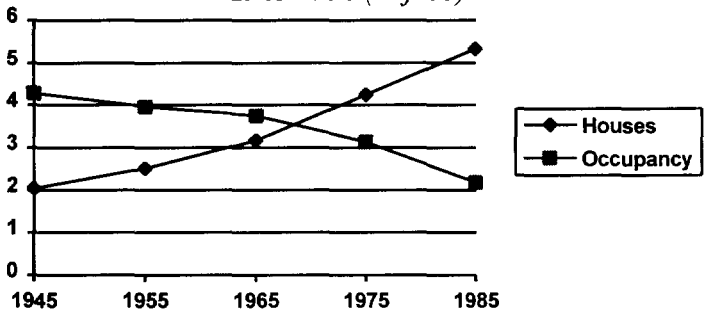
First of all, the most significant social developments that have had a strong influence on traffic systems are described briefly. Subsequently, the figures related to the growth in numbers of vehicles and vehicle use are discussed. This is followed by a brief description of the characteristics of the current traffic system, particularly in the major Dutch cities. Finally, the developments in traffic safety will be dealt with.

Social Developments

The number of inhabitants in the Netherlands increased from 10.0 million in 1950, to 14.9 million in 1990, an increase of 49 percent. In the same period, the professional population increased by 56 percent, from 3.9 million to 6.1 million. The number of houses increased from 2.1 million in 1947, to 5.9 million in 1990, while at the same time the average house occupancy rate decreased from 4.33 to 2.53. These developments are illustrated in Figure 1.

The combination of these developments has, of course, had a strong influence on mobility. The relative share of the various modes of transport has also been strongly influenced by changes in spatial relationships. Between 1950 and 1990, the size of the built-up area increased by a factor of 3.4. Particularly in the cities, this process was accompanied by a decrease in population density, which has generally led to longer travel distances.

FIGURE 1: TOTAL NUMBER OF HOUSES (IN MILLIONS) AND HOUSE OCCUPANCY (PERSONS PER HOUSE), 1945-1990 *(Ref. 13)*



Expansion of housing facilities initially took place on a large scale immediately adjacent to existing urban areas. Often it involved high-rise buildings. In the mid-1960s, extensive new residential areas in centers of urban growth were created at a distance of some 25 to 50 km from existing cities. The assumption was that employment would follow after a while, but this in fact happened very little. As a result, commuting, largely by car, intensified.

The modal share was also strongly influenced by a considerable increase in size of almost all social units (with the exception of household size, which declined): in companies, in all forms of education, hospitals, institutes, shops and shopping centers. In general, this sometimes very dramatic development has led to an increase in travel distances, which has had important effects on the volume of traffic flows and the choice of means of transport. The increased specialization of people and companies, too, has generally led to larger spheres of influence, and consequently to longer travel distances. This increased specialization is evident from the large diversity in professions and expertise, which has influenced commuter traffic and commercial traffic. Specialization in industry and in the service industry has influenced commercial traffic as well as cargo transport. All these developments generally led to longer travel distances, and—as a result—to an increased use of the car at the expense of the bicycle.

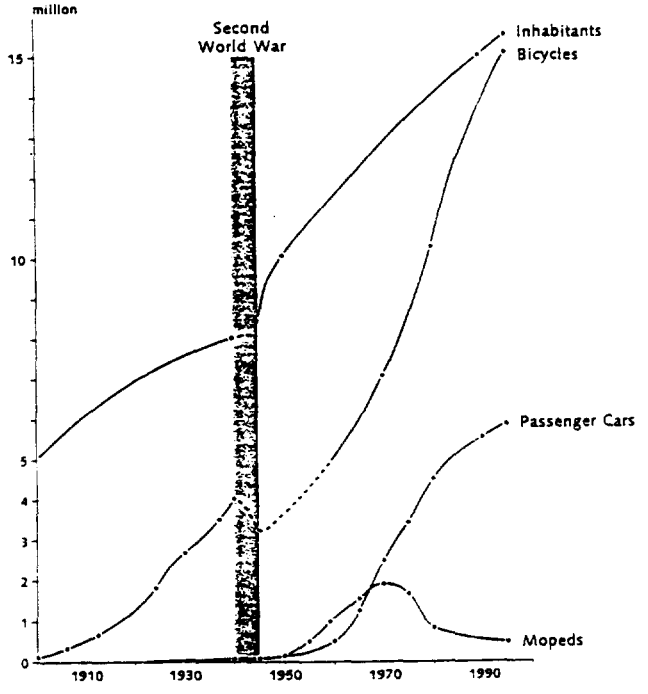
Using as a measure of prosperity an index figure based on the total family consumption per head of the population, corrected by the price index for family consumption, the period between 1950 and 1988 shows a 185 percent rise in prosperity. The increase of free spendable income has consequently been high, especially between 1960 and 1970. The rapid increase of car ownership, particularly since 1960, is closely related to this increase in prosperity.

Another relevant factor, particularly after 1960, is the emancipation of women, which was made possible by increased prosperity, education, more liberal views, smaller family units, and household mechanization. The increase of women's activities outside the house has also had its effect on the extent and nature of their travel.

Development of the Number of Vehicles and Vehicle Use

Figure 2 illustrates the development of the vehicle fleet. The number of passenger cars grew from 139,000 in 1950 to 5.5 million in 1990 (1994: 5.8 million). Currently, 77 percent of all households and single persons have at least one car, while 16 percent have two cars or more. There are nations with a higher level of car ownership than the Netherlands, but none with a greater number of cars per square kilometer.

FIGURE 2: NUMBER OF INHABITANTS, BICYCLES, PASSENGER CARS AND MOPEDS IN THE NETHERLANDS, 1900-94



Since their introduction in the Netherlands in 1949, mopeds (motorized bicycles) showed a spectacular growth to a maximum of 1.9 million in 1971. The decline that followed (primarily because more and more people could afford a car) was just as spectacular: to 463,000 in 1994.

Estimates are that between 1950 and 1960, there were between 5 and 6 million bicycles in the Netherlands. In 1970, this number had gone up to 7 million and in 1980 to more than 10 million. By now, there are about 15 million bicycles, one for each inhabitant. Cycling in the Netherlands therefore involves all social groups and income groups.

The number of cars increased strongly after 1950, but the kilometers driven per car remained practically the same (Figure 3).

This means that the increase in the number of passenger kilometers traveled by passenger cars can almost entirely be ascribed to the increase in the number of cars. After the Second World War, the total number of kilometers of passenger car showed an explosive increase: from 15.9 billion in 1960 to 125.1 billion in 1990 (1994: 129.0 billion). Total kilometers by moped, bicycle and train are very much lower in this period, and also show remarkable fluctuations. The number of passenger kilometers by train was relatively stable until 1990, showed strong growth during the 1990-93 period, and then fell again in 1994 and 1995. The strong growth in 1990-91 was closely related to cheap railway passes provided for students and many civil servants.

More kilometers were traveled by bicycle than by tram, bus and subway put together. These statistics do not include the vast number of trips to and from railway, bus and subway

stations. At some railway stations, nearly half of all passengers travel between home and the station by bicycle (Figure 4).

FIGURE 3: AVERAGE ANNUAL NUMBER OF KILOMETERS DRIVEN PER PASSENGER CAR, 1963-90 *(Ref. 13)*

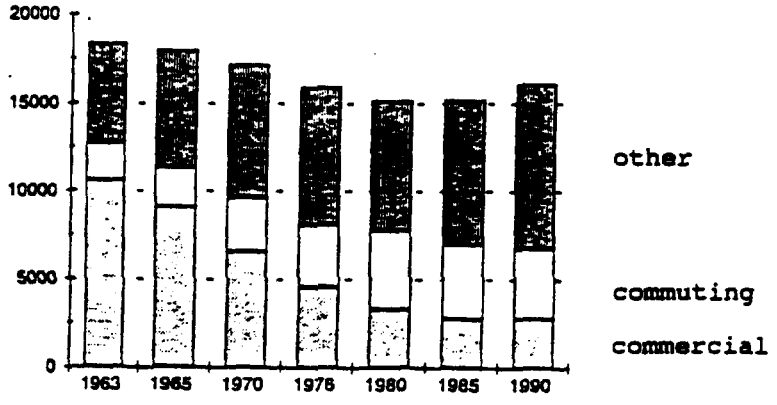
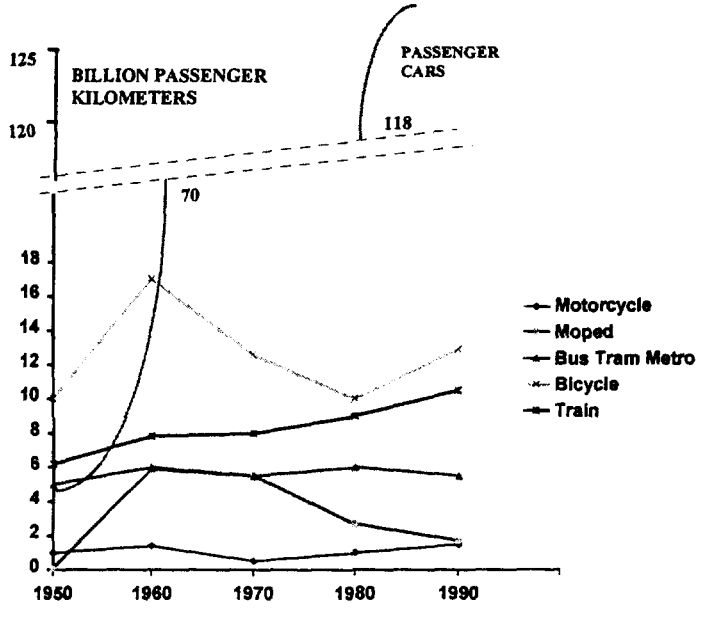


FIGURE 4: PASSENGER KILOMETERS (BILLION) IN THE NETHERLANDS, 1950-1994 (AGE GROUP 12 YEARS AND OLDER)



Until 1960, the number of passenger kilometers by bicycle was still higher than that of the car. Bicycle use fell sharply after that, and was back at the 1950 level by 1974. This was the result not only of mass motorization, but also of the related, relatively uncoordinated process of suburbanization. Also, the infrastructure actually available for bicycle traffic diminished strongly in this period because available space was increasingly dedicated for car use.

Around 1975, there was a turnaround in bicycle use: it started to grow again. Various cultural and social trends may have played a role in this revitalized growth in bicycle use. A strong increase in environmental awareness was one of them, and the increasing attention paid to healthy exercise and leisure. There was also a growing realization that large-scale car use has disadvantages as well as advantages. That was the conclusion not only of transport users, but also of government officials and politicians.

Characteristics of Urban Traffic

The Netherlands is very conducive to cycling. Conditions favor the use of bicycles for many different purposes. The climate is not perfect but it rains only 6 to 7 percent of the time. The country is flat and densely populated. For a long time, the population was spread across many relatively small towns and villages. This has resulted in a dense road network, which makes many destinations easily accessible.

TABLE 2: POPULATION AND POPULATION DENSITY OF THREE MAJOR CITIES IN THE NETHERLANDS

	Population	Population per km^2 of land
Amsterdam	725,000	4,550
Rotterdam	600,000	2,980
The Hague	450,000	6,980

These characteristics of the Netherlands are relevant in explaining the role of the bicycle in satisfying mobility needs.[2]

In the Netherlands as a whole, the bicycle is *the* means of transport for short distances. Up to 2.5 km, most trips are made either on foot or by bicycle, but also above that distance, certainly up to 7.5 km, the bicycle takes a considerable share. It is also clear that for these short distances, up to 7.5 km, public transport plays only a minor role. These conclusions are all the

[2] The meaning of the term "mobility" used in this paper should be clearly understood. In the Netherlands, but in other countries as well, mass motorization has mostly resulted in people moving across longer distances. The average time spent on travel has hardly changed over the years, but the average driving speed and travel distance have increased. So, it is actually the number of kilometers that people travel that is increasing, and not their "mobility." In this paper, the following abstract definition is used: *Mobility: the extent to which people, companies, and organizations are able to participate in (economic and social) activities.* Mobility, defined in this way, should be expressed in the number of trips, rather than in the distances traveled.

more relevant because in the Netherlands many trips take place over such short distances. No less than 70 percent of all trips are shorter than 7.5 km.

TABLE 3: MODAL SPLIT (IN %) OF TRIPS PER DISTANCE CLASS (IN KM), THE NETHERLANDS, 1991-93 (AGE GROUP 12 AND OLDER) *(Ref. 7)*

	0-2.5 km	2.5-5 km	5-7.5 km	>7.5 km	Total
Car	23	52	65	75	48
Public transport	1	4	5	14	6
Bicycle	40	34	23	8	27
Walking	35	9	5	-	16
All modes	40	16	12	29	100

Note: Reliable data concerning trips of children aged 0-11 (15 percent of the population) became available for the first time in 1994. This group uses the bicycle for an average of 31 percent of all trips. Until they are four years old, these trips are mostly made as bicycle passengers, and from that age on they cycle themselves more and more.

In urban areas, the bicycle plays an even more important role in the modal split. Following are two examples. Table 4 sets out the relevant data for Amsterdam, the largest city in the Netherlands (725,000 inhabitants).

TABLE 4: MODAL SPLIT (IN %) OF TRIPS PER DISTANCE CLASS (IN KM), BY INHABITANTS OF AMSTERDAM, 1991-93 (AGE GROUP 12 AND OLDER) *(Ref. 7)*

	0-2.5 km	2.5-5 km	5-7.5 km	>7.5 km	Total
Car	13	33	47	64	34
Public transport	4	18	17	28	16
Bicycle	28	35	28	5	23
Walking	54	10	6	-	25
All modes	39	17	13	26	100

The Amsterdam public transport system is one of the best in the country, which is supported by the following data. But even in Amsterdam public transport accounts for fewer trips than cycling. Looking only at trips shorter than 5 km, we can see that for every trip made by public transport, four trips are made by bicycle. For the Netherlands as a whole, this ratio is 1:25. In Amsterdam, more than in the Netherlands as a whole, car is a minority mode for trips shorter than 7.5 km.

The second example is Groningen, as set out in Table 5. This is a much smaller city (170,000 inhabitants), which for a long time has had a clear pro-bicycle policy.

TABLE 5: MODAL SPLIT (IN %) OF TRIPS PER DISTANCE CLASS (IN KM), BY INHABITANTS OF GRONINGEN, 1991-93 (AGE GROUP 12 AND OLDER) *(Ref. 7)*

	0-2.5 km	2.5-5 km	5-7.5 km	>7.5 km	Total
Car	15	37	57	72	36
Public transport	2	3	9	17	6
Bicycle	41	49	30	11	35
Walking	41	9	4	-	22
All modes	47	17	14	18	100

As early as the 1970s, Groningen opted for a strict traffic management plan favoring bicycles and public transport. The inner city was divided into four parts. Only bicycles and public transport were able to reach one part from another part. Later, a considerable car-free zone was introduced in the city center. In addition, in the 1990s some f. 8 million were spent each year on bicycle infrastructure. The results are evident. Groningen shows a pattern for many smaller Dutch cities: a marginal role for public transport, and for trips within the city—up to 7.5 km—a more important role for the bicycle compared to the car.

Another relevant aspect is that the bicycle plays an important role for nearly all journey purposes as shown in Table 6. The trip purposes indicated in Table 6 are the most important in terms of size, with 18, 25 and 33 percent respectively of all trips. For all three trip purposes, the role of the bicycle is significant and public transport plays an extremely minor role. In social and recreational trips, as well as shopping, walking is an important mode.

TABLE 6: MODAL SPLIT (IN %) OF TRIPS PER PURPOSE, TOTAL AND FOR TRIPS UP TO 7.5 KM, THE NETHERLANDS, 1986-90

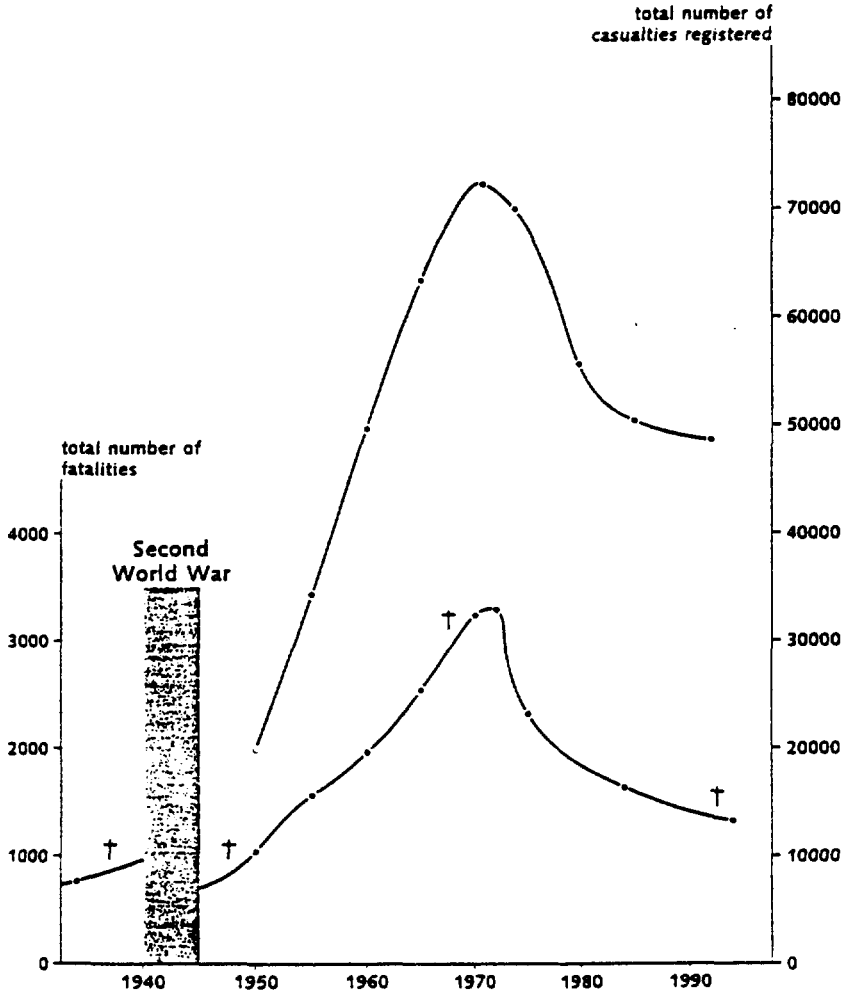
	Commuter		Shopping		Social and recreational	
	Up to 7.5 km	Total	Up to 7.5 km	Total	Up to 7.5 km	Total
Car	42	58	37	43	37	50
Public transport	2	6	2	3	1	3
Bicycle	42	26	36	32	30	24
Walking	10	5	24	20	29	21
	(55%)	(100%)	(80%)	(100%)	(65%)	(100%)

Developments in Traffic Safety

Traffic safety trends are illustrated in Figure 5. In the period when the car started to dominate (1950-70), traffic safety started to deteriorate. In 1950, the total number of traffic fatalities was 1,021 while 19,500 casualties were registered (share of cyclists 32.5 and 41.8 percent, respectively). By 1972, there were 3,264 traffic fatalities and 70,000 casualties (share of cyclists 17.1 and 12.7 percent, respectively). In other words: a 200 percent increase in fatalities

and a 250 percent increase in registered casualties over a period of 20 years. Increased accidents could be attributed to increasing car use in an environment where traffic behavior, traffic regulations, and infrastructure had not yet adjusted to a dominant role for cars.

FIGURE 5: NUMBER OF REGISTERED FATALITIES AND CASUALTIES, THE NETHERLANDS, 1930-94



From 1970 on, traffic safety improved greatly, and this trend, although leveling off somewhat, continues until today. In 1995, a total of 1,334 traffic fatalities and 50,970 casualties were registered in the Netherlands. This decrease applies to all groups of traffic participants. The share of cyclists in the total of traffic victims has, over the years, been relatively stable. Since 1980, the share of traffic fatalities has fluctuated around 20 to 22 percent, the share of hospital casualties between 22 and 24 percent, and other registered casualties around 23 to 25

percent. For comparison: the share of bicycle trips fluctuated between 27 and 29 percent during this period.[3]

That an increased use of bicycles can go hand in hand with fewer casualties among cyclists is also shown by the trend in bicycle use and the number of casualties between 1980 and 1990. During this period, the number of kilometers traveled by bicycle increased by 30 percent, and the number of kilometers by car by 25 percent. At the same time, the annual number of fatalities among cyclists declined by 30 percent, and the number of cyclists receiving serious injuries by 25 percent.

The safety of cyclists is still improving. In 1995, the number of fatalities was 12 percent lower than in 1990, and the number of cyclists admitted to hospital with injuries was 24 percent lower, as shown in Table 7.

TABLE 7: NUMBER OF HOSPITAL-TREATED CASUALTIES AND OF FATALITIES BY MODE OF TRANSPORT IN 1990 AND 1995

	Hospital-treated casualties		Fatalities	
	1990	1995	1990	1995
Car-occupants	5,115	4,778	702	657
Bicycle	3,277	2,499	304	267
Moped	2,691	2,129	98	118
All modes	13,652	11,688	1,376	1,334

This downward trend in hospitalized accident victims has been in progress for 20 years and applies to other categories of road users too. However, the total number of registered injured cyclists shows no clear pattern. For decades, it had been fluctuating between 8,000 and 13,000 per year. In summary, the risk of being injured per traveled kilometer has been falling for many years, and the gravity of injuries to cyclists is steadily declining.

DEVELOPMENTS IN TRANSPORT POLICY

The developments in traffic described here did not, of course, occur by themselves. Besides social, spatial, demographic, cultural, and economic influences, the development of traffic is determined by the government policy related to this field. The following section deals

[3] There is a persistent misconception that promoting bicycle use instead of car use would result in an increase in road accident victims. As a result of this misconception, the desirability of promoting bicycle use is constantly being questioned. The argument is that the risk per traveled kilometer of being killed or injured in an accident is three to five times as high for cyclists as for car passengers. On average this is correct, but this provides an incorrect comparison. In a balanced comparison, only short trips of cyclists and motorists of 18 years and older should be compared, as only those are interchangeable. And car kilometers should be linked with all victims involved in car accidents, not only with victims among car passengers (in the Netherlands no motorist has ever been killed by a cyclist!). When calculated in this way, 18-40 year old motorists can easily leave their cars and use their bicycles without an increase in road accident victims. Considering that in this case cyclists would meet considerably fewer cars, the contrary seems more likely.

with developments in traffic policy. First, there is a brief discussion of the policy basis related to the bicycle until 1990. Then, more specifically, the attention given to infrastructure is discussed, followed by a description of the current policy situation. In each case, overall traffic policy is discussed first, and then specific bicycle policy.

Policy Attention to the Bicycle, 1950-90

The 1950s and 1960s focused on making room for the car. Large-scale motorization was not only accepted, but was actively promoted. Urban development was dictated by the needs of car traffic.

In the early 1970s, the annual number of road victims reached an all-time high. Traffic safety became a political item, and resistance to the demands of the car rapidly gained ground. Car traffic regulation and the promotion of public transport became subjects of discussion. In the city centers, parking fees started to be levied. The first "woonerfs" (small city areas where pedestrians have priority and car use is restricted) were created. Bicycle policy initially focused on traffic safety of cyclists. In order to improve this, the construction of separate bicycle lanes and the protection of cyclists at road intersections was encouraged. Only later was attention also given to the promotion of bicycle use. Central government encouraged municipal and provincial authorities by providing financial support for innovative approaches to improving bicycle use. Around 1975, experiments were carried out with high-quality bicycle routes in two cities (The Hague and Tilburg). Evaluations concluded that the routes functioned well, but they were very expensive and they did not lead to an increase in bicycle use.

The 1980s were characterized by consolidation. Traffic safety developed favorably, which was mainly due to further improvement of infrastructure, separation of different modes of traffic (by constructing the motorway network, as well as by constructing more bicycle routes), and speed reduction in residential areas (by creating 30 km/hour areas). People began to realize that the accessibility of all kinds of economic and social activities is important, and that the car did not have to be central to this.

Thinking on bicycle needs evolved toward the recognition that complete networks of bicycle routes would be desirable in the cities. A large-scale experiment was carried out in Delft, a city with 90,000 inhabitants. Between 1982 and 1987, a network was constructed consisting of three hierarchically distinguishable subnetworks: the city network, the district network, and the neighborhood network. The results were twofold: bicycle use initially increased due to the newly-built facilities and safety for bicyclists improved. In the long term, the growth of bicycle use proved to have been a one-off occurrence. Traffic safety developed favorably in the long term. Although the total number of victims among bicyclists did not decline, the percentage of fatalities and severely injured did drop dramatically (*Ref. 7*).

Developments in Infrastructure, 1950-90

Between 1950 and 1990, the length of the paved road network grew from 12,000 to 103,000 km. This increase was partly related to the expansion of the built-up area, and partly the result of paving existing roads. Between 1950 and 1990, the total number of kilometers of motorway increased from 120 to more than 2,000. Not only did the length of the road network expand but the number of lanes per direction also increased from one to two, three, or four.

While highway traffic capacity has increased greatly, nevertheless, congestion has became a rapidly growing problem since 1980. The main bottlenecks occur in morning commuter traffic, especially at connections between motorways and the urban road networks.

Information about the lengths of bicycle tracks and bicycle lanes is available only from 1978 (Table 8). As a highway authority, the central government invested in bicycle facilities alongside national highways. From 1975 until 1985, it also operated a subsidy scheme for the construction of cycle paths by other tiers of government. This contributed to a sharp rise in the total length of cycle paths, especially in built-up areas. Between 1978 and 1992, the length of cycle paths doubled to over 18,000 km, with 63 percent situated outside built-up areas. During the same period, the total road network expanded by 16 percent to 105,000 km and the motorway network grew by 28 percent to over 2,100 km.

TABLE 8: LENGTH OF CYCLE TRACKS AND CYCLE LANES (IN KM) IN THE NETHERLANDS, 1978-94

	1978	1985	1992	1994
Cycle Tracks (km)				
In urban areas	2,120	4,140	5,500	5,920
In rural areas	6,540	9,280	11,110	11,550
Cycle Lanes (km)				
In urban areas	480	880	1,310	-
In rural areas	140	180	260	-

This strong expansion of the bicycle traffic infrastructure was undoubtedly one of the contributing factors in the recovery of bicycle use since the mid-1970s. People use bicycle ways because they usually have fewer delays and they feel safer than on mixed traffic highways.

Traffic Policy in the 1990s

The policy of the Dutch central government related to spatial planning, the environment, and transport has gradually changed direction over the past years. Until a few years ago, the objective was to meet perceived demands or demands created by the market. Now, there is an increasing desire to influence these demands. Although for Dutch society (a parliamentary democracy, and an open free-market economy) it is not easy to change direction, providing objectives and guidelines is a useful first step. Support for this has been growing since the mid-1970s, among the population as well as their political representatives. Increasing pollution of air, water, and soil, disintegration of urban areas, health threats, a consistent and excessive number of traffic victims, negative effects on the accessibility of economic centers, etc. generated widespread concern and the realization that "things have to change." How exactly this should be realized is a continuous subject of discussion.

As a result, the government formulated a new policy in 1990 aimed at improving the quality of life, while at the same time giving a fresh boost to economic development. Restriction

of the growth in car use is an important part of this policy, aiming to bring about a switch from the private car to public transport and bicycles. This policy was formulated in the Second Transport Structure Plan, a policy document outlining transport policy until 2010, and was approved by Parliament in 1990. The strategy laid down in the Structure Plan comprises the following targets:

- road safety must improve to such an extent that by 2010 the number of fatalities will be 50 percent lower than in 1986, and the number of people injured 40 percent lower;
- the total number of kilometers traveled by car in 2010 should be no more than 35 percent higher than in 1986 (in 1986 a growth of 70 percent was predicted for 2010).

The most important elements in the transport policy are:

- Managing the car. This means improving vehicle emissions, limiting land use for car-related infrastructure, and restricting vehicle access in towns and areas of natural interest.
- Managing mobility. This emphasizes shorter distances between places where people live, work, shop, and spend their free time.
- Providing selective accessibility by road. Not all places should always be completely accessible by all modes of transport.
- Improving the alternatives to the car. In terms of passenger transport, this means the bicycle, public transport, and car-pooling.

To achieve the objectives of transport policy, including cycling policy, central government advocates a *decentralized approach* as well as an *integrated approach.* Municipalities and provinces have to take the main responsibilities. Central government mainly plays a catalytic role in this process. For instance, it encourages innovation, gathers and disseminates knowledge, provides financial support and takes care of legislation and regulations.

Bicycle Policy in the 1990s

There is still plenty of scope for increasing bicycle use in the Netherlands. This particularly applies to short trips currently made by car. Almost 40 percent of them are no longer than 5 km, and 55 percent are no longer than 7.5 km. Most of them take place within the built-up areas. Motorists themselves admit that a quarter of *all* car trips could easily be made by bicycle, and another quarter could be made by bicycle with some slight inconvenience. Almost 50 percent of car trips in towns and cities could be replaced by bicycle trips.

The scope for *increasing* bicycle use for trips currently made by car clearly merits further attention. But it is also important to treat existing cyclists in particular with care, as is shown by the following. Between 1963 and 1973, the number of trips made by bicycle in the Netherlands fell by half. If that were to happen again, it would, in theory, result in roughly a tenfold increase in the number of trips made by public transport or in 50 percent more car trips in

towns and cities. Such an increase in the use of public transport would necessitate enormous investments, while the increase in car use would be virtually impossible to accommodate and would certainly be undesirable.[4]

To flesh out the cycling element of transport policy, a project group was set up in 1990 within the Ministry of Transport with the specific task of promoting bicycle use while at the same time increasing its safety and appeal. In 1992, Parliament approved a policy memorandum on a Bicycle Master Plan, in which this task had been translated into a number of objectives:

- In 2010, the number of passenger kilometers traveled by bicycle should be 30 percent higher than in 1986.
- By improving the transport chain for the combined use of bicycles and public transport, the number of passenger kilometers traveled by train should in 2010 be 15 percent higher than in 1990.
- In 2010, the annual number of fatalities among cyclists should be 50 percent lower than in 1986, while the annual number of cyclists injured should be 40 percent lower.

The project group Bicycle Master Plan sees bicycle policy as an inherent part of the total transport policy. In order to realize an increase in bicycle use and a higher safety rate for cyclists, the promotion of cycling is important, but insufficient on its own. In order to realize these objectives, the Netherlands also requires a structural change in the entire transport and traffic system, which will be a major challenge. For such a change, it is necessary to make choices in the city as well as outside, on the desired function of public space. The next step involves determining the conditions, depending on time and place, under which the various modes of transport are allowed to use this space. Such decisions are not made for car traffic,

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[4] Promoting bicycle use fits perfectly well within the objectives and strategy of the present government policy.

- Cycling is fast. Especially in the city, bicycles often prove to be faster than cars and public transport for distances up to 5 or 7 km.
- The bicycle is always available and offers door-to-door transport and a predictable traveling time.
- Moving, as well as parked, bicycles take up little space, especially compared to cars. A 3.5-meter-wide lane theoretically has a capacity of 2,000 cars per hour, but can handle 4 to 7 times as many bicyclists. The place of one parked car can be used for parking between 8 and 12 bicycles.
- The bicycle is a clean means of transport: no noise, fumes, or emission of damaging materials.
- Increased bicycle use leads to a decrease in traffic accidents!
- Cycling is cheap for the individual as well as for society. Investing in good bicycle traffic facilities in the long term provides benefits in the form of saving on costs of the car infrastructure, traffic safety, and environment-protection measures. Per traveled kilometer, the costs of bicycle traffic in the Netherlands is almost negligible compared to the costs of municipal public transport. The ratio is approximately 1:20.
- Cycling is healthy and relaxing. Research has shown that cycling regularly, to work for example, improves physical fitness, prevents overweight, and reduces absenteeism.

bicycle traffic or public transport separately; it is a matter for integrated thinking in which all modes of transport are involved, including freight transport.

An increasingly important element of policy for restraining the use of cars is parking policy. Parking fees have become widely accepted since 1990, also outside the city centers, and parking fees have increased considerably. Also, increasingly larger areas in the inner cities are made car-free; and the first car-free residential areas have been implemented.

Bicycle policy is strongly linked with spatial planning and environmental policies. Coordinating these relationships and the factors that influence them is therefore essential. To develop these, the project group Bicycle Master Plan, as part of the ministry's total transport policy, has since 1990 promoted and financially supported some 120 research projects, innovative activities, testing and pilot projects. These activities are divided into four action areas:

- modal shift from the car to the bicycle;
- safety of cyclists;
- modal shift from the car to the Public Transport + bicycle combination
- bicycle parking facilities and prevention of theft.

Disseminating acquired knowledge, experience, and information is an important task of the project group. The communication efforts focus on the parties responsible for the realization and maintenance of good bicycle traffic facilities. These are first of all municipalities, provinces, and public transport companies, but companies, interest organizations, and other institutions are also involved.

CONCLUSION

Bearing in mind the Chinese situation for comparison, various conclusions may be drawn from the description of the Dutch transport system in this section. Conclusions that mainly have to do with the relationships between:

- bicycle use,
- spatial structures, and
- traffic policy.

Bicycle Use

Despite the rise in car use in the Netherlands, the role of the bicycle has continued, especially in urban areas. In the whole of the Netherlands, the bicycle has for the past two decades had a 27 to 29 percent share in the modal split; in medium-size and large cities people travel by bicycle for 30 to 40 percent of their trips. This means that sometimes more than 50 percent of the local trips are made by bicycle. The bicycle is used for the most important transport purposes: commuter (26 percent), shopping (32 percent), and social and recreational

(24 percent). This current role of the bicycle is largely the result of the fact that, before the rise in car use, people already cycled a lot. Contrary to many other European cities, public transport in cities such as Amsterdam and Rotterdam played a minor role during the period between the two World Wars.

However remarkable bicycle use in the Netherlands may be, one should not forget that between 1960 and 1980, the bicycle lost a lot of ground to the car. Both in number of trips and in kilometers, the car began to dominate the traffic system in a short time. This rapid change was strongly related to such social developments as house occupancy, increase of scale, specialization, and emancipation.

Space

Besides the points mentioned earlier, the impact of "spatial structures" is an important factor in explaining bicycle use in the Netherlands. Of course, the scale of bicycle use in the Netherlands cannot simply be explained by spatial factors. The differences in terms of bicycle use between cities and regions within the Netherlands are too large for that; the differences between the Netherlands and spatio-geographically comparable regions in Europe (e.g., the German federal state Nordrhein-Westphalia and the London agglomeration) are also too large for that.

The strong connection between spatial phenomena and bicycle use, however, are clear. Together with the country's morphology, the high population density of the entire country, and the spatial spread of the population over a relatively large number of relatively small cities, make the Netherlands a bicycle country. The density of the population and of activities in many cities makes high car ownership, comparable to the level in the United States for instance, simply impossible in view of the available space. Per square kilometer, the Netherlands already has more cars than the United States.

While spatial density makes car use problematic, it makes bicycle use more attractive. The average journey distances in the Netherlands are, after all, short. This is not only the result of the country's limited size. The fact that 70 percent of all trips are shorter than 7.5 km is strongly related to the high level of urbanization in relatively many small cities.

Policy

In general, one could state that a high level of spatial density, combined with a traditional familiarity with bicycle use, favors bicycles as a solution for traffic problems. From the 1980s onward, the Dutch have increasingly seen bicycles as a solution to transport problems, rather than one of the obstacles. Two important lessons are worth mentioning here.

(a) A policy to promote bicycle use can only be effective when it forms an integrated part of the total transport policy.

- Of the *transport policy*, because cycling is first of all a means of transport, and its other characteristics (being environmentally friendly, good for health, and cheap) are secondary; and

- an *integrated part* of that transport policy. To make cycling more attractive is not enough simply to provide good facilities (infrastructure and otherwise). The promotion of bicycle use also requires policies and measures related to other modes of transport. And the improvement of road safety for cyclists first of all demands measures related to motorized traffic and the division of the available traffic space between all modes of transport.

(b) Bicycle traffic is not inherently unsafe but it is vulnerable to motor traffic and therefore needs protection.

- Bicycles do not threaten other traffic participants; at most they are sometimes a nuisance. In collisions with motorized traffic, the risk of injuries is mostly with cyclists. Bicycle traffic should therefore be protected against motorized traffic, especially when driving speeds are high.

- In another sense, cyclists are vulnerable because most attention is still given to private car. Bicycles and public transport in most cases can only play a role of importance when there is substantial government support. Strengthening the position of the bicycle primarily requires the attention of the local, regional and central authorities.

SECTION 3: BICYCLE USE IN CHINA

In this section an attempt is made to draw a picture of the place of the bicycle within the Chinese traffic system. First of all, there is a brief discussion of the historical development of bicycle use in China. Subsequently, we will look at current characteristics of bicycle use. This sections draw on the impressions gained from the sector mission with the World Bank in April 1995 when visits were made to the cities of Guangzhou, Chengdu, Shanghai, Jinan, and Beijing. Then, some possible policy issues are discussed related to the future of the bicycle in China. The section ends with some conclusions concerning the subjects that were also mentioned in the description of the Dutch situation.

HISTORICAL DEVELOPMENT OF BICYCLE USE IN CHINA

The *use of bicycles* as a mode of transport in China has a history of nearly 100 years. Since the founding of the People's Republic of China in 1949, the nation's urban transport policy has encouraged walking and bicycle use, emphasizing energy conservation. This policy was consistent with wages and income policies and strict government controls on vehicle ownership, as well as residential and employment location strategies that housed workers within reasonable cycling distance (about 5 km) from their respective workplaces. However, in the 1950s and 1960s, the masses in China used buses, and only a favored minority of workers used bicycles. Only the very privileged had access to cars. The use of the bicycle began to rise in the late 1970s after economic reform provided the Chinese people a higher disposable income.

Especially in the 1980s, *bicycle ownership* increased explosively. This was a result of the rapid economic growth, but also of government policy to make bicycle use more attractive.

For example, some municipalities offered people who cycled to work a cash incentive equal to the price of a bus pass. Or people would get money for bicycle maintenance if they used the bicycle to commute. Bicycle ownership appears to have increased most strongly in the cities. Of all bicycles registered in 1982, 40 percent were used in urban areas, with an average bicycle ownership of one bicycle for every three persons. During the 1980s, bicycle ownership rose to one for every two persons in 1990. At this moment, almost every adult owns a bicycle, and the majority of workers use them for their daily trip to work. The development of bicycle ownership varies per city, probably depending on local circumstances and municipal policy. In Guangzhou, for instance, "registered" bicycle ownership increased from 17 percent in 1971 to 78 percent in 1991 (the actual "active" bicycle ownership rate is around 53 bicycles per 100 persons). In Shanghai, the increase went from 15 percent in 1980 to 55 percent in 1990. In Beijing, bicycle ownership was 70 percent in 1993, after an increase in the number of bicycles from 2.9 to 7.4 million between 1980 and 1993. For the whole of China, bicycle ownership is currently estimated at 39 percent, after a doubling of the total number of bicycles from an estimated 225 million in 1985 to approximately 450 million in 1993.

Bicycle production blossomed from just three factories producing 14,000 bicycles per year in 1949 to 115 factories in 1983 with a combined annual production of some 30 million. In 1988, more that 41 million bicycles were manufactured. At this moment, the China Bicycle Association has about 380 bicycle and bicycle part manufacturers in its membership. Ten companies can each produce over 1 million bicycles a year, and three of these companies can produce more than 3 million bicycles a year. In 1989, the largest bicycle producer in China, the Tianjin Bicycle Manufacturing Group, produced 6.1 million units. China's bicycle industry is able to produce in accordance with overseas quality standards, which is why it has been possible to increase bicycle exports from 3.7 million in 1990 to 10.5 million in 1994. Depending on the quality, the price of a bicycle is Y 200-400 ($35-70), approximately one month's salary. This price does not form an insurmountable obstacle. In comparison, for the majority of the population a private car is financially beyond their reach (car prices range between Y 80,000 and Y 200,000).

Thanks to the bicycle, for many Chinese people mobility has increased dramatically during the past years. A large number of activities, situated farther away, now came within reach; people and goods can be transported faster in a manner that is effective, efficient, friendly and safe for the city and its inhabitants.

As a result of the increase in bicycle ownership and use, the share of the bicycle in the modal split rose in a number of cities during the 1980s. This was probably at the expense of public transport. General conclusions concerning the shifts in modal share are difficult to make, as these shifts show significant differences per city.

CURRENT CHARACTERISTICS OF BICYCLE USE

The functioning of the present traffic system in China, and the role of the bicycle in it, is difficult to assess for outsiders, certainly in a short period of time. This is also due to the lack of comparable data. Nevertheless, an attempt is made in this section to provide a quantitative analysis of the traffic system, which is followed by some more qualitative observations of the positive and not-so-positive aspects of the present transport system.

Bicycle Travel Compared with Other Modes

The relevance of the bicycle for the mobility of the inhabitants of 10 major Chinese cities is evident from Table 9. The data relating to the number of trips per mode of transport were extracted from urban origin-destination surveys. It is difficult to make a proper comparison since all are simply one-off snapshots of a rapidly changing situation, and the data refer to different years. The overall picture is reasonably clear: accounting for more than half of all trips, the bicycle is at this moment the main transport mode in most Chinese cities, while walking follows in a solid second position.

TABLE 9: SHARE OF TRIPS PER MODE OF TRANSPORT IN 10 CHINESE CITIES *(Ref. 15)*

City	Year	Transit	Bicycle (& ADT)/a	Pedestrian	Private Vehicles	Others
Beijing	1986	24	54 (5.2)	14	4	4
Shanghai	1986	36	24 (4.0)	36	2	1
Tianjin	1990	8	75 (3.7)	11	4	2
Guangzhou	1992	22	34 (3.8)	31	NA	1
Zhengzhou	1987	3	63 (2.5)	33	NA	2
Shenyang	1985	10	59 (3.4)	29	NA	2
Fushun	1987	22	25 (4.6)	40	NA	13
Chengdu	1987	6	55 (3.4)	36	NA	3
Wuhan	1987	20	35 (3.8)	37	NA	7
Hangzhou	1986	13	56 (3.4)	28	NA	3

/a ADT = Average Bicycle Travel Distance, in km.

The considerable use made of the bicycle can be explained largely by the average bicycle travel distance, which in the 10 cities varies between 2.5 and 5.2 km, with a 3.9 km average for the 10 cities (whole of the Netherlands 1991-93: 3.6 km). For these distances in normal city traffic, other modes of transport cannot or can hardly compete with the bicycle in terms of travel speed. This is shown in a very convincing manner in Table 10: up to 5 km, the bicycle has a comfortable lead on public transport; for trips of 5 to 10 km the differences in travel time are limited.

Table 10 also shows that those who travel by bus or subway can cut their travel time considerably by going to the bus stop or station by bicycle instead of on foot. In case of 8 to 10 km trips, public transport users can also save time by using a combination of bus/subway and bicycle. Some survey results *(Ref. 15)* show that people might prefer cycling instead of walking to the public transit facility if the distance is more than 400 m. In Beijing in 1990, about 30 percent of the subway passengers traveled to and from the subway station by bicycle.

These data show the importance of not treating public transport and the bicycle as competing modes of transport. From the point of view of traffic management, it makes sense to investigate which combination of transport modes would be most efficient for certain segments of the transport market.

TABLE 10: TRAVEL TIMES (IN MINUTES) FOR VARIOUS TRAFFIC MODES IN BEIJING *(Ref. 15)*

Traffic modes	Trip length: 2 km	4 km	6 km	8 km	10 km
Bicycle (no transfer)	11.0	21.0	31.0	41.0	51.0
Bus (no transfer)	16.5	24.0 (21)	32.5 (34)	40.0 (34)	48.0 (40)
Bus (one transfer)	20.0	27.5 (24)	36.0 (32)	43.5 (37)	51.5 (44)
Subway (no transfer)	31.0 (22)	34.0 (25)	37.0 (28)	40.0 (31)	43.0 (34)
Subway (one transfer)	39.0 (30)	42.0 (33)	40.0 (36)	48.0 (39)	

Note: The statistics in parentheses are the times the transfer procedure takes when using the bicycle instead of walking.

The various sources create an impression that the bicycle is often used for commuting, and that women cycle less frequently than men and, on average, cycle slightly shorter distances. The flat topography of many Chinese cities facilitate more than just passenger transport by bicycle. Freight transport in the form of local deliveries are frequently made by flatbed tricycle.

The Functioning of the Traffic System: Observations

One of the authors of this paper (A. G. Welleman) took part in the World Bank sector mission to the cities of Guangzhou, Chengdu, Shanghai, Jinan, and Beijing in April 1995. Observations of the traffic situations in those cities, combined with discussions with traffic experts, provided a glimpse of the Chinese transport scene. However selective these impressions may be, they do illustrate how an interested outsider may look at the traffic in Chinese cities.

General

Many foreigners visiting China talk about how bicycles dominate the streets in Chinese cities. From the point of view of the Dutch, who are more familiar with mass bicycle usage, the impression is rather different. In the five cities that were visited, the impression is that they are mainly dominated by motor vehicle (MV) traffic; not in terms of numbers, but in terms of usage and allocation of road space.

Taking into account the large number of trips per unit of surface area, the bicycle certainly dominates some streets, counting both moving and parked bicycles. Bicycles for both passengers and freight use a considerable amount of the available transport capacity, and obstruct the flow of MVs. In those streets, bicycles also take up a large part of the available parking space, including sidewalks.

In general, significant traffic congestion is evident. The large number of cyclists are partly the cause of the congestion of MV traffic, including public transport. Solutions are sought in systems of ring roads, partly with flyovers, combined with major radial roads to divert MV traffic. On many roads, "fast" and "slow" traffic are segregated by fenced-off bicycle lanes, and some roads and bridges are dedicated to pedestrians and cyclists. In some cases, vertical segregation is achieved by putting motor-vehicle-only roads on viaducts above the existing mixed traffic streets.

Urban traffic in Chinese cities, from a Dutch point of view, does not look very orderly. Channeling of traffic flows and separating traffic by time and place do not appear to be well developed. Many traffic signs are evident but few road markings. In short, traffic management is not a well-developed science in Chinese cities. Some more detailed impressions are given for each city visited.

Chengdu

Around the old city, which is surrounded by rivers, there are two ring roads that can be reached from the center via a number of 35 to 40 meter-wide radial roads. The street pattern in between is largely rectangular. With further development of the economy of the city and its environment, combined with sensible traffic management, the network of hierarchically-ordered roads should be able to function well for many more years. The main roads consist of wide main lanes for motorized traffic with, on both sides, physically-separated bicycle lanes that are 5 to 6 meters wide. On the wide secondary roads, there is no physical separation for MVs and cyclists. Cyclists keep to the right reasonably well, and there is still as yet relatively little MV traffic. The large volumes of bicycle traffic and the subsequent relaxed behavior of cyclists, as well as motorists, results in traffic flows that appear disorganized but not threatening. Between the primary intersections there is little turning MV traffic, partly because it is difficult to enter residential areas by car. In the narrower district and neighborhood streets, even the small number of MVs causes problems for cyclists and pedestrians.

Guangzhou

The city's present economic boom is clearly evident from large-scale building activities and infrastructure projects. While MV ownership is still very low, the maximum capacity of the urban infrastructure appears to be nearly reached. The city is expanding rapidly, and subsequently the average trip is becoming longer. Public transport is an efficient mode for only some of these trips, although public transport is clearly widely used (bus, taxi, trolleybus) and on the water (ferry).

Shanghai

Along the main roads there are wide bicycle lanes, some of which, however, are opened for MV traffic at certain times. Closer to the center, driving speeds are lower because traffic density is higher and the street pattern more intricate. Here, MV traffic mixes with large numbers of cyclists. The distances between the houses are small, so roadways and sidewalks are narrow. Traffic management is well developed in Shanghai. However, maintaining disciplined traffic behavior is less successful, which clearly reduces the effectiveness of these traffic management measures. Nevertheless, traffic makes a reasonably orderly impression compared to Guangzhou. Public transport—buses, minibuses and trolleybuses—clearly has problems in the narrow and busy streets, and this has contributed to a decline in public transport usage in recent years.

Jinan

Jinan is undergoing a major construction boom, reflecting strong economic growth. Residential housing is gradually moving to the suburbs, and land does not appear to be a scarce

commodity. Compared to the other cities we visited, traffic is not as intensive. Freight traffic appears to dominate on the city exit roads, but the city center is largely forbidden to this kind of traffic. The ring roads that have been constructed are intended to relieve the city center of freight traffic and through traffic. Driving behavior is generally relaxed and the attitude of MV drivers toward bicyclists appears to be reasonably tolerant. This is probably the result of the financial penalties imposed on MV drivers in the case of an accident involving physical damage. By the early 1990s, unregulated parking of bicycles in the city center started to cause problems that limited the flow of traffic and formed obstacles for pedestrians. A strict parking policy for bicycles was introduced in 1994. There are now 320 fenced-off parking places for bicycles, largely situated in and around the city center. Parking for cars is also becoming a problem in some locations.

Beijing

The increase of MV traffic is clearly visible in the newer parts of the city. The city has several multilane ring roads that seem to function well. On either side of the major roads there are lanes of 5 to 10 meters that are primarily meant for the transport of people and goods by bicycle and for an occasional bus use.

After several long bicycle trips through the city, an image emerged of a vibrant city with a hierarchically-organized network of main roads and streets that are able to process traffic in a reasonable manner. Apparently, the ring roads provide good accessibility to the city and good connections between city districts for MV traffic. Especially in the narrow streets in the city center, bus speeds are severely limited by the large numbers of cyclists. Particularly during rush hours, large numbers of cyclists swarm between the sometimes double rows of buses. Buses stopping at bus stops in turn cause delays for cyclists. There is not enough space for a physical separation, all the more so because the pavements are for a large part used for parking bicycles. Another striking feature is that bicycle and bus, although in many places fighting each other for space, also complement each other. Near many bus stops in the outer urban areas, there are facilities for parking bicycles, sometimes covered and in some cases also guarded. These facilities are used well, which makes the bicycle-public transport chain an excellent manner of crossing large distances between the city outskirts and the center.

CURRENT BICYCLE ISSUES

Quantitative data, and observations and conversations made during the study trip indicate that a number of policy issues are in urgent need of attention:

- *accessibility*, or the allocation of road space between moving vehicles;
- *parking*, or the allocation of public space between stationary vehicles;
- *safety*, or: the relative safety among the various traffic modes.

These policy issues are of the greatest importance to the future role of the bicycle, but they are not only bicycle issues. In the Chinese situation, too, bicycle policy is part of overall transport policy.

Accessibility

Some city managers see bicycles as a significant cause of traffic congestion, and would like to discourage their use in city centers. Others see the bicycle as a cheap, readily available, and nonpolluting mode of transport that should be encouraged further. Intermediate positions are also taken, including acceptance of high bicycle use into the near future irrespective of what would be desirable. It is debatable whether a strong reduction of the share of bicycle traffic is feasible (in view of the cultural and social costs and the space that alternatives would take up) or necessary. In the Netherlands, bicycle shares comparable to those of Shanghai (approximately 24 percent) and Guangzhou (approximately 34 percent) have proven to be an acceptable and desirable element in the traffic systems. A well-functioning traffic system in Chinese cities does not require making choices between car, bicycle, and public transport: all three modes have an important role to play. Such an approach in which the desired shares of the various modes of transport in the modal split may vary by city is more realistic. Take the Beijing situation where during rush hours some intersections are used by 16,000 to 20,000 cyclists. Such traffic streams would lead to enormous congestion and pollution if bicycles were substituted by MVs. Of course, large traffic flows of these dimensions are very suitable for public transport. However, one should not forget that such large traffic streams are a consolidation of a large number of smaller streams of traffic, which represent a diffuse pattern of movements that are not easily served by public transport, but that are very suitable for bicycles.

Parking

Parked bicycles demand space. Much less space than a car (one eighth to one tenth), but nevertheless—in view of the enormous amounts of bicycles—a real problem. It is evident that in the five cities that were visited, bicycle parking is a problem, and this appears to be a general problem in China. But the scale of the problem varies considerably by city. The main reason for this difference appears to be the difference in building density. At the same time, it is clear that the demand for parking space for cars as well as for bicycles will result in more and more conflicting claims in the future. This problem is already visible in the streets of Beijing. The narrow streets simply do not have enough space for parking cars. Wherever possible, cars are parked on the pavements, although this phenomenon does not appear to be excessive yet. This is also caused by the large numbers of parked bicycles, guarded or not, which in many places already take up much of the available space.

Safety of Cyclists

Traffic safety is also a problem. Through Dutch eyes, the traffic safety situation in Chinese cities is bad (often two to three times as many fatalities as in the Netherlands). But in view of the circumstances—especially the size of the traffic movements—it is debatable whether this is so remarkable.

Traffic congestion, by slowing traffic speeds, is probably the main reason why traffic accidents are still reasonably limited in numbers. While many intersections appear chaotic, the limited number of collisions is partly explained by well-developed skills of both cyclists and motorists. This type of traffic behavior is not strange in the eyes of someone from the

Netherlands. Grade-separated infrastructures are also quite well developed and play an important role.

In cases where adequate separation of mixed traffic occurs, the number of serious accidents is low. In Tianjin, China's third-largest city, for example, bicycle use is very intensive, and separation of motorized and nonmotorized vehicles along the city's generally wide streets is commonplace. The accident rate here is 80 percent lower than in comparable developing country cities. The rate in Shanghai's congested narrow streets resembles the world norm more closely (about 100 fatal accidents per million population).

The traffic safety problem is often blamed on the cyclist. From the Dutch perspective, this is incorrect reasoning. Looking at the Beijing figures, for example, the total number of registered traffic fatalities in Beijing was nearly 500 in 1980, passed the 700 mark in 1985 and 1986, and between 1989 and 1993 fluctuated around 450. The total number of registered traffic casualties fell from approximately 7,000 in the early 1980s to approximately 3,000 ten years later. The share of accidents involving a MV was more than 80 percent in the early 1980s and 98 percent in 1993. The share of cyclists among traffic fatalities dropped from nearly 60 percent during the first half of the 1980s to less than 40 percent in 1992 and 1993. Among the registered casualties, the share of cyclists decreased from more than 70 percent to some 35 percent. However, during the 1980-93 period, car ownership multiplied by five and bicycle ownership more than doubled. The conclusion must be that a very sharp rise in car use and a doubling of bicycle use between 1980 and 1993 (after some fluctuations) went with a considerable improvement of the total registered traffic safety, and that of cyclists in particular. In general terms, this is also what has happened in the Netherlands during the past years, as discussed earlier.

CONCLUSIONS

In the description of the Dutch transport system, attention focused on the connections between:

- bicycle use,
- spatial structures, and
- traffic policy.

The same connections can be used to summarize the Chinese situation. Conclusions, however, are not interchangeable. This has to do with socioeconomic differences (although a comparison with the Dutch situation in the 1960s and 1970s would certainly be relevant), and with historical and cultural differences, and particularly with the differences in size. The Netherlands is a small European country with 15.5 million inhabitants, with the largest city (Amsterdam) having a population of just 725,000, and with a relatively large number of quite small cities. In comparison, China has about 230 times the land area of the Netherlands, approximately 75 times as many inhabitants, and many cities with populations of several millions. On the one hand, this makes it difficult to compare urban traffic systems and the role of the bicycle in them. On the other hand, one could also argue that the much larger size of the

Chinese cities only makes the lessons from Dutch developments the more poignant. It can also be noted that the difference in population density is relatively small in the urban concentrations.

Bicycle Use

The role of the bicycle in China has increased markedly in recent years, strongly related to rises in income, and a sharp growth of bicycle production. The bicycle share in the modal splits of nearly all larger cities is large, even though there are exceptions, especially in those cities where public transport has a large share. The main difference is the small share of the passenger car. In this respect, the situation is somewhat comparable to the Dutch situation on the eve of the rise of the car, around 1950.

It is certain that the share of transport performed by the car will increase strongly for many economic and social reasons. At the same time, it is likely that the bicycle will maintain a considerable share of transport:

- Journey distances will increase, but many short trips will remain. Where in the Netherlands 70 percent of all trips is now shorter than 7.5 km, the percentage in China may be lower (due to the larger scale of cities and districts), but it is not likely to go below 40 to 50 percent.

- Like the Dutch, the Chinese are used to cycling. Even though the alternative of the car will become more attractive in the future, people know the bicycle, they know the advantages and disadvantages, and they know how to deal with this. This cultural factor should not be underestimated.

Another question is whether the bicycle will, in the future, lose ground to public transport. This is a matter that can be strongly influenced by government policy, more so than in case of the car, because it will depend much on the supply of public transport that is offered. Government policy is particularly important in this, because there is a large degree of interaction between bicycle and public transport, more so than between bicycle and car. This can be demonstrated by a Dutch example. The 1991 introduction of a free student pass for public transport led to a strong increase in train and bus use among students, 80 percent of which was at the expense of bicycle travel. In China, it can be observed that wherever bicycle use is high, public transport use is relatively low, and the other way around.

Space

Data on traffic in Chinese cities show that there is a strong link between spatial characteristics and bicycle use. The high population density per square kilometer is responsible for relatively many short trips, which is favorable for bicycle use. These spatial characteristics will continue to determine the options for development of the traffic system in the future.

Even more so than in the Netherlands, building density in Chinese cities will be a primary obstacle for greater car use from the point of view of space needed for highway infrastructure and for parking. In view of this, it seems that the bicycle and public transport will remain essential for the proper functioning of the transport system.

As far as the use of space is concerned, public transport may be a favorable mode of transport; in certain circumstances even more favorable than the bicycle. However, this does require good organization of available infrastructure such that public transport has significant road priority. Public transport services are very vulnerable to congestion, which at the same time increases costs and reduces the quality of service. Under congested conditions, bicycles will continue to have an advantage over public transport services for short- to medium-distance journeys.

Policy

Irrespective of future Chinese transport policy directions, there are limits to the extent to which car use and public transport services can serve transport needs. The bicycle can continue to play an important role, and many will prefer the bicycle mode to others. Given this, a balanced traffic policy is appropriate that focuses on:

- car infrastructure and space-saving parking facilities,
- *and* efficient public transport systems,
- *and* facilitation of bicycle traffic.

SECTION 4: PRACTICES IN OTHER ASIAN COUNTRIES

In order to put the future of the bicycle in Chinese cities in a broader perspective, it is useful to take a look across China's borders to other countries in Asia that are going through similar developments. The sources available to us are limited and only permit brief observations. These observations may be also be tainted because the data used are unreliable (the data from various sources are sometimes contradictory), they are outdated (most data are not very recent), and they are incomplete (the information only refers to a small number of cities). Nevertheless, they give rise to a number of interesting observations of bicycle traffic.

The first part of this section is a brief description of the spatial and socioeconomic backgrounds of some Asian cities, followed by data concerning the urban modal splits, with explanations where possible. The place of the bicycle within current transport policy is then discussed, with special attention to Tokyo.

SPATIAL AND SOCIOECONOMIC BACKGROUNDS

The social environment to a large extent determines the characteristics of the transport system: population size and density in the cities, average income, vehicle ownership, etc. For a selection of Asian cities these sort of data are well known *(Ref. 10)*, and they are summarized in Table 12.

Table 12 gives an indication of the relationship between population density and vehicle ownership (related to the purchasing costs of a vehicle). In some very densely populated cities such as Hanoi, bicycle ownership is very high (comparable with Shanghai); in other cities, like

Kanpur, bicycle ownership is relatively low, but people walk a lot instead. This probably (no data available) requires a spatial organization in which housing and community facilities (employment, shops, etc.) are situated closely together. The average journey distances in these circumstances are usually short.

TABLE 12: TRAFFIC CHARACTERISTICS OF SOME ASIAN CITIES *(Ref. 10)*

City	1991 Country GNP/cap. ($)	1992 City population (million)	1991 Population density (pop/km^2)	Bicycle ownership/price /a	Bicycle ownership/price /b	Car ownership/price /a	Car ownership/price /b
Pnom Penh	200	0.7	16,200	156	40	16	25,100
Hanoi	200	1.1	25,600	909	36	44	35,800
Dhaka	200	3.4	27,400	12	61	20	?
Kanpur	330	2.3	7,600	227	53	93	6,400
Shanghai	370	8.4	23,500	865	60	17	34,000
Surabaya	610	2.7	9,300	129	138	53	24,600
Manila	740	8.4	13,200	12	176	73	31,300
Chiang Mai	1,580	0.2	2,300	100	178	136	19,800
George Town	1,490	0.3	10,300	528	180	221	16,000
Tokyo	26,920	11.9	5,500	534	160	234	12,000
Amsterdam	n.a.	0.7	4,600	n.a.	n.a.	n.a.	n.a.

/a Number of vehicles per thousand population (1992).
/b Average price of new standard vehicle in US dollar (1992).

Something could also be said about the correlation between income level and vehicle ownership (related to the purchasing costs of a vehicle), based on Table 12. The general conclusion is that a low income level goes with a relatively large share of cheap vehicle ownership (including the bicycle), and a small share of more expensive vehicles. The bicycle is a vehicle that relatively many people can afford, although in those countries where income levels are lower, they can easily cost more than one monthly wage.

URBAN MODAL SPLIT

The place of bicycle traffic in a city can best be characterized by its share in the modal split. Table 13 gives this information for a number of Asian cities. This is not the same selection of cities as in Table 12.

The data are not very recent, and in view of the developments during the past decades, it is to be expected that in a number of cases significant shifts have taken place in the use of traffic modes. The cities differ greatly in character: ranging from heavily motor-vehicle dependent (Tokyo, Manila) to cities with light vehicle use (Kathmandu, Kanpur, etc.). The amount of nonmotorized traffic—bicycles (including cycle rickshas) and pedestrians—is related to this, and is therefore large in the latter cities. In all cases, bicycle use is lower than, or at best equal to, most Chinese cities mentioned previously. In some cities (Bangalore, Bombay, Tokyo), public transport provides a large share in the use of transport modes.

For those cities of which data about the choice of transport mode (Table 13) as well as social and vehicle ownership characteristics (Table 12) are known (Kanpur, Surabaya, Manila, Tokyo), it is not possible to give a uniform explanation for mode of transport use. No data are available to explain the differences between the cities with a large share of nonmotorized traffic (Kanpur and Surabaya) and the two others with a small share of nonmotorized traffic. In particular, the relatively large share of motorized traffic in Manila cannot be explained by income levels and ownership data. For Tokyo, the large share of public transport in particular is striking.

TABLE 13: SHARE OF TRIPS PER MODE OF TRANSPORT IN ASIAN CITIES *(Ref. 12)*

City	Year	Transit	Bicycle	Pedestrian	Motor vehicles	Others /a
Kanpur	1977	0	24	72	4	0
Bangalore	1984	36	12	44	8	0
Bombay	1981	58	11	15	9	7
Bandung	1976	?	16	40	46/b	-
Jakarta	1984	25	17	23	21	14
Surabaya	1984	13	25	20	35	7
Kathmandu	1987	16	8	56	14	6
Manila	1984	14	0	8	23	55
Tokyo	1978	64	?	21/c	15	-

/a Others includes motorized paratransit and taxi modes.
/b Transit and private motor vehicles together.
/c Pedestrian and bicycle together.

Note: The source does not indicate whether the data refer to the cities or to the entire metropolitan area.

THE BICYCLE WITHIN TRANSPORT POLICY

In most Asian countries where the bicycle plays an important role in urban traffic, the promotion of bicycle traffic is usually not a matter of consideration. In fact, the local authorities, in some cases encouraged by national authorities, often follow a policy that is aimed at discouraging bicycle use. This concerns the ordinary bicycle (Hanoi) as well as cycle rickshas (Dhaka, Manila, Jakarta). In cities like Dhaka, Surabaya, and Manila, a registration obligation has been introduced. In practice, however, this obligation is often avoided, and enforcement is weak. In some Asian countries (e.g., Bangladesh), the ownership of motorized vehicles is favored compared to ownership of nonmotorized vehicles through tax measures *(Ref. 10)*. The justification used is that bicycles, because of their large numbers, cause congestion. Bicycles are also criticized due to the supposed inefficiency of nonmotorized vehicles on city streets because of their slower speeds *(Ref. 1)*. Very often, however, bicycles are penalized because they do not fit with political ideas on what constitutes a "modern" transport system.

In most Asian countries, car ownership is expected to increase with increasing incomes, and this leads inevitably to higher car use. Bangkok is a well-known example where massive

traffic jams clog the city daily. Traffic participants spend many hours in traffic jams, and work days of 15 or 16 hours (including the journey to work) are no longer exceptional. This also has serious social implications. The gravity of the expected problems may, among other things, be deduced from the characteristics of many Asian cities, as described earlier. The population density in particular is of interest here. At an equal number of trips per person per day, the number of people on the streets in cities with 25,000 inhabitants per square kilometers is five times as high as in Amsterdam, for instance. When they travel on foot, or by bicycle, or by public transport, traffic progress will already be limited. When these modes of transport are exchanged for the car, situations like Bangkok become inevitable.

However, there are also cities where local authorities follow a policy that promotes bicycle use. Surabaya is an example *(Ref. 1)*, but also Kanpur. For example, easy loans are made available in Kanpur for the purchase of bicycles. The real problem of these cities (in terms of traffic and transport) is the way in which bicycle traffic and motorized traffic can best operate together.

With an increase in motorized traffic, redistribution of the available traffic space among the competing modes is inevitable. This may apply to individual streets, the entire road network, but also to city areas. In the first case, it concerns the distribution of space on the street between various modes of traffic. In the busy sections of many Asian cities, street space is divided between pedestrians and the remaining road traffic. Motorized and nonmotorized traffic, passenger cars, and buses share the same infrastructure. Pedestrians in this case often have to make do with narrow sidewalks, and often use the road for walking. This is not conducive to the flow of the remaining traffic. Separate infrastructures for cyclists and motorized vehicles rarely exist in these cities. In Tokyo, the infrastructure for pedestrians is often also meant for cyclists. This obstructs the flow of bicycle traffic and causes a lot of hindrance for pedestrians.

In some cities, simple measures have been taken on busy connections with ample physical space to separate bicycle traffic and motorized traffic. In Hanoi, the separation has been realized by a raised curb; in Kanpur, lane markings have been applied to separate fast and slow traffic. In Surabaya, there are also some dedicated facilities for cyclists.

A deliberate separation of traffic space at the road network level often occurs. In many cities, the rise of the car has led to establishment of a hierarchy in the traffic system. This hierarchy mainly focuses on the car, with the urban expressway at the top of the hierarchy. Such organization exists mostly in more developed countries (Japan, Republic of Korea, etc.). It is remarkable that the assumed high efficiency of transport by bus *(Ref. 11)*, for instance, has rarely in Asian cities led to the construction of specially separated facilities for bus traffic (bus lanes). This could provide a considerable contribution to increasing the average travel speed of urban passenger transport. Probably there is an unwillingness to take this space away from passenger cars. Nevertheless, dedicated bus streets or lanes provide opportunities to organize traffic in a more efficient manner.

Some cities such as Pnom Penh, Kanpur, Hanoi, and Surabaya reserve public space for parking bicycles *(Ref. 1)*. These parking places are often located near facilities that attract a lot of visitors, like marketplaces and train stations. In some cases the parking places are guarded (Hanoi, Pnom Penh). In Kanpur, many parking facilities can be found near workplaces, such as

factories, libraries, and offices. In many cases they are also covered *(Ref. 1)*. In Japan, large-scale parking facilities have been built near stations and stops in order to promote the use of bicycles as a feeder for public transport. Due to the lack of space, high-tech facilities have appeared in many places, which automatically store and return bicycles. They are often very efficient: 3 to 5 bicycles per m^2 of land area.

TOKYO: REVIVAL OF THE BICYCLE

The growth of bicycle use in Tokyo is remarkable. One can speak of a revival. Although the available sources offered little data on this subject, it is known that during the decades before motorization in Japan, bicycle use was substantial. So Tokyo is witnessing a renewed growth of bicycle traffic. In particular, bicycles are being used for longer trips in combination with public transport.

While this may indicate perceived limits to the usefulness of motorized vehicles in the city *(Ref. 1 and 11)*, city growth tends to extend travel distances. As a result, both walking and bicycle use are declining relative to motorized modes. An illustration of this is the development of the use of transport modes in Tokyo between 1968 and 1988, which is represented in Table 14.

TABLE 14: USE OF TRANSPORT MODES IN TOKYO AS A FUNCTION OF TIME *(Ref. 4)*

Year	Walk	Bicycle	Motorcycle	Car	Bus	Railway
1968	42.9	8.1	0	16.8	7.0	24.8
1978	33.8	12.9	2.2	24.1	4.0	22.9
1988	26.8	14.8	2.8	27.7	2.8	25.1

During this period, walking as a mode of transport has decreased considerably. Bicycle use has increased, despite the pressures of motorization and increase of scale. The motorcycle and, to a higher degree, the car have also become more popular. The decrease in bus use is ascribed to the growing congestion, which also negatively affects the bus. The increase of bicycle use in Tokyo is also manifested in the use of bicycles for trips in combination with public transport. For 25 percent of these trips, the bicycle is used as feeder *(Ref. 4)*. This is also indicates increase in average travel distance.

Tokyo indicates that the bicycle is competing effectively in a modern urban transport environment. Japanese experts see the developments in Japan as a learning process: investment in motorized traffic for several decades has not led to faster and more efficient transport, certainly not in the urban environment. A comparison of travel speeds in a number of Asian cities (Table 15) is significant in this respect. Despite the high level of motorization, the travel speed in Manila is not higher than that in Shanghai.

In Tokyo, the average travel speed is approximately twice as high as Shanghai, but it is still not more than 15 km/hour. This is a very inefficient speed for vehicles designed to drive at more than 100 km/hour. Only in Singapore are significantly higher travel speeds reached. This

is the result of a traffic and transport system that is controlled to a high degree by strict government policy, including high car prices, restrictions on central city access, and a good public transport system.

TABLE 15: INNER-CITY AVERAGE TRAVEL SPEEDS IN SELECTED CITIES IN ASIA *(Ref. 6)*

	km/hour
Jakarta	15
Shanghai	8
Bangkok	9
Manila	10
Seoul	8
Tokyo	15
Singapore	30

SECTION 5: DIRECTIONS FOR FUTURE BICYCLE POLICY IN CHINA

In this section, a number of possible options are suggested on urban traffic and transport policy in China related to the bicycle. Experiences from other countries serve as support. The question of at which government level, local or national, these choices should be made is not dealt with here.

There are two reasons why the policy suggestions in this section are less explicit than the reader may expect:

- Focus in this paper is on information: providing data and knowledge related to bicycle use and bicycle policy in the Dutch situation and comparing them with data and knowledge about China and other Asian countries. This focus on information has been chosen because (a) this might be a useful contribution for Chinese policymakers and experts and (b) the authors of this paper have insufficient knowledge of urban traffic in China to make well-founded and specific recommendations concerning traffic policy and bicycle policy.

- Specific suggestions would in this paper be almost equal to detailed recommendations for bicycle policy—mainly technical suggestions about forming networks of bicycle routes. As argued earlier, much more fundamental choices have to be made in the total transport policy: What can or should the role of the bicycle be in future urban traffic and transport systems? What place should the bicycle be given in China, compared to other modes of traffic? If the bicycle is given an important role, there is a greater need for specific and detailed bicycle measures.

This, by the way, is also something that we have experienced in the Netherlands. Focusing attention on details of our "own" area of bicycle policy is not effective if the purpose is to promote bicycle use. Attention should also focus on fundamental choices concerning the

place of the bicycle within the total traffic and transport system. This paper focuses on these fundamental issues.

First, some likely developments in the traffic system and the subsequent government tasks, as indicated in the previous sections, are reviewed. Then the consecutive levels of policy choices are distinguished, indicating for each level which choices may be made related to traffic and transport systems.

DEVELOPMENTS AND TASKS

In the areas of transport in general, and of bicycle traffic in particular, developments in China appear familiar to Dutch people, because they have already taken place in the Netherlands earlier. Cautiously formulated, there appears to be a difference in phase, which makes it interesting and useful to compare China and the Netherlands, particularly in terms of bicycle traffic and bicycle policy.

Developments in China seem to be turbulent, also in the areas of transport. Where will it end? The answer seems to be obvious. With an unchanged policy, the present developments will end in traffic chaos, large-scale congestion, and stagnating city economies. This is a situation that is generally undesirable.

The conclusion from such an assessment is that the emphasis in urban traffic and transport policy should shift from expanding the urban infrastructure to making better utilization of it. The emphasis should also shift from a choice between the car and public transport, to a choice for a traffic system in which *all* traffic modes play a role, although each being more important than other modes in different situations.

Such a well-balanced policy is within reach. Fully recognizing the benefits of car traffic, it has to be admitted that these benefits can be lost. The urban traffic absorption capacity—which is more than the road network capacity—is after all limited. Of course, all destinations should be easy to reach if a city wants to function properly. This does not mean, however, that anyone should be able to reach any destination at any time using any mode of transport. All this is, of course, only a starting point in policy development. The difficult choices occur in deciding when and where each mode of transport has a particular advantage.

LEVELS IN POLICY CHOICES

Urban transport policy is a constant search for balance between desirable and undesirable developments and the interests of transport service providers, travelers, and residents. The basis for this is a vision of the city's future and the position of the transport system in it. This vision includes solutions for allocating city space and attention for particular modes of transport. Here are some examples. The choice for an effective and efficient public transport system cannot be combined with a system in which the passenger car is given all the space it needs. Neither can a safe and livable neighborhood or district be combined with full access for passenger cars. A third example: a city center area that is accessible for all forms of passenger traffic cannot at the same time be efficiently supplied. Choosing one thing has consequences for the other. Not choosing is also a choice, and the consequences can be painful.

Basically formulated, the desired well-balanced traffic policy, specifically related to bicycle policy, can be seen as a series of choices at different levels, the most important of which are the following:

(a) Limiting City Expansion

When urban population growth is accompanied by expanding the urban area, population density does not increase, but the size of the urban area does. As the population of the suburbs to a high degree depends on the existing urban facilities (e.g., for cultural facilities and service industries), this will lead to an increase of travel distances. Irrespective of the mode of transport used to travel these distances, it will lead to a more intensive use of transport infrastructure.

There is a connection between city size and the length of journeys within this city. The urban structure, of course, also plays an important role in this. A city with a number of more or less equal central areas will have fewer long journeys than a city with one center. In the Dutch situation, a population of some 100,000 is considered ideal. With the population densities that are usual in the Netherlands, this size implies a city with a considerable high level of facilities (shops, hospital, libraries, sports facilities, etc.), and with limited travel distances (maximum 6 km), which can easily be traveled by bicycle. If the various cities of this size are also connected by a rail system, the exchange between those cities can take place without too much inefficient car use.

For Chinese cities these relationships are undoubtedly different. Nevertheless, this idea may offer a possibility to influence the situation from the point of view of controlling growth of long-distance traffic (in this case mainly passenger traffic). For bicycle use this is essential. A continuous decrease in the number of short trips was an important reason for a decrease in bicycle use in the Netherlands, especially in the 1970s.

(b) Linking Functions of Areas to Characteristics of Mobility

Urban areas consist of a large number of subareas that have different characteristics. In Western countries, one can distinguish: residential areas, shopping areas, and work areas. These subareas are usually not strictly monofunctional, and areas with mixed functions also occur. In various European cities, conscious efforts are being made to improve the quality of each of these areas. In city-center areas, parking is moved from the streets to parking garages. Pedestrians and cyclists are given a greater share of the available space.

In residential areas, moving car traffic is restricted and car parking is moved to concentrated parking facilities on the edges of these areas. As a result, more scarce public space is available for social activities (playgrounds for children, meeting places, etc.) and for bicycle and public transport infrastructures. Such a policy has a large influence on people's choice of vehicle. The lack of space to drive or park in certain areas forces people to choose the bicycle, which in these situations are usually also a faster and more desirable mode of transport.

Here too follows the translation to the Chinese situation. Not the West European solution itself, but the way of thinking is important. What function would one want to ascribe to a city subarea, how should transport be organized, and what type of traffic would be appropriate? A conscious choice for an allocation of space in urban areas during the current phase in China when the presence of the passenger car is not yet so dominant offers many opportunities to influence the way in which the transport and living space is organized.

(c) Financial Influence on Vehicle Ownership and Use of Transport

Government can encourage or discourage vehicle ownership and use of transport modes using financial instruments. Public transport fares are a well-known example of this. The available choices are effectively interventions in the competition between modes of transport.

To discourage the use of motorized traffic in certain urban areas, levies could be imposed for this type of transport to be paid when entering those areas. Imposing taxes on the use of vehicles has proved to be a successful policy to restrict use. The taxation of fuel, for instance, which only affects the individual motorized passenger traffic and motorized cargo traffic, is an example of this. Another obvious instrument is a purchase tax on vehicles, successful in the West as well. Conversely, favorable arrangements for loans for the purchase of vehicles, such as for bicycles in Shanghai for instance *(Ref. 10)*, can influence vehicle ownership. In addition, in order to promote bicycle use, one could make public transport rates for short distances relatively expensive. The measures are discussed in the paper on "Motorization in China: Issues and Actions."

The disadvantage of financial instruments is that the increases in costs be shifted on to others. Employees pass them on to their employers (increased wage costs), business travelers and cargo transporters on to their customers, and so on. Only extremely high prices will influence conscious transport choices. Also from a social point of view, the conscious allocation of space for transport as a means for influencing policy is possibly easier to justify than a policy based on financial incentives.

(d) Infrastructure

The effectiveness of spatial policy is strongly related to transport policy. The considerable attention paid in Chinese transport policy to car infrastructure, in the shape of systems of ring and radial roads, can in the long term form a good basis for a clear hierarchy in the urban road network and street pattern. This can create opportunities for improvements of roads and streets at the lower end of the hierarchy. For each mode of transport and for each area (street, neighborhood, district), restrictions in terms of accessibility should be the starting point. Those restrictions are already used in many Chinese cities, but they should be used more intensively to liberate residential areas and shopping streets from large amounts of fast-driving cars. In various Chinese cities, there appear to be possibilities for systems of bicycle streets, which would create separate networks for bicycle traffic and car traffic. This policy is being pursued in Shanghai. At the busiest intersections, systematic grade separation can be applied, although this is

costly. The less-busy intersections can be equipped with traffic lights. At even lower intensities mini-roundabouts offer an effective and safe solution.

In the construction and improvement of streets and highways, difficult choices will be necessary in China. The scarcity of financial resources and the responsible application of those resources forces the Government to make choices in infrastructure investments. Of course, the investment policy is primarily based on the vision of future urban development, but it is also necessary to consider the true costs and benefits of infrastructure investments. For the bicycle, the cost-benefit analysis can easily be positive, because the investment costs for bicycle infrastructure are relatively low, and operating costs for the government minimal (e.g., guarded parking facilities). This is particularly true in urban areas where major highway infrastructure can be very expensive.

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THEME PAPER 6: INVESTMENT IN MASS RAPID TRANSIT

ROGER ALLPORT [1]

PART 1: CONTEXT

THE IMPORTANCE OF MASS RAPID TRANSIT POLICY

"Transport is civilization," said Rudyard Kipling.[2] Well, this may be overstating the central importance of transport to Asia's megacities—but not by much. For today's cities are rapidly becoming the antithesis of civilized living and are fundamentally threatening future economic growth. Asia's leaders are increasingly recognizing that "something must be done". What is this something?

There is only one known remedy to chronic traffic congestion in these cities—traffic restraint, but this often is not politically implementable without first developing a first-class alternative to the car—a mass rapid transit (MRT) network.[3] As this will be the largest investment a city will ever make—unsurprisingly it is no easy option.

Resources

Hong Kong and Singapore are different from other cities—they anticipate future problems, produce the resources to tackle them and by and large they succeed. Other cities have an enviable city form—for example Lahore and Kuala Lumpur, but in most cities their environment is being sacrificed to traffic.

There have been widespread efforts to maximize the capacity of roads but with little systematic success. New infrastructure is seen by many as the key to "solving the problem." Thus Manila, Seoul, Pusan, Beijing, Shanghai, and Bombay all have effective MRT systems; Taipei, Guangzhou and Kuala Lumpur soon will have; while Bangkok and Jakarta are not far behind.

Attempts at traffic restraint—in Bangkok and Kuala Lumpur—failed in the late 1970s and there has been little attempt to develop effective parking controls. The motorist is king in most cities, and in some countries the car industry is of strategic importance, making controls on car ownership problematic. Only where incomes are low (such as in Lahore), or where vehicle

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1 Roger Allport is Director, Halcrow Fox, London, England.

2 This section is based upon Reference 1.

3 China may be an important exception if restraint is implemented before car ownership takes off. There is a Window of Opportunity for action now.

ownership has been controlled by the state (as in Beijing) is traffic congestion not yet serious—and this will change quickly as incomes grow.

There are times when people say "enough is enough," and there are examples of action proving effective such as the introduction of clean fuels, vehicle checks, and public information. But issues that require coordinated, interagency action are rarely tackled effectively.

Results

Traffic congestion is rapidly taking on the mantle of No. 1 problem in many cities because:

- increasingly large numbers of people are spending a large part of their lives frustrated in traffic jams, arriving jaded at work and returning home late and exhausted. Where is the fulfillment that big-city life should bring—and for which access is the key?
- with two-thirds of gross domestic product (GDP) produced in cities by the end of the decade, it is little wonder that the economists ponder the impact of gridlock on national economic prospects;
- cities sprawl, up to 70 km along the major transport routes, and yet land in the inner city is often vacant or underutilized because there is no access to it; and
- the environment rapidly degrades—there are fewer green spaces, little respite from traffic, air is increasingly unpleasant to breathe and injurious to health, the noise all-pervasive, and some say that national character is being changed—to a more aggressive, and less gentle people.

Impediments to a Solution

In a sector that touches most aspects of people's lives, it is the general lack of coordination between government agencies, and the frequent lack of a collective sense of purpose that distinguishes the more effective from the less effective performers. Big cities are where the key people live and yet it is also where implementation is most difficult. Implementing a mass transit railway through the heart of a living, vibrant and congested city is one of the greatest challenges that any administration will fact—witness the chaos that results without due planning.

Funding is a problem too—for two reasons. First, urban transport infrastructure is very costly—and often so costly that it raises political concerns that too much is being invested in the capital city and too little in the provinces. So, there has been a sea-change in approach, and a commitment to solve this problem by using the private sector to implement what government cannot. There are a few examples of success, and many projects in Asia where this is planned but, unfortunately, it is a fact that few such urban transport projects are financially viable and some government funding is therefore essential. This then requires partnership between the private and public sectors—which raises new problems.

Then, there is the "technology fix," which misleadingly relies on technology for a solution. While there is a natural evolution in the application of technology throughout the region—rarely is

this anywhere near as important as planning well, generating a consensus for priority action and funding effective action.

The Way Ahead

There are no easy answers and all evidence indicates that progress requires three things. First, the determination of priorities, given what is affordable, and making realistic assumptions about what the private sector can do. Second, generating consensus behind the priorities. Third, funding and implementing the priority projects.

MASS RAPID TRANSIT IN CHINA

China is different from most developing countries. Cities and the transport that serves them have evolved to meet these different circumstances. The dominance of the bicycle—catering for most travel in most cities, is the most notable feature of this difference, contrasting with the "usual" dominance of buses and paratransit in other developing countries.

The modal characteristics of the case study cities visited are as follows:

City		% Walk	% Bicycle	% Public Bus	% Other
Guangzhou	1984	39	34	19	8
	1992	31	34	24	11
Chengdu	1987	36	55	6	3
Shanghai	1986	24	38	35	3
Jinan	1988	23	63	7	7
Beijing	1986 /a	NA	60	21	19
Tianjin	1981	30	56	11	3
	1990	11	75	8	6

/a Excluding walking trips.

In all cities in all years bicycles were more important as a mass travel carrier than buses (in terms of trip numbers), while the public buses carry under 10 percent of travel in the medium-size cities, and 20 to 35 percent in the major cities. Works buses carry significant numbers of travelers too.

The extent of mass **rapid** transit in China today is the few metro systems. There are no busways or other transit systems that allows travel to be "rapid."

SCOPE OF THE PAPER

The subject of this Paper is not just about mass transit, but about the future of China's big cities, and the lives of its citizens.

Increasingly, metros are seen to be central to the answer. Since these systems are often extraordinarily costly, often representing the biggest investment a city will every make, the decision to proceed down this route is one of major strategic importance. This paper examines the evidence,

identifies the key issues, analyses the potentials for private funding, and draws implications for future policy.

There are two distinct claims made for implementing such transit systems, which are, in summary:

- The "micro" argument: This is the "traditional case": that transit project will help solve traffic congestion, improve public transport, is essential to carry forecast passengers etc.
- The "macro" argument: This is rapidly gaining ground: that a transit network holds the key to unlocking a "sustainable future" for Asia's big cities.

This paper examines these claims in the light of experience and future prospects. It concludes that metros will be the exception in Chinese cities for many years, until rising prosperity provide conditions for their economic viability and the resources to fund them.

Bus transit is shown to be central to future city needs, and vital to the future prosperity of most big cities. This will require a major refocusing of priorities, and the paper sets out a practical and affordable strategy that will allow cities to continue to function effectively.

The Paper follows a straightforward structure. Section 2 summarizes Chinese transit experience, and plans: this concerns rail systems because no lower-cost bus systems exist in China. Section 3 then describes international experience—for metros and lower-cost options, respectively.

The international experience of metros relies upon a major research study of metros in developing countries, which were all **pubic sector** operations. Since that time, the role of the private sector has become prominent in metro planning/development. Worldwide experience of this fundamental change in approach are described—and the validity of conclusions based upon public sector systems is reviewed.

Section 4 summarizes the lessons for future metro development in China, and provides policy guidelines for possible application in China; while Section 5 highlights the need for development of bus transit, and provides guidelines for the development of a bus transit strategy.

Definitions

There are no internationally agreed definitions for the transit systems. Thus, the following are all in common usage:

MRT—Mass **Rail** Transit, <u>or</u> Mass **Rapid** transit
LRT—Light **Rail** Transit <u>or</u> Light **Rapid** Transit
Metro
Tram
Transit, etc..

Annex A suggests a meaningful definition, based upon the important characteristics of such systems, namely that

"They carry a mass ridership rapidly."

This paper adopts the following convention:

- **Mass Rapid Transit (MRT)**—refers to all such systems, both rail and bus.
- **Metro**—refers generically to all rail systems.
- **Light Rapid Transit (LRT)** is used only where specifically defined, and refers to medium-capacity rail systems, often designed to tighter design standards, to better fit into the urban environment.
- **Busway**—is a route, often the central section of a roadway, for the exclusive use of buses.
- **Bus transit**—is shortlisted for bus mass rapid transit, and includes extension bus priorities, such as busways.

PART 2.: CHINA MASS RAPID TRANSIT EXPERIENCE

OVERVIEW

This section focuses upon the experience of the five case study cities visited by the World Bank/ Asian Development Bank/Ministry of Construction Mission in Spring 1995. Together with Tianjin, to which a short visit was made, these cities include the main metro experience in China, and examples of planned activity in the medium-size cities. There are no busways or high-capacity light rapid transit systems in China, so this metro experience is representative of all mass rapid transit experience in the country.

Figure 1 summarizes the metro characteristics—operational, under construction and planned—in the six cities visited. Figure 2 summarize all the metro activity in China of which the Mission was advised. This may not be comprehensive, but it sets the scene for the range and scale of activity that is planned.

Today there are just 65 km of operational metro—in Beijing, Tianjin and (since April) Shanghai—with tramways in a few cities. Three metros are under construction: in Beijing (Line 1 extension—11.5 km), Guangzhou (Line 1—18.5 km) and Shanghai (Line 1 extension—5 km). When these are open, there will be 102 km of metro in operation in China.

The plans (in the short term, summarized in Figure 2, and in the longer term for the six case study cities, summarized in Figure 1) suggest an "explosion" of metro/LRT development in China. At present, there are 29 projects in 20 cities.

Figure 1: METRO CHARACTERISTICS IN CHINA: CASE STUDY CITIES

City	Population (million)	Mode Choice % metro	% bus	% bicycle	Bus priorities?	Metro Operational/Under Construction: Description	Vertical Alignment	Integration	Cost (Y billion)	Passengers p.a. million	Revenue/Op Costs	Funding Structure	Metro network planned	Priority
Guangzhou		n.a.			None	Line 1 - 18km under construction. 1998 opening	Mostly underground	Development at 27 station sites	(12.75) 6.7 spent to date	(135) on opening, (250) after 5 years	Fare revenue forecast less than op. cost for 12 yrs	Foreign loans (30%) Municipality (30%) Development (40%)	3 Metro lines - 57km + 2 LRT lines - 49km 106km	Line 2 to follow Line 1 after 1998
Chengdu	2.6	n.a.	6%	54%	None	(Line 1 - 13km)	(Underground)	-	(5.0)	-	-	-	4 radial Metro lines and 1 orbital line - 43km.	Line 1
Shanghai	7-8				Minor	Line 1 - 16km Open 4/95	Mostly underground	No bus/bicycle integration planned. (Development at stations planned for L2)	L1 (10.1) 1995 prices	65 based on April 95 initial ridership (will increase)	Fare revenue forecast less than operating cost.	L1 L2 Foreign loans 30% (30%) Municipality 70% (40%) Development 0% (30%)	7 Metro lines 238km + 7 LRT lines in a grid network Total 340km	Line 1 extension under construction. Line 2 to follow - all underground
Jinan		n.a.	7% (1988)	64%	None/no interest	(Line 1 - 11 km)	(Elevated in center, at-grade in suburbs)	-	(1.0-1.2)	-	-	-	3 Line LRT Network	Line 1
Beijing	13	4%	21% (1986 data)	60%	Minor	L1 - 19km L2 - 23 km 42km Severe congestion problems. L2 a converted air-raid shelter	L1/2 entirely underground	Bus/metro fares integration. Shortage of bicycle parking	Per km ug'd 0.4 elev 0.3 at-grade 0.1	533 - 1994 (increasing at 11% p.a.)	0.28 in 1994	-	300km grid network of 12 Mtetro lines	Line 1 being upgraded to increase capacity and extended.
Tianjin		0%	8% (1990 data)	75%	None	Line 1 - 7km converted air-raid shelter, which skirts the city center	All underground	-	-	low (not "mass" transit)	-	-	6 radials and 1 circumferencial Metro - 107km	Line 1 to be renovated, increasing capacity and extended.

Note: Forecast Figures shown in parentheses ( ).
Population figures include floating population.

Figure 2: STATUS OF LRT/METRO PROJECTS IN CHINA

Existing No. Projects: 3	Awaiting Approval 2/Under Construction 3 (2 under construction)	Approval 1 Given 6	Submitted for Approval 1 7	Other Proposals 10
Beijing Metro Lines 1, 2	**Beijing** Metro Line 1 - Extension to Bawangfen, 12km (under construction)	**Beijing** Metro Line 1 - Bawangfen to Tong Xian	**Beijing** Metro Line 3 N-S 19.5km	**Anshan** Tramway - Upgrading of 11.5km to LRT
Tianjin Metro Line 1		**Tianjin** Line 1 Capacity Exp. and extension 10.3km north		**Changchun** Tramway - Upgrade of 8.5km of the 12km network and extended to create a 16.5km LRT Line for Y 1.5 billion. 4km underground, 6km elevated and 6.5km at-grade
Shanghai Metro Line 1 14.6km		**Shanghai** Metro Line 2 (most recent approval) 13.5km	**Shanghai** LRT Line 1 Xin Zhuan - Min Heng, 13.2km (Big problems: Agreement with Canadians canceled when Australians gave an apparently better deal, but only apparently.)	**Dalian** Tramway - Upgrading 12.7km
	Guangzhou Metro Line 1 (under construction) 18.5km for Y 12.75 billion	**Guangzhou** LRT Line 1. 31km for Y 5.6 billion (note status unclear)		**Changping** plans 40km suburban LRT line
	Shenyang LRT Stage 1. 25km and Y 1.8 billion (but funding problems)			**Foshan** planning suburban LRT project, 20.0km
		Qindao Subway Line 1, 15.5km		**Hangzhou** plans elevated LRT/monorail 14.1km long at Y 1 billion
		Chongqing LRT Line 1 (BOT, 17.4km and Y 4 billion) (Big problems - HK developer has completed development but no transit funding provided. Project stopped)	**Chongqing** Monorail Line 2, 17.7km (Japanese Government funding)	**Harbin** plans 14.5km underground light metro
			Nanjing Metro Line 1 - 17km and Y 3.5 billion (in trouble. Given Green Pass but cannot find foreign finance)	**Lanzhou** plans 16.0km LRT Line
			Chengdu Subway - 13.2 (or 14.8) km and Y 5.0 billion (likewise difficult to attract foreign finance, particularly as inland, although some Canadian interest)	**Taiyuan** plans LRT project
			Shenzhen Metro Line 1. Not approved by SPC: high cost, not enough foreign finance, HK political uncertainty. CIECC suggested more elevated structure to reduce cost. 25.4km, 22 stations, Y 15.9 billion incl uding $0.65 million cost	**Jinan** plans LRT project
			Wuhan LRT Line 1 - BOT Project. On hold as funding problematic. 8.9km and Y 1.1 billion elevated alignment	

PLANNING AND CONSTRUCTION

Reasons for Building a Metro

No systematic overview exists for Chinese cities. However, the 1995 Mission to five cities sought to establish answers to this question.

There is a requirement by the state that a mass transit system should be economically viable. Justification comprises forecasting ahead 30 years (25 years after opening), determining the technology—LRT if for a capacity of 10 to 30,000 passengers per hour per direction (pphpd) and metro for higher capacities—and confirming its economic viability (which should exceed an economic internal rate of return of 12 percent).

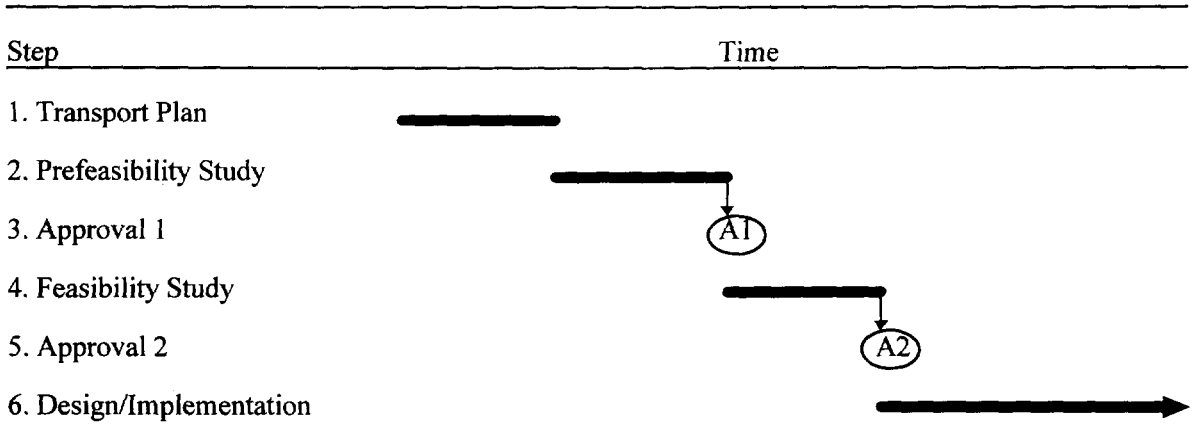
Other comments made in answer to the question "why metros?" were:

- "a historic city needs protecting"
- "resettlement requires underground construction"
- "the huge pressure on land plus growth of everything makes the need for a metro obvious"
- "other developed cities show what is necessary"
- "demand forecasts are beyond the capacity of buses - there is no alternative"
- "if there is no transit, economic development of the city will be much hampered."

The Planning/Implementation Process

There is a systematic process—which can be built upon. This is important. The process has the following features (Figure 3):

FIGURE 3: THE METRO PLANNING PROCESS IN CHINA



- the State requires to give two approvals prior to go-ahead (A1 and A2)

- a Transport Planning Study is followed by Prefeasibility Study, Approval 1, Feasibility Study, Approval 2. *Then* Design/Implementation is by the Municipality: this is a largely hands-off process by the State in which the Municipality takes the initiative.

- the involvement of a Group of Chinese experts who are influential in recommending what should happen.

This Process incorporates a number of features, which are discussed in this Paper. Key issues are:

(a) It is technically/engineering oriented, and narrow in institutional terms.

(b) The objectives for the metro—as part of the transport system, serving wider development objectives, are not explicitly set. Who are its target market—hence what fares policy and what level of service is required to best achieve this? The role of the "floating population" is currently important for public transport: how is this expected to change?

(c) It focuses on the development of a Master Plan, which is a long-term goal of policy.

(d) It is not clear what transport policy assumptions are set, such as the future role of the car, vehicle restraint policy, etc.

(e) Plans are not constrained by available funding. Rather, funding is seen as a "problem to be solved" once the plan is determined, one that determines timing of implementation. No financial planning (such as how to fund the operating subsidy) appears to take place.

(f) Lower-cost alternatives to the metro (bus alternatives for example) are not evaluated. Rather, justification depends on comparison with the "do-nothing" situation.

(g) It is not clear how demand forecasts are prepared; for example, how they are influenced by the profound socioeconomic changes occurring, by fares, and by the nature of bus/ cycle integration. More generally the crucial importance of bicycle/bus integration does not appear to be fully recognized.

(h) Cost estimates often build in assumptions set by the State that may not reflect actual local condition (for example, in respect to inflation).

(i) It is not clear that the (very important) decisions about the vertical alignment of the metro are based upon technical evaluation.

(j) No rigorous before-and-after studies appear to be carried out. An obvious example would be Line 1 of the Shanghai Metro. Without such study, facts will be too few for the proper analysis of metro systems to be undertaken.

It is sometimes reported as State policy that "any city with a population of 1 million or more should have a metro"; but it is understood there is no such policy in existence.

Funding

Funding determines what happens in practice. The State has seen the very high cost of metros (all the metros existing/under construction are substantially underground systems), and has adopted a conservative decentralized approach to metro development and funding. Key aspects of this are:

- there is a system for project approval (described above), with two approvals being required from the State before anything can be implemented
- no substantial State funds are available for metro investment.
- The State can offer preferential treatment, such as allow municipalities to borrow foreign funds at low rates, allow land development and allow municipalities to issue bonds to finance such projects.

The Possible Funding Sources: thus, there are in practice only three possible sources of substantive metro funding:

(a) **the Municipalities**—in the form of land sales, taxes, or bonds/international loans (which need repaying);

(b) **passengers**—through payment of fares; and

(c) **developers**—in the form of development gain: up-front finance for construction and recurrent income from real estate dividends.

Recent experience is that:

- **The Municipalities** are usually unable to invest substantial resources in metros (although they are, with State approval able to contract loans/issue bonds).
- All Chinese metros in operation/under construction are subsidized—or expected to be subsidized annually (see Figure 1): there is no surplus of fares income over operating costs to fund their construction cost; indeed, funds are required to finance normal operations, and asset replacement.

So funding—and therefore implementation—depends currently upon **development gain.** Yet the scale of future development gain, and therefore metro development, is not clear:

- to be significant as a funding source, massive development is required. In Guangzhou 27 identified sites would realize a **target** 40 percent of construction cost. Shanghai Line 2 has a 30 percent **target**. These figures are much higher than the largest figures *known* elsewhere—15 percent for the Hong Kong MTR (actual), and London Jubilee Line Extension (expected).

- Massive simultaneous development at stations along a metro threatens oversupply, and "bust" in the boom-and-bust property market that undoubtedly exists in Chinese cities. This can perhaps only be avoided in the biggest/most vibrant cities, such as Guangzhou and Shanghai.

- Development is almost entirely by Hong Kong (and Taiwanese) developers. Yet there is Asia-wide competition for their management skills/finance, which are at a premium. Even though Chinese Municipalities own all land, which gives them an enormously important resource to lease, "buyers" are needed to realize massive real estate development, and this is probably a bottleneck at present.

The Funding Options. There appear to be three practical funding options that could be models for the future:

(a) A combination of foreign loans for equipment (typically half the cost), developer profits and minor funding from the Municipality

(b) A Build-Operate-Transfer (BOT) concession granted to a private developer, combined with government incentives (tax breaks, land grants, etc.) to "create" viability.

(c) And, exceptionally, Municipality funds (raised, for example, from the issue of bonds, specific taxes) together with foreign loans for equipment (as in Shanghai Line 1).

The expectation in Guangzhou Line 1 and Shanghai Line 2 is for the following funding structure (Option 1):

Overseas loans for equipment, to be repaid by Municipality	1/3
Municipal taxes, bonds (to be redeemed)	1/3
Development profits	1/3

Option 2: BOT—may have a limited application in this sector. It appears that State policy is cautious and somewhat ambiguous. Experimentation may be the way ahead on a limited scale, and may require the law and administrative procedures to be clarified before progress can be substantial.

Industrial Policy/Technology—this directly affects the availability of foreign loans for equipment. The early metros—Beijing and Tianjin—and the current Beijing Line 1 Extension were substantially manufactured locally. Meanwhile, the Municipalities (Shanghai, Guangzhou and others) have contracted loans to buy off-the-shelf equipment packages from foreign suppliers. Now, the State is understood to be reviewing its policy toward domestic manufacture.

Other countries, Korea and Brazil are examples, decided as a matter of strategy to implement metros, thereby developing a manufacturing capability that could become a world exporter. There may be strong imperatives for China to develop in this way at some stage; but also strong imperatives for foreign funds to continue until the State finances can support such development.

Summary. There is therefore an apparent paradox between the planned "explosion" in metro activity, and the available funds to finance these very costly investments.

Metro Plans

Figure 4 illustrates the metro plans of the case study cities. Four features are noteworthy:

1. **Network Size**—all of the planned networks are large—and some very large (Figure 1). The total planned network of just these six cities is two to three times the entire metro network that exists in Asia today.

   Beijing has a network of four north-south and four east-west high-capacity metros feeding its inner city area. This represents a combined capacity of, say, 240,000 passengers per hour per direction, in each of the four directions—an enormous capacity, many times that of the existing mainly road-based system.

2. **Network Configuration**—the metro networks tend to be either grid (as in Beijing and Shanghai), or ring-and-radial configurations (as in Tianjin and Chengdu). One of the major conclusions from international experience is that, while these configurations are often excellent for highway networks, they are not for metros—because they require passengers to interchange (something that, of course, is not necessary for passengers of road vehicles).

3. **Technology: LRT and Metro**—the planning system defines these as:

   LRT is medium-capacity (10-30,000 pphpd), elevated, usually (except for medium-size cities) outside the Inner Ring Road (itself often a considerable distance from the city center)

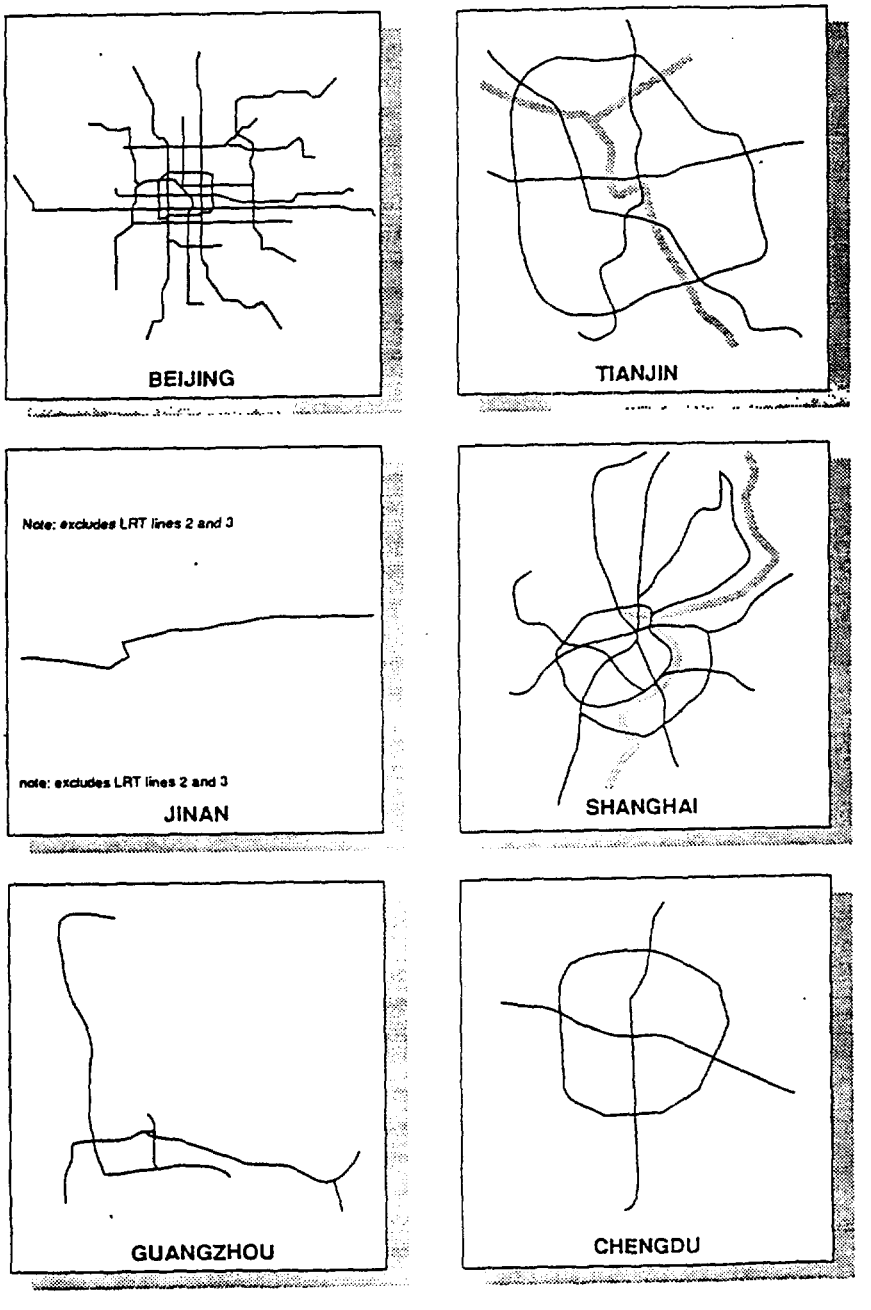
   Metro is high-capacity (30,000+ pphpd), underground, and usually inside the Inner Ring Road.

   It seems that these guidelines are followed closely. The result is that the great majority of metro construction is underground, and medium-capacity systems are not considered for construction through the centers of most cities.

   This is very different from the experience elsewhere: even "green" Singapore has 67 percent of its metro elevated, and many cities have built elevated LRT systems through their centers—because they were affordable at the stage in their development.

4. **Comparability in Evaluation: Metros and Expressways**—elevated expressways are accepted through the Central Area of cities (as in Shanghai), but not elevated metros. Yet, the environmental impact of a metro is much less intrusive than that of an expressway. It is difficult to understand why this is so—maybe it is a reflection of different institutional responsibilities.

FIGURE 4: CHINA CASE STUDY CITIES—METRO PLANS



Implementation and Construction Cost

Implementation—the implementation approach appears to be narrowly focused on the construction process itself. Coordination problems are common during construction, and delay is the norm.

Construction Delay—in Shanghai construction started in 1990, and the line fully opened in April 1995. Construction was hampered by poor ground conditions. Implementing the full 300+ km metro network would take more than 100 years at this rate, which has lead to increased interest in elevated LRT. In Guangzhou construction is scheduled over five years, with an end-1998 opening. Implementation is broadly on schedule.

Construction Cost—information from the Beijing and Tianjin metros are out-of-date, but there should be good data from Shanghai Line 1, now open. Unfortunately, there is no confidence that this exists. The main reasons for the increase in cost of this project are likely to be:

- devaluation,
- inflation (in excess of the assumed 6 percent per year),
- other factors: poor estimates, unforeseen ground conditions, difficulties with utilities diversions, contractor problems, etc.

The first two factors alone result in a cost of about $75 million/km (1995 prices, excluding inflation) for Line 1, which is mostly underground. The current estimate for underground metro construction in Shanghai is Y 0.7-0.8 billion/km; equivalent to $85 million/km (1995 prices, excluding inflation).

It seems likely that the outturn cost for underground construction is likely to be $100 million/km (1995 prices, excluding inflation); but it could be higher, depending upon the magnitude of the "other factors" identified above.

The cost structure for Chinese metros is as follows:

Category	Percent cost by category in:		
	Guangzhou	Shanghai Line 1 1990 Estimates	Beijing Line 1 Ext
Resettlement/acquisition	?	13 (including utility diversion)	?
Civil Works	45-50	30	63
Equipment	50-55	30	37
Management, etc.	?	27 ("other") (before devaluation/ inflation adjustment)	?

Relocation costs are said to be important and high, but how important and how high it is difficult to know.

METRO OPERATIONS AND TRAFFIC

Operations

All the metros work and are effective. Beijing and Tianjin are, to some extent, like London, having to deal with the legacy of the past; whereas Shanghai and Guangzhou have first-world metros, similar to those in many cities of the world.

In Beijing there are severe operational problems: the system capacity cannot cope with the traffic, and extremely severe congestion occurs, creating a very unpleasant traveling environment at peak times. Paradoxically, the worse the congestion, the longer the station delays, and the lower the system capacity, creating a "spiral of decline," and occasionally requiring a station to be closed on safety grounds. But capacity improvements are mostly complete on Line 1—and once extra cars are obtained, capacity will be 40 to 45,000 pphpd (compared with 25,000 pphpd at present). It is noted that the Line 1 Extension to Bawangfen is being designed for eight-car trains (as compared with the existing six-car trains).

In Shanghai, there have been problems with the ticketing system, and paper tickets are being issued until automatic fare collection equipment is installed. There have been early problems too with the ATC equipment, which restricts the frequency of trains that can be run. These will without doubt shortly be resolved.

In Tianjin, scheduled headways are very high—15 minutes in the peak, 35 minutes off-peak. It is not clear why, although the alignment is not good (it is a converted air-raid shelter), and it may reflect poor demand. In any event, in no sense can this be termed **mass** rapid transit at present.

There is evidence (Figure 1) of a lack of integration of the metro with bicycles and buses. While not currently a problem on Beijing Line 1, where capacity is constrained, more generally traffic and revenue may be forgone.

Tariffs are as follows:

- Shanghai: Y 0.5. 1, 2...averaging Y 1.7 (20 cents). This is three to six times the bus fare; and will be adjusted "to ensure the metro is well used"
- Tianjin: Y 0.3 (4 cents)
- Beijing: Y 0.2 (2 cents—average of monthly passes and single tickets).

Traffic

Beijing metro passengers in 1994 were about 1.5 million per day; and 15 percent of all public transport passengers. The maximum peak flows were 24 to 25,000 pphpd. Roughly 40 percent of passengers access the metro by bus, 10 percent by bicycle and 40 percent walk. Ten years ago, two-thirds of riders were "floating population," but this is now about one-half.

In Shanghai the early figures are 180,000 passengers per day. It is not possible to draw any conclusions from this.

METRO IMPACTS AND VIABILITY

Few conclusions can be drawn on the basis of the evidence available. However, the following can be said:

(a) Metros increase the **quantity** of public transport substantially (with Tianjin the exception)

(b) The "first-world" metros of Shanghai/Guangzhou also increase the **quality** of public transport substantially.

(c) Shanghai (Line 2 in particular) and Guangzhou Line 1 are likely to have a major impact on land use and city structure.

(d) None of the metros is anywhere near being financially viable. None is likely to operate at a surplus at least for some time:

(i) Guangzhou forecasts annual operating subsidies for 12 years

(ii) Shanghai forecasts annual operating subsidies

(iii) Beijing funds about 30 percent of its direct operating costs from fare revenues.

Thus, construction costs and most asset replacement costs will need to be funded externally.

PART 3: DEVELOPING CITY METRO EXPERIENCE

PLANNING AND CONSTRUCTION

Reasons for Building a Metro

Metros carry large numbers of people rapidly by being segregated from road traffic, and, as a result, are exceptionally costly to build. So, given their very high cost, why are metros universally popular?

To answer this question the UK Overseas Development Administration commissioned a major research study with the active technical support of the World Bank. Twenty-one developing cities were selected as "case studies"—Figure 5. All either had constructed or were planning to construct metros. All contained more than a million people and they included the world's largest cities.

Why were metros so widely advocated? Interviews and documentary evidence provided a clear picture—Figure 6. Principally, metros were expected to:

- Improve the quantity and quality of public transport;
- Solve traffic congestion problems;
- Promote land use policy;
- and to do all this while being financially viable.

FIGURE 5: METRO CASE STUDY CITIES

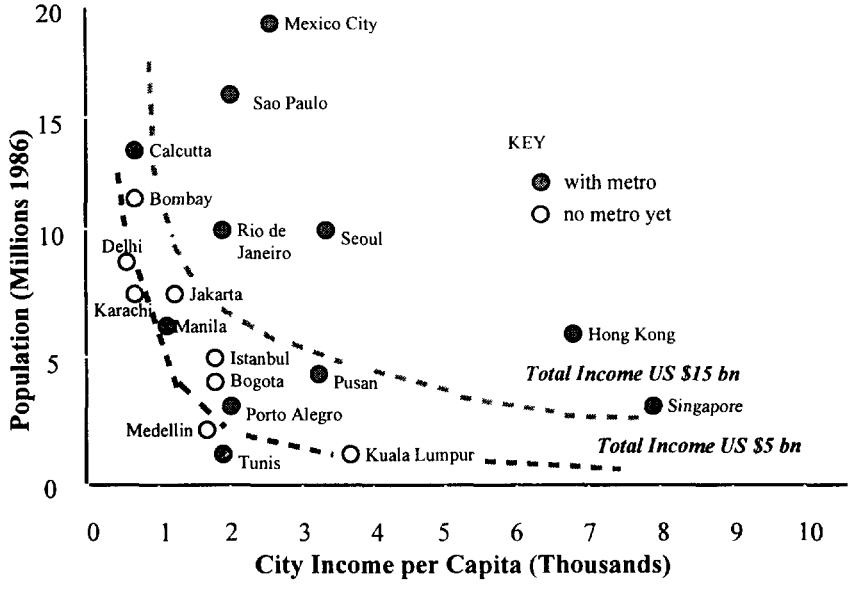


FIGURE 6: METRO CASE STUDIES—REASONS WHY METROS ARE ADVOCATED

Reason		% Cities
1. Public Transport is not good enough		80
2. To relieve traffic congestion		65
3. - Financially Viable		60
- To promote land use policy		50
- Neceessary to carry forecast passengers		45
4. Others:	Economically viable }	
	Environmental Policy }	
	Prestige }	25-45
	Industrial policy }	
	Energy Policy }	

Many cities considered "there was no alternative" to a metro, based upon forecast passenger numbers. Economic viability was little mentioned, probably because of the widespread view that metros would be financially viable.

Planning

Metro planning was, except in a few cases, poor; and most of the faults were made because of poor or nonexistent feasibility studies.

Many plans were unrealistic, and unaffordable, and when implementable were many years out of date. Thus, it was not unusual for large metro networks comprising many lines to be adopted as policy—in the expectation that they would be financially viable (and thus affordable). Many plans were carried out in isolation from the "hard realities" of metro planning: the large public investment necessary, the fares that passengers are prepared to pay, the land requirements, the construction problems—and the environmental consequences once implemented; and the need to effectively integrate the buses with the metro. Often, the effective involvement of policymakers was not adequate during the planning process, and consensus was not achieved, with resulting problems in securing the necessary funds, land, etc. necessary for implementation.

There were examples where the choice of route appeared to be at fault, since the metro failed to penetrate the city center or the major suburban residential centers; or because the route was indirect. This is the most serious of all problems, since once built, the route cannot be changed. The reason for the problem was often cost overruns, and the attempt to reduce the cost by finding "an easy alignment," such as a disused railway alignment. But the saving was achieved at a very high cost—a major reduction in traffic/revenue/benefits. It is essential for a metro to penetrate the heart of the city center, and that "missing" the real traffic objectives by only 600-800 meters could substantially reduce ridership.

Rarely was the crucial importance of bus integration, and the difficulty of achieving it, recognized. Without this, the metro will always serve a small walk-in catchment area, and can never carry the "mass" ridership upon which its justification depends. Yet planners failed to recognize many of the realities of bus-metro integration.

And rarely was the role of the metro clearly identified. Who were its target market, and how was the metro to serve overall transport and development policy objectives? Sometimes, in practice, fares were kept low as a matter of public policy, resulting in large subsidy requirements; sometimes fares were pitched to attract a mass ridership but at a premium over the buses—in effect providing a two-tier public transport system; and occasionally, fares were set high, resulting in the metro being used mainly by the middle classes.

In many instances, it was assumed that the metro would result in high-density development in the metro corridor. But only a very few city authorities took steps to bring about this desirable objective of integrated land use/transport planning. These were those who were also the major provider of housing in the city: Hong Kong, Singapore and Sao Paulo.

Figure 7 shows the main characteristics of the metros:

Figure 7: METRO CASE STUDIES—NETWORK CHARACTERISTICS

City	Technology	Length km	% under-ground	Station Spacing km	Minimum Headway min	Cars/train	Hourly Design Capacity p/dirn	Average Journey Speed kph
Cairo	MRT mostly at-grade	42.5	11	1.3	2'30"	6/9	60,000	-
Calcutta	Full metro	16.5	95	1.0	2'10"	8	59,000	33
Hong Kong:								
Kowloon	Full metro	26	77	1.1	2'00"	8	75,000	33
Island	Full metro	12.5	84	1.0	3'30"	7	38,000	33
Tuen Mun	LRT at-grade	23	0	0.6	1'00"	1/2	14,000	26
Istanbul	LRT mostly at-grade	24	14	1.3	1'30" - 2'	3/4	28,000	-
Manila	LRT elevated	14	0	0.8	2' - 2'30"	2	25,000	28
Medellin	LRT elevated	32	0	1.3	2'30"	6	-	-
Mexico City:								
Metro	Full Metro	131	75	1.2	1'55"	9	46,000	35
Tren leger	LRT part grade part elevated	11	0	-	-	-	-	-
Porto Alegre	Metro mainly at-grade	26.7	0	1.9	6'00"	4/8/12	16,000	41
Pusan	Full metro	32	79	1.0	2'00"	6	27,000	32
Rio de Janeiro:								
Line 1	Full metro	11.6	100	0.8	3'00"	6	45,000	29
Line 2	Pre-metro	22	5	1.6	-	2	-	-
Santiago	Full metro	26	81	0.7	2'40"	5	20,000?	32
Sao Paulo:								
Line 1	Full metro	17	82	0.9	1'45"	6	58,000?	29
Line 2	Full metro	11.5	32	1.2	1'50"	6	48,000?	38
Seoul	Full metro	116.5	80	1.2	3' - 4'	6	29,000?	36.5
Singapore	Full metro, u/g and elevated	67	30	1.6	2'00"	6	-	-
Tunis	LRT at grade	10	0	0.8	1'00"	2	24,000	19

(a) The network size is not large—only Mexico City, Seoul and Hong Kong in the developing world had large networks at the time of the study.

(b) Only one system is 100 percent underground. Overall, 50 percent of construction is underground and 50 percent elevated or at-grade. Even "green" Singapore has only 30 percent of its system underground.

(c) The great majority of lines are radial to the city center. The main exception is Mexico City Lines, which create a grid network. These lines carry very much lower flows than lines 1-3.

(d) There is a wide range of technologies/proprietary systems. But all are steel-wheel-on-steel-rail. To the passenger, the major difference is whether the system is fully segregated from road traffic and therefore fast, or not.

(e) Operating speeds are in the range 28-41 kph for the fully grade-separated systems—the speed being primarily determined by the distance between stations. The at-grade systems achieved 19 kph (Tunis LRT) and 26 kph (Hong Kong Tuen Mun LRT).

Construction And Cost

There was almost uniform agreement that building a metro through the middle of a congested, dynamic, large city—often the capital city where all the influential people work—was extraordinarily difficult to achieve; and that the metro investment was often the greatest investment the city would ever make.

Often the problems of construction were totally underestimated and the real impact of even tunneled construction was not appreciated. Partly for this reason, the construction was not planned for, and at worst the metro resulted in the metro corridor being devastated for several years, with public protest often requiring intervention at the highest level. In some cases, the problems during construction resulted in the decision to avoid cut-and-cover construction in the future.

Almost without exception, the final engineering of the metros was good. But for half the metros, important changes to the original plan were made, and the final metro differed substantially from that intended when construction commenced. Their level of sophistication varied widely, from "basic" designs appropriate to lower-income cities (with limited attention to visual aspects, no escalators to stations, simple ticketing, absence of air conditioning) to the sophisticated metros of Hong Kong and Singapore.

Delay and construction cost overruns were the common experience (Figure 8), with 75 percent having cost and time overruns, often large. These were attributed to a wide range of factors including: land acquisition/resettlement problems, unforeseen utilities diversions, changes in system specifications, currency devaluations and rises in interest charges. But in practice, the estimates were probably unrealistic, because the scale of the metro construction task was not appreciated, or because metro authorities lacked the management skills to avoid the problems, and to control the costs; or sometimes because it suited the parties to "justify" the system, and get approval for implementation.

FIGURE 8: METRO CASE STUDIES—CONSTRUCTION EXPERIENCE

% difference from target	Capital costs (no. of cities)	Construction time (no. of cities)
-10 to +10	3	3
0 to +20	1	2
+20 to +50	3	4
+50 to +100	4	3
+100 to +500	2	1

The costs were analyzed in detail, to determine the cost characteristics of metro construction in developing cities. Figure 9 summarizes the results, which are in 1987 US dollars. In practice, they remain a good guide to 1995 costs, as depreciation against the US dollar has typically been offset by inflation.

Figure 9: METRO CAPITAL COSTS

Alignment	Cost per route kilometer /a ($ million, constant prices)
At-grade	8-27
Elevated	22-60
Underground	50-165

Factors influencing costs	Impact on cost
Ground conditions (underground construction)	Very large
System features	Small/moderate (spread of up to 5-10%)
Urban constraints and topography (utilities diversions, proximity to buildings, ability to divert traffic, environmental constraints)	Large
Land costs	Moderate (spread of up to 10%)
Labor costs	Moderate (spread of up to 10%)
Taxes and duties	Small (spread of up to 5%)
Freight costs	Small (spread of up to 5%)
Competition in the equipment/construction market	Moderate (spread of up to 10%)
Finance costs	Very large (spread of up to 35%)
Quality of management	Moderate/large (spread of up to 10-15%)

/a These are total costs including acquisition, civil works, equipment, financing.

The major conclusions that should be drawn are:

(a) Metros are extremely costly - a 15 kilometer line will cost

(i) $1/3 billion if at-grade

(ii) $2/3 billion if elevated

(iii) $2 billion if underground

(b) The biggest factor determining cost is the vertical alignment. At-grade construction is rarely possible in developing cities, but underground construction is three times more costly than elevated construction.

(c) By contrast, technology does not have a major up-front cost.

So, optimization of the vertical alignment is crucial to good metro planning. Yet, this was not always recognized. Often the metro was "assumed" to be underground (sometimes it was called a "subway," which suggests underground construction), in the mistaken belief that this was the norm in other countries. Even in "green" Singapore 65 percent of the Metro is elevated, and only the city center sections are underground; while the London "Underground" or "Tube" is mostly at-grade or elevated.

METRO OPERATIONAL PERFORMANCE

Operations and Operating Cost

Nearly all systems were well operated, and gave good service to passengers. They were popular with passengers, and were often supported, even by those who rarely used them. They were respected too—passengers behaved sometimes particularly well, and graffiti is very much a developed-society problem: only one of the metros suffered from this problem.

Operational problems were rare, and only in Hong Kong severe—due to the extraordinarily high passenger flows: more than 80,000 passengers/hour/direction being regularly carried down the Nathan Road corridor. Operators agreed that over a peak hour they can reliably operate about 30 trains (one every 2 minutes)—perhaps a few more in the best environments; and this determines the system capacity.

But operating costs were nearly always above expectations, often very substantially, by orders of magnitude. There was little understanding by the planners of the crucial importance of operating costs (it is the surplus of fare revenues over operating costs that repays loans and pays dividends to shareholders), or of the very substantial costs of maintaining the cars and permanent way.

Operating efficiencies varied widely between operations. Taking a very crude measure, the staff/million passengers per year varied between 5 and 35. Typically, operating costs were in the range of 10 to 20 cents per passenger carried.

Sometimes the metro management did not have clear objectives, and sometimes the operating costs were considered as preordained, rather than being outputs that are under the control of, and substantially determined by, the actions and inactions of management.

The difficulty of integrating buses with the metro were nearly always underestimated (Figure 10). Metros in developing cities are typically small networks with one or two lines extending from the city center along major radial corridors to the suburbs. Without bus integration, its catchment is limited to people's walking distance from the stations—say 800 meters; and the metro then becomes isolated from most of its potential passengers.

Figure 10: METRO CASE STUDIES—TRANSPORT INTEGRATION MEASURES

City	Integrated Fares		New Feeder Routes		Removal of Competing Bus Routes	
	Planned?	Implemented?	Planned?	Implemented?	Planned?	Implemented?
Cairo	x	x	✓	x	✓	x
Calcutta	x	x	✓	x	✓	x
Hong Kong:						
MRT	x	x	✓	✓	✓	x
LRT	✓	-	✓	✓	✓	✓
Istanbul	x	x	✓	-	✓	-
Manila	x	x	✓	✓	✓	x
Mexico City	✓	✓	✓	✓	✓	✓
Porto Alegre	✓	✓	✓	✓	✓	x
Pusan	x	x	✓	✓	✓	x
Rio de Janeiro	✓	x	✓	(✓)	-	x
Santiago	✓	(✓)	✓	-	✓	x
Sao Paulo	✓	✓	✓	✓	✓	✓()
Seoul	x	x	x	x	✓	x
Singapore	✓	✓	✓	-	✓	(✓)
Tunis	x	x	✓	✓	✓	✓

Integration requires three things:

1. Physical integration—the provision at stations of interchange facilities, and pedestrian/ bicycle access facilities. This is a matter of physical design, and is readily achieved.

2. Bus route integration—ensuring buses serve the metro stations. Usually this is also interpreted as "banning the bus competition" to the metro; but hardly ever was it possible (let alone desirable) to do this because many people still need to use the buses for short trips, or because they cannot afford the higher metro fares.

3. Fares integration—the ideal sought by many was for a single payment (at a premium fare, recognizing the time/comfort advantages of the metro) for the combined bus + metro trip, with the revenue being shared between operators on an agreed basis. But this has been extraordinarily difficult to achieve, mainly because of great reluctance by bus operators to reveal their finances to government. In practice, only in San Paulo was such a system effective, and only at the cost of a large operating subsidy for the metro.

But fares integration can, to a substantial degree, be achieved "naturally," providing both the bus and metro fares are graduated (increasing with distance traveled), minimizing the deterrence of interchange.

The consequences of both underestimating operating costs and (erroneously) assuming that integration would be effective explain much of the mismatch between metro expectations and the reality.

Metro Traffic

Patronage varied widely—between 1 million passengers per year per route-kilometer in Porto Alegre, to 17 million in Sao Paulo (the equivalent figures for London and New York being 1 and 3 million, respectively); and with peak hour flows between a typical 20,000 pphpd to more than 80,000 pphpd down Hong Kong's Nathan Road Corridor.

Without exception, the "successful" metro lines were radial to the city center -and lines that were tangential/orbital carried much lower passenger numbers. This was particularly notable in Mexico City—the first three lines were all radial, and carried very high flows (typically 15 million passengers per year per route-kilometer); while all the subsequent lines have not been radial, and have formed a grid network. They typically carry one-fifth the number of passengers per route-kilometer.

The forecasts of traffic were almost always optimistic, and often very optimistic (Figure 11). In no case was the forecast an underestimate, while in all but one case it was an overestimate. The reason for this stems largely from overoptimism in the planning phase because: integration has not been achieved on the scale expected, passengers have not been forced to use the metro as the planners intended, car occupants have not switched to the metro in the numbers expected, there has not been the growth in population or incomes that was predicted, and sometimes the metro alignment was poor, reducing its catchment area.

FIGURE 11: RIDERSHIP EXPERIENCE: PATRONAGE ON METRO

% difference from forecast	No. of cities
As forecast	1
1 to -20	1
-20 to -50	2
-50 to -60	2
-60 to -70	2
-70 to -90	1

The profile of the metro riders was determined almost entirely by the tariff. Where this was very low—notably in Latin America—then all income groups used the metro. But where it was high, then it was restricted to those whose income was not low.

The metro is used by low and some middle income travelers. Over 90 percent of metro passengers, and often close to 100 percent, were former bus passengers. The metro did not attract a large number of car and taxi passengers (bicycle use was minimal in all the case study cities), not perhaps surprisingly, given the extent to which the car is a status symbol in most developing cities, and the fact that most high-income residents do not live in the high-density developments through which a metro is normally aligned.

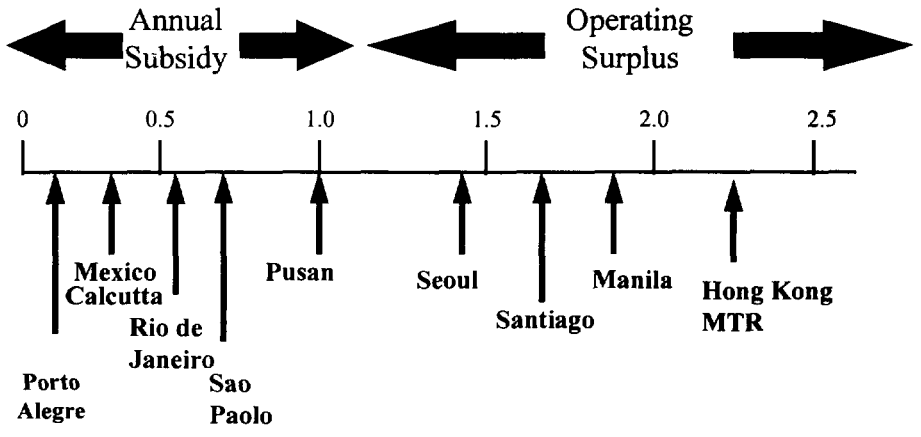
METRO FINANCIAL PERFORMANCE

Financial Viability

Figure 12 summarizes the financial performance of the case study metros. This compares the farebox revenues with the direct cost of operations, maintenance and administration (namely, excluding depreciation/interest charges). Of the 10 metros, 5 required an annual operating subsidy,

and 4 produced a cash surplus on day-to-day operations—with the Pusan Metro being at break-even.

FIGURE 12: METRO CASE STUDIES: FAREBOX RATIO REVENUE/OPERATING COSTS



Fares policy plays a major role in explaining these differences. Thus, in Hong Kong the average MTR fare per passenger was 40 cents, while in Mexico City it was just 5 cents. Thus, the Hong Kong Mass Transit Railway Corporation was set a substantially commercial objective by Government (probably similar to maximizing profit), and allowed substantial autonomy to achieve it; while in Mexico City the social objectives were paramount in ensuring that passengers were not deterred by the metro fare as long a spare capacity existed.

Only the Hong Kong MTR shows the possibility of making a respectable return on the capital invested, although not one that would attract private investors; and this will only be achieved with substantial ancillary revenues; development profits will have contributed 15 percent to the capital cost. Seoul, Santiago and Manila all provide cash surpluses on operations that will substantially fund the large asset replacement costs and may make some small contribution to the construction cost.

Financial performance has rarely matched expectations: construction delays have been the norm, both capital and operating costs have exceeded estimates—often by a large margin—while patronage and revenues have generally fallen short—also often by a large margin. All the outturn results have therefore been adverse.

The unambiguous conclusion that should be drawn from these results is that no metro in the world is financially viable on a stand-alone basis—in the sense of being attractive to the private sector, without Government incentives/investment/development opportunities, etc. and only the Hong Kong MTR is close.

METRO IMPACTS

Improvements in the Quality and Quantity of Public Transport

The speed, reliability and comfort of the metro have undoubtedly transformed the image of public transport and the quality of life and business efficiency for travelers. Journeys can be made much more quickly than on buses—and with great reliability: thus, in Hong Kong four to five face-to-face meetings can be scheduled during the working day, but only two to three in Bangkok or Jakarta. Little surprise that metros are uniformly popular with the populace and business community.

On the busiest lines trains do, of course, get overcrowded during the peaks, so do the buses; and the loadings have to rise above 40 to 50,000 pphpd before conditions become objectionable—figures much beyond the capacity of any bus system.

The quantum increase in public transport capacity is self-evident in every metro corridor. The passenger carrying capacity of the corridor typically increases by a factor of 3 to 4.

Bus passengers usually benefit from a metro too. It is the usual experience that, following the introduction of a metro, bus overcrowding reduces and bus operators may be stimulated (by the "competition") to provide greater variety and quality of service.

Traffic Congestion

Had the metro helped to reduce traffic congestion? The conclusion was that none of the cities offered any evidence of any long-term reduction in traffic congestion. In a few instances, a noticeable improvement in traffic conditions had been reported immediately after the metro opened, but the effect had been short-lived.

The reason is that, although there is a large switch of passengers from bus to metro, the number of buses does not decrease in proportion (bus overcrowding reduces), while very few car trips are diverted to the metro. Most of the road space that is released is taken up by generated traffic, particularly car traffic in the short term.

Thereafter, the metro allows public transport demand in the corridor to continue to grow (where previously it could not), and after a period of time, the number of bus passengers may be back to the premetro figure—in addition to the large number of new metro passengers.

It is not, however, correct to say that a metro has **no** impact upon traffic congestion. It does—because at the margin the exasperated bus passenger (or motorist) has an option, which he will use. So congestion never reaches the gridlock situation that can occur in cities without a metro network.

Land Use and City Structure

A city with a metro will follow a very different development path from a city with no metro, but this may not immediately be apparent from observation. The impact of the metro on city structure is likely to be profound. Why this apparent paradox?

The cities in which metros were studied included many of the great world cities, whose centers are the focus of economic activity at national and regional levels. Efficient public transport is **essential** (not just desirable) to the continuing growth of their central areas. All the evidence is that bus systems, however organized, have a practical capacity (of about 20,000 pphpd), which when reached on the main radial corridors frustrates the continuing growth of the central area. At this time, there are two possible scenarios: either this natural growth of the center is forced to other less attractive locations, or a metro is built that overcomes the public transport bottleneck. The role of the metro is to be permissive—it allows this dynamic growth to continue—allowing the city to continue to function with a strong city center; but it does not create the underlying growth.

In a few cities—Hong Kong, Singapore and Sao Paulo—the city administrations practice land use/transport planning, and adopt a policy of enlarging the metro's catchment area by concentrating high-density public housing and commercial development close to metro stations. Here, the impact of the development is immediately obvious. This has been achieved by a combination of public-sector land ownership, housing and infrastructure provision, major development over stations and depots, and in the case of Hong Kong, particularly vigorous private sector development.

In the absence of such positive measures, which require considerable management skills, there was, contrary to expectations, little obvious sign that the metro had resulted in land use/development changes. This is less surprising than it may appear: the metro is always located in the densest part of big cities, where land ownership is both fragmented, and sometimes uncertain. Land assembly in such situations is difficult, and requires a government, but government has its hands full keeping the implementation on track

So the development impact of the metro is complex. The obvious expected high-rise developments along the alignment do not just "happen." They require strong government action—either because government is itself the developer (in the case of public housing), or by advance land assembly. But the metro can have a profound impact upon city structure, in allowing the continuing development of a strong city center. Whether this is desirable, compared, for example, with a polynuclear form, is a matter of vigorous debate.

The long-term impact of a metro network is to create a more concentrated form of city structure, which contracts strongly with the geographical sprawl that characterizes many developing cities.

Environment

During construction, the impact of the construction process could be severe -in terms of road closures/traffic diversions, dust, noise and vibration. Many of these adverse impacts could be mitigated by good planning, but it remained the fact that often they were not.

Once constructed, elevated structures had a major impact upon the urban environment for all time—for better or worse. This was partly a matter for design and partly a matter of subjective judgment. Where the corridor was wide, and fronted by high-rise development, it was arguable that a metro enhanced the urban environment (as well giving passengers a welcome view), but in other locations the impact was obviously adverse.

There is some evidence that an elevated metro is more acceptable than an equivalent elevated road. Thus, at the time the Manila LRT was under construction—a 15 kilometer heavy concrete viaduct through the very center of the city—the decision was taken to underground all proposed flyovers in the city. The LRT was "green," the roads were not.

When operational, because the impact of the metro on congestion was very small, then so were the apparent savings in energy and air pollution. However, in the long term the impact of the metro is likely to increase urban densities, reduce urban sprawl, and reduce reliance on the car. The environmental benefits arising from these changes in the long term could be substantial.

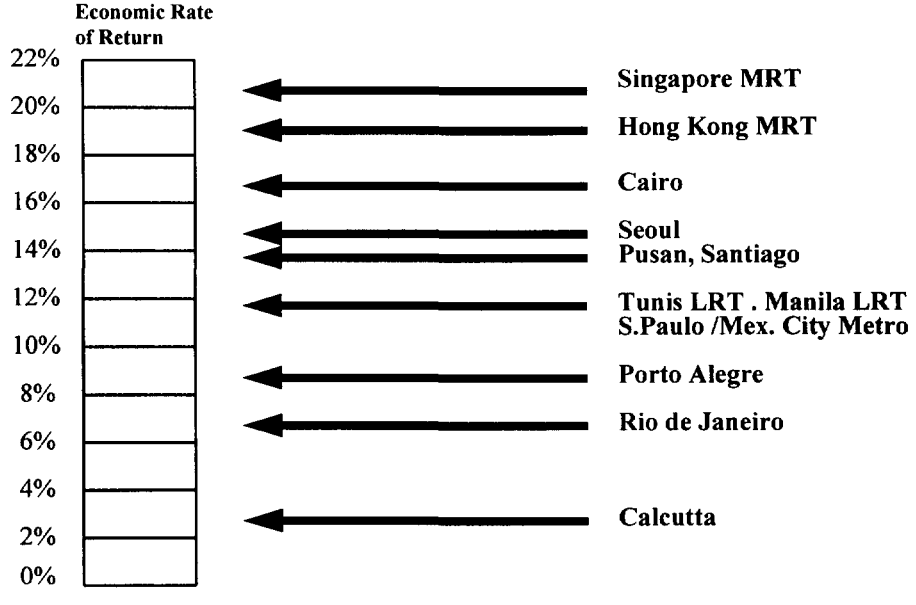
METRO VIABILITY

Economic Viability

The study developed a strategic prefeasibility model that could give a quick assessment of the main economic characteristics of a metro project. The model MRTAP is described elsewhere (Reference 4), and was validated against the database assembled from the case study cities. It simulates real-life behavior in the centers of the most congested cities in the developing world, when people are faced with a metro. The model assessed the impact—past and future—of the metros in the case study cities, relative to the "Do Minimum" situation, and determines the expected economic internal rate of return (EIRR), and the probability curve associated with this.

Figure 13 summarizes the results. Three metros showed low rates of return (less than 10 percent), three were marginal (between 10 and 12 percent), and seven were quite good, and in the case of Singapore, Hong Kong MTR and Cairo (a "missing link" between two busy suburban lines), good rates of return.

FIGURE 13: METRO CASE STUDIES: ECONOMIC PERFORMANCE



The results suggest that, despite the high costs and despite all the problems and poor forecasts that had characterized most of the metro projects, the economic returns of metro projects can be quite high when the conditions are right, and indeed comparable to other sectors of public investment.

But metros can be risky investments too. The experience in most cities has demonstrated that much needs to go right to achieve a good economic performance, and one or two bad decisions can be irreversible, and undermine the project viability for all time. This highlights the importance of proceeding purposefully and with caution, and constantly learning from the experience of others.

The benefits (Figure 14) typically consist of nonworking time savings, relief of discomfort, benefits from generated traffic; and the remaining comprise resource costs (of which about half is offset by the operating cost of the metro itself).

The benefits are enjoyed largely by former bus passengers who now use the metro, but the remaining bus passengers gain greatly from the relief to the bus services. The benefit to other road vehicles are only small, because congestion is little affected. Government is a net loser—from the investment in the metro, and because of lower tax revenues from road vehicles.

A major conclusion from the economic analysis is that typically half of the metro benefits are received by other road users, who do not pay toward the cost of the metro. It is these major external benefits generated by a metro that provides the rationale for government investment to secure them. Put another way—it is not surprising that metros are not financially viable, when they receive no income for a substantial part of the benefits they create.

FIGURE 14: METRO ECONOMIC BENEFITS AND BENEFICIARIES

	Percent
Metro Benefits	
Passenger time savings	70
Comfort/convenience	8
Generated passengers	8
Operators - Car	7
- Public transport	2
Other	5
Total	**100**
Metro Beneficiaries	
Car, occupants	18
In car	16
In metro	2
Bus passengers	67
In bus	29
In metro	38
Generated passengers	8
Transport operators	9
Metro	3
Bus	6
Others	-2
Total	**100**

Finally, there is almost no identifiable foreign exchange benefit to offset the high foreign exchange borrowing commonly incurred in metro construction.

Noneconomic Viability

There are three other impacts that should be considered, two being distributional (the social and developmental impacts), and then the environmental impact (incorporating all externalities).

Social Impact of Metros. Whether or not low-income people use the metro depends upon the tariff: if it is low, they will; otherwise they may not. But all bus passengers (and, to some

extent, other road users too) benefit from the metro: bus passengers through less overcrowding, and often by better service stimulated by the "competition" of the metro.

Construction is usually through the inner city, where low-income people often live. They may be adversely affected by the construction: how adversely depends upon the relocation process and the compensation payments made. Others may be displaced as land values increase, from which they may not benefit.

Development Impact of Metros. Each city should have a development (or structure) plan, setting out its major development objectives. To the extent that development is encouraged to conform to this, then there are additional development benefits. A metro network may be critical to this, where a concentrated form of city structure is favored—for example, in Hong Kong and Singapore—but there can be no general conclusions.

Environmental Impact of Metros. Again, general conclusions are not possible. The net impact of a metro depends upon:

- the construction process: how well managed this is
- the vertical alignment: elevated or not
- the traffic it carries (not being carried by road vehicles)
- and the complementary transport and land use policies.

These determine its impact on congestion, and on city density structure. It is to these issues that we now turn.

Macroviability

International experience has been that transport is not like other sectors: because it impacts pervasively on big-city life. It profoundly influences economic performance (uncongested cities are productive cities), and the quality of life (creating "civilized" cities, in which citizens can access the range of facilities provided).

Transport action does this by:

- controlling traffic congestion,
- controlling traffic emissions, and reducing accidents,
- influencing the use of land, and
- upgrading the lives of the urban poor.

Figure 15 shows how an integrated transport strategy can create a **Virtuous Circle of Improvement.**[4] There are two fundamental components:

1. **A metro network** is the "key" that "unlocks" the route to major improvement. This is because it provides the high-quality alternative to the private car/motorcycle, which

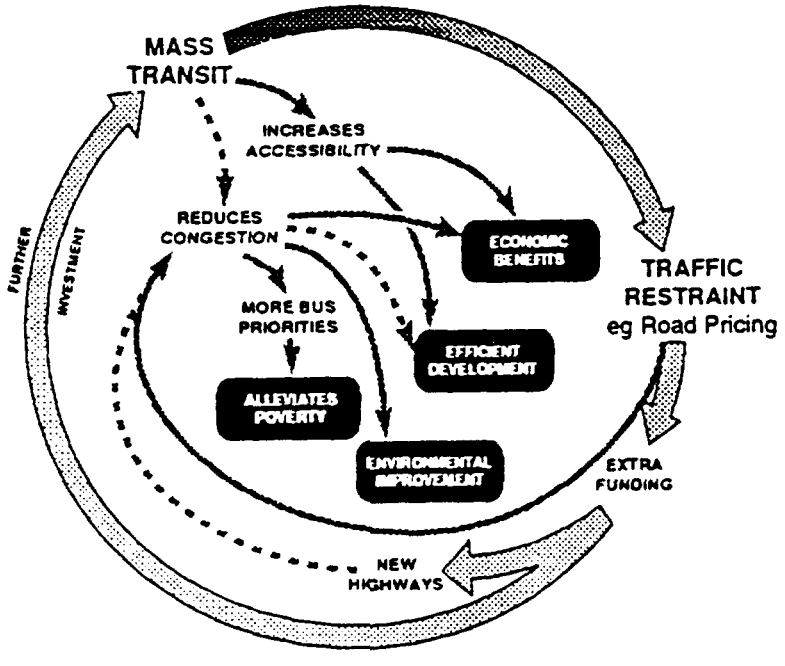
[4] This was first developed during the "Seventh Plan Urban and Regional Transport Study," for the Royal Thai Government (Halcrow Fox and Associates, UNDP/The World Bank, 1991).

offers the only route away from the private transport-oriented, low-density sprawling city.

2. **Traffic Restraint (for example, Area Road Pricing)** is then, and only then, feasible—and it is the only way in big cities to control traffic congestion. Wider benefits then follow:

   - bus fares can be low, assisting the urban poor in particular;
   - environmental opportunities on a wide scale can be achieved; and
   - accessibility and therefore the quality of life can be improved for the majority of the City's people.

FIGURE 15: INTEGRATED TRANSPORT STRATEGY CONCEPT—
THE VIRTUOUS CIRCLE OF IMPROVEMENT



This strategy builds upon the common experience: that traffic congestion and its many adverse consequences will not be materially relieved without demand management, and demand management will not be feasible without first the "carrot" of a metro system. A metro system is apparently the "key" in big cities to unlocking its seemingly intractable problems and providing some measure of control over their destiny.

The implications for metro viability are most important. The macroviability of metros is, under this "Virtuous Circle," much greater than the microviability case determined above. The reason is that the metro is not (should not be) evaluated alone, but as part of a package including road pricing. Their benefits are indivisible.

In the recent past, two most important developments have coincided:

1. There is now in the transport/urban planning profession, and increasingly among city administrators, a broad measure of agreement that such a strategy is, where it can be afforded and implemented, the way forward.

2. Technology in 1995 is allowing road pricing/demand management strategies to be planned in the knowledge that they can be implemented—for the first time.

We thus know what to do, in the knowledge that we can implement it—for the first time. However, whether/when this strategy can in fact be implemented will depend upon two questions:

1. **(When) can a Metro System be afforded?**

2. **(When) can an Integrated Transport Strategy be Implemented?**

METRO FUNDING AND IMPLEMENTATION

Metro Funding

Nothing will be implemented, however important the benefits, unless it can be funded. This may seem obvious. So, what are the prospects, and options for metro funding, based upon international experience?

The prospects for metros being financially viable, that is, **not** requiring any public sector investment, are, it seems, not promising. Consider the evidence:

- The above TRL/HF Study showed that no metro today is financially viable—even the outstandingly successful Hong Kong MTR. Of course, it could be argued that these were all public sector projects, and that private sector implementation/operations will be better. But few who know the Hong Kong MTRC could be other than impressed by its consistent and strongly commercial, market-oriented approach. It is not obvious that the private sector would markedly better this.

- Today, there is only one free-standing private-sector metro known to be in operation—the Manchester Metrolink. That too is regarded as a private-sector success story, but almost all the capital cost (90+ percent) was funded by government.

Development gain from associated property development is the hope of many in avoiding this need for government investment. The international evidence (Figure 16) shows the scale of development gain that has been generated by private-sector projects worldwide. For large projects, rarely more than 15 percent of the capital cost is funded from this source—even with massive development activity—as with the Hong Kong MTR. To date, there is no example of development gain transforming the financial viability of such projects.

Moreover, linking development gain to project funding has a distinct "downside": in creating implementation problems. The property market in most cities exhibits a "boom-bust"

cycle, and the realization of development gain depends critically upon project implementation at the right time. Large delays in project implementation are the frequent result when the time is not "right."

While there are those who envisage private-sector skills substantially changing this picture, there is little evidence or (in our view, based on technical review) reasonable likelihood that private-sector ownership/operations will transform the best performance achieved by the private sector. In other words, we conclude that metro investment will normally require large injections of public investment.

FIGURE 16: CONTRIBUTION OF DEVELOPMENT GAIN TO MASS TRANSIT FUNDING

	Development Gain Contribution (% capital cost)
London Docklands	
Docklands Light Railway (DLR) City Extension	40
DLR Beckton Extension	100
Jubilee Line Extension	15
DLR Lewisham Extension	5/a
East London Line Extension	40/a
Light Rail Projects Outside London	
Manchester Metrolink	
Bury/Altrincham	0
Trafford Park/Salford Quays	10
Sheffield Supertram	5-10
Hong Kong Mass Transit Railway`	15
Bangkok Hopewell Project	Substantial /a
Taipei MRT	Substantial /a

/a Forecast.

The rationale for government investment in good projects is strong: metros normally create substantial or even very large benefits, typically half for people who do not use the system, and which can therefore not be captured in the farebox. It is entirely reasonable that government should invest to capture these external benefits.

Timing is, of course, everything. The key questions is: "at what stage in the development of a city/country can this investment be justified"?

Metro Implementation

More than most areas of public interest, the gap between rhetoric and action is at its most wide when considering metros, and particularly private-sector schemes. Figure 17 summarizes Asia's experience to date, and our expectations through to the year 2000. The major systems (in

terms of route-kilometers, and excluding tramways) are likely to be as follows—roughly in decreasing system size:

1984	**1995**	**2000**
Seoul	Seoul	Seoul
HK—MTR	Singapore	Singapore
Beijing	HK—MTR	HK—MTR
Pyongyang	Beijing	Beijing
Manila LRT	Pusan	Taipei
	HK—LRT	Guangzhou
	Pyongyang	Shanghai
	Manila LRT	Manila
	Shanghai	Pusan
		HK—LRT
		KL—STAR
		KL—PUTRA
		Taegu
		Pyongyang

Two features are clear from this Figure:

1. There is an obvious link between economic performance and investment (which links back to the conditions of microviability) and

2. "Wealthy" countries have not pursued private-sector implementation and implementation to date. There are now signs of increasing interest in private-sector implementation worldwide, with the new problem of making this work effectively..

In practice, other systems being planned, and awaiting implementation may get the go-ahead and be open by 2000; but past experience is not encouraging. Others are expected to be under construction, and may open in the early years of the next decade.

Just two of these projects (both in Kuala Lumpur, programmed to be open by the 1998 Commonwealth Games)[5] are likely to be private-sector implemented/operated. This is in spite of enormous attempts to implement such projects in many countries in the Region. Moreover, the situation is similar in other parts of the world. Why is this?

Fundamentally, it has proved very difficult to implement BOT projects—just about everywhere. When this is combined with the recognition that implementing a metro through the center of a dynamic developing city is profoundly difficult, then there is little surprise that results to date have been disappointing.

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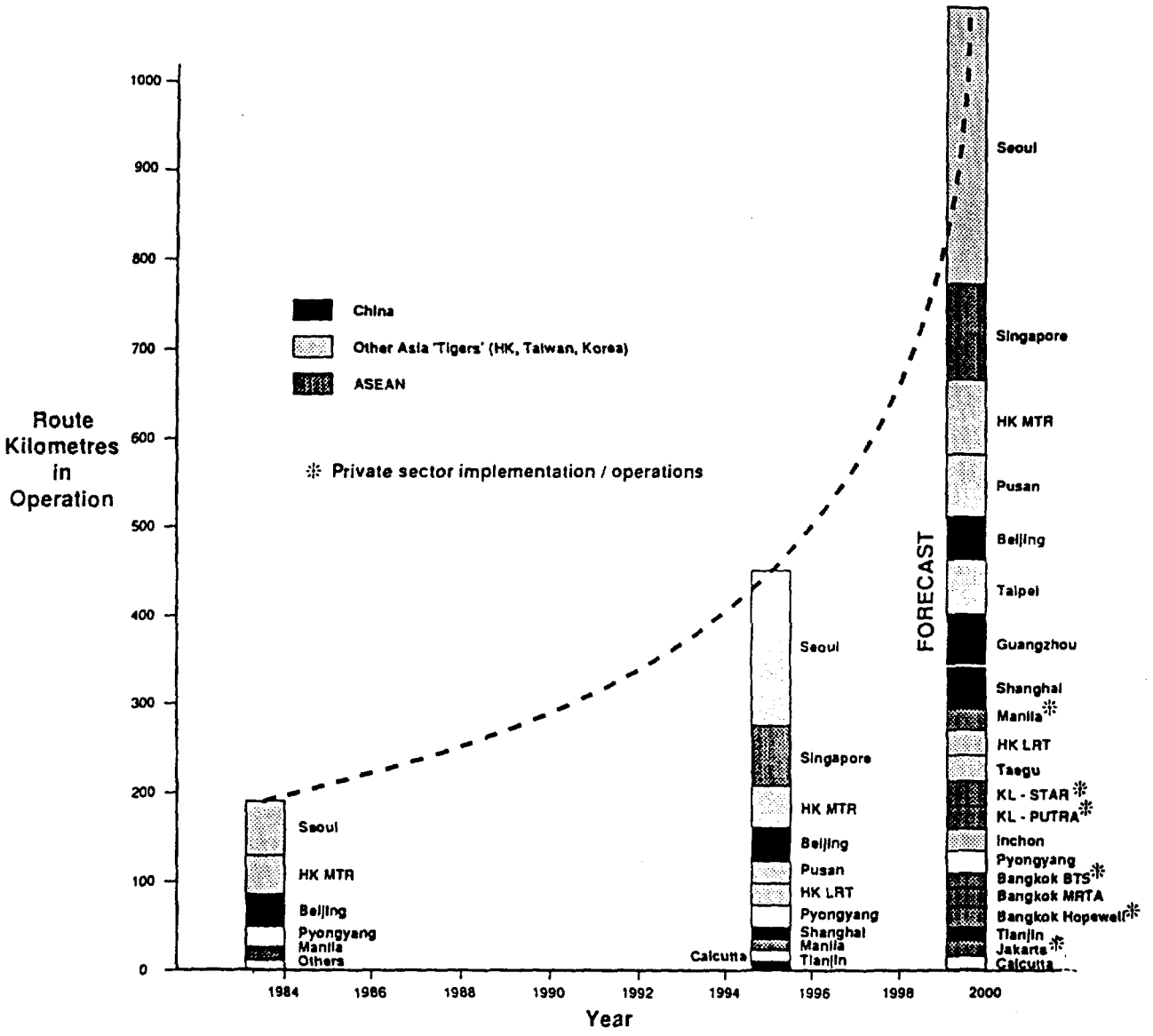
[5] This is not a coincidence; many of the world's metros (such as Seoul, Mexico City) have been "triggered" by international sports events.

FIGURE 17: METRO IMPLEMENTATION EXPERIENCE IN ASIA



There are seven key problems that have frustrated implementation and that must apparently be tackled:

1. **Institutions**—intersectoral coordination and cooperation between different tiers of government is often difficult, but is absolutely essential. Often private-sector implementation by one entity of government is seen as avoiding this; but in practice this approach does not solve the problem, and can exacerbate the institutional coordination problem.

2. **Political Will**—this is a different issue. Because there is rarely a "vision" of how life could change for the better with an integrated transport strategy, resulting in a quantum improvement in lifestyle and income for all the people in a developing city, then public support is not forthcoming. In the absence of this, political will is, not surprisingly, often weak.

3. **Adequate and Sound Planning**—is essential. Yet, we have seen in the TRL/HF Study that this is very often absent. Moreover, things have not changed materially in recent years. The result is poor, and invariably optimistic estimates of the financial viability of metro projects.

4. **Government Funding Requirements**—Government funding is (see 3 above) routinely underestimated. There is a common "hope" that none will be needed. The result is that "the hard decisions"[6] that should precede any decision to proceed with such a project are often not faced prior to deciding to give the go-ahead.

5. **The Private Sector is the Answer**. Yet, there has been little success in private sector implementation to date in this sector. Project implementation is the exception, and there have been very few profits generated for the private sector, in spite of all the rhetoric. So, the private sector is apparently no panacea to making things happen. Undoubtedly change for the better will take place, but where and after how long?

6. **Environment v Economics and Finance**—most metros (and urban expressways too) are assumed to be elevated for good reason: at-grade construction is rarely feasible, and elevated projects are much cheaper (typically one-third the cost) of underground construction—Figure 2. Yet, the proposed scale of elevated construction is becoming questioned in many cities. City administrators and citizens, are questioning the "green credentials" of such projects, which threaten an elevated infrastructure complex, arguably degrading the environment for all time. Striking the right balance is difficult, and requires strong political leadership.

7. **Land Acquisition**—always necessary and difficult, requires a strong government sense of purpose.

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[6] Namely where the funds are to come from (what will not be implemented, or what extra taxes will need to be imposed) because a metro system is being implemented.

Juri Pill, General Manager Planning of the Toronto Transit Commission, summarized the implementation problem succinctly:

> "If transit is to really work in any city, there must be a long-term and consistent sense of purpose that permeates the entire community for a very long period of time."

COMPARISON OF METRO EXPECTATIONS AND RESULTS

Conclusions from Case Study Experience

The conclusion is clear: the actual impact of metros is curiously at odds with the expectations, reported earlier (Figure 18):

- Metros certainly increase the quantity and quality of public transport, including substantial benefits for bus passengers
- But they certainly do not solve the core problem of traffic congestion (as shown by Seoul, Sao Paulo, or Mexico City—all heavily congested cities with metro networks)
- And no metro in the world is financially viable.
- The impact on land use and city structure can be important, but is different to that expected. The obvious real-estate development along the metro corridor is apparent mainly when government itself is the developer. But the major strategic impact is in allowing a dynamic city center to continue growing.
- Because forecasts of metro ridership have been shown to be almost always optimistic, and often very high; and because knowledge of the potential of lower-cost options has been shown to be poor, there are strong reservations about the reason that "there is no alternative," and a metro is necessary on capacity grounds. Often in retrospect, this has not been so.

Figure 18: COMPARISON OF METRO EXPECTATIONS AND RESULTS

Reason for Building a Metro		Results
1.	Will improve public transport	✓
2.	Will relieve traffic congestion	x
3.	Will be financially viable	x
4.	Will promote land use policy	?
5.	Necessary to carry forecast passengers	?

LOWER-COST OPTIONS

Incremental Strategy

Few developing cities, or even countries, can rationally support a metro today. Some can, along the biggest corridors in the major cities, but most cannot—at least not yet. However, as incomes (in particular) rise, metros will progressively become a rational investment. This central message for most cities is difficult to sell unless some intermediate stage in improvement is feasible, one that may in time lead to a metro. Without this, many will continue to plan for and some will build metros when they have little relevance to the city's immediate needs, just because it is believed that "there is no alternative."

It would indeed be surprising if there were not such intermediate stages of improvement. It is a paradox that the bus passengers of developing cities who routinely experience slow journeys in overcrowded buses in congested, polluted streets sometimes leap to (or ahead of) many first-world standards in terms of speed, reliability and cleanliness when metros are opened. Between these extremes, what are the options for carrying high passenger flows, and (how) is it possible to develop mass transit incrementally as affordability and aspirations increase?

Two factors above all others produce improvements in performance: the progressive grade—separation of the track and the change in technology from bus to rail. The benefits from grade separation are unambiguous, markedly increasing accessibility, and thereby land prices and development pressures. At high-demand levels, greater than about 20,000 pphpd, only rail systems are feasible; while at lower flows both rail and busways are feasible options.

The central principle underlying the concept of an incremental strategy is that land is secured for a mass transit track, initially for the use of buses at ground-level (busways) and progressively over time converted to partial or full grade—separation and, perhaps, rail technology. This land is usually the median of the big city corridors where demand is commonly at its highest.

The key advantages of the incremental approach are:

1. that decisionmakers plan for a realistic strategy of improvement over time (and do not precipitately embark on metro construction);

2. that conditions improve markedly for the vast majority of travelers from the earliest time; and

3. that subsequent upgrading is then feasible, because the mass transit right-of-way has been secured.

Such a strategy recognizes that even in the largest and wealthiest cities there will be many corridors where metros are not appropriate—different standards of provision will be appropriate in different locations.

Figure 19 illustrates the main mass transit options. Only two of the four options exist today—metros, together with some at-grade busways, notably in Brazil. Nowhere in the

developing world is light rail transit known to provide the main line-haul mode along major city corridors, and nowhere, yet, has a partially segregated busway been constructed.

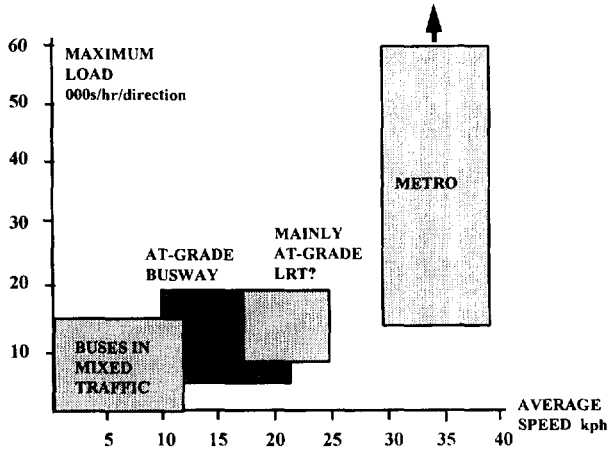
FIGURE 19: THE MASS TRANSIT OPTIONS

Option	Grade-Separated?	Proven?	Upgrading Proven?
Busway	At-grade	Yes	
			No
Busway	Partial	No (Karachi planned)	
			No (Karachi planned)
LRT	Partial	No	
			No
Metro	Full	Yes	

Moreover, nowhere in the developing world has this concept of an incremental strategy been implemented. Only in Karachi has the principle of a "transitway" allowing conversion from busway to LRT been developed in any detail, and this has not been implemented.

Figure 20 summarizes what is known about the operational performance of the main options.

FIGURE 20: PERFORMANCE OF MASS TRANSIT MODES IN DEVELOPING CITIES



A major study (Reference 5) has established the operational performance of at-grade busways in developing cities. A theoretical performance of 20 to 25,000 pphpd at operating speeds in the range of 16 to 22 kph is considered achievable, given appropriate design and effective operational control. Surveyed performance, mainly in Brazil, showed that 15 to 20,000 pphpd was currently achieved on the better busways at these operating speeds.

The problems preventing the widespread, routine development of **busways** are primarily institutional rather than technical—they have no natural promoters, perhaps because of their lack of image and lack of knowledge of what is achievable, even though their effectiveness and economic worth are demonstrable. Where they have been implemented widely, in Brazil, they are sometimes seen as a step toward LRT.

The performance of a **mainly at-grade LRT system**, designed to perform the line-haul role along the major corridors of a developing city, is not known: no such system is known to exist. However, a study of the operational performance of existing tramways/LRT in developing cities (Reference 6) sets out the probable bounds of achievement. This concludes that there are difficulties:

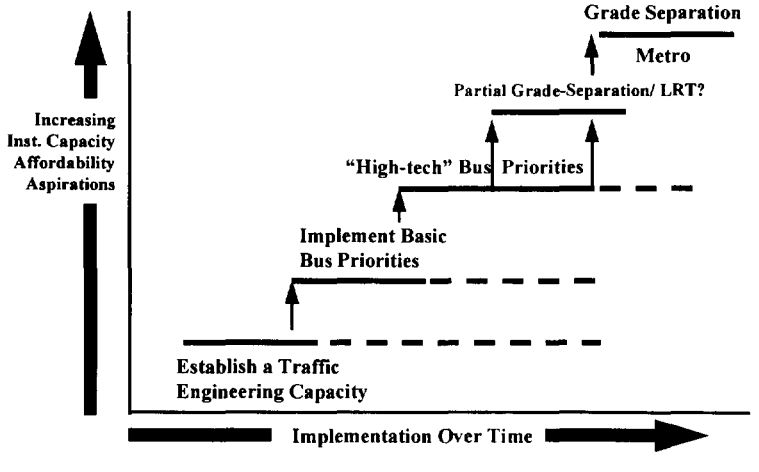
> "In order to carry the high passenger demands, vehicles must be large. This size makes them vulnerable to interference from other road users. Many developing cities are very crowded and have high levels of on-street activity: this causes delay to street-running transport of all types. Delays to an LRT vehicle carrying nearly 1,000 people can seriously reduce capacity, especially when cumulative. LRT operates best with regular headways, but this requires a high degree of control and organization, which is uncommon in developing cities."

It is concluded that such a mainly at-grade LRT system would not achieve the outputs of an equivalent busway, perhaps achieving 15,000 pphpd at operating speeds in the range of 15 to 20 kph.

The performance of **metros** is extensively documented —they have carrying capacities of up to 80,000+ pphpd at operating speeds of 28 to 37 kph.

There are no known technical problems that question the concept of an incremental strategy, described above and illustrated in Figure 21. The absence of technical innovation to date should not question such a strategy, but focus attention on where major progress needs to be made.

FIGURE 21: AN INCREMENTAL STRATEGY FOR MASS TRANSIT



PART 4: LESSONS FOR CHINA: METROS

The Context for Action

China is different, very different from many other developing countries contemplating investment in mass rapid transit systems:

- There are very few facts about the impact of metros in China. Crucially, there is little information about diversion from the main transport mode—bicycles; and information on capital costs is not complete. The importance of the floating population to bus and metro ridership are apparent, but little is apparently known about them.

- Socioeconomic change is rapid, leading to profound changes to the structure of demand, and in particular trip lengths, which are difficult to forecast with confidence.

- The economy growth of recent years has produced a strong increase in motor vehicle use in urban areas. This is creating rapidly worsening traffic congestion, which represents a major challenge for municipalities and threatens the viability of the existing mass transit system: the bicycles and the buses.

- Forecasting ahead many years is more than ordinarily difficult. The ability to do so in this sector, with the existing poor basis of factual evidence is strictly limited. The need is to collect the behavioral evidence that exists, and to improve this capability.

It is very clear that forecasts of metro ridership and economic/financial viability in China must be very uncertain. Given the strong conclusions from worldwide experience that metros are often the largest investment a city will ever make, and that metros are even under normal circumstances risky investments—where much needs to go right, and one or two bad decisions can seriously undermine viability—the need for caution in investment and active applied research is paramount.

China has a "Window of Opportunity" in which to develop its mass rapid transit policy. This is created by a funding bottleneck for metro projects. It seems likely that until the public finances can invest substantially in these projects, the scale of development will be constrained to those larger, wealthier cities where large real estate profits can contribute to funding. The awakening of realists about funding has been the experience of most countries—in the United Kingdom 40 to 50 cities planned to build transit projects five years ago, now there are just 10 considered as fundable in the near future.

The "Opportunity" is to improve the planning system, based upon factual evidence of the impact of those projects that are implemented, in the context of housing and industrial policy, and the particular circumstances of China. The output should be: more realistic transport plans, better mass transit projects, and better economic, social and environmental conditions in China's cities.

China is also different through the government's ownership of land, providing the ability to control development, and ensuring that land can be secured to implement transport projects. Government is in a position to be proactive in practicing land use/transport planning on a scale not

normally possible. This is a crucial advantage that most other developing cities do not have. Fully exploited, it can give China's cities a strong competitive advantage in the Asia Region.

Metros: The Answer?

In some special cases, the answer is "yes" and as the Chinese economy delivers increasing prosperity, the answer will increasingly be "yes." But for the foreseeable future, for most cities and for all but the biggest corridors, metros are not the answer—they are not economically viable, nor are they affordable. This is the firm conclusion from all the experience worldwide. It remains the case that no country in the world can afford to implement metros other than the occasional, small network.

It is concluded that many Chinese cities face a dangerous vacuum, created by planning for something that will not (for many years) be built, while ignoring here-and-now mass transit problems.

This is particularly serious, because many of the changes that inaction bring are irreversible. Implementing the right policy too late will not secure the benefits.

What are these lessons of international experience? The following six lessons summarize the main conclusions for China:

1. **Metros are Popular.** Metros are desired in virtually every major city in the world. This is true in the developing world, and it is true in developed cities too. In this sense, China is no different from other countries in seeking massive metro building.

2. **Metros are Costly.** Typically, a new metro line in China will be 15 kilometers long, and will cost between $0.75 and $1.5 billion, depending on whether it is elevated or underground. Worldwide experience is that a metro will often be the largest investment a city will ever make. Faced with this level of cost, few cities in the world can afford to construct large metro networks—and those that can have the following characteristics:

    - they are economically successful

    - in Western cities they were developed over many decades, when special conditions often prevailed: there was often little competition from road transport; they thus had a major impact on land use in the areas they provided access to, in turn generating passenger revenues, and metro construction was low-cost, being labor-intensive, often with subsistence wages paid.

3. **Expectations and Reality Often Differ.** Why are metros so popular, and are expectations matched by reality? Figure 18 summarizes the results for developing cities. They are true for developed cities too. It would be most surprising if they were not true for Chinese cities. So, even if metros could be afforded (which is the exception), they do not achieve their proponents' expectations. In particular:

    - They do **not** alone solve traffic congestion.

- They are **not** financially viable.
- They do **not** result in major development along their route, without very strong government action.

4. **Private Funding is not the Answer.** Many countries have planned metro systems on the basis that, while government cannot afford them, the private sector can. The result has, in most cases, been the same: much rhetoric, but no action. Meanwhile the city congestion problems have increased, and little has been done.

   There is only one stand-alone BOT metro project operational in the world: Manchester Metrolink in the United Kingdom. This is a success story for the private concession approach, but 90+ percent of the construction cost was funded by Government. In Kuala Lumpur two LRT projects are under construction. Both have government inducements to "create" financial viability; and their operational performance is not known. Otherwise, there are many projects, but little or no construction and no benefits for city dwellers.

   The review of China's experience concluded that private-sector finance was unlikely to allow a large program of metro development to be funded. BOT approaches had many problems, and land development associated with station/depot sites, while potentially important in a few, mainly coastal, big cities depended crucially upon the state of the property market. At the best, construction timing would be dictated by the stage in the boom-and-bust property market, and at the worst a "bust" in that market would cause great problems.

   It is our overall view that private funding is **not** the answer to the metro funding problem. There is in fact no answer, until the municipality (and/or State) finances can afford to substantially fund the construction cost (and any operating subsidy, where this is required).

5. **"There is an Alternative to a Metro."** Often it is argued that "there is no alternative" to a metro, because only a metro can carry the forecast ridership. The answer to this proposition is in two parts. **First**, demand forecasts have been shown to be wrong in nearly all cases, and very high/optimistic. **Second**, there is always an alternative: only the wealthiest cities have the option of building a metro; all others must plan realistically, in the knowledge that they can only afford a metro when their economies have generated the wealth to fund them.

   Thus, it not unusual for cities to plan metros for 25 or even (as in Santiago, Chile) 50 years before they can be afforded. Meanwhile, it is essential that the best alternative strategy is developed and implemented—one that does not assume a metro will be built to solve the problems. Bus transit is central to that alternative strategy, creating "spines" that may in future be upgraded to a metro—the subject of PART 5.

6. **Particular Caution is Necessary in China.** There is an extra reason to be cautious about metro development in China:

- Very little is known about metro benefits, because no before-and-after studies have yet been undertaken. For other developing cities, it is known that 90+ percent of passengers will be former bus passengers, and the benefits can be estimated for them, and for other road users with some confidence—because there is a substantial body of research available. But in China this does not exist.

- Information on construction costs is incomplete. It is not known with confidence what the outturn cost of Shanghai Line 1 will be, and past information for Beijing/Tianjin is out of date. We estimate that an underground line will cost $100 million/km, and an elevated line $50 million/km; but these may be underestimates.

Rather, we know that most people travel by personal transport—the bicycle—making relatively short trips; and we know that in many cities the bus is the mode of last resort. It is currently a matter of conjecture, rather than science, to forecast how many people will choose to travel by metro, and what the resultant benefits will be. In view of their extraordinarily high cost, extra caution is essential before embarking upon massive metro construction.

Metro Planning and Implementation

The system of planning in China parallels that in many other countries; but its application is at present different, and its output provides goals of policy, rather than plans to guide action over the next 1, 2,...5 years. It is likely to be very beneficial to develop this approach in several respects. Because the metro is a strategic part of the Urban Transport Plan, the starting point is to define the basis for that.

Urban Transport Plan Guidelines

1. The planning process should be holistic, not narrow, recognizing the broad impacts of transport policy. The transport plan should be compatible with the overall city Development/Structure plan.

2. Produce both a transport strategy for 15 years ahead, and a five-year Plan of Action, which is implementable/fundable.

3. Formulate Plans on the basis of realistic estimates of available public funds.

4. Produce the Plan by developing a wide range of possible strategies, and evaluating them to determine the preferred strategy.

5. Include both metro and lower-cost options in the alternatives; and for metro options, consider both elevated and underground options (this being by far the major determinant of cost), and evaluate them.

6. Develop restraint policy options, and determine their desirability and implementability with and without a metro.

Metro Planning. The metro planning process is essential for generating consensus behind the project. Without this, funding will not be secured, and implementation will not happen. This requires all the key agencies to be involved in the planning process. The key questions that need to be addressed during this stage are:

1. What is the role of the metro? Is it to be a "premium product," offering high service level at premium fares (in which case no operating subsidy should be required) or should it be accessible to most of the population, and charge low fares or should it provide for two classes in one train?

2. What route, and what station locations and depot site? The route will probably be radial to the city center, and stations should be the heart of the major generators and attractors. What land would be required and is this obtainable?

3. What ridership at what fares will be carried? Realistic assumptions should be made about bus/bicycle integration. Fares need to be socially acceptable.

4. What options are there for elevated and underground construction? What is environmentally acceptable? And what are the costs of the options?

5. What is the economic viability? And how robust is this?

6. What is the funding gap? What are the prospects and desirability for private sector funding? What is the scale of funding which government would need to meet? Is this affordable?

The project development process should be a process of **optimization.** Hard decisions will be needed. The output should be consensus behind a clearly identified project whose important consequences are known, as a basis for decision.

Metro Construction. Metro construction will affect the lives of virtually all the key people in the city during the four- to five-year construction period. Everyone involved in metro development has concluded that metros, whether elevated or underground, are not by any means "the easy option." All aspects of implementation need to be brought together to minimize the problems.

Attention should focus on the following:

(a) The implementation process should be holistic, not narrow/technically oriented. This recognizes the many components of implementation: relocation planning/compensation for displaced residents and businesses, establishing the organization to oversee the project implementation, institutional change, financial planning, coordination with utility companies, traffic diversions, public information strategy, etc.

(b) The accountability for project physical and financial achievement, considered essential to effective project completion in many countries, appears not to apply in

China. Yet, without this, project viability may be undermined due to cost overruns, time delays, and technical problems.

(c) Plans should be prepared for the operational phase: the operations, maintenance and administration of the metro should be planned for, based upon achievable efficiencies.

(d) Financial plans should be prepared to fund the estimated operational subsidy requirement (if any).

Metro Operations. The metro is a tool of policy, which can only achieve its objectives when it attracts a mass ridership. Yet experience is that this is by no means easy to achieve, because it requires effective integration with buses and bicycles. The reason is obvious: the metro network will always be small in relation to the urban area, and the walk-in catchment area will also be small. It is therefore essential to extend the effective catchment area of the metro by integrating it with the buses and bicycles.

Figure 10 summarizes the very mixed success in achieving this goal in the developing world, and we noted earlier that very little integration had been planned for metros in China. A holistic, rather than narrow approach, is required to secure the potential benefits from metro integration. It is not coincidental that the world's most successful metros—the Hong Kong MTR and the Singapore MRT—have achieved their performance by focusing all their efforts on achieving this.

Metro Plans

"Metro Plans" under Part 2 identified four characteristics of metro planning in China that either differ from overseas experience, or require comment:

1. Network Size— it is not unusual for cities to plan large metro networks. These are an expression of hope, but in all except the wealthiest cities not implementable plans. Sometimes reference is made to the large networks of London, New York or Paris as a "justification" for such networks in developing cities. But these were constructed over many decades, and when costs were relatively low. By comparison, today these cities only contemplate new lines after the most searching examination, and often after many years waiting for the funds to be made available.

Large networks will only be implemented when they can be afforded, and for almost all developing cities this will be when they approach "developed" economic status.

Moreover, the planning of large networks is not cost-free. It can lead to serious errors in planning:

- Attention is diverted from developing real implementable strategies (for example, implementing bus transit corridors), which will bring real benefits, to metro plans that, in practice, are not for the most part implemented.

- Metro lines that are built will, in practice, need to carry higher passenger flows than forecast, because other lines which are assumed to exist will not.[7]

It may be argued that "it is just a matter of timing." But this argument does not stand up. In practice, the ability to forecast ahead more than 15-20 years in a developing city is strictly limited. Beyond that time it may be that other metro projects, very different from those identified today, may be required.

The firm conclusion from worldwide experience is that in the great majority of developing cities where a metro network is affordable/needed, the metro network should comprise one or two, or maybe three lines, which will be in the biggest corridors of the wealthiest cities. In most cities and most corridors, attention should instead focus on developing good bus-based systems, which may perhaps be progressively upgraded in future years to a metro.

2. Network Configuration—metros are very different from highways. Most new highways in a developing city, wherever they are located, will rapidly become full of traffic, whereas a metro in the wrong location will attract little traffic. The reasons are twofold:

- All successful metros are radial to the city center. The viability of the metro is inextricably linked to the dynamic growth of the city center.

- If it were necessary to change cars each time a new road was taken, then grid highway networks would fail; but because it is not necessary, they are often successful. However, with a metro system, it is necessary to change trains where lines cross. This is a major cost/ time penalty for passengers, and in practice where excessive interchange is necessary, metros are little used.

The firm conclusion is that grid and circumferential metro configurations need to be reviewed very critically, as they are unlikely to be viable.

3. Technology—is important for two main reasons: it must allow efficient, safe and trouble-free operation and it must be designed for ease of upgrading (which does not mean it is necessarily high-tech). Cost is largely determined by vertical alignment, and ridership by horizontal alignment/station locations, tariff policy and integration arrangements with buses and bicycles.

Annex A suggests a meaningful definition of MRT systems. The key issues are:

- What is the expected ridership/capacity required?

- What are the tradeoffs between elevated alignments and the much more costly underground alignments?

In some corridors the need will be for high capacity either underground (as in Shanghai Line 1) or elevated (as in Pusan Line 1). In other cases, the need will be for moderate capacity,

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[7] In practice, the often overprediction of ridership, noted above, offsets this.

either elevated (as in Manila Line 1) or underground. Whether the terms "metro" or "LRT" are used is immaterial. The need is for a certain train length/car width (which determines capacity to carry forecast ridership) and vertical alignment (which substantially determines cost).

4. Comparability in Evaluation: Metros and Expressways—it is important to evaluate elevated and underground alignments objectively. It seems strange that elevated expressways are regarded as acceptable through Central Areas, while metro systems, which have a lower environmental impact, are built underground.

Guidelines for Identifying Economically Viable Metros

First, the results of international experience are described, derived from the Study of Mass Rapid Transit in Developing Countries (References 2.3). Then, their applicability to the particular conditions in Chinese cities are discussed.

International Experience. Most of the following conditions were found to be necessary for economically viable metros (Figure 22):

FIGURE 22: GUIDELINES FOR IDENTIFYING ECONOMICALLY VIABLE METROS

Most of the following conditions should hold:

1. High existing bus/paratransit demand
2. Incomes that are not low
3. Prospects for sustained growth
4. Expanding city center
5. A low-cost alignment
6. A fares policy to encourage ridership... and limit the need for financial support
7. Government institutions with proven track record
8. Strong metro management

- **Corridor Size**—high existing public transport flows down the main corridor, of the order of 10 to 15,000 passengers per hour per direction are required;
- **City Income**—city incomes that are not low (typically at least $1,800 per person);
- **Growth Prospects**—prospects for sustained growth, notably economic growth;
- **City Center Growth**—an expanding Center, preferably of a national/provincial capital city;
- **A Low-Cost Metro Alignment**—with little underground construction;
- **Fares Policy**—a fares policy on metro and bus systems to encourage ridership yet limit the need for financial support;

- **City Management**—government institutions that were stable and had demonstrated competence; and
- **Metro Management**—strong, largely autonomous management, with clear objectives.

The important issues which underlie these guidelines are the following:

1. Metro viability is concerned with the size/characteristics of big city corridors, not with city size. Thus, in a linear city (such as Pusan) a metro may be viable, even though the city is not large. Similarly, in Singapore the city has a very few big corridors, and the metro is not only economically viable, but essential to the city form that has been determined. Metro viability is linked to the nucleated city structure.

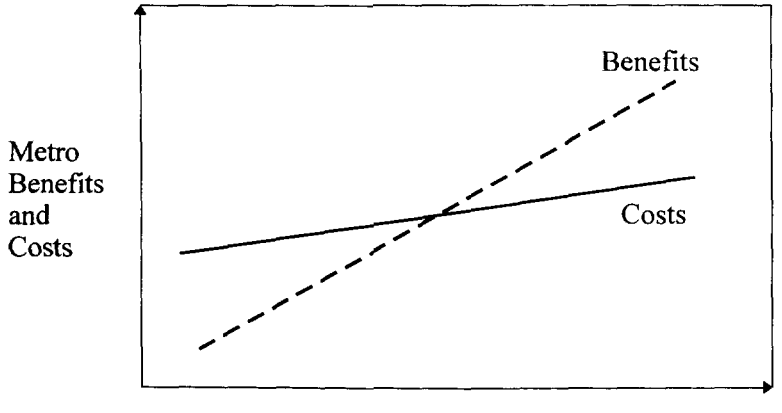
2. The "obvious" need to keep costs low, and passenger traffic and revenues high. Annex A sets out the key factors. Low costs require: an alignment that is elevated rather than underground and at-grade rather than elevated; and an effective Metro Operator. High ridership/revenues require: station locations in the right place (penetrating the heart of the city center, and major residential areas); integration between buses and metro (requiring physical measures, bus route changes, and fares to be set correctly).

3. The great majority of metro passengers formerly used buses. Large existing bus passenger flows (the potential metro market) should therefore exist in any potentially viable metro corridor.

4. Most of the benefits depend upon future conditions. It is thus important that there is a scenario of future growth in incomes (particularly) and an underlying growth in the City Center.

5. Metro costs do not vary substantially with city income (a large part are foreign costs, similar throughout the world), but benefits do (most are time savings, which increase proportionately with income)—Figure 23. Thus, metro viability is strongly correlated with income. The question concerning metro viability should often be: "When will the conditions be right to implement such a project?"

FIGURE 23: THE INFLUENCE OF INCOME ON METRO VIABILITY



The strategic prefeasibility model MRTAP was developed into a user-friendly package and is being marketed worldwide on behalf of TRL to encourage the realistic evaluation of metro proposals. It is described in Reference 4.

Applicability to Chinese Cities. The above are guidelines for use in most developing cities. **They are in general terms applicable to Chinese cities.** Thus, there can be no doubt that a "good" metro project in China should have the following characteristics:

- High **existing** demand in the metro corridor
- City incomes **(existing)** that are not low
- Good growth **forecasts** for incomes
- Underlying growth **forecasts** for the City Center
- A **low-cost** metro alignment
- **Integration** between the metro and bicycles/buses
- The right **fares** policy
- An effective city administration
- An effective Metro Operator.

What is different about Chinese cities is the source of the metro traffic, and the dominance of bicycle transport in most cities. How many metro passengers will be ex-bus or ex-bicycle? How many will be from the floating population, and how will this change in the future? These are central questions, which underlie metro ridership and viability. Not only do they determine metro traffic, but also the impact of metros upon general traffic congestion.

The questions are not straightforward to answer, and they can usefully be regarded as two sets of questions:

- What would happen if the metro existed today?

- How will the role of the bicycle, bus, taxi, etc. change in Chinese cities in the future? Hence, what would be the impact of the metro then?

Further research is urgently needed, based upon before-and-after study of projects such as Shanghai Line 2 and Guangzhou Line 1. More specific guidelines can then be developed for Chinese cities—for example suggesting the scale of existing bicycle/bus demand that is required in a metro corridor.

PART 5: LESSONS FOR CHINA: BUS TRANSIT

THE NEED FOR BUS TRANSIT

"Bus transit" is shorthand for bus mass rapid transit. Today, bus transit is not a feature of Chinese cities, but tomorrow it will need to be. This section explains why.

The reasoning starts with two important observations about Chinese cities in 1995:

1. City residents would much prefer a car to a bicycle, and, usually, a bicycle to the basic buses operating on most routes.

2. Traffic congestion is rapidly becoming Problem No. 1 in Chinese cities, particularly on roads to the city center. Traffic levels are close to the existing capacity of the roads.

Looking ahead, the expectation is for an "explosion" in demand, as the number of trips increases, and trips become longer. This will be particularly so for city center trips, as service jobs increase rapidly in the economy. The prospect is for severe congestion at peak times.

Moreover, only a small increase in cars threatens **chronic** congestion; and a large increase in cars is widely expected—with far-reaching consequences. Clearly, strong government action is needed, urgently. What should this be?

Road capacity can be increased to help, but not by so much. A 33 percent increase from the existing roads is probably achievable—by good traffic management practice and public education to improve driver discipline. New construction of radial roads to and through the city center may be an option too, although increasingly less so, due to their huge environmental impact. But in any event they will rapidly fill with traffic, and will not solve the core congestion problem.[8] So, worldwide experience is that it is not possible to "build out" of the congestion problem by building more roads. What then can be done?

International experience provides only one known solution to this situation: a strategy to ensure the roads carry the maximum number of **passengers**, rather than vehicles. The efficiency of the transport modes in carrying passengers is often the opposite of what people individually want to do:

> Buses (often the least popular mode at present) can carry more passengers than bicycles, and bicycles far more than cars (the most sought after mode).

There are three key components to the strategy that will maximize the **passenger** capacity of the road system:

1. development of bus transit—the most efficient of the modes

2. restraints on car use (the least efficient) by city center parking controls/pricing, and

3. restraints on bicycles in the busiest corridors, when road space is at a premium.

In addition, the image of buses needs to be upgraded through reform of bus operations and the introduction of modern, new buses. This will change people's attitude toward bus transport.

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[8] Many cities have attempted to "build out" of the congestion problem—Los Angeles being an example—but none have succeeded. Instead, the new roads have rapidly filled with traffic, and cities have sprawled, irreversibly, as car-oriented developments have taken hold. See Theme Paper 1 for more discussion.

Bus transit needs to attract and carry a mass ridership **rapidly**. As buses are commonly the slowest of all road vehicles, this means that **widespread bus priorities are essential.**

There is experience of effective bus priorities, notably in Latin America. What is necessary in Chinese cities has been shown to work overseas—for many years. A combination of busways (bus-only roads in the center of existing roads), bus-only roads and contraflow bus lanes provides the prospect for the necessary "solution."

If this solution is implemented with restraint policies, it will represent an enormously important step on the road to "sustainability." But if it is not, the results will be wide-ranging and serious. Widespread congestion will lower city efficiency, the quality of life of most people will deteriorate rapidly, and cities will sprawl, creating irreversible damage to their future prospects.

Bus Priority Systems

Those city corridors that carry a "mass" ridership (of 5,000+ passengers pphpd), and that suffer from congestion require special consideration. The objective of transport policy is to maximize the number of **people** (not vehicles) that can be carried on the road network, and bus priorities help do this. Many approaches have been developed, and shown to be effective in different circumstances:

1. Where there is a grid road network, bicycles can be segregated from fast-moving traffic (including buses) using different streets, increasing the speed of all vehicles.

2. Roads can be segregated by direction (with bicycles in one direction, other traffic in the other direction) or time.

3. Where there are large numbers of slow and fast-moving traffic using a big city corridor, then it may be necessary to grade separate the busiest junctions, removing conflicts.

4. Where the corridor is large, busways (bus-only roads) can be introduced in the center of the road median, as has been shown so successfully in Latin America.

5. At the busiest junctions, the busway may be grade-separated. In due course, this may be upgraded to LRT (as was planned for Karachi "transitways").

Reference 5 is based upon extensive developing city experience, and establishes the practicable performance of busway transit. Where busways conflict with large numbers of turning/ crossing bicycles, grade separation at critical junctions may be necessary to achieve the levels of output recorded elsewhere.

Developing a Bus Transit Strategy. Rapid transit routes will usually need to be radial to the city center. The bus transit strategy should therefore comprise a network of (one or more) radial routes, effectively penetrating the city center. First, it is necessary to determine the desired road hierarchy in the built-up area, determining the **function** of individual roads. The roads should be designated their intended function, based upon identified need, for example:

- reserved for slow-moving traffic (bicycles)
- used by heavy longer-distance traffic
- secondary/access roads
- city center roads reserved for buses...or pedestrians.

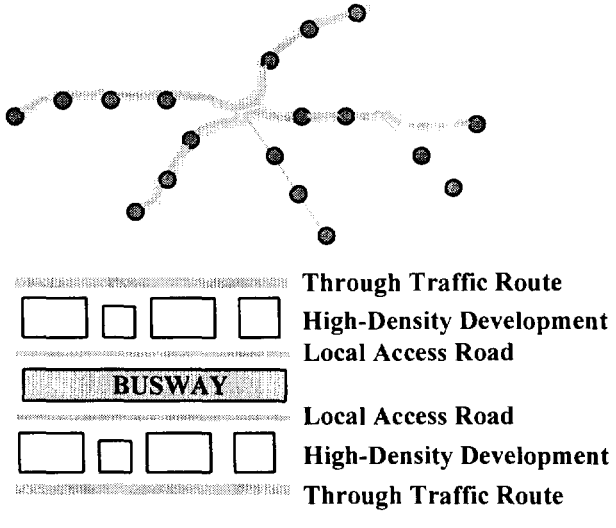
For the identified bus transit corridors existing problems (such as the reasons for slow bus speeds) should be identified and quantified. Options for improving the performance of the buses should be developed, and these should be costed and evaluated, allowing a strategy for improvement to be developed.

It will sometimes be necessary to invest substantial amounts to achieve effective solutions in the big city corridors. But these will be a tiny fraction of the cost of the alternative—a new metro. Busways along an existing right-of-way typically cost $0.5 to $1.0 million/km—about 1 percent of the cost of an elevated metro system, or 0.5 percent if the system is underground.

Experimental busways are required, to establish the facts in Chinese cities, and to demonstrate what is possible. They should be implemented: in selected big bus corridors, and as part of comprehensive traffic management schemes in which separate bicycle networks are introduced, reducing the conflicts between bicycles, buses and other traffic.

Integrated Busways and City Development. Busways can also be used to create a new form of city structure in medium-size cities, as has been demonstrated in Curitiba, Brazil. The principle is straightforward—Figure 24. The busway forms the central axis (or "spokes") of high-density development corridors that radiate from the city center. Buses penetrate the city center, while other road vehicles are restricted. The result is a low-cost but highly popular transport system, and a civilized, high-density and efficient form of city development.

FIGURE 24: INTEGRATED BUSWAY AND CITY DEVELOPMENT, CURITIBA, BRAZIL



The Curitiba system has been progressively developed over 25 years, and consideration is being given to upgrading the busways to a more costly LRT system. The busway provides for the long term a reserved public transport corridor, and it is then capable of incremental upgrading as conditions—and finance—allow.

It is because Chinese cities are in the almost unique position of controlling land use that this important possibility exists, which is not achievable in other countries.

ANNEX A

DEFINITION OF MASS RAPID TRANSIT SYSTEMS

Key Issues

1. The subject of this paper is: transit systems that can carry **mass ridership quickly**;[9] it is not concerned with people-movers that perform a "moving pavement" service.

2. The key objective is to attract riders. This requires **low fares and speed in operation.** Funding is always a problem, as large subsidies are rarely available in developing cities. So, **low fares usually requires low cost.** The central question that transit planning needs to address is therefore:

" How can **low cost and speed in operation** be achieved?"

The Important Transit System Requirements

3. Transit system **costs** are above all determined by their segregation characteristics. For rail systems, the following apply (similar results would apply for bus systems):

Construction	Construction Cost
At-grade	1
Elevated	3
Underground	6 (wide variation depending upon ground condition).

Other factors, such as technology, have relatively little effect on cost.

4. Sometimes constraints of the urban environment require the transit system to be designed to fit—with tighter horizontal radii and/or steeper climb capacity. This too can keep the cost down, allowing elevated construction where underground would otherwise be necessary.

5. **Speed in operation** requires segregation. There are three generic levels of segregation:

- **Complete**—allowing operating speeds (including stopping time) of 30 to 40 kph, depending dominantly upon station spacing. No at-grade junctions with other traffic are possible.

- **Substantial**— meaning horizontal protection from other road traffic (fencing); and priority over other traffic at road traffic junctions (by fully signalizing the route and

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[9] Hence LRT should mean Light Rapid Transit (not Light Rail Transit); MRT Mass Rapid Transit, etc.

providing signal preemption for the transit system). Typical operating speeds are 20 kph.

- **Partial/None**—meaning that other traffic may use the same road as the transit system, and little/no signal preemption is provided. Typical operating speeds are 12 to 15 kph.

6. Transit systems that are successful (because they have low fares/costs and achieve speed in operation) need **high capacity. High capacity requires complete segregation.** Partially-segregated systems **inevitably** become subject to system perturbations (due to passenger behavior, other traffic behavior, driver behavior).

7. Fully segregated rail systems can be **automated**—meaning that they do not need "drivers." Whether in practice they still have an operative on board is a matter of passenger reassurance/marketing/fares protection.

Classification of Mass Transit Systems

8. The above leads to the following generic types of transit system:

	Cost			
Segregation	Low	Medium	High	Automated?
Complete	X	Yes	Yes	Yes
Substantial	at grade	X	X	X
Little	at-grade	X	X	X

9. The following generic transit system types then follow:

	Cost			
Segregation	Low	Medium	High	Automated?
Complete	X	Metro	Metro	
Substantial	LRT/(Busway)			(LRT)
Little	Tram/Busway			

10. Thus, **trams** are low cost and low speed—because they are not segregated. They thus carry few riders, which suits their low-capacity.

Busways are very low-cost, faster if well designed/operated (buses can overtake if necessary, and typically achieve 20 kph), and they can carry a "mass" ridership—typically 20,000 pphpd for a well-designed/operated busway.

Partially grade-separated LRT is higher cost and higher speed. It may attract more riders, and has a higher capacity to match—up to 30,000 pphpd. No **partially-segregated busway** exists; but if it did it would probably achieve a similar performance.

Metros are very costly and achieve high speeds in operation—because they are fully segregated. They attract a "mass" ridership, and have a very high capacity to match. Sometimes they may be designed to lower design standards to fit into the urban environment.

ANNEX B

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THEME PAPER 7: THE REFORM AND DEVELOPMENT OF CHINA'S URBAN PUBLIC TRANSPORTATION ENTERPRISES

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CURRENT STATUS AND DEVELOPMENT TRENDS OF CHINA'S URBAN PUBLIC TRANSPORT

Public transport development in urban China is closely associated with the extremely low level of private car ownership and poor road conditions. Rapid economic development in urban areas has brought about a sharp rise in person-trips. The often obsolete telecommunications system, lagging behind the rapid economic growth, has also contributed to the increase in traffic. With improved living standards and a renewed sense of time cost, the urban population has asked for better public transport services supported by improved infrastructure. The primary objective of the urban public transport sector is to provide residents with a safe, timely, convenient, economic and comfortable means of transport. However, a large gap still exits between this goal and reality, although significant progress has been made in the last decade through enormous efforts by government at all levels and the public transport enterprises in general.

In the mid-1980s, the Chinese Government established a policy that public transport should be the dominant mode of urban passenger transport. *The State Council's Document No. 59 of 1985*, *The 1985 Blue Book of Technology Policy*, and *The Current Sector Policy* (1989) have all clearly elaborated the Government's position on this issue. To relieve the pressure of urban passenger transport, the public policy emphasizes the development of a public transit system and containment of the rapid growth of privately owned vehicles. This policy is justified on several grounds. First, significant progress in road construction is not feasible in the near future because of the lack of funds and the prolonged length of the construction cycle. Second, with one bicycle per capita in urban areas, bicycle ownership has reached a few million in large cities. Operated in parallel with motor vehicles, they have overloaded the transport management capability and congest the roads to an unbearable degree. Third, the use of minivans and cars in urban areas has dramatically increased since the 1990s; and the Government's new automobile industry policy, announced in 1994, indicates that growth in privately owned vehicles will be even faster. The increased importance is highlighted against this background to make public transit more enticing through better service and faster development. Failing to achieve this, the

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road congestion problem will be aggravated, further lowering living standards, hindering economic development and damaging the environment.

Bus and trolleybus are the major mode of urban public transport. During the last 10 years, the total number of these vehicles has increased by 97.4 percent, and the number per 10,000 urban residents by 32.6 percent. The vehicle fleet growth outpaced population growth. However, total ridership increased by only 8.7 percent per year. The percentage of urban residents using public transit has declined considerably in recent years; this is especially true in big cities. There are many factors responsible for existing public transport problems. People have gradually realized that these problems can only be tackled effectively in a comprehensive way. This paper focuses on the public transit sector and its reforms. Some statistics quoted are not official yet and thus are used here for reference purposes only.

Domain of China's Urban Public Transport and Background

The Existing Management System. Cities are the hubs of comprehensive communication and transportation systems of a nation, playing an important role as connection points. Due to the traditional division of administrative functions among government departments and the channels of investment, road transport, railway, civil aviation, pipeline transport, and postal services and telecommunications are currently administered by different government departments in China. Urban public transport is classified as a subsector of the "social services sector" instead of "the transport sector." Together with water supply and drainage, roads, bridges, residential gas and heating supply, urban public passenger transport is defined as urban public utilities. Its investment channels are basically unrelated to the road transport sector, and depend entirely on local government finance. The making of industry policies, planning, administration and management, the service standards, and the construction and technical norms and standards of the industry are responsibilities of competent urban construction departments.[2]

Since replacement of the planned economy management model, the Central Government no longer has grants and subsidies for the construction and operation of urban public transport, including metros. The municipal governments are responsible for the construction funds and subsidies of public transport infrastructure and facilities. A small portion of the urban construction and maintenance tax has become the main financial resource. With the ever-growing economic development disparities among different cities, the imbalance of urban transport development among cities is increasingly severe. This imbalance is related much more with the region where a city is located than with the size of the city.

Scope and Sector Classification of Urban Public Transport. According to the "Sector Classification and Codes of the National Economy," which was revised and promulgated by the National Statistics Bureau in August 1994, the urban public transport sector is classified and coded as follows:

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2 See Theme Paper 3 for more details.

K. Social service sector.

75. The public infrastructure and facilities service sector.

751. The intracity public transport sector, including the management and operation of urban public bus, trolleybus, taxi, metro, funicular, rail, cable car, ferry, etc.

Apart from the detailed classification of all subsectors as mentioned above, the classification also designates the minibus as a component of the urban public bus (minibus has been developing rapidly in Chinese cities since the mid-1980s). It also puts "motor vehicle transport sector" under "road transport sector"; that is, G.53.531.5310, and specifies that road transport "does not include intracity public transport."

With the development of the urban economy, the size of cities grows; these planned areas and administered areas also become larger. The geographic coverage of urban public transport service increases accordingly. The routes from city center to its near and far suburb areas as well as its satellite towns expand rapidly. Most of the urban public buses and trolleybuses operate in the busy downtown area; a small number of them operate on longer routes to either the suburb areas or farther counties and towns. The latter's operation overlaps with intercity buses, which belong to intercity road passenger transport. In some cases, such as in Beijing, urban transport services compete with intercity buses, and this brings about conflicts. Except for a few megacities, most cities now allow intercity buses to enter the downtown areas. This practice provides convenience to passengers and, at the same time, however, contributes to traffic congestion on urban arterial roads. Liuhua District in Guangzhou province is an example of this.

The Existing Urban Public Transport Structure

Overview. The public bus and trolleybus constitute the main body of urban public transport, taking up more than 75 percent of passenger transport volume. This is one of the main characteristics of the public transport structure. Compared with large-capacity rail transport (metro and light rapid transit—LRT), the public bus and trolleybus transport is characterized by small investments and short construction cycles. At present, the intercity passenger transport rail system is separated from urban public transport and hardly involves passenger transport in the urban area.

The maximum carrying capacity of a bus corridor for public buses and trolleybuses is normally considered to be 8,000 passengers per hour per direction during peak hours. The actual operating load of most public buses and trolleybuses already passed this limit during the 1970s and 1980s. In order to solve the social problem of "difficulty in taking the bus" (overcrowding), more buses have been added and headway shortened. In addition, more and more larger-size buses have been used. As a result, the number of articulated vehicles (the body length is about 14 to 16 meters) has sharply increased.

Table 1 shows the growth of public buses and trolleybuses. For a meaningful comparison, buses of different lengths are converted to the standard bus equivalent units, which are 10 meters long. For instance, a 14 meter-long bus is converted to be 1.6 standard buses.

Table 1: BUSES AND TROLLEYBUSES IN URBAN PUBLIC TRANSPORT, 1985-1994

Year	Operating vehicles in standard bus equivalent unit	Total route length (km)	Total annual ridership (billion passengers)	Vehicles/10,000 population
1985	55,115	105,512	25.067	
1986	56,585	145,695	26.183	46
1987	59,484	123,455	27.260	46
1988	63,705	141,563	28.007	46
1989	66,842	156,901	27.233	46
1990	70,140	161,932	27.680	48
1991	80,182	146,235	28.431	54
1992	91,341	157,679	29.105	59
1993	99,669	177,586	27.759	60
1994	108,788	199,480	27.238	61
1994/1985	197%	189%	109%	133%

Trolleybuses in China were first operated in Shanghai in 1914 and developed rapidly during the period 1949 to the 1970s. Its development had been favored by the sector, the government and residents alike because of its low pollution, low noise and quick engine startup. However, its development is now stagnant due to its requirement of large investment, poor flexibility and power shortage. By the end of 1994, there were 4,447 trolleybuses operating in 24 cities all over the country (converted to 7,335 standard bus equivalent units), the annual ridership was 2.95 billion passengers, and the operating routes were 1,412 km long in total. Compared with 1981, the number of buses increased only by 1.75 percent. There are only 198 tram coaches now operating in three cities: Changchun, Dalian and Anshan.

It was clarified in a document issued by the State Council in 1985 that "rail transport should be developed gradually as the major means in big cities' passenger transport. It is very difficult to solve the problem of 'difficulty in taking bus' by relying on the existing buses, trolleybuses and limited road space. To solve the problem, we must 'go up into the air and down to the underground,' and develop a multistratified and multistructured stereo transport system. Rapid rail transit with large capacities (including metro) must be put into our agenda of development and constructed with careful planning to meet the needs of large traffic flows." The planning and construction of rail transit in megacities have noticeably accelerated since the mid-1980s.

However, due to the large investment required for the construction of metros and other rail transit means, the planning authorities are very cautious in the appraisal and approval of metro projects amid government macrocontrol of infrastructure investment scale. (The capital on metro construction is self-raised by local governments; however, it must be approved by pertinent government departments and the State Planning Commission.) Thus far, only eight cities have received permission to build metros or LRT systems, and only three cities have a

metro or LRT in operation, with a total length of 67 km, and annual ridership of 542 million passengers. In Beijing the metro carries 15 percent of the total transit ridership.

Commuters, floating population and residents who could not bear the crowding, poor service and low speed of buses have turned their eyes to taxi and minibus. As a result, minibus and taxi transport has developed dramatically in the last 10 years. Taxi plays a significant role in urban public transport in Chinese cities where private ownership of cars is very low. In the last eight years, the number of taxis has increased by 5.4 times (Table 2). Taxi transport now carries more than 15 percent of the total person-trips in some big cities such as Beijing and Guangzhou. A minibus usually has 17 to 19 seats, and operates mainly in the downtown area and along public bus routes. The minibus fare is slightly higher than that of bus, but the seating condition of a minibus is better and it can stop any time to pick up passengers. Minibuses alleviate the crowding of large-size buses. They, however, also contribute to traffic disorder; in particular, they affect adversely the operating order of buses and trolleybuses at their terminals and stops. Some cities now have many more minibuses operating than buses and trolleybuses. A number of cities have issued administrative orders restricting the further development of minibus transport.

Table 2: INCREASES IN NUMBER OF TAXIS IN CITIES

Year	Number of taxis ('000)
1987	61.5
1988	82.0
1989	98.5
1990	110.7
1991	128.3
1992	190.3
1993	286.2
1994	393.0

The urban ferry (mainly cross-river) is one of the most important public transport means in cities alongside rivers. There are 1,123 ferries at present all over the country, with an annual ridership of 801 passengers.

Table 3 provides public transit modal splits.

Table 3: TRANSIT RIDERSHIP BY MODE, 1994

	Annual ridership (million passengers)	Share (%)
Bus	23,516	75.89
Trolleybus	2,950	9.52
Tram	230	0.74
Metro	542	1.75
Taxi	2,948	9.51
Ferry	801	2.59
Total	**30,987**	**100.00**

Evaluation of Service Level and Quality of Urban Public Transport. In "A Study on Public Transport System and LRT Mode in Large Cities," one of the key national science and technology projects during the Seventh Five-Year Plan sponsored by the Ministry of Construction in 1991, an urban public transport evaluation index system was proposed based on the hierarchical analysis method. This system assesses the level of urban public transport from three aspects: facility standard, service standard, and profitability. There are 29 indices, of which 14 are designed for evaluating the service quality.

Service Level. Table 4 reports the average level of public buses and trolleybuses in 22 cities. There are quite large differentials among these cities, which are determined mainly by the following factors:

- the development level of public transport;
- the urban form;
- the economic development level;
- the person-trip habit;
- the network coverage area.

Table 4: SERVICE LEVEL OF BUSES AND TROLLEYBUSES

Indicators	Statistics for 20 cities
Traveling speed (km/h)	11-24
On-schedule rate (%)	79-92
Average distance between two stops (m)	500-900
Transfer rate (%)	22-80
Transfer walk distance (m)	70-500 (usually 200-300)
Peak hour load factor (%)	80-115
Full day load factor(%)	36-81 (usually 50-70)
Passenger waiting time (minutes)	3-20 (usually 5-10)
Vehicles in operation/total vehicles (%)	88-95
Passenger trips per resident per year	120-760 (usually 200-400)

Since the mid-1980s, the operating speeds of public transport vehicles have consistently followed a downward trend. In extreme cases, it slowed down to 10 km/h. The main cause is the road condition deterioration and the growth of motor vehicles more than offset the growth of road space. In 1994, per capita urban road area (only for urban population) was only 6.6 square meters and most of cities do not have dedicated bus lanes. In addition, the rapid growth of bicycles and their unauthorized use of motor vehicle roads, the unauthorized use of bus stations by nonpublic transport passenger vehicles, and the flourishing of roadside markets have all contributed to the slowdown of public transport vehicles' speed. At the same time, operations in this chaotic environment have led to a decrease in the on-schedule operating rate.

The main reasons for the overly long headway and long distances between transfer stops are as follows:

- On certain segments of roads, bus stations are not allowed or are required to be far away from ground-level intersections;
- For the consideration of transport planning and public transit network optimization;
- Operation management has a tendency to increase station intervals, assuming that long intervals will increase operating speeds.

With the rapid development of minibuses and taxis in last five years, urban passenger transport is now multimodal. Public transport loses some users to other modes; the upward adjustment of public transport fares has also contributed to a decrease in ridership. The load factors of public buses and trolleybuses therefore tend to go down.

Technical and Economic Indicators for Public Transport Enterprises. The technical and economic indicators, as well as statistic methodologies for state-owned public transport enterprises, are defined in the National Industry Standards. Here we take bus and trolleybus enterprises as an example. They have the following indicators: the full operating days per vehicle, vehicle average breakdowns, frequency of electric cable breakdown, gasoline and diesel consumption, power consumption of operation, operating revenue, total operating cost, average fares, etc.

The attainment of technical and economic targets, which are measured by the indicators, are directly related to an enterprise's economic efficiency. Because of public transport's social benefits, the Government's guiding policy for enterprise operation is to balance the social benefits with economic benefits and efficiency, with priority given to the realization of social benefits. In practice, however, the balance of these two relationships is a very delicate matter for enterprises. Analysis of operating revenue and fares will be carried out in the next part of the report.

Buses and trolleybuses are almost all domestically made, of which gasoline vehicles account for a large percentage. In order to extend the vehicle lifespan as long as possible and delay its replacement, an operating vehicle undergoes frequent major overhauls. Large- and medium-size enterprises have their own maintenance facilities to meet these needs. Vehicles' poor technical condition directly contributes to the breakdown rate. On average, a vehicle's first breakdown is under 3, 000 km. The mileage at the first overhaul and the lifespan of a corrosion-resisting vehicle body are only 40 percent of those of the same type of vehicle in the international market.

Fuel Consumption Efficiency. Fuel consumption is one of the serious concerns of enterprises, especially after the multifold price increases in recent years. In 1994, the national average of fuel consumption by a standard bus was 26 to 29 liters per 100 km, 32 to 36 liters by an articulated bus. Power consumption is 65 to 85 kilowatts/hour per 100 km for an articulated trolleybus.

Main Contributors to and Constraints on the Development of Public Transport

Urbanization. Since the reform and opening up to the outside world, urbanization has been accelerating rapidly. The number of cities in China increased to 622 in 1994 from 225 in 1981. Big cities with more than 1 million population went up to 36 in 1994 from 22 in 1985. The urban built-up area and planning area keep expanding along with economic development, and the floating population has increased sharply. Accelerating urbanization provides the opportunity and potential for development; in the meantime, it puts great pressure on the existing public transport infrastructure and facilities, which are far from sufficient to meet the demand. While actively promoting economic development, many new cities have not realized the importance of providing public transport to their residents, which is a basic necessity for person-

trips. A chaotic state of passenger transport will adversely affect social stability and the investment environment. Too often the importance is not fully recognized in the strategy- and policy-making process. As an important aspect of the urban transport system, the relationship between the public transport sector and a city's structure, as well as the city plan, has not received enough attention. In many cases, satellite towns and residential neighborhoods are not fully functional after their construction due to the lack of public transport service facilities.

Change of Urban Residents' Demands for Public Transport. From 1985 to 1994, the number of buses and trolleybuses increased by 97.4 percent and the total length of operating routes extended by 89.1 percent. The number of vehicles per 10,000 people increased by 32.6 percent (the slower growth of per capita vehicles in the presence of the quick increase of vehicles is caused by the fast growth of urban population). The total public transport ridership, however, only increased by 8.7 percent during this time period. The contrast between the fast growth of public transport facilities and the small increase in passenger volume is a reflection of the serious fact that public transport is gradually losing its stake in residents' choice of mode. The ridership of buses and trolleybuses in 1994 decreased by 6.5 percent from that of 1992, indicating that this situation is continuing. The main reasons are as follows:

- **Service Quality.** In the last 10 years, people's living standard has remarkably improved in such categories as food, clothing, housing and cultural life. Against this background, the service quality of the current public transport has not caught up with residents' growing demand. The shortcomings of public transport in convenience (number of buses, headway and transfer) and comfort just cannot be compensated by the low fares. Residents therefore turn to other means of transport. Those who have high incomes choose either minibuses or taxis; those who have low incomes ride bicycles. In Tianjin, 90 percent of residents travel by bicycle to work.

- **Adjustment of Fares.** The policy of low bus fares has been in place for a long period of time. The bus fare in Beijing is the cheapest in the world (it only costs Y 0.10, equivalent of $0.012, for 3 km). A monthly student pass allows the student to travel on all urban routes at a small cost of Y 2 (equivalent to $0.30). Shanghai has a flat bus fare system, where one ticket costs only Y 0.5 (equivalent to $0.06). Bus fares at such low levels are no longer practiced in most cities in China. The fares have been adjusted a few times in last 10 years (see Table 5). According to a survey of 13 cities, the fares went up by 152.3 percent in 1994. The increase in fares is one of the reasons why ridership is decreasing.

- **Road Condition.** The reduction in operating speeds due to traffic congestion is a very serious problem. With average operating speed around 10 km/h, the buses and trolleybuses no longer have an advantage in speed over the bicycle. In 1987, the average ratio of vehicle/capacity of the urban road network had already reached 81 percent in China, and the situation is increasingly getting worse. The increased reliance on bicycle transport further intensifies traffic congestion. Up to now there are no lanes designated for the sole use of public buses and no traffic laws and regulations favoring public bus operations in most cities.

According to a survey to people who used to travel by bus but now by bicycle, 80 percent of them would like to go back to buses if they can meet the following three basic conditions: increased operating speeds (29.5 percent); on-time (25.6 percent); and convenience (16.1 percent).

After the adjustment of bus fares, the price of monthly passes for workers, which are quite popular in big cities, increased sharply as well. A large percentage of monthly passes used to be bought by enterprises. Some enterprises stopped buying monthly passes and simply gave cash subsidies to workers. This practice unwittingly discourages person-trips by bus, because the sum of two years of fare subsidies is sufficient to buy a new bicycle. In addition, a large number of cities exempt the bicycle license tax.

Table 5: ADJUSTMENT OF BUS FARES IN SOME CITIES
(Yuan/passenger-km)

City	1987	1994	Growth Rate (%)
Beijing	0.020	0.029	44.5
Tianjin	0.017	0.035	100.0
Shijiazhuang	0.018	0.062	250.0
Shenyang	0.022	0.041	86.1
Changchun	0.028	0.043	51.9
Harbin (trolleybus)	0.020	0.067	231.7
Hefei	0.025	0.066	167.2
Jinan	0.014	0.049	242.6
Guangzhou	0.021	0.104	393.8
Wuhan	0.021	0.067	214.6
Shenzhen	0.050	0.106	112.0
Xi'an	0.023	0.038	70.4
Kunming	0.022	0.054	144.1
Average	**0.023**	**0.059**	**252.3**

CAPITAL FOR PUBLIC TRANSPORT ENTERPRISE OPERATION

Structure of Operating Costs

The cost of public transport operation comprises mainly fuel, salaries, vehicle depreciation, maintenance and management. The weight of each of these component in the total cost is quite different for each enterprise depending on the size, operating conditions and management level of the enterprise.

From a 1994 survey of 118 public transport enterprises, the composition of total operating costs of a representative enterprise is as follows:

Fuel (gasoline, diesel or power)	26.4%
Salaries	30.5%
Maintenance	17.0%

Management	17.6%
Depreciation of vehicles and facilities	8.5%

Change in Operating Costs

Fuel. Up to 1992, most of the public transport enterprises were entitled to buy gasoline, diesel and lubricant at government-controlled, lower-than-market prices when these petroleum products were under the "two-tier price system." The enterprises no longer enjoy this privilege after reform of the petroleum products price system. The sharp price increases of petroleum in recent years contribute to the rise in operating cost in public transport enterprises. The fuel prices have increased multifold. For public transport enterprises, gasoline prices increased by 105.2 percent from 1991 to 1994, diesel price by 74.3 percent.

Increases in Salary and Welfare Payment Year by Year. Besides the workers' salaries, state-owned enterprises are burdened by pensions, medical care payments, etc. The nonoperating cost is especially a heavy burden for old enterprises, which is the result of "enterprise socialization" under the old system.

Increase in Maintenance Cost due to Deterioration of Vehicles' Technical Conditions. This increase is a common phenomenon. The lifespan should be 800,000 km according to the national standard set in the 1970s. However, a lot of vehicles that are near or in the scrap stage are still in operation because of a lack of funds for new vehicle purchases. According to a survey sample, this kind of vehicle accounts for 17.6 percent of total vehicles in operation.

Too Many Managerial Staff and Inefficient Management are the Main Causes for High Management Cost in Some Public Transport Enterprises. Management costs in some mid- and small-size enterprises account for more than 20 percent of the total operating cost. Simplifying the departments and reducing the number of redundant workers are two of the important measures taken in many enterprises' internal reform.

Factors Affecting Operating Revenues

Monthly Pass System Characterized by Heavy Subsidy. The monthly pass system in big cities can be traced back to 1949. The relative prices between a monthly pass and the ordinary bus fare is getting bigger over time. The amount of subsidy for each monthly pass is increasing as well. The percentage of passengers using a monthly pass is quite high. Therefore, as more monthly passes are sold, the more serious are enterprises' operating losses. This situation is reported in Table 6. A series of measures have been taken in some big cities to control this situation. For example, a ticket book system is being introduced in Shanghai and Changchun (a monthly ticket book contains a certain number of tickets while one ticket is required for each trip taken) while the monthly pass system, which allows pass holders to take an unlimited number of trips, is demolished.

Fierce Competition in Passenger Transport Market. In a large number of cities, the administrative regulations and the management system are not adequately formulated. A large number of nonstate-owned passenger vehicles compete with public transport vehicles on the same bus lines, fighting for passengers at stations designated for public buses. This is especially

so in downtown areas and on lines with high-level ridership. But only public transport serves passengers in remote areas and during off-peak hours. Under this confused and unregulated competition, the public transport enterprises have neither franchise nor pertinent laws and regulations for protection. As a result, their operating revenues have been adversely affected to a large extent.

Table 6: SALE OF MONTHLY PASSES IN SOME CHINESE CITIES

City	Number of monthly passes sold ('000)	Average price of monthly pass (Yuan)	Average cost of monthly pass (Yuan)	Revenue from monthly pass sales/ total transport operating revenue (%)
Beijing	1,264	8.46	47.86	44.0
Shanghai	2,093	25.00	-	47.8
Dalian	367	16.50	-	59.6
Xi'an	95	12.82	43.61	15.7
Urumqi	75	15.11	32.00	10.5
Wuhan (trolleybus)	54	20.38	-	46.4
Luoyang	12	17.17	44.60	10.3
Hefei	55	15.00	26.50	18.5
Harbin	66	13.40	41.20	22.8
Changchun	151	14.20	45.00	29.8

Defects in the Fare Collection System and Management. This is one of the reasons for revenue loss. There are two shortcomings in the traditional and commonly used system of fare collection where bus attendants sell and collect fares: fare evasion by passengers and embezzlement of fare revenues by bus attendants. Very light punishment is applied to fare evaders and measures to prevent and find out embezzlers are also very ineffective. With the reform of the fare collection system and the use of a revenue contract system, the situation is now improved. Currently, 50 cities have adopted the one-man operation system with a fare box installed in buses. The magnetic ID cards have been introduced in a small number of cities.

Government Subsidies under Different Forms

The low bus fare policy and continuous annual increases in operating cost cause growing losses in public transport enterprises. A survey of 124 cities indicates that their losses increased by 60.5 percent in 1992 from that of 1991, by 74.9 percent in 1993 from that of 1992 (based on current prices). During the same period, government subsidies increased by 27.7 percent and 61.8 percent, respectively. The rest of the losses is offset by cost reduction or revenues from other business activities. Subsidies to public transport are now commonly considered as a heavy burden for municipal government finance.

The list below describes several typical ways of giving away subsidies.

- Based on the last year's operating cost accounting report and financial statement and the current year's operating plan, the municipal finance bureau will decide the subsidy amount.

- Subsidies based on vehicle-km. The subsidy amount is decided based on total vehicle-km. The Construction Commission of Sichuan Province suggested a unit subsidy of Y 0.50 per bus-km. Except for Beijing and Shanghai, the average unit subsidy in 1993 was Y 0.39 per bus-km in 122 cities.

- Subsidies based on passenger-km. The main purpose of this method is to offset the incentive for enterprises exclusively seeking travel kilometers but neglecting ridership. The operating revenue is normally used to measure the ridership. The product of operating revenues and vehicle-km is then used as a comprehensive index for the subsidy amount.

- A large number of cities have adopted a system of keeping the subsidies to public transport enterprises constant for a few years (normally about three years). Once the subsidy amount is determined for that period of time, no adjustment will be made regardless the changes in enterprises' profitability or loss. The purpose is to encourage enterprises to take initiatives to reduce costs and increase revenues.

Adjustment and Trends of Subsidy Policy Regarding Public Transport

Among governments at all levels, enterprises, and other social sectors, there have been many discussions regarding the unstandardized methods giving away subsidies. If the social benefits and public welfare generated from public transport is overemphasized, and governments make every effort to provide large amounts of subsidies to public transport enterprises to maintain their normal operation and development, the result will be an unsustainable financial burden to governments on the one hand; and a de-facto incentive encouraging the dependence of enterprises on government subsidies on the other hand. Policy-induced losses often are used as a cover for losses caused by mismanagement. However, if profit-making is emphasized as the objective of public transport enterprises and the public transport enterprises are required to self-survive in the competitive market, state-owned public transport enterprises under the present external operating environment will be in a difficult position facing market competition. The social benefits provided by public transport services will be adversely affected to a large degree. In recent years, most enterprises have made great efforts to reduce government subsidies through improvement of management and business diversification. According to incomplete statistics, the share of government subsidies to total revenue was 28.0 percent in 1991, 26.3 percent in 1992 and 22.3 percent in 1993, an annual reduction of 6.2 percent and 14.5 percent, respectively. As a service sector, public transport directly affects the economic benefit of low-income residents. On the other hand, the subsidies given to the public transport sector directly involve the taxpayers' rights and interests. The establishment of a scientific and rational subsidy policy is an issue of great importance in public transport reform.

The Impact of Capital Shortage on Public Transport Operation

The quality of services and the technical conditions of equipment and facilities (mainly vehicles) have declined. Due to a lack of funds, the enterprises are unable to invest in new vehicles or carry out the vehicle maintenance plan on a systematic basis. As a result, not only does it reduce the attraction of public transport to passengers, but also increase the potential for vehicle breakdowns during operation. According to a survey sample of 74 cities, there are 3,921

buses over the 800,000 km threshold for scrap; and 5,337 buses need to be overhauled but are still in operation because of lack of funds. In 15 cities, there are some buses that have run over 1 million km and are still in operation. The worn-out vehicles and vehicles with a lot of body corrosion can often be seen around. This problem is even more serious in economically underdeveloped areas.

There has been ineffective management of the passenger transport market. Because state-owned public transport enterprises could not meet the demand of residents for passenger transport in quantity as well as in quality of services, a new guiding policy, "operations by enterprises of different ownership and a unified management," was introduced in 1985. As a result, the number of vehicles in operation has increased, and the ownership of passenger transport has become mixed. However, appropriate market regulation, supervision and inspection of qualifications (for vehicles as well as for operators) were left behind in market development. "Unified management" has not be carried out effectively. This situation has adversely affected traffic order. The operating order along the original operation lines of state-owned public transport has been hit especially hard, and many disputes have harmed passenger interests.

The state-owned public transport enterprises are at their low points due to the lack of funds. The difficult external environment for operation results in low salaries and benefits for employees, which are not commensurate with the their work hours and workload. The salaries and benefits are usually lower than the average of those in other state-owned sectors. The working force is thus not stable. For example, in 1993, the number of drivers who quit increased by 36.9 percent compared with that of 1992 in 100 cities. A small number of enterprises have lost more than one-third of their drivers in recent years.

There has been a negative effect of diversified operations in public transport enterprises. As mentioned before, the revenues from fares and government subsidies are not enough to cover the operating costs. The public transport enterprises thus diversify their operations to increase revenues in order to fill up the gap. Some of them have started a "minibus" service with government permission along certain routes. The minibus fare is higher and the profit is used to cross-subsidize the loss of the main busline operations (Wuhan and Hefei are typical of this practice). More enterprises are involved in many nontransit services and retail businesses. The direct benefits of these operations are an increase in income, and the indirect benefits are the provision of employment opportunities to redundant workers. However, if enterprises' managers spend too much their energy on those diversified operations, it is very difficult to ensure that the public transport service will not be influenced, and there will also be new problems for income distribution.

FUNDS FOR DEVELOPMENT (CAPITAL CONSTRUCTION) AND RENOVATION AND UPGRADING OF PUBLIC TRANSPORT ENTERPRISES

Current Situation

Most of the public transport enterprises inherited from the planned economy system are invested by local governments. Their fixed assets include vehicles, depots, terminals and some other facilities, of which governments are owners.

In recent years, some changes have occurred in the newly established enterprises regarding property rights and often the government is not the sole owner of an enterprise. For example, cooperative transport companies (Harbin city and Dalian city are representative in this case) are joint ventures of nontransit enterprises in the industrial and service sectors. Some transport companies (Shanghai city is representative in this form of investment) are jointly invested and thus owned by local public transport companies and the large- and medium-size enterprises who will receive transport services from their joint-venture transport companies. The foreign joint ventures (Wuhan city and Guangzhou city are good examples in this experiment) are set up by local public transport companies and foreign investors. The size of foreign investment in the bus and trolleybus sector is still very small. Nonetheless, it has been growing in recent years. Some cities such as Beijing, Shanghai, Guangzhou and Dalian have used foreign capital to buy new vehicles or to build up bus stations, terminals and other facilities. Advertisement revenue is used for loan payment as these loans are conditional on vehicles and facilities being carriers of commercial advertisements.

When public enterprises face great difficulties and lack funds for renovation and upgrading, funds from different sources inject fresh blood into enterprises and are beneficial to the improvement of vehicle technical condition, revenue growth, improvement of service quality and increase of transport capacity. At the same time, public transport enterprises can acquire advanced administrative and management experience and promote technology progress through this practice.

Government Investment

The capital construction funds of state-owned public transport enterprises are mainly used for the construction of garage, maintenance plant, depot and parking yard, transfer station, stop, dispatching center, electricity transformer station, feeder network, etc. Capital construction funds for metro systems will be discussed later.

There have been basically no funds from the central government for the construction of urban public transport infrastructure, but there has been a limited number of earmarked loans. The funds for infrastructure construction mentioned above are provided mainly by local municipalities. Enterprises with good economic performance have a small amount of self-raised funds. The provincial (or autonomous region) construction departments and their relevant administrative departments (the Construction Commission, the Construction Department) provide some financial aid to large-scale projects.

Funds for infrastructure construction and renovation and upgrading of facilities mainly come from the urban maintenance tax. The tax revenue, however, is shared by many municipal public utility sectors, including water supply and drainage, gas and heating, roads and bridges, environment and sanitation, parks and green areas; only a small portion is allocated to public transport. This ratio has followed a downward trend every year since 1990 (Table 7). The capital construction funds for public transport accounted for 3.3 percent of municipal construction funds on average during 1986-94, while renovation and upgrading of public transport consumed 10.4 percent of municipal construction funds in the same period. These two funds totaled Y 251 million in 1994.

Depreciation Policy

The depreciation rate of all kinds of facilities and fixed assets of state-owned public transport enterprises is decided by the finance department of higher authorities. The current standard was formulated in the 1970s and 1980s and needs to be adjusted. The depreciation cost is counted as part of the operating cost. The current depreciation rate is too low and the amortization of facilities takes an abnormally long period of time, which results in overtime service of many facilities and therefore lowers the safety and service standard. Lower-than-required depreciation or even a zero-percent depreciation rate is a poor accounting practice used to reduce the book-value operating cost. However, there is no effective supervision and control of this practice. In some coastal regions in southern China, facing market competition, public transport enterprises have already shortened the vehicle service period in order to attract passengers as well as reduce accidents and maintenance cost. Some of the enterprises accelerate vehicle replacement and have eliminated the overhaul system. Experience of some interior cities also indicates that an overly long vehicle depreciation period actually increases the maintenance fee and operating cost.

Table 7: RATIO OF FUNDS FOR CAPITAL CONSTRUCTION, RENOVATION AND UPGRADING OF PUBLIC TRANSPORT TO URBAN CONSTRUCTION FUNDS

	Capital Construction		Renovation and Upgrading	
Year	Y'000	Ratio (%)	Y'000	Ratio (%)
1986	225,040	4.86	335,380	9.92
1987	212,240	4.00	336,060	9.01
1988	221,530	3.32	381,530	8.20
1989	262,120	4.13	505,220	11.60
1990	342,670	4.41	571,390	12.52
1991	349,490	2.98	630,840	11.78
1992	528,210	2.57	964,050	12.47
1993	740,670	2.11	1,468,850	8.56
1994	830,320	1.71	1,680,330	9.24

Construction of Depots, Terminals and Stations

Because of a shortage of funds, managers pay much more attention to investing in vehicles and neglect the construction of facilities (in ferry transport, the ship and harbor facilities). The prominent problem in this area is: since there are no relevant regulations and rules, there are no sources of funds for the construction of public transport facilities for important passenger attraction and distribution centers. In some cities a "matching construction fee for comprehensive development" is collected from the construction of residential communities, and part of it will be used for the construction of public transport facilities, such as parking lots, dispatching stations, etc. But the construction of relevant public transport facilities serving railway stations, airports and harbors, which have large passenger flows, has not yet received due attention. In some cities, there are no parking lots for buses and trolleybuses in newly built airports and railway stations. The main reason is that funds and land needed for parking lot construction did not materialize before the construction of the airport or railway started.

Main Channels to Increase Funds for Public Transport

There is no government investment in the profitable minibus and taxi operation, whose business owners raise funds through bank loans or share issuance. Some public transport enterprises establish a minibus business themselves by raising partial or total funds among employees.

For those enterprises that still implement the low bus fare policy and offer monthly tickets at preferential prices (including ferries and metro transport), the government continues to provide them with subsides for policy-induced losses and most of the funds needed for capital construction, as well as renovation and upgrading. With the gradual reform oriented toward a modern enterprise system, the Government will authorize investment organizations or government departments as state asset investment entities. Investors' ownership rights and the property rights of enterprises as legal economic entities will be clearly defined, and the investment organizations or the authorizing departments are not allowed to interfere with enterprises' operating activities.

In situations where municipal government finance is in difficulty, the Government encourages all social forces and foreign investors to enter the public transport sector on the condition that laws and regulations as well as the norm of markets are established or are in the process of improvement. Some municipalities have already established a certain number of shareholder limited-liability companies as an experiment. Under the principle of "comprehensive planning, unified management and coordinated development," fair and reasonable competition is beneficial to the development of public transport.

The construction of a rapid-rail transit system has become a development must for megacities. A great deal of preparatory work has been done in more than 20 cities; however, only projects in seven cities had been approved by the State Planning Commission by the end of 1994. The key problem lies in the difficulty in assembling the huge amount of funds for the construction of a metro or light rail transit (LRT) system. Even in cities with approved projects, funds needed for construction have not materialized completely. There are mainly four channels of financial resources for metro and LRT: (a) municipal government investment; (b) foreign loans; (c) funds raised in society (usually collection of earmarked fees); and (d) revenue from land leases, real estate development and industrial development. Foreign loans are used in all metro projects, and usually account for 30 to 50 percent of the total investment. The active but cautious attitude toward metro construction is based upon the fact that China is a developing country and a large number of big cities do not have strong economic strength. Whether metro or LRT should be constructed depends on (1) the city's gross national product (GNP) value; and (2) the road public transport situation and the volume of potential passenger flow in the medium and long run. It is neither practical nor feasible to introduce a large amount of foreign capital to build subway systems when the central government macro-controls and adjusts the fund-raising activities, credits and loans. Up to now, cities that have built or are building metro systems basically use foreign government loans or mixed loans. There has not even been one case using commercial loans.

With the 17 years of reform starting in 1978, great changes have taken place in economic structure, mechanisms and development; in social development environment, motivation and

pace; and in public's expectation of economic and social development. In particular, the change in people's thinking and ideas is one of the power basis for China's continuous reform and development.

The reform in urban public transport enterprises is only a micro component of China's overall reform and development in an extension of the overall reform. The reform in urban public transport enterprises must comply with and fit into the overall reform and development principles; it also depends on the environment of the overall reform and development.

The reform in urban public transport enterprises must relate to the overall development. This report cannot and will not be confined only to urban public transport reform; it will inevitably involve the other related aspects.

OBJECTIVES OF CHINA'S URBAN PUBLIC TRANSPORT ENTERPRISE REFORM

The primary goal of urban transport is to facilitate the movement of people and goods. Transport means are the modes people choose in order to realize the movement. Modal choice is based on convenience, comfort, speed and cost. With social development, the modal choice behavior also changes dramatically. This change is a comprehensive reflection of economy, science, society, ideas, region, population, environment and resources at that time. There is no one absolute choice. Different transport modes are complementary to each other and coexisting. Public transport is one of the modes people have chosen and this choice is a natural result of urban transport development.

The urban road system is the carrier of urban transport. Its primary objective is to meet the needs of the urban transport means and therefore realize the movement of people as quickly as possible. The primary goal of urban public transport should be to realize people's movement in a convenient, comfortable, quick and economical manner. The primary goal of urban transport enterprises should be to realize maximum economic, social and environmental benefits in the operation of transporting people and providing services of convenience, comfort, speed and low cost.

The primary objective of urban public transport enterprise reform should be as follows. In the operation of transporting people and providing services of convenience, comfort, speed and low cost, they should realize the unification of economic, social and environment benefits while adapting to the establishment of a market economy mechanism and the process of reform and development. Urban public transport facilities constitute the infrastructure for urban economy and social development. As a special form of service providing passengers with movement means, it creates benefits and values that permeate into all economic, sector and social development. While ensuring its overall social benefits, public transport enterprises must also realize economic benefits required for their survival and development.

"Realizing people's movement" should be the key starting point for studying urban development (including urban public transport). Research, design, construction and management must all revolve around this point. Any design, construction and management that deviates from this point of thought would be detrimental to the development of urban transport, and would produce great damage to urban development. Great attention must be paid to this point.

CHARACTERISTICS OF CHINA'S URBAN PUBLIC TRANSPORT ENTERPRISES

China's urban public transport enterprises were originally developed during the period of a highly centralized, planned economy system. In the *"Notice of the State Council's Approval and Distribution of the Working Report about Urban Public Transport Reform by the Ministry of Urban and Rural Construction and Environment Protection"* (State Document, No. 59, 1985), it is clearly stated that "[we will] change the 'sole ownership' operation system in urban public transport, and implement 'multiple economic elements' operation and unified management. [we encourage] the development of the collective and individual-owned operations while state-owned enterprises play the main role." On the basis of state-owned public transport enterprises (i.e., public bus, trolleybus, rail trolleybus, subway, ferry, etc.) and management organizations, there are now collective and individual-owned public transport enterprises, including individually owned taxis, etc.

China's urban public transport enterprises possess a strong social management function, which is the legacy of a long period of the planned economy system. During the formulation of policies concerning urban public transport, the state-owned public transport enterprises can participate and offer comments frequently. They also carry out certain functions in supervising and checking the implementation of administrative laws and regulations.

Services provided by the operation of China's urban public transport enterprises are neither complete public goods (i.e., products or services that individuals are not willing to produce or will not be able to produce, and are therefore provided by the government; they are characterized by their nonexclusiveness and noncompetitiveness in consumption) nor complete private goods (characterized by their exclusiveness and competitiveness in consumption). Services provided by taxis, minibuses and other intracity public transport sectors basically belong to the category of private goods. Enterprises providing these goods normally possess complete authorities on enterprises, and are able to operate completely in the market mechanism. Services provided by the urban public bus and trolleybus sector, rail transport sector and urban ferry sector are neither complete private goods nor complete public goods. They are indeed quasi-public goods, which are between the two polar cases. Consumers all intend to consume these public goods or quasi-public goods at no cost; that is, to obtain benefits without paying or paying less than the full cost. Actually, the market cannot be relied up for the production and consumption of these goods. Those goods are usually provided by the government. Moreover, those enterprises are not considered as complete enterprises.

The commercial benefits and social benefits are mixed together in China's state-owned urban public transport enterprises. On one hand, in order to realize overall transport benefits, the enterprises attract the public by offering lower-than-cost fares, of which the price does not reflect the cost; this is to realize the social benefits. On the other hand, they want to realize profits and seek funds for healthy self-development; this is, to realize the commercial benefits. The social benefits are placed over the commercial benefits.

China's urban public transport enterprises have a large volume of passengers and a high load factor and overload factor. Based on the urban nonagricultural population, one standard urban bus equivalent unit has, on a national average, 1,640 potential passengers daily; based on

urban public transport ridership statistics, a standard bus carries 686 passenger trips; in Beijing it is up to 1,195 passenger trips, and 1,172 in Shanghai, 624 in Tianjin.

China's urban public transport enterprises lack transport means of large capacity and exclusive rights-of-way. There are only a few subways with a total length of less than 70 km operating in Beijing, Shanghai and Tianjin. Only Shanghai is now starting to consider specially designated exclusive roads or lanes for buses and nothing has been done in other cities. Double-decker buses are operating on only a few lines in a small number of cities.

In China, there are no stable funding channels for public transport enterprises' facilities such as yards, stations, vehicles, etc. Their renovation and upgrading are not assured either. Vehicles operating with overload or beyond scrap years are a widespread phenomenon. Consequently, the operating speed is low and breakdown rate high.

China's urban public transport enterprises have a high worker/vehicle ratio and heavy burden. The national average of workers/bus ratio in 1994 for the state-owned urban public transport enterprises was 8.8:1 in cities; workers/trolleybus 9.5:1; workers/rail trolleybus 12.2:1; workers/metro train 42.4:1. The total salary accounts for about 30 percent of enterprises' costs. Salary, housing, medical care and other expenses for retirees are one of the main burdens to the enterprises.

Large losses have occurred in China's state-owned urban public transport enterprises. The total loss in urban public transport of the nation was Y 1.01 billion in 1994. That is Y 9,304 for a standard bus equivalent unit. The total government subsidies to urban public transport was Y 2.91 billion. That is Y 26,800 per standard bus equivalent unit. It was Y 120,000 in Beijing, Y 89,600 in Shanghai and Y 49,400 in Tianjin, respectively. Based on the year-end number of workers, the annual per worker subsidy was Y 14,700 in Beijing, Y 10,000 in Shanghai and Y 5,800 in Tianjin. In 1993, the average annual income of a worker in state-owned public transport enterprises was Y 4,984, Y 6,742, Y 3,256 in Beijing, Shanghai and Tianjin, respectively.

OPERATION MODELS OF CHINA'S URBAN PUBLIC TRANSPORT ENTERPRISES

The main operation models of China's urban public transport enterprise comprise: the three-tier contract responsibility system (company-subcompany-vehicle team); joint-operation company; foreign and joint-venture company; privately owned company; monopolized operation company; shareholder company; enterprise company; limited enterprise company, etc.

Three-tier contract responsibility system (company-subcompany-vehicle team). This is one of the main models of enterprise operation in bus, trolleybus, metro and ferry in big cities. Vehicle teams have contracts with subcompanies, subcompanies have contracts with companies, companies have contracts with the Public Utilities Administrative Bureau (the Urban Construction Bureau). The main content of a contract includes: fixed service levels and standards, which are not subject to adjustment; revenues in line with expenditures, no additional subsidies for more than targeted loss, no deduction taken for reduction in loss; strict control of costs with emphasis on fuel, parts, labor force and enterprise management cost; improvement in service standard, the check and evaluation of managers' fulfillment of responsibilities and targets in their service duration, the vehicle schedule, frequency of peak hour vehicles in operation, the

time of first and last bus operation, maximum headway in off-peak periods; allocation of transport capacity, dealing of passenger complaints, vehicle conditions and outlooks, and serious traffic accidents.

Beijing and some other cities have adopted the individual vehicle contract responsibility system within a vehicle team. That is, each group of crews has contracts with a fleet team; they submit all fare revenue to the fleet team, get rewards for fulfilling the base services and additional rewards for overtarget performance. The latter will increase proportionally and are distributed among the group members (the driver gets 35 percent and 30 percent each to two attendants); there is also a contract for fuel consumption, compliance with the contracted consumption level will be rewarded, and rewards for further saving is distributed within the group (40 percent to the driver, and 30 percent each to two attendants). There also exists a contract for certain operating lines and buses or for a certain period of operation time. Let's take the vehicle team of No 392/902 (Xizhimen-Qinghe in Beijing) as an example. During the before-and-after-work peak hours, they display the plate of No. 392 which indicates that monthly passes are valid during that period of time; the rest of time, the No. 902 plate is displayed and it means that monthly passes are not valid. The fare for one trip on the entire route is Y 0.6. The contracted base for fare revenue submission for an individual bus is Y 50 to Y 120 for one run.

This model was actually introduced during the transition from the planned economy to the market economy. It allows workers to take initiatives and the quality of services is thus improved as well. It, however, has many limitations: although income of workers is increased, the percentage of lossmakers and the total amount of losses keep increasing, the improvement of service quality is not institutionalized and is hard to get support from the improvement in facilities.

Joint-operation transport companies. Many of them are minibuses, taxis and regular buses. Parties providing capitals or vehicles only take part in profit sharing, but are not involved in the operation and services. The property rights of vehicles remain unchanged. Minibus companies usually are responsible for serving a few fixed operation lines. The joint-operation transport companies composed of a certain number of buses, and they usually organize and operate as follows. As organizers, the state-owned bus companies take the initiative and are responsible for coordination. They decide the operation lines, time and schedule of operations, number of bus runs, and fares. Fare revenue during peak hours normally belongs to each unit of the joint-operation company and is exempted from income tax. There is no financial relationship among the units of a joint-operation company, each unit is responsible for its own operation as well as the benefits and risks associated. These joint-operation companies in buses are quite numerous in Harbin and some other cities.

This model is actually a way to make use of society's idle vehicles and empty-hauls when the number of buses in public transport companies are short of needs.

Foreign and joint venture companies. Foreign investors provide all or part of needed capital and vehicles; either one side or both foreign and Chinese sides are responsible for management and operation as well as the profits or losses. Wuhan Hengtong Bus Passenger Service Ltd. Co. belongs to this model. Its distribution of profit is based on investment share (55 percent to foreign side and 45 percent to Chinese side). A flat fare is applied for operation, it is

Y 2 in summer and winter with air conditioning and Y 1 in spring and autumn without air conditioning.

Without a doubt, this model plays an important role in the initial period of establishing an operating system based on market economy principles and in the transition of public transport enterprises' organization. It will especially promote the establishment of a bus fare adjustment mechanism.

Social group companies. Usually enterprises and nonprofit organizations in society contribute funds to set up this kind of companies. There is a small number of cities (for example, Wenzhou) having privately-owned companies, of which many are in minibus and taxi services. Minibus companies operate along designated routes and on regulated prices, and are themselves responsible for profits or losses. They are also subject to passenger transport market management by the Urban Construction Department and other relevant departments. The operations rights are transferred through paid leases, which have to be obtained through open bidding.

State-owned companies. State-owned companies now carry the majority of the passengers. Because their operating routes, time and schedules and ticket prices are set by the Government, the Government, in principle, compensates their policy-induced losses.

The transport mode of state-owned companies plays an important and special role in China. Especially in large-volume passenger transport, individually owned enterprises' services are not sufficient. This is one of the aspects for which the Government wants to ensure public transport efficiency. Undoubtedly the Government has to give strong financial support.

Shareholder companies. This model has been in place in minibus and taxi operation. Some bus and trolleybus companies are also considering corporatizing into shareholder companies. This model is the result of establishing the market economy mechanism.

Industrial enterprise-sponsored companies. The development of vehicles running along special lines or for special purposes has increasingly taken on this model. Nonpublic-transport enterprises provide vehicles and public transport companies provide drivers and attendants; they operate along the routes as requested by the vehicle-providing companies; and the public transport companies are responsible for profits or losses. Enterprises in mining areas and suburban towns and other enterprises generally apply for bus operations of this nature.

Limited-liability enterprise companies. Under the franchise system, these companies operate independently, are responsible for profits and losses, and shoulder limited liability. Shanghai Shenxin Public Bus Limited Company started its operation in June 1995 covering 16 public transport lines including Xugang, Mingwu and Mingsong lines, which used to belong to the Shanghai Second Public Transport Company. The current situation is: Shanghai Public Transport Company provides 90 percent of the capital, the other 10 percent is contributed by Mingwu Public Bus Company, which was an employee shareholding company. The new company now is a Class A legal entity. It shoulders economic responsibilities as an independent legal entity. Its service covers the main industrial and residential areas in Mingxin County. It also undertakes passenger transport on the line from the city area to Songjiang. The municipal

government department concerned has granted the franchise to operate on these 16 lines to the company and no other company can repeat these lines.

This model is the result of urban public transport adjusting its operation to the market economy mechanism. Studies to identify and summarize successful applications of the market mechanism in this aspect are now underway. They will benefit future reform and development of urban public transport.

The coexistence of multiple models is a good start for gradually moving toward a market economy operating mechanism. It is of great importance for promoting reform and development of China's urban public transport sector and establishing an urban public transport market mechanism fitting China's characteristics.

ESTABLISHMENT OF A MARKET ECONOMY MECHANISM IN URBAN PUBLIC TRANSPORT ENTERPRISES

Internal reform of urban public transport enterprises must fit into China's overall reform and development framework and follow its general principles. The internal reform of enterprise must give answers to the employment system, price reform, diversified operations, and application of science and technologies.

The relationship between enterprises and the government. "*The Implementation Measures for the Transition of the Operating Mechanism of State-Owned Urban Public Transport Enterprises*" ask the Urban Construction Department and the departments concerned to change their functions based on the principle of separating government from enterprises, and carrying out sector management, providing enterprises with services, coordinating and supervising enterprises' activities according to existing laws.

In order to ensure the enterprises' property rights, the Urban Construction Department and its relevant departments must take on the following responsibilities: according to laws and due procedures, decide on or approve the appointment and removal (hiring or dismissing) of the enterprise manager as well as their reward and punishment; check and evaluate the reserve and growth of enterprise assets; audit and supervise enterprise financial positions, i.e., the liability and profitability. When enterprises are unable to repay their matured debts and meet the legal condition for bankruptcy, the Urban Construction Department and the relevant departments should conduct timely evaluations and report to the municipal government. If the municipal government decides that it is not suitable for the enterprise to go into bankruptcy, it provides financial assistance or adopt other measures to help the enterprise pay off its debts.

The Urban Construction Department must work with other departments concerned to strengthen macro control and adjustment to promote the development of urban public transport. They should formulate development strategies, guiding principles and industrial policies for urban public transport sector; make urban public transport plans and supervise its implementation; fit urban public transport development into the plan for national economic and social development; raise funds through multiple channels, and make full use of foreign and domestic loans to support the development of urban public transport; together with the price bureau, actively promote the price reform in urban public transport sector, adjust the public transport prices in a timely manner, and gradually form a rational price system and methods for

government subsidies; guide enterprises in restructuring to carry out personnel, labor and wage reforms; promote technology progress and undertake technical and professional training; provide enterprises with commercial information and advice.

The urban construction department and its relevant government departments should adhere to the principle of "comprehensive planning, unified management, operations based on multiple structure of ownership, and coherent development"; formulate effective measures and strengthen sector management; foster and improve development of an urban public transport market mechanism. They should normalize the urban public transport market through economic, legal and administrative means; establish and enhance a level field for competition and a unified market with sufficient and sound rules and regulations; encourage buses, trolleybuses, metro, light rail transport and ferry enterprises to play the mainstay role; make use of all international as well as domestic economic forces to develop public transport; implement a certification system for enterprises and individuals involved in public transport operation; maintain normal operation orders of all kinds of transport modes; strengthen the management of paid lease and transfer of minibus and taxi operation rights, and subject the so-generated revenue to local government's ex-budgetary management and channel most of the revenue into the development of urban public transport; establish a franchise system for operations on public transport routes and lines, make detail implementation plans, and specify the franchised operators' rights, duties and legal responsibilities.

Granting full autonomy to enterprises is the key to vitalize state-owned urban public transport enterprises. *"The Implementation Measures for Change of Operating Mechanism in State-Owned Urban Public Transport Enterprises"* stipulates that enterprises adhere to the state-defined assets management and operating forms, and make full use of their operation rights according to the law.

Enterprises have decision-making power in production and operation. Buses, trolleybuses, and light rail transport enterprises must operate along routes and lines designed and designated by the Government, and carry out its passenger transport plans. Enterprises have rights to set prices for transport fare, products and services. The transport operating costs of an enterprise should be calculated based on relevant government regulations and rules; pricing of transport operations should follow the principle of "recover the cost and make a marginal profit" and within the government-supervised and controlled range; prices have to be approved by the local government before their implementation. Enterprises have rights to ask the government to give compensations for policy-induced losses. Enterprises have rights to make investment decisions. Urban bus, trolleybus, metro, LRT and ferry transports are mainly government-run businesses. Enterprises have rights to use the retained funds; to manage and dispose of assets; to hire and fire workers; to undertake personnel management; to decide and distribute wages and bonuses; to set up internal organizations.

Enterprises currently have not made full use of their rights, which are clearly defined by the Government as stated above. With the market economy development, the relevant government departments are actively creating favorable conditions to give free rein to enterprises' initiatives.

To seriously fulfill enterprises' duty is the key to improve the quality of urban public transport services. "*The Implementation Measures for Change of Operating Mechanism in State-Owned Urban Public Transport Enterprises*" stipulates that: with state assets of which the government conferred to a certain enterprise to manage and operate, the enterprise shoulders civil responsibilities. If an enterprise's loss is caused by its mismanagement, the government will handle this enterprise with regulations and rules pertinent to a mismanagement-caused lossmaker. If a state-owned urban public transport enterprise is making policy-induced loss because it tries to realize the social benefit targets required by the government, the government should then give subsides to this enterprise. However, the loss caused by mismanagement should be separated from the policy-induced loss and be handled according to regulations for mismanagement-caused lossmakers. Complying with the rules and regulations formulated by the urban construction and the relevant government departments, enterprises should provide passengers with transport services of safety, on-schedule, convenience and economy. Normal operations cannot be stopped without the approval from the urban construction and the relevant government departments. Enterprises must set up the restraint and supervision mechanism for income distribution. Enterprises must vigorously comply with the laws and regulations in government finance, taxation, and state assets management. They should make inventory and have auditions on a regular basis.

The government has clearly stated that the responsibility of state-owned urban public transport enterprises is to vitalize urban public transport enterprises and improve the quality of urban public transport services. The urban construction and other relevant government departments should strengthen effective supervisions through all kinds of measures.

SUGGESTIONS FOR THE FRAMEWORK AND PRINCIPLES FOR CHINA'S URBAN PUBLIC TRANSPORT REFORM AND DEVELOPMENT

We should clearly understand that urban public transport is a basic sector that has an overall and guiding influence on national economic development, and position it appropriately. We should adhere to the principle that urban public transport should be run mainly by the Government while developing and improving urban public transport, and providing gradually improved social services. Meanwhile, we should introduce the competition mechanism, and mobilize all resources from the local, the government functional departments and collectives to develop urban public transport under the principle of "unified planning and unified management."

Adhere to the principle of different guidelines and treatment to different modes of urban public transport. Urban bus, trolleybus, rail trolleybus, LRT, metro and ferry services should be mainly run by state-owned enterprises; taxi, minibus and other urban public transport should involve both state-owned enterprises and private sector under unified planning and management; an adequate market operation mechanism should be established.

Within the range of state-controlled prices, the state-owned public transport enterprises should follow the principle of unifying social, environment and economic benefits. Provided that maximum attraction to passengers is ensured and different situations are taken into consideration, we should gradually establish a price and value compensation mechanism that will promote a sound development of urban public transport.

Make use of financial, taxation and other economic means to support the urban public transport development. In allocation of foreign and domestic loans, priorities will be given to key projects such as LRT, metro, exclusive busways and bus lanes, parking lots and garages, etc.

Strengthen the formulation of a legal system governing urban public transport. The formulation of relevant laws and regulations should be accelerated, sector management be enhanced, adequate regulations and rules be set up to induce the public transport enterprises' behavior and the market's behavior to follow norms. Enterprises must conduct business according to the laws and regulations; and the relevant line bureaus and departments carry out their administrative duties and supervision based on the existing laws, in particular, the supervision of minibus, taxi and other urban public transport enterprises' market behavior. For the latter, the relevant government departments should focus their management and supervision on the two ends; that is, the evaluation and certification of qualifications at the establishment of an enterprise; and the supervision of service quality.

Strengthen the planning and management of urban public transport. Development priorities should be selected in accordance with national industrial policy and based on local specifics. In particular, the development of urban public transport with large capacity should actively promoted, and routes and lanes for the exclusive use of public transport means be developed. Cities with more than 2 million population should consider the development of LRT and metro systems. Emphasis should be put on the establishment of a comprehensive and sound urban public transport mechanism, which will be guided by the principle of "unified planning and management, and a coordinated arrangement" and benefits a balanced development.

Promote the role of science and technology in urban public transport development. The research and development, and the choice of models for vehicles used in urban public transport, should be based on new science and technology as well as new ideas. Analysis and designs using computer simulation of dynamic models should be introduced into the professional planning of urban public transport, urban public transport networks, and the structure of public transport, etc. In the formulation of an overall urban plan, especially the urban layout, large-scale public facilities and urban transport development strategies, due attention should be paid to the overall efficiency of urban public transport regarding the time, economy, environment, society and other aspects.

We should give full consideration to nonmotor vehicle transport, especially the importance of bicycle transport, which is a special feature of China. Realizing the fact that China is a country with a large population and high urban population density, many systems and mechanism needed for her urbanization are still far from fully established. The standards of road system and public transport services are not high enough. We should, with all precaution, gradually reduce bicycle ownership and the ratio of bicycle usage; lower the bicycle travel distance through the development of public transport; and induce bicycles away from roads used by motor vehicle through road traffic channeling and exclusive bus lanes. It is not appropriate to forcefully restrict bicycle transport using administrative orders. Nonetheless, we could propose policies to restrict bicycles before public transport is fully developed.

We should uphold the idea that the objective of urban public transport is to realize people's movement efficiently, and the development of different transport modes must take into

consideration of passengers with different income levels, especially the welfare of low-income people. This principle must be adhered to in research, design, policy formulation, implementation, operation, management and other matters.

There should be effective separation of owners' rights and management autonomy. The state-owned urban public bus, trolleybus, rail trolleybus, LRT, metro, ferry, taxi, minibus and other assets of enterprises are state property. Enterprises carry out the operating rights according to the state-stipulated assets management norms. On behalf of the state, the urban construction and the relevant departments are responsible for the coordination, supervision, and sector management of enterprises.

Enterprise owners should undertake effective supervision and management of enterprises. The urban construction and the relevant departments audit and supervise the financial positions, mainly assets, liabilities and profits/losses of bus, trolleybus, rail trolleybus, LRT, metro, ferry, taxi, ferry and other state-owned urban public transport enterprises. They appoint and dismiss or dispose of enterprise managers, and decide the pertinent rewards and punishments according to the existing laws. We should establish a qualification certificate system for enterprise operations, formulate as well as effectively implement standards for public transport services; establish a system of "awarding the excellence and punishing the shortfalls" in public transport services; uphold the principle of fair competition in awarding operation rights of state-owned minibuses and taxis through open bidding, paid lease and transfer; adopt the franchise system for public transport lines, and let competition stimulate the development of public transport.

Strengthen the enterprise internal management mechanism. The market competition mechanism should be introduced into employment, wages, rewards, services and the system reform of enterprises. Enterprises should set up standards for services, use small cost accounting units and contract system for effective cost control. A mother company should require her subsidiary companies and vehicle teams to adopt a complete and independent accounting system. The mother company must strengthen her functions in the administration and decision-making, the appointment and disposition of managers, planning of networks; coordination and supervision. She should reduce the staff/vehicle ratio; introduce automated ticket sale; establish a system of comprehensive and sound service standards; enforce strictly the evaluation and inspection system; reward model units and worker for good services; separate the policy-induced (lower-than-market ticket prices) loss from the mismanagement-caused loss. At the mother company level, it should set up special funds for retirees' pension insurance, and special funds for workers' welfare, housing, medical care, etc.

While doing research and studies on China urban public transport development strategy, we should also identify and outline the key technology policies for China's urban public transport. While learning other countries' experience, the formulation of an individual city's key technology policies for urban public transport should take into consideration both the nation's as well as the city's specifics, such as the travel pattern, urban layout, transport structure of the road system, economic and social environment, and the development of science and technology. These policies will be used to guide a healthy development of urban public transport. At present, the prior position of urban public transport should be recognized, and the research should focus

on "urban public transport priorities." Studies should be carried out to identify and outline the contents and implementation measures of these priorities.

Set up urban public transport development funds. In the short run, we should look at the following resources: the central government-controlled and allocated public transport investment grants; the urban construction maintenance tax; the municipal public utilities comprehensive development fee; all kinds of raised funds; foreign and domestic loans; depreciation of fixed assets; government investment (increasing every year) in facilities; the revenue form urban comprehensive development and other financial resources. In the long run, we should stabilize the investment channels for urban public transport, the investment should be around 1 to 3 percent of the urban gross domestic products.

Set up the Advice and Appraisal Commission for Urban Transport Planning, Construction and Management. They will give advice and be responsible for the appraisal and evaluation of urban transport plan within the urban master plan. They will guide and coordinate the concerned departments in the formulation of a comprehensive urban transport plan, and in construction, management and supervision. Serving as advisor and helper to the municipal governments, they help ensure the implementation and improvement of the comprehensive urban transport plan.

THEME PAPER 8: OPTIONS FOR BUS TRANSPORT: OVERSEAS EXPERIENCE

JOHN FLORA [1]

Summary

In most Chinese cities, buses do not have as large a role in the urban transport system as in other parts of the world. Whereas buses typically account for between 40 and 80 percent of the trips in most other countries, only 6 to 25 percent of trips in urban areas in China are made by bus. This is due primarily to past settlement patterns, the relatively short trips, and the government policy to promote bicycle use. Urban areas are growing much larger, however, and as the Chinese economy continues to grow, many people are seeking economic, social, and educational opportunities farther from their homes. As trip lengths increase, people are spending much more of their time commuting, which ultimately affects productivity and the quality of life.

This paper, "Options for Bus Transport: The Overseas Experience," outlines lessons learned and the experiences—both good and bad—that other countries have had in developing their bus transport systems. While every country has unique challenges that may preclude the direct transfer of practices, the experience of others often provides insight into appropriate policies and strategies, and provides a basis for comparison. The following summarizes the results of a review of worldwide experience, which has resulted in efficient and cost-effective bus service:

- **Local Control**. Local governments should determine the level of standards, fare, and operational procedures most appropriate and acceptable to their community. Likewise, responsibility for financing bus services should also rest with the local government. If the decision is made to subsidize fares, then appropriate sources of revenue should be developed at the local level.

- **Separation of Administration/Regulation of the System, and Operation of the System**. Those systems in which the government is both owner, administrator, and the operator of the services have been shown to be more costly and often less efficient. Government's primary role should be to plan, coordinate, and regulate the provision of services. The operation of services is best done by private-sector concessions, or autonomous, commercially-operated publicly owned companies.

- **Transition to More Efficient Operations**. Many large government-owned companies have made the transition to greater cost-effectiveness and efficiency

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through a series of steps: (a) legislation to provide greater local government control, and local enabling legislation; (b) establishment of regulations and operating procedures, and creation of profit centers within the government-owned company, which allows operational autonomy and accountability; (c) concession to the private sector of part of the operation (various activities or routes) of one or more of the profit centers to gain experience and establish workable contract procedures; (d) concession of all operations to the private sector. Throughout this procedure, local government has maintained a role of coordinator and regulator of services.

- **Fare Levels and Subsidies**. Bus fares should be developed to promote and support local economic, transport, and social policies. Many of the world's most successful systems recover all costs from the farebox and no subsidies are provided by government. In those cases where government feels it should subsidize public transport to assist low-income segments of the population, or to promote public transit use, means of subsidy need to be developed that reach the targeted group, do not provide disincentives for efficient operation, and are affordable to society as a whole. If subsidies are provided, other sources of revenue such as special taxes should be developed at the local level to finance the subsidy.

- **Transportation Systems Management**. The transportation system should be managed to emphasize the movement of people, not vehicles. Those means of transport that can accommodate the demand for accessibility most efficiently should receive priority. Efficient use should be made of the infrastructure network by construction of any missing links, providing safe movement for pedestrians and bicycles as appropriate, and ensuring integration between the transport system and land use development. The use of street space should be organized, and conflicts reduced through the implementation of policies, regulations, and actions such as computerized traffic signals, restricted turning movements and parking, channelization and regulations to separate conflicting movements, and appropriate geometric design. Priority should be given to bus movements, and where warranted, exclusive lanes and roadways made available in high-demand corridors.

Role of Buses in the Urban System

Accessibility to jobs, social services, education, and cultural opportunities is essential to economic growth of a community and the social well-being of its citizens. In smaller communities, the distance between home and work, school, or shopping tends to be relatively short, usually within 5 or 6 kilometers. Walking and other forms of individual transport such as the bicycle provide adequate levels of access except for the aged and infirm. As urban areas continue to grow, however, and economies improve, journeys tend to become longer and more frequent. Individuals spend much more of their time commuting. While many cities try to practice efficient land use planning, combining residences, jobs, schools, commercial and health services in close proximity to one another, actual experience in most parts of the world has indicated a need to provide effective transport systems, which enable citizens to take advantage of opportunities that may not exist within their communities. Without efficient public transport, the competitiveness of a city's economy suffers due to the adverse effect on labor availability, and individuals spend much more time and money commuting.

This is happening now in China as urban areas are spreading outward, new factories are opening across town, and people living in the rapidly expanding suburban areas come to the city center each day to take advantage of the many amenities and service jobs available there. While walking and bicycles have traditionally been the primary modes of transport in Chinese cities in the past, accounting for over 60 percent of trips in large cities like Shanghai and Guangzhou, and over 90 percent in smaller cities, the need for improved public transport service is becoming evident as the trips increase and journeys become longer. This is not unusual and mirrors experience in much of the rest of the world.

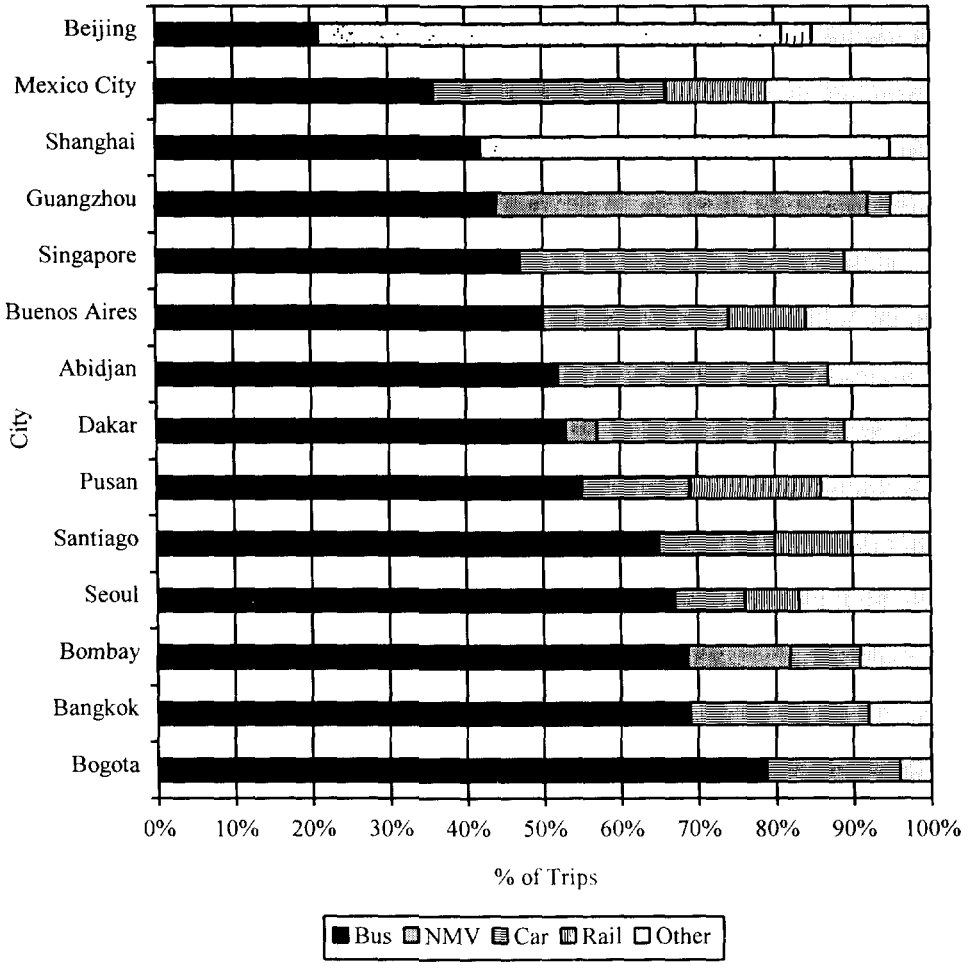
While most transport systems are made up of many modes—walking, bicycles, bus, trains, autos, boats—buses form the backbone of most urban transport systems. With the exception of some automobile-dominated cities such as Los Angeles or Detroit in the United States, buses are typically the most important form of transport for trips in excess of approximately 6 kilometers. Buses are an affordable means of transportation, and provide a high degree of flexibility and convenience ("door-to-door" service) when compared to other means of mass transport. They are relatively easy and inexpensive for government planning bodies to organize and implement, and are amenable to operation by the private sector, competitive practices, and changing conditions. Through appropriate management, they can efficiently carry as many as 20,000 passengers per hour in high-demand corridors, or can serve sparsely populated areas cost-effectively. They also play a major role in providing access to and integration with high-volume transport modes such as suburban trains and metros. They often receive less attention because they cost less, and may be operated by many different companies, but they are truly the "workhorse" of the transport industry. Figure 1 indicates the modal split in various cities of the world, and the role buses have in providing access to economic and social opportunity.

At the present time in China, however, buses are not providing the same levels of service as can be found in most other parts of the world. In the medium-size cities such as Chengdu and Jinan, buses carry only 10 to 13 percent of the trip demand, and only about 25 percent in larger cities such as Shanghai and Guangzhou. Of particular relevance is that despite these low levels of use and increasing trip lengths, ridership is actually decreasing in many cases. The reason cited by many potential users is the lack of reliability of service and the delays encountered when riding the bus. Traffic congestion is increasing rapidly in many Chinese cities and buses must compete with bicycles, pedestrians, automobiles, and vendors for road space. Bus speeds in many cities are less than 10 kilometers per hour, and long waits for the next bus are common. Lack of equipment and spare parts make many bus fleets inadequate to provide the necessary service. Consequently, people continue to use less efficient forms of transport, which leads to more congestion and further deterioration of bus service.

As mentioned previously, the bicycle is a key element in the Chinese transportation system and should remain so. It is the most efficient mode in terms of short trips and as a means of getting to and from high-volume mass transit systems. At present, however, uncontrolled use of available street space by bicycles is discouraging the use of buses. In corridors with high demand, this is an inefficient use of road space inasmuch as the capacity of a traffic lane devoted to buses is much higher than one devoted to bicycles. Bicycles are and should remain an important element in the transport system, but it is necessary to develop appropriate policies toward the use of bicycles and, in high-demand corridors, provide appropriate separation

between bicycles and motorized transport. The role of the bicycle in urban transport and planning and design criteria will be further discussed in Paper 9: *Treatment of the Bicycle.*

Figure 1: URBAN MODAL SPLITS



Effective traffic management is another key to realizing the efficiency of buses. In addition to uncontrolled usage of street space by bicycles, China is beginning to experience rapid rates of motorization. While levels of car ownership and usage have not reached crisis proportions as yet, ineffective management of the street system is already producing unacceptable delays for bus operations. Freight movements, automobiles entering and leaving the roadway at any point, frequent turning movements, unrestricted parking, poorly timed traffic signals, geometric design that is no longer suitable for conditions, and conflicts between fast- and slow-moving traffic and pedestrians all contribute to congestion, slow bus speeds, and consequent poor utilization of buses.

Organization of Bus Transport

The organization of bus transport takes many different forms around the world, and there is no single system that can be taken as the ideal model for all cities. The optimal organizational

structure must be suited to local conditions, attitudes, objectives, and resources. There are several basic principals, however, which seem to be associated with the most cost-effective and efficient systems. First among these is the need to separate the operation of the services from the administrative and regulatory functions and the need for local control.

There is inherent conflict of interest in having a single entity as the owner, planner, regulator, and operator of a bus company. The primary role of government is to represent the people's interest, and protect the public welfare. With respect to bus services, this means the creation of an environment that allows and assures that adequate and efficient service is provided at affordable rates. Government's primary role should therefore be strategic planning, setting standards, and appropriate regulatory regimes. The actual operation of services should be carried out by separate autonomous entities operating under commercial conditions.

At the present time, urban bus operations in China are owned, managed, operated, and regulated by municipal authorities. Standards, operational parameters (that is, staff per bus, etc.) and fare levels are generally prescribed at the national level. Innovative practice and efficiency gains based on local conditions are difficult (often discouraged) and the conflicts presented when the regulator of service performance is also the operator contributes to deteriorating service. While different forms of ownership exist in various countries of the world, those bus systems operating most efficiently have one thing in common: (a) local control of operational parameters and fares, and (b) autonomous operating entities separate from the planning/regulatory function. Some insight may be gained by examining international experience and the more successful organizational arrangements.

Private Sector Operation. While ownership and organization take many different forms, the most cost-effective and efficient—measured in terms of levels of service and cost to government—are those where government provides strategic planning, sets the standards of service and regulates compliance, and the private sector provides the service. Private-sector companies, route associations, or individuals own the buses and bid for the right to provide bus services within specific areas or routes within the urban area. Hong Kong, Singapore, Seoul, Korea, cities in England, as well as most all major cities in Latin America are typical examples of this type of arrangement.

The benefits of involving the private sector derive primarily from the private sector's incentive to reduce costs and increase income—thereby maximizing profits—and access to private capital. While sometimes there are efficiency gains from more skilled management, this is not necessarily the case. Public officials are often equally capable, if not more so, than their private-sector counterparts. Bound by public regulations and procedures, however, as well as no tangible reward for innovation or service improvement, the public company does not have the same incentive to increase ridership and income by being more attentive to customer demands or institute cost-saving procedures. In fact, the reverse is often true; efficiency gains could threaten the jobs of employees. Cumbersome bureaucratic procedures, originally developed to protect the public, quite often become barriers to efficient procurement and operation. Public companies also, over time, tend to have many more employees than is necessary to run an efficient operation and usually it is very difficult to reduce their number. Employee costs are a major problem for government-owned Chinese bus companies due to general overstaffing and because they must bear the financial responsibility for the social programs and costs of retirees.

Another major benefit is the access the private sector has to financial resources. Municipal companies usually must rely on government budget allocations to buy new vehicles or spare parts, as well as the construction or repair of terminals and stations. Consequently, in times of reduced budgets, no replacements can be financed and service deteriorates. Availability of financial resources for the private sector is more related to direct income, and contracts are more likely to be honored between government and the private sector than between two government agencies. Boxes 1 and 2 describe typical private sector operations in England and Brazil.

Box 1: Urban Bus Services in the United Kingdom

Prior to 1985, all UK urban bus service operations were publicly owned and planned. Since that time the situation has changed dramatically. The private sector has been introduced. Government subsidy has been reduced in all areas, though both the form of competition and the effects of competition have differed between London and the rest of the country.

Outside London. The major changes were introduced in the 1985 Transport Act. Free entry was allowed for all operators, the publicly owned companies were corporatized and gradually privatized, and labor regulations were relaxed. Regional public planning authorities retained the residual role of planning and contracting for noncommercial, socially necessary services.

Since 1985, bus-kilometers operated have increased, on average, by 24 percent, costs have fallen by 28 percent, and passenger-kilometers traveled have fallen by 27 percent. Prices have consequently risen a little in real terms despite the reduction in real costs. The reduction in bus patronage continued, at a slightly reduced rate, the trend of the previous decade. Most significantly, government subsidy has fallen by 55 percent. The main problem has arisen in the larger metropolitan areas where freedom of entry and exit of private-sector operators has entailed some loss of integrated information and ticketing, and some instability of service have caused rather more patronage loss than might have been expected on the basis of the price and service quantity changes. These adverse effects appear to have been avoided in London, where a slightly different competitive system applied.

London. Following the London Transport Act of 1984 private-sector operators were gradually introduced through competitive tendering (at gross cost, with fares set and revenues retained by the planning authority). Initially public operation continued, through subsidiary "arm's length" companies, though in 1994 these were also privatized. All routes (including service levels) are now planned publicly and operated privately. In most cases, these are under three-year competitively bid contracts. Those routes that had not been placed for competitive tender before last year's privatization, are now operated under negotiated net cost contracts (that is, the private operator retains fare revenues). It is planned that all services will be operated under competitively bid, net cost contracts from 1998. Performance measurement is used to ensure that service quality is maintained.

Under this regime, bus mileage operated in London has increased 20 percent, the cost per bus-mile has fallen 40 percent, and total network costs have fallen by 27 percent. Passenger journeys have increased by 0.5 percent, in contrast to a preceding period of steady decline. Above all, real government subsidy has been reduced by 80 percent. Competitive franchising can thus reduce costs of operation and fiscal burden without losing the benefits of network integrity and intermodal coordination in large metropolitan systems.

Box 2: URBAN BUSES IN CURITIBA, BRAZIL

The urban bus system in Curitiba is one of the most efficient and cost-effective in Brazil. While recent performance improvements have in part been due to a combination of well-chosen transportation and land-use planning decisions, one of the most important changes has been the elimination of municipal involvement in the provision of passenger services. Instead, over the last two decades, Urbanizacao de Curitiba (URBS) has evolved itself from the role of service provider into a regulatory body responsible for system administration and planning, as well as property management for publicly owned transportation infrastructure.

Private bus companies in Curitiba operate under parameters established by municipal decree in 1987. In place of the previous systems of territorial concessions, the decree established a system of permissions, which reimburse bus companies subject to the number of scheduled kilometers that they actually travel. A simple two-page document sets out the basic legal framework and standard form for all permissions, with fares calculated based on URBS experience and private firms' operating costs, including both those that vary with kilometers traveled (maintenance costs, personnel and administrative costs) and capital costs.

Currently there are 10 bus companies operating specified routes in Curitiba, with companies tending to concentrate their routes in certain areas of the city. Some routes are shared, especially central area routes, interdistrict routes, direct routes, and certain express routes that serve more than one area of the city. Classification of companies and consequent assignment of routes is done according to the size of bus fleets, with the largest bus companies operating over 200 buses and the smaller ones around 50-60 buses.

The expansion in ridership and capacity after privatization has been dramatic. In 1974 the first of the cities express buses operated along two arterial routes and carried 54,000 passengers per day. By 1982, the existing system of five structural roads carried approximately 400,000 passengers per day. Today, after improvements in fare collection and distribution, vehicles, and route extensions, the system transports more than 1,000,000 passengers per day at cost and service levels that have outstripped other large- and moderate-sized Brazilian cities.

Commercial Operation of Government-Owned Companies. An alternative arrangement can be found in many cities in which the government is the owner of the company providing the bus services. Toronto, Canada and most major cities in Germany (Box 3) are examples of this arrangement in which an independent Transport Authority—or Government Corporation—is created by legislation responsible for providing transport services. While different forms exist conforming to the laws of each country, the Authority has its own board of directors, and has legal authority to borrow and act independently. It has its own budgeting, accounting , and auditing responsibilities and is usually financially independent of government except for the possibility of capital contributions. Government control, however, is often exercised through the appointment of government officials to the board of directors. Often this Authority is responsible for all forms of public transport (bus, tram, rail) and is charged with coordination and integration of services, fare integration, and investment.

The actual services are typically provided by separate operating companies managed independently from the Authority on a day-to-day basis under contractual arrangements with the Authority. Although levels of service are good under these arrangements, the cost to government per passenger-kilometer is typically higher than in those systems where the private sector provides the operation. Despite well-qualified staff, the incentive for cost-cutting efficiency and responsiveness to changes in demand are not as evident in government-owned operations as in

those provided by the private sector. By having several operating companies, however, management in the Authority can compare performance among the various operators. On-time performance, utilization of buses, number of buses available for use each day, and other performance parameters can be compared to stimulate more effective management.

Box 3: THE BUS SYSTEM IN WUPPERTAL, GERMANY

Wuppertal's bus system is owned, planned and operated publicly, by Wuppertal Stadtwerke AG (WSW AG). The company was reorganized in 1993 to reduce costs and improve service efficiency. WSW AG operates 250 buses and 28 tramcars, employs 1,400 people, and carries 87 million passengers each year.

Passenger demand has increased by around 40 percent over the last five years, leading to service expansions, and higher net costs. The city of Wuppertal has been under financial stress and was not able to absorb these higher transport costs. Hence, WSW AG looked to the 1993 reorganization to reduce costs, without reducing performance levels or quality of service, to increase revenues in the traditional areas of business, and to enter new fields of activity to generate new revenues.

Cost Reduction. Cost reductions were achieved by rationalizing the management structure. At the same time, the workforce was reduced by 10 percent, through early retirement schemes and a hiring freeze. Profit centers were introduced, with clear business mandates and budgetary responsibilities. Internal contracts were established between the profit centers, to increase the downward pressures on costs. A 5 percent reduction in the reserve fleet, made possible by the improved maintenance efficiency, illustrates the success of this strategy. Route-level accounting was also introduced to enhance both planning and management.

Increasing Fare Revenues. Fare levels are controlled by the regional transport authority and, hence, to increase revenues WSW AG must carry more riders. Given the need to reduce costs, the new riders must be attracted in the off peak, when spare capacity is available without increasing service levels. A 1994 marketing campaign helped to produce a 7 percent increase in passenger numbers.

The budget deficit has been reduced, from DM 102 million in 1993, to a predicted DM 97 million in 1995, while increases in service have continued (6 percent increase in vehicle-kilometers in 1993 and 3 percent in 1994.)

Under this arrangement, it is necessary to develop performance contracts between the Authority and the operating companies. At the beginning of the fiscal year, contracts are agreed between the Authority and the operating companies that provide complete details regarding the objectives of the contract, and obligations and terms and conditions regarding performance for each party. The operating company commits itself to provide agreed levels of service and appropriate maintenance under a specified budget. The Authority agrees to provide, if necessary, financial payments to support social objectives of the community, which may preclude full cost-recovery, or to assist with the capital costs of equipment and facilities. While, in theory, this system should prove effective, there have been mixed results. In times of particular budget constraints, the government, through the Authority has not provided the financial support to which it agreed, or did not do so in a timely manner. In these situations, the operating companies have no real recourse except to cut maintenance and services and a spiral effect begins that ultimately leads to overall deterioration of service. Although the public suffers, the service companies cannot ultimately be held accountable for poor service. The opposite is also true.

The operating companies may, because of management, planning, or lack of incentive, not be providing the levels of service to which they have agreed. The Authority does not usually have the recourse of canceling the contract and choosing another provider; they must continue to work with the government company. They can withhold budget transfers but this typically causes service to deteriorate further. Once again, it is the public that suffers. In general, performance contracts have worked only where there are incentives for management and personnel to meet contracted expectations, and where the performance of the parties is not dependent on the performance of other governmental bodies.

Combination of Public and Private Operations. Some cities tend to combine the two systems. In France, municipal and regional authorities are responsible for planning and coordination of urban transport services, setting bus fares, and assuring proper levels of service (Box 4). While some of these authorities operate their own bus fleets, most contract with the private sector to provide bus services under contracts that specify the routes, frequency and other standards of service, and fare levels. Consequently, there is greater recourse for the public Authority in the case of nonperformance by the operator (the contract can be terminated and another contractor hired). In Sao Paulo, Brazil all services are provided by the private sector under concessions from the municipal government with the exception of one government operating company. After several years of losses, this government company has just signed contracts with the private sector to provide the services for which it is responsible. Not only is it no longer losing money, it is making money by leasing its buses to the private sector. Under this form of organization, however, the incentive for innovation and quick response to changes in public demand is less than in the "private sector" example cited in earlier paragraphs due to the level of government control over routes, fares, and service standards, and the financial nature of the contracts.

Transition to More Efficient Operation

As previously described, international experience indicates that the old model of a government-owned and operated bus system is neither cost-effective nor, more importantly, does it provide the levels of service necessary to support the economic growth and social requirements of a community. Those systems that seem to provide the best service at the least cost to government have ultimately been developed around the model where the government's role is that of strategic planner, coordinator, and regulator, and the private sector is responsible for the actual operation of services under minimal regulation and in a competitive environment.

In some cities—for example, Santiago, Chile, cities in England, and Buenos Aires, Argentina—this organizational change was made all at once. As a result of deteriorating service and continued losses, the public bus company ceased operation, and concessions were awarded to competing private sector operators to provide the services under various degrees of regulation by the government. In several cities, however, a more graduated approach has been adopted.

Box 4: Organization of Urban Mass Transport in France

In the early 1970s, after decades of vacillating between state and private ownership of urban mass transport operators, France introduced a new organization for this sector, featuring decentralized decision-making, locally generated finance, and private sector operation. The key sectoral institution is local transport authority (TA), made up of elected officials from constituent municipalities. TAs have jurisdiction for all mass transport matters in a given city, owning mass transport vehicles and infrastructure, and deciding on service routes, frequencies and fares. Actual mass transport services are provided by specialized operators, working under contract with TAs, awarded following open competition. Operators are mainly private firms, but can also be in mixed-ownership, involving various private operators and interests, but keeping the TA as a majority stockholder. The relations between operators and labor unions are defined through collective contracts. The mass transport industry has a high degree of concentration, with about 75 percent of the market in cities outside Paris held by subsidiaries of three holding companies (VIA-GTI, CGEA, and TRANSDEV). Early contracts featured fixed remuneration per vehicle-kilometer of service supplied, or negotiated management contracts, with most commercial risks taken by TAs. The current trend is for operators to take on increasing levels of risk.

In the aggregate, fare revenues of mass transport operators in France cover only about 50 percent of their operating costs, reflecting a public policy of slowing down the loss of passengers in favor of the private car. The balance of operating costs is made from the proceeds of a special local tax ("versement transport"), levied on the wage bill of local firms employing more than nine staff. A national law defines the principle of the tax, and sets a range of rates from which local TAs can choose the rate to be applied in their city, in accord with financial needs of their mass transport system. Discounts for low-income or handicapped citizens are decided by local governments and financed from their budgets, independently of operators.

Except in the Paris region, the National Government of France does not provide any operating cost subsidies for urban mass transport. It does provide capital subsidies, however, whenever the project in question represents a major expansion. This has so far taken place in some 10 large cities, typically for new metros or light-rail based lines. In return, the cities in question had to ensure that their unimodal transport plans were integrated into a common framework. The new rules, adopted in 1994, vary the amount of subsidy depending on the project type, with 30 to 35 percent rate for at-grade mass transport projects, 25 percent for elevated sections, and only 20 percent for underground sections.

In some cases, the first step was to separate the operations from the establishment of standards and regulation of compliance with these standards. Toronto, Canada is undergoing such a transition now. Public transport in Toronto is provided by the Toronto Transit Commission (TTC), a wholly-owned government corporation responsible to the Metropolitan Toronto Council. TTC operates trams, light rail, and metro services in addition to bus services. The buses carry approximately 200 million passengers per year with a fleet of approximately 1,800 vehicles. They are now separating the company into separate operating companies, each managed and operated independently. TTC will maintain administration and coordination of the system, continue to establish objectives and standards, and audit the accounts of the individual companies, but day-to-day operation including purchasing and maintenance arrangements, budgeting and accounting will be the responsibility of the operating entities. The bus operation will be divided into several operating companies assigned to various areas of the region and will operate under performance contracts agreed with TTC. The individual companies will have the authority to vary service frequencies and routes in their service area based on demand within the parameters of their service agreements. This separation of the operating companies begins the first step in more a commercial orientation.

The next step, as has already been taken in several cities in Canada, the United States, New Zealand, Latin America, and France, is to begin to contract certain services being provided by the operating companies to the private sector. Major rehabilitation, user surveys, training, and maintenance of facilities are candidates for contracts to the private sector. This reduces the administrative workload, overheads, and employee costs that, due to various pressures, can be quite substantial. In some instances the operation of certain routes can be contracted to private sector suppliers, or (as is being done in Guangzhou) joint ventures can be developed with the private sector for the provision of some services. Special services such as air-conditioned buses, express routes, and facilities for the handicapped can also be contracted to the private sector.

This provides an opportunity to assess the performance of the private sector and develop and refine procedures for activities in which a public company may have little experience. These include procurement through competitive bidding processes, development and administration of contracts, and regulation of commercially-oriented entities. This will be discussed further in this paper, but it is important to recognize the difficulties inherent in these activities, and this transition can provide valuable experience.

The third step in this transition process would be the ultimate concession of all operations to the private sector. Government would retain control through the establishment of standards, coordination, and regulatory mechanisms, but the operation and maintenance of buses would be the responsibility of the private sector. Private-sector operators would be selected using competitive bidding practices and regulated through provisions in their contracts. The experience of those cities that have adopted this system indicates two important points: (a) a minimum amount of regulation is needed to maintain social objectives; and (b) several operators should be contracted in order to foster competition, enable comparison of performance, and maintain acceptable levels of service. Buenos Aires, Argentina, Santiago, Chile, Hong Kong, Seoul, and Singapore provide good examples of cities with bus services provided solely by the private sector under license to the government (Box 5).

The provision of competitive services through route franchising requires that substantial skills be exercised by the government in designing networks and bid documents. Franchises should contain a clear specification of the service to be provided, including details of monitoring and enforcement procedures, the terms of remuneration for the service supply and the penalties for nonperformance (specified in a form that is capable of being legally enforced). Safe and environmentally acceptable operation must also be monitored and enforced, though the more constrained the conditions, the less competition there is likely to be. Local knowledge and experience are key elements in designing and enforcement. Combining the planning skills of the existing state-owned enterprise in a regulatory role with the cost efficiency of private sector supply has generally led to the highest levels of service at the least cost.

Regulation of Bus Services

The regulation of bus services is an essential element in assuring the public receives the level of service it expects, provided under safe and sanitary conditions. This is a primary role for government in facilitating the provision of urban transportation. Regardless of whether the operations are provided by government-owned companies or the private sector, government as a

minimum, has the obligation to ensure that the vehicles used to provide service are safe and operated in a safe manner.

BOX 5: URBAN BUS SERVICES IN HONG KONG AND SINGAPORE

Hong Kong and Singapore provide models of public transport operated entirely by the private sector on commercial lines. Social and "network" objectives are imposed by regulatory frameworks administered by specialist departments within government, independent of any interest in operation, exercising a high degree of regulation. In both cities the process of consolidation of small private operators resulted in the award of monopoly franchises that produced unsatisfactory levels of service and poor responsiveness to market conditions. Additional operators have been licensed to create competition and reinforce incentives to efficiency. Due to the favorable operating environment (high population density, restraints on private car use, travel patterns well dispersed in time and location) the costs of the social and network obligations can be met by the operators from internal cross-subsidy without a need for external subsidy. In Hong Kong the regulatory framework includes a maximum level of annual return on assets invested.

The role of the government regulatory agency in both cities is that of planner and coordinator of the public transport system of which the bus operations form a major part. A more recent "network" obligation imposed by the regulating agencies is the coordination, or subjugation, of the bus network to the new mass transit railway networks. In Hong Kong MTR ridership has risen to the point where full competition can be permitted between bus and mass transit services and the incentive of competition with the railway has resulted in the rapid development of premium, air-conditioned bus services.

Source: From Theme Paper 4 by Richard Meakin.

International experience has shown that the greater the degree of regulation, the less flexibility the provider has to respond to user demands and competitive practices. Consequently, most transport planners consider "least regulation the best." An appropriately competitive environment enabling private sector operators (or, alternatively, autonomous commercially operated publicly-owned companies) to compete freely with one another for passengers should, theoretically, provide the best services at the least cost. In practice, however, most cities have found that some regulation is essential to balance social and commercial objectives. Regulations are typically used to assure comprehensive geographical coverage, adequate service on sparsely populated or undesirable routes, and during periods of little usage, and to provide integration of modes. In addition where there is the risk of the formation of cartels or where little real competition can be achieved, the regulation of fares is considered necessary. Regulations not only protect the public, but assure all transport providers that they will be treated fairly and equally, and protected from predatory practices. This is important in creating an environment that will encourage private sector participation.

Regulatory mechanisms take many forms but are generally administered in one of three ways: (a) a general regulatory body responsible for general regulation of all industry within a jurisdiction; (b) a regulatory agency established specifically to regulate transport activities; and (c) regulation through enforcement of the covenants of a specific contract or franchise with an individual bus operator. The last (regulation through contract) has been found to be the easiest to implement during the transition from public ownership and operation to operation involving the private sector. It is more flexible and allows conditionality to be matched to the conditions and objectives of the service. While all three methods are used equally throughout the world, it is

essential that some form of regulation be adopted. Santiago, Chile provides a good example of the need for appropriate regulation (Box 6).

Box 6: Designing an Effective Competitive System: Buses in Santiago, Chile

At the end of 1977, public road passenger transport in Santiago was provided by a public sector operator with 710 large buses (90 seats) and a number of strictly regulated private associations operating about 3,167 regular buses (capacity 78 passengers) and 1,558 taxibuses (capacity 40 passengers). Fares, routes, frequencies and bus imports were strictly controlled.

In November 1979, entry to the sector was effectively deregulated, though a formal power of regulation remained. Fares were progressively decontrolled, and became completely unregulated in June 1983. Entry to the taxi business and taxi fares were also liberalized over the same period.

The effects of deregulation were dramatic. The public-sector operator was driven out of the market. Total capacity more than doubled over the next decade, with beneficial effects on frequencies and seat availability. Other effects were not so benign. By 1985, the regular bus fares had increased in real terms to nearly three times their 1977 level (partly due to collusion between operators), and the differential between bus fares and taxibus fares had disappeared. The average age of buses increased from 6.95 to nearly 11.6 years and that of taxibuses from 4.95 to 9.51 years between 1980 and 1986. City center congestion and bus-generated air pollution increased substantially.

Those problems have since been addressed. In 1987, 20 percent of the vehicle fleet was not allowed to operate each weekday on a rotating basis. In March 1989, buses built in or before 1966 were prohibited in the city. Most recently, in order to reconcile the desire to maintain competition with restrictions on the congestion and environmental effects of buses in the central city, licenses have been put to competitive tender, with the quality and cleanliness of the vehicle, as well as the price to be charged, being among the decision criteria. In this way, competitive pressure is being retained while new environmental and quality incentives have been introduced. As a result of this renewed regulation, there has been a 12 percent reduction in fares, and pollution resulting from bus emissions has been reduced.

Source: Based on Ian Thomson. 1992. "Urban Bus Deregulation in Chile." *Journal of Transport Economics and Policy*. September.

Public Transport Financing

A key element in the provision of adequate and sustainable bus service is the financial viability of the system. One of the most often cited reasons worldwide for poor bus service is the lack of financial resources to purchase vehicles and spare parts to maintain them. This is one of the primary issues in the deterioration of some of the bus systems in China. Throughout the world, those systems that have been most effective are those in which mechanisms have been developed to ensure a reliable source of income sufficient to meet the commercial and social goals of the providers and the community.

Bus Fares. Bus fares typically provide the single largest source of finance for bus companies. In general, the most cost-effective systems are those that are required to cover all operating costs through fare box revenues with associated income from activities such as advertising. This provides an incentive to the operator to match service with demand, to maximize ridership, and operate in the most cost-effective manner. Fares and service levels for public transport (whether supplied by government-owned companies or by the private sector)

should be determined in a systemwide multimodal context and be clearly related to comprehensive economic and social strategies for urban development and transport. Efficient charges for road use will increase public transport patronage and allow greater cost recovery even if modal diversion does not occur. However, as long as road use is underpriced, the financial viability of public transport will be prejudiced and there will be a "second best" case for setting public transport fares in such a way as to compensate for the undercharging of private road transport. This would involve linking moves to recover the full costs of public transport to moves towards setting appropriate fuel tax or road use charge levels.

Many of the most efficient bus systems in the world are able to operate with no government subsidy. Most all systems in Latin America, Hong Kong, Singapore, Korea, and many others receive no government support. They are operated by the private sector under government regulatory control. In many countries, however, it is considered necessary to subsidize bus transport as a way of assisting the lower-income segments of the population and encourage public transport use. In doing so, two major issues must be addressed.

First, fare revenues will be insufficient to meet full operational and vehicle replacement costs. Financial sustainability thus requires some other "secure revenue" source such as contract payments from government in association with annual performance agreements financed from general taxation or by earmarked taxation as in France, (described in Box 4.). Many municipal governments have neither sufficient grant revenue from central government nor sufficient local taxing power to satisfy this requirement. In those circumstances, because failure to sustain the service will also involve failure to meet environmental and distributional objectives, *financial sustainability must be a preeminent concern.*

The second problem, referred to earlier, concerns management incentives. Where a public transport mode is expected to contribute to social objectives, full cost recovery directly from users may not be appropriate. When management knows that losses will be funded, or at least they will not be held accountable because of "external" circumstances, there is less incentive for efficiency or cost-cutting measures. In order to stimulate managerial efficiency and to prevent subsidy being appropriated by employees, any support, whether in the form of capital or operating subsidy, must be based on a contract specifying clear performance standards and effective penalties.

As described earlier, some of the most successful systems in the world operate with no government subsidy. Others, equally successful with respect to levels of service, only achieve approximately 50 to 70 percent cost recovery from their operation (for example, companies in France, Germany, Austria, India, Indonesia). These companies rely on annual subsidies provided by government to meet operating deficits and capital expenses. This is similar to the current situation in most cities in China. Where government subsidized operation is deemed to be the most appropriate for cultural or social reasons, however, there must be mechanisms in place to provide confidence to the operator that sufficient resources will be available. A social objective of providing low-cost transport to all citizens, no matter how well-intentioned, is worthless if there are insufficient resources to provide enough buses operating on reliable schedules.

One of the most effective means of providing a subsidy to low-income citizens, while maintaining the incentive for operator efficiency, is to provide the subsidy directly to the person—not the enterprise. In that way, fares can be set at a commercially viable level, and operators would

compete through efficiency measures that would allow them to operate with the best service at the lowest cost. Experience indicates that fares would remain at reasonable levels, and the operators would be much more responsive to user demand in order to raise ridership and income. This was achieved in Peru whereby tickets were sold at kiosks and other outlets around the city and neighborhoods at a reduced price that was considered affordable to the population. The bus companies would redeem these weekly with the regulatory agency and receive the commercial value of the ticket that had been agreed to in the franchise negotiations. The amount of income received by the operator was directly related to the ridership and his profit was related to his operating efficiency. This subsidy is financed by a special municipal tax on gasoline.

In Brazil, it is felt that no one should spend more than 6 percent of their salary on public transportation. (Note: the figure of 6 percent was derived at arbitrarily through negotiations with labor leaders and business and reflected local feeling at the time; most studies conducted worldwide indicate that a figure of 10 to 12 percent of income is a more realistic figure for low-income households to spend on transportation before it becomes an unrealistic burden.) Consequently, legislation was passed so that all major employers would provide a subsidy directly to workers equal to the difference in their transportation costs and 6 percent of their salary. The employer would then deduct this expense from his income taxes. This had the advantage, similar to that in Peru, of being a subsidy directly to the user, and the bus companies had the incentive for efficient operation in order to reduce costs and maximize ridership. The main disadvantage of the Brazil system is that it only reaches workers employed in the formal sector, only about 40 percent of the working population and not necessarily the poorest.

In France, as discussed in Box 4, a tax is levied on businesses and collected by the local governments. This revenue is used to subsidize transport operators that operate under franchise agreements with the local transport authorities. The franchise agreement stipulates the fare that can be charged (usually only about 50 percent of what would be necessary to fully recover costs) and the remaining costs are paid by the transport authority to the bus operator in a manner agreed to in the contract. While levels of service are very good, the costs per vehicle-kilometer are typically 20 to 30 percent higher than in those systems where the user is subsidized rather than the operator.

Subsidies in themselves cannot be described as good or bad; each community has its own values and must review the implications and tradeoffs that are associated with the use of subsidies. International experience has demonstrated some of the effects of subsidies, however, and it is important to mitigate the adverse impacts so as to fully realize the benefits. In international experience, two issues stand out:

- The incentive for efficient and responsive operation should not be negated by the payment of subsidies to operators, which just serves to equalize revenues and costs. To the degree possible, subsidies should be targeted to the user. The ideal situation would be to subsidize low-income people through a system such as a general welfare program. Where this is not possible, those systems that subsidize the user directly (such as the example from Peru) and allow commercial rates to be charged under competitive conditions have resulted in the most cost-effective service. A third-best solution found in some countries such as France and India is to pay subsidies to the operating company based on achievement of predetermined performance criteria.

- To facilitate the rational use of subsidy and ensure a reliable source of revenue, local governments should have the authority to determine the level of subsidy and raise the revenue necessary to finance it. Local taxes on business (which ultimately benefits from accessibility of workers and customers), gasoline and vehicle use taxes, or special sources of revenues such as Guangzhou's tax on hotel rooms can be used to finance the subsidies. Without these special taxes, however, bus systems—often inefficiently operated—are subsidized at the expense of other social programs.

Traffic Management and Bus Operations

As mentioned earlier, a primary reason given by people for not using the bus is its unreliability and delay. As cities continue to grow and economic activity is increasing, congestion has reduced bus speeds in some corridors to less than 10 kilometers per hour. This has two dramatic effects on the viability of bus operation. Ridership is reduced as people seek alternative means of travel, and the costs of operation are raised causing further deterioration in the service. Effective traffic management, particularly in China whose cities are generally blessed with wide major streets, could greatly reduce the effects of congestion on bus operation. It is important to remember that the objective of an urban transport system is to move people—not vehicles. Consequently, those means of transport that can accommodate the demand for accessibility most efficiently should receive priority.

In order to facilitate bus movement, the first step is to make the most efficient use of the road infrastructure network, constructing any critical missing links, providing safe movement for pedestrians and bicycles as appropriate, and ensuring integration between the transport system and land use development. The use of street space should be organized, and conflicts reduced to the degree possible to facilitate the movement of traffic in general, thereby reducing delays to buses. Some actions that have proven effective in this regard include:

- Computerized traffic signal control and appropriate timing; in many cities of the world this has reduced delays by 30 to 50 percent.

- Medians on wide boulevards to reduce traffic cutting across the roadway; in a group of secondary cities in Mexico, this produced significant results in reducing accidents (45 percent reduction), and in increasing overall speeds (about 25 percent increase).

- Restriction of on-street parking in congested areas and in the vicinity of bus stops; this can significantly reduce delay depending on the capacity of the street and the volume of traffic;

- Turning-movement restrictions during congested periods; in Bombay, India this reduced traffic delays at intersections by over 40 percent.

- One-way streets with contraflow bus lanes.

There are numerous other actions that can be applied including appropriate geometric design, paint marking, and signing to channelize traffic. Most cities have found, however, that the most critical element of traffic management is effective law enforcement. Unless rules and regulations are obeyed, the efficiency gains of traffic management will not be realized.

Coordination between traffic management and enforcement should be a priority of street management.

Other actions may be taken to specifically improve bus operation such as priority for buses at intersections. The technique can work in two ways: (a) a green signal for all traffic moving in the direction the bus is traveling; and (b) a green signal for the lane in which the bus is in, applicable to buses only. In the first case, the bus usually is equipped with a transponder and as it approaches the intersection, a signal is sent to the traffic signal controller that causes the signal to advance its cycle and give the approach with the bus the right of way. This is most applicable where there are distinct differences in the volumes of traffic, including buses, between the approaches to the intersection. Experience in the United States has shown reductions in delays to buses of as much as 40 percent in central networks. Delays to other vehicles usually increases depending on the number of buses and the timing of the signals.

In the second situation, a specific lane is designated at the intersection for the bus. The traffic signal display includes a separate indication for this lane and it is identified for buses only. The traffic signal timing is then adjusted so as to provide a leading or lagging green for this lane when a bus is there in order to enable the bus to advance ahead of traffic, turn without interference, or maintain prescribed synchronization with the next intersection. The experience in Japan, United States, and Brazil indicate savings in time of 10 to 30 percent on bus journey speeds. The critical factor here is having sufficient width at the intersection to devote to the bus, and avoiding overly long signal cycles.

Where bus demand becomes heavier, the most appropriate solution has been the dedication of street space for the use of the bus only. Bus lanes have been used in many countries for this purpose. The capacity depends on the frequency of intersections and stops. Passenger flows of up to 18,000 passengers per hour have been recorded in several cities but typical volumes range in the 12,000 to 15,000 range. Most cities have found that it is necessary to provide some type of physical separation for the bus lane to keep other vehicles from using it and blocking the buses. The physical separation, however, needs to be low enough for the bus to cross to get around other stalled or delayed buses.

The ultimate action to facilitate efficient and high-capacity bus movement are busways. These are distinguished from bus lanes in that they are usually built especially for the use of buses only and provide for movement in each direction. Bogota, Colombia is now starting on an extension of its four-lane busway; the first in the world. With a capacity of about 20,000 passengers per hour, busways rival light rail modes of travel and are much less expensive. Busways are discussed more fully in Paper 7.

Buses and Road Space

As discussed earlier in this paper, buses are an integral part of the transport system in cities throughout the world. In most cities they are the single most important element. In China, this is not yet true because of a number of factors that, however, are changing. In the past, the proximity of jobs, homes, schools and commercial activities meant that most trips were short. People were encouraged to use bicycles and walk. Changes in policy, economic growth, and rapid growth of urban areas, however, are changing people's travel patterns. Trips are becoming more frequent and

longer, and the bicycle and walking are not as attractive alternatives as they once were. Although motorization is increasing, there will still be a large part of China's population for many years to come that will not be able to afford an automobile, or to drive it for every trip purpose. This leaves mass transit and cities across the world have found the bus to be the favored alternative. In designing street systems and planning traffic management schemes, the bus should be given priority based on the volumes it carries. Up to about 3,000 passengers per hour, the bus can be accommodated in general traffic if effective traffic management is provided to reduce delays and conflicts. As passenger volumes increase, priority for buses should also increase following the adage that the purpose of the system is to move people not vehicles. Special lanes, turning movements, and priority signal timing should give priority to buses at the expense of other vehicles. When passenger demand begins to exceed 7,000 passengers per hour, exclusive busways should be considered. They have been found by the cities that have introduced them to be both economically and socially very valuable investments.

THEME PAPER 9: PRIVATE FUNDING OF TRANSPORT: INFRASTRUCTURE

KWOK HUNG LEE [1]

1. INTRODUCTION

The purpose of this paper is to provide a general overview on the use of private funds in urban transport infrastructure in China. It looks at the various facets of private sector participation in transport projects, the impact on government policies and practices and the problems confronting the investors. This paper explains the process involved and considerations required from the inception of the project to the invitation of proposals from private investors and finally the tender negotiations.

Following this introduction, Section 2 looks at the background that leads to the participation of the private sector in public infrastructure. Section 3 looks at the forms of private sector participation and the more successful examples in South Asia. Section 4 identifies the types of transport projects that may be suitable for private sector participation and Section 5 examines the impact that private sector involvement would have on the traditional role of government as provider of transport infrastructure. The types of private investors who would be interested in transport projects and their expectations are discussed in Section 6. The key to private investment is financing and the various facets of project financing are looked at in Section 7. This is followed by an examination of risks to both the government and the private investor in implementing a transport project as a private venture. To conclude the overview, the process of inviting and evaluating proposals from private investors for transport projects is described in Section 9. This is followed by concluding remarks in Section 10.

2. BACKGROUND

Rapid Economic Growth

Since the start of economic reforms in the late 1970s, China has achieved a long period of fast economic growth. The fast economic development and improvement in the standard of living have generated a huge demand for infrastructure, such as transport, energy and water. This situation is particularly acute in the coastal cities and special economic zones.

Like most developing countries, China traditionally invests only a small percentage of her resources in transport infrastructure. The inadequacy of transport infrastructure is adversely affecting the quality of life in many cities and the traffic congestion is causing significant economic loss. It is no longer possible to rely on traditional public sector resources to support a

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transport infrastructure investment program, which is necessary to meet the existing backlog and expected demand.

For the purpose of this paper, public sector includes the central government, local governments, government agents and public corporations. A public corporation is a private company created under statutes, which may be wholly or substantially owned by the government. Public sector resources refer to revenue and assets that are available and/or owned by government, such as tax revenue, charges and fees levied directly or indirectly by the Government on government land and properties.

Shortage of Funds

The shortage of funds and transport infrastructure has become a common problem to most municipalities. To raise the necessary funds, approaches commonly adopted by municipalities include:

(a) **Mobilizing Additional Revenue**. This involves primarily exploring domestic financing sources. Common measures include increasing general revenue through additional taxation; fees; user charges such as special fees for metro construction, a freight surcharge for construction of new railway lines, road tolls, congestion charges, a gasoline tax, road maintenance fees, airport fees; and public sector borrowing; etc.

An increase in general revenue may appear to be the simplest approach, but it may not be politically acceptable. Excessive taxation/charges would leave insufficient private sector resources to sustain economic growth. It would also affect investment incentives.

(b) **Seeking an Institutional Solution**. This involves primarily exploring foreign financing sources. It will, but to a lesser extent, tap domestic investment and loan financing. Measures include using autonomous public corporations to handle the investment on a commercial basis, invite private sector participation and foreign direct investment.

This approach has been widely adopted also in China. State-owned corporations have been set up for the implementation of large transport projects such as metro lines, tolled roads and river crossings. These corporations undertake the initial planning and investigation of the projects, seek funds from the domestic capital markets and invite private foreign investors to form a joint venture for implementation.

User Pays

The transport infrastructure or services may be paid individually by those who use the goods or services or by the general public with funds collectively collected through the various forms of taxation. The current political philosophy in the West is that the user should pay the cost instead of general taxpayers subsidizing users.

This fundamental shift in policy sets the foundation for public-private sector partnerships in transport infrastructure. The ability to impose user charges means it is now possible to derive revenue from a transport infrastructure. The revenue could be used to provide a return to investors and serve as security for loan financing. Thus, it is possible to make transport infrastructure, like a public utility service, available for investment by the private sector.

Private Sector Investment in Transport Infrastructure

As is increasingly the case, the Government does not have the financial resources to meet the need for providing an adequate infrastructure. Borrowing has been a "convenient" alternative means, but it is becoming increasingly difficult to borrow significant sums in the international capital market. Also, the central government, for macroeconomic reasons, would like to maintain control over the external debt and total public sector borrowing in order to contain inflation and protect the nation's credit rating.

To overcome these limitations, many municipalities are looking for "off balance sheet" financing to support their new infrastructure investment program. Private sector investment, provided that it does not involve a government guarantee, does not increase the foreign debt of the state. Internationally, it has become a favored approach for implementing and operating large-scale transport infrastructure projects in the past decade. Examples include the Channel Tunnel in Europe, Sydney Harbor Tunnel in Australia, Malaysia North-South Highway, Bangkok Second-Stage Expressway, Bangkok Transit Systems, the road tunnels and the Mass Transit Railway in Hong Kong, many river crossings in China and the Guangzhou-Shenzhen Expressway.

3. PRIVATE SECTOR PARTICIPATION

Why Private Sector

In developed countries, the private sector has been involved, for a long time, in the planning, design and construction of roads, bridges and tunnels and investments in rolling stock and freight-handling equipment. In China, the design and construction of transport projects have been entrusted to design institutes and construction contractors that are state-owned enterprises. Since the 1980s, the momentum of private sector participation has reached the spheres of promotion, financing and operation of transport systems.

Private sector participation can:

(a) provide a more cost-effective service, which would respond more quickly to public (or customer) demands;

(b) operate with greater flexibility as it is not rigidly bound by government procedures;

(c) avoid any radical shift in resources into the transport sector, putting pressure on other social and infrastructure investments;

(d) have access to new forms of financing, in particular foreign direct investment;

(e) lead to the import of new technical skills in construction, project and financial management;

(f) introduce private sector efficiency and free-market practices; and

(g) introduce better risk sharing, accountability, monitoring and management in infrastructure provision.

Forms of Private Sector Participation

There are three common forms of private sector participation. They are:

- contractor-arranged financing,
- concession, and
- contracting out of services.

Contractor-Arranged Financing. This includes commercial loans, export credits and, occasionally, soft loans from the Government or international lending agents, acting as "seed money." The Government would not have to meet the capital costs up-front. The contractor will arrange and secure the loan necessary to meet the contract payments for the supply and construction contracts. Debt servicing starts only after the Government (and the public) begins enjoying the benefits of the completed infrastructure. The ultimate borrower may either be the municipal government or a public corporation, which acts as the project owner. Such financing arrangements would require an acceptable security arrangement, which often involves "sovereign guarantees." This arrangement is also known as build and transfer (BT).

Concession. The private investor finances, builds, and operates the project and collects tariffs from users, under certain rights conferred to it by statute or a private contract. Concession can take many forms, as listed below. The prime difference between these forms of concession lies with their financing structure:

- **BOT** (Build, Operate and Transfer)
- **BOOT** (Build, Own, Operate and Transfer)
- **BOO** (Build, Own and Operate)
- **BLT** (Build, Lease and Transfer)

In all cases, the private sector takes a leading role in planning, financing and management of the project. The private sector, which often includes major construction firms, also participates actively in the design, construction and management of the project. However, in China, the Government would prefer these be undertaken and/or controlled by the Government or state-owned enterprises.

Except with the BOO arrangement, the entire asset (that is, the transport infrastructure) would be transferred at no cost to the Government at the expiry of the concession. The BOO arrangement does not involve a transfer of asset and is more akin to a license arrangement.

Contracting out of Services. This involves primarily contracting out a transport service to the private sector. For example, the Government may contract out to a private firm the operation and management of a government toll road, including toll collection,

The prime reasons for this form of private sector participation is to reduce the size of government staff establishment, to bring in private sector management efficiency and to make the service more responsive to the customers' expectations.

Experience in the Region

BOT Projects. Privatized transport infrastructure projects have become popular in the region since the mid-1980s. Hong Kong has been the forefront and pace-setter in the implementation of BOT projects in Asia. It has three BOT projects already successfully completed and in operation and two projects under construction for completion by 1997 and 1998.

- Central Harbor Crossing Tunnel (1971)
- Eastern Harbor Crossing Tunnel (1989)
- Tate's Cairn Tunnel (1990)
- Western Harbor Crossing (under construction, target completion 1997)
- Tai Nam Tunnel and Yuen Long Approach Road (Route 3) (under construction, target completion 1998)

In Thailand, Malaysia and the Philippines, the governments are supportive of private funding for transport projects and they have achieved varying degrees of success. The best-known successful large projects include the Malaysian North-South Highway and the Bangkok Expressway.

Each BOT project has its unique feature that reflects the characteristics of the project and the political and financial climate affecting the project. A brief description on the key concession conditions and financial structure of some of these projects are given in Annex 1.

Contracting out of Services. Hong Kong has successfully contracted out to the private sector the management of public car parks, parking meters, and the management, including toll collection, of all the five government tolled tunnels. Experience shows that this has resulted in a reduction in operating costs and improvement in the quality of service. The public's reaction has been favorable.

4. Public Interest and Government Intervention

Transport Policy

Transport infrastructure has a strong impact on economic and social development and transport infrastructure investment often takes up a significant portion of the government's resources. It is an area in which government policy has an important role to play. This includes

setting policies on the allocation of scarce government resources to meet the increasing demand for transport services, creating incentives for innovative and competitive services and encouraging private sector initiatives.

Transport policy encompasses the overall fundamentals such as financial accountability, social stability, public finance and macroeconomic management. The major policy goals include:

- resolving conflicting goals between social services and profit-making,
- avoiding premature investment and wasteful competition,
- establishing monitoring bodies and regulatory framework to ensure financial accountability, quality of service, safety and environmental protection,
- containing and sharing private sector risks via rules on land acquisition, inflationary effects, etc.,
- ensuring an environment within one transport mode and among different transport modes that is competitive in order to spur efficiency,
- promoting the use of private funds for urban redevelopment and regional development.

Most government would like to retain strong control over the planning and operation of strategic transport infrastructure. In China, the Government tightly guards its ownership and planning control of transport infrastructure projects.

Social Obligations

Social service obligations include fare subsidies and maintaining operation of routes that are commercially not viable. With high inflation and salary increases, most public transport services in China are running at substantial operating losses and relying heavily on subsidies from the municipal government and revenue from "associated businesses." Associated businesses are those side businesses, such as real estate development, warehouses, restaurants, entertainment and business undertaken by the transport operators. It is not uncommon that the attractive, speculative return from the associated businesses has diverted the attention, interest and effort of some operators away from the original transport objectives.

Protecting the Public's Interest

Private enterprises, regardless of whether they operate under a monopolistic or competitive environment, should be subject to regulatory instruments that protect consumers' interests. A good example is the Profit Control Scheme for public bus operations in Hong Kong. The public buses in Hong Kong are operated by listed private companies. The purpose of the scheme is to achieve a proper balance between the interests of investors and those of the traveling public, as well as the responsibilities and obligations undertaken by the investor and the return and protection afforded to it.

There are also relevant examples for controlling profits and toll levels for BOT projects in Hong Kong. They are:

(a) **Tate's Cairn Tunnel Project.** When the traffic flow through the tunnel exceeds a predetermined level (which has been used also as the basis to assess an acceptable rate of return for the project), the Government is entitled to 30 percent of the surplus revenue. The Government may use this windfall to defer a toll increase.

(b) **Western Harbor Crossing.** The minimum and upper levels of revenue for each year of revenue operation have been defined in the concession agreement. Toll adjustments can only be made when the net revenue falls below the minimum. Any surplus revenue in excess of the upper level will be transferred to a "Reserve Fund" that, if the Government so decides, may be used to defer a toll increase.

Government Perspectives

Government perspectives include:

- the purpose of the project is to provide a public service;
- maximizing the availability of service at a reasonable cost;
- minimizing costs at an acceptable level of services;
- retaining control over the design and quality of the works, standards of the operations and quality of the service, ownership of the infrastructure and "undue" profit to the private investor;
- minimizing risk to the public sector, such as public debt, revenue forgone, subsidy

The Government should also be mindful of the private investor's perspective and allow enough room for the latter to make the project a viable proposition.

Government Intervention

The Government may intervene when necessary to protect the interest of the public or to achieve certain policy or political objectives. Such intervention could affect the private sector's incentives and economic efficiency and these should be handled with care. In most free-market economies, government interventions are often restricted to safety and environmental issues.

5. Private Profits and Initiatives

Profit Motive

The private investor is profit-motivated, with his initiatives stemming from the supply of efficient, innovative and competitive service to gain higher rates of return on his investment. For

this, a private investor needs a clear picture of the social, economic and legal environment under which the project will be operating.

Minimizing Uncertainties—Legislative Framework

A clearly defined legal and regulatory framework and policy goal would help to remove many of the uncertainties and anxiety facing potential investors. It would also help to provide a level playing field and set clear rules of the game for the private sector participating in transport infrastructure projects.

In China, the transition from a planned economy to a market economy and from public-funded projects to private financing could create a lot of confusion to foreign investors, especially those who are new to the country. Rules or regulations provided by the central government would help to mitigate much confusion and fear. It is understood that actions have already been initiated by the State Planning Commission and good progress has been made.

Legislation that would help to attract and protect private investment, private interest and initiatives on infrastructure projects would include :

- institutional issues, such as the role of different transport modes and each mode's respective structure;
- a franchise framework, such as percentage of foreign ownership, minimum equity participation, nominal maximum franchise period, etc.
- a tendering and evaluation process for franchises, construction, etc.;
- a mechanism for monitoring progress and quality assurance of the works,
- a profit control mechanism;
- land appropriation and granting of development right; and
- government support in the form of subsidies, capital injection, subordinate loans and guarantees.

Many countries produced special legislation covering the above as part of their efforts to encourage private sector investment in infrastructure projects.

Private Sector's Perspectives

The private sector's perspectives include:

(a) the project represents only a commercial investment and is determined by commercial principles;

(b) creating construction and supply contracts and selling services;

(c) obtaining repayment of capital with adequate return on investment;

(d) developing and establishing further business opportunities in the China; and

(e) minimizing commercial and political risks.

Investors

Investors of BOT infrastructure projects may be divided into two groups: "connected" and "arms-length" investors.

Connected Investors. "Connected Investors" are those who expect to enjoy direct additional rewards from the implementation of the project, such as construction contractors, equipment suppliers and property developers. They are interested in securing supply or construction contracts or property development rights. They are parties who will first benefit from the realization of the project.

Often such investors would have little or no interest in the operation of the transport infrastructure as it may not be compatible with their mainline business. In such cases, they would seek to dispose of their equity and operation obligations as soon as possible after they have secured the construction and supply contracts. The Government should make sure that there are sufficient provisions in the concession agreement and guarantee that investors can only pass their obligations (including any guarantees that they have provided in order to secure the concession) to any third party until some years after commencement of revenue operation.

Arms-Length Investors. "Arms-length Investors" are those investors whose expectations of return are entirely based on future revenue potential of the project, such as private investors, institutional investors, pension funds and insurance firms. They are looking for a long-term, stable, inflation-protected or adjusted income in their investment portfolio. The concession period of a BOT project can range from 20 to 50 years. Often the revenue derived from user charges is inflation-adjusted. This type of income would be attractive to many genuine long-term investors.

6. SELECTION OF PROJECTS

What Type of Projects

The private sector treats a BOT project as an investment item. The project must therefore be able to generate a net operating revenue that would pay back the investment with a reasonable profit. Transport projects that meet this requirement include:

- tolled roads, bridges and tunnels,
- car parks, freight stations,
- public transit systems, and
- modern toll collection systems, especially those fully automatic electronic toll collection systems.

Prerequisites

A transport infrastructure project must satisfy the following basic criteria before it can be considered for implementation as a private venture:

- there must be a genuine need for the project,
- the prospect of profits on reasonable (and politically acceptable) user charges,
- there is a market for the services provided by the project, and
- the project must be financially viable and attractive to potential lenders and financiers.

Investor's Perspectives

Whether the private sector will be attracted to a project is determined by an investor's perception and evaluation of the project's inherent financial viability and risk exposure.

The appeal of a transport infrastructure project to private investors will depend on:

- the willingness of the government to share certain risks and responsibilities, in particular those that an investor would have little or no control over;
- the ability of the project to generate sufficient cash flow to cover debt servicing, operating cost and capital repayment, plus an acceptable safety margin;
- the rate of return must be compatible with the perceived project risk and attractive when compared with alternative investment opportunities such as good-quality, long-term bonds. The expected rate of return is dependent upon the state of the economy, the market, the cost of funds and perceived project risks. For international investors, there is the "country risk" considerations; and
- the clarity of current government policy toward private investment and the availability of an efficient institutional and regulatory framework to define operational matters related to the transport infrastructure and protection of investors' interest.

7. Project Financing

Characteristics of BOT Projects

The common characteristics of transport infrastructure projects are high up-front capital costs and long payback periods. A long construction period and the need to capitalize interest until the commencement of revenue operation results in a high financing cost. A positive cash flow rarely occurs in the initial years of operation. In the longer term, the project would provide a stable cash flow against low operating and maintenance costs.

In most cases, the concession would not involve an alienation of title. The investors will not own the roads, bridges or tunnel that they finance and build under the project. There is no fixed asset involved. Under a BOT project, the investors gets the right to earn revenue from these structures. Accordingly, there will be no capital appreciation in the project.

Part of the project will be financed in foreign currencies. Foreign monies would be used to cover the operating cost of the foreign partner, cost of imported materials, plants and services of foreign professionals. However, revenue is in local currency.

There are often conflicts of interest between the social service and profit-making goals of the project.

What is Project Financing?

In traditional lending, the lender looks to the asset or the "balance sheet" of the borrower, the ability of the borrower's projected earnings to service the debt and repay the principal.

The funds required for a BOT project is often too substantial to be raised on the strength of the investor's asset or balance sheet. Also, this could handicap the investor's ability to raise funds for other investment. An investor would therefore be reluctant to put assets behind such projects. Instead, the investor would seek to limit his liability to the value of equity and look to financiers to share part of the risks.

Consequently, a new form of infrastructure project financing has been developed. It focuses on the future revenue potential of a project and its ability to repay the debt. In other words, the "project becomes the borrower" and not the investor as in the case of traditional or corporate financing.

Project financing may be defined as a means of loan financing for the acquisition and construction of specific fixed assets that would be capable of producing a separate, identifiable and predictable revenue stream. It looks to the future revenue potential of the project to service the debt and repayment of principal.

Project financing is often called "limited recourse" or "nonrecourse" financing. Nonrecourse financing is a form of (long-term) loan financing extended to a project with a future debt repayment expectation limited only to the future earning potential of the project. The investor assumes no liability for the risks of the project. Such form of financing is rarely available in recent years. The more common form would be limited recourse financing where the investor would have to bear some specific risks of the project, such as extending some agreed form of support to the project in the event of a cost overrun or delay in completion.

The success of a large-scale BOT project is critically dependent on the ability of the private investor to successfully secure adequate "limited recourse financing" for the project.

The Process

The ultimate decision by a foreign investor to invest and implement a BOT project depends critically on the availability of funds, for both equity or loan financing. The investor evaluates the viability of the project and develops a feasible business plan. The investor would then seek the necessary funds, mostly in the form of project financing, from commercial banks and institutional lenders.

A financial institution, usually a commercial bank, would act as the financial advisor for the investor, and appraise the financial viability of the project. If the result of the evaluation is affirmative and the investor has succeeded in winning the concession, the financial advisor would normally be appointed by the investor to act as the arranger and be responsible for developing a suitable security package and financing plan. The financial advisor would implement the financing plan to raise the required funds, for example, through loan syndication or private placement. The loan drawdown and the subsequent repayment will be managed by one or more banks acting as the security agent on behalf of the lenders.

Key Considerations

Financial Viability Study. One important part of the financial viability study is the cash flow analysis. It will examine the project's predicted future revenue stream and its ability to cover the operating costs, debt servicing and repayment, and provide a reasonable return on the investment. For a highway project, a parallel traffic study would be required. A traffic study predicts the volume and composition of the traffic flow on the highway and the expected toll revenue in each year of first 10 to 15 years of operation. A wide range of scenario tests would be conducted to examine the effects of unfavorable changes in the assumptions, such as economic growth rates, land use, government transport policy, toll charge levels. For Chinese cities, extensive tests often would have be conducted on the timing and availability of potential competing roads. This is one of the risks that worry many investors and lenders, especially in urban transport projects. Most municipalities do not practice long-term transport planning or have a clearly defined long-term transport investment program. There is also little planning coordination between adjacent cities and counties. Any "surprise" competing road would have a negative impact on the revenue potential of an existing BOT road project. The traffic and revenue study would normally be undertaken by an independent transport consultant firm of international repute. The study report will be made available to potential investors and lenders. It will also form part of the loan syndication documentation. In addition, the financial study will conduct a series of sensitivity tests on the downside risks of the project, including adverse changes in the financial market such as fluctuations in interest and exchange rates.

Financing Structure. The financing structure of a project comprises equity and debt financing, which includes export credits. The common sources of funds include:

- private investors—project sponsor (equity input);
- contractors who would benefit from the project (loan financing and/or equity participation);

- securities firms—some securities firms are becoming active in the international project finance market for infrastructure projects in emerging economies;
- commercial bank loans; and
- placement with private and institutional investors.

Conflicting Social Objectives. One of the challenges in financing transport infrastructure projects is the social nature of the services provided. For the Government, the prime purpose of a BOT project is to satisfy public demand for transport services.

To meet the social objective of a transport project, the level of user charge, road toll or transit fare, should be set at a level that would be socially acceptable and affordable to potential users. It should take into account the disposable income and affordability of users and must not hamper the achievement of the original economic transport objectives of the project.

In structuring the contract conditions, the Government is often influenced by public expectations of the services and public opinion of permissible private sector profits. This could result in specification for less-than-viable services or road links, low fare or toll level and too rigid control over fare and toll increases during the life of the project.

On the other hand, to meet the commercial objective, the charge level will have to be sufficient to service the debt and to generate a rate of return that would, at least, be compatible with those obtainable from alternative, competing investments opportunities.

Where these objectives are in conflict, as is very often the case, the Government may find it necessary to introduce "incentive" or "encouragement" so that the project would remain attractive to the investor and acceptable to potential lenders.

Lenders' Typical Requirements. The project must be financially viable on its own accord or in conjunction with other financial incentives (such as confirmed and assured subsidies). Lenders, when evaluating the degree of risk and attraction of a transport project in China, would look at the following:

- a robust cash flow to service the debt within a maximum of 10 to 13 years;
- approval of the project by the relevant authority, such as the provincial authority or State Planning Commission;
- adequacy and availability of supporting infrastructure upon project completion and commencement of revenue operation, such as connecting roads and traffic generators;
- the construction works undertaken by reliable, reputable and experienced contractors;
- the creditworthiness of the local Chinese parties (including the contractors) to fulfill any obligations/guarantees;

- support from the Government and local financial institutions;
- sufficient level of equity contribution to ensure the investor's commitment to the project; and
- availability of foreign currencies to repay the foreign commercial loans

Incentives

The common forms of incentives that may be provided by the Government include:

- traffic volume guarantee, such as minimum traffic volume guarantee for the Guangzhou-Shenzhen superhighway. This is equivalent to a revenue guarantee;
- limited competition (no competing services will be introduced until an agreed level of utilization has been achieved—trigger point), such as the triggering point mechanism that determines the timing for new container terminals in Hong Kong;
- cross-subsidy from revenue of existing services/operations, toll from existing toll roads/bridges, such as the proposed Chongqing Friendship bridges and tunnel;
- subsidized tariffs, such as for the elderly, children and underprivileged: These are sometimes known as social obligation costs, that is subsidies to school children and the elderly on Hong Kong buses and metro;
- compensation for unprofitable services, such as commercially nonviable bus routes or road links;
- minimum revenue assurance, such as the privatization of the four bridges and one tunnel in Guangzhou;
- property development rights; this is a common feature in Chinese Projects;
- low interest rate loans (subordinated or subsidized loans to mitigate part of the project risks, such as cost overrun);
- equity and/or (revenue-generating) asset injection; and
- tax incentives including exemptions and tax holidays, etc.

It is difficult, and sometimes impossible, to assess the true value of a subsidy and to quantify its effects on the return to investor. This makes it difficult for the Government to properly and equitably evaluate BOT proposals and to protect the interest of the public. In other words, it would not be easy for the Government to assess if it has made the "best" deal or sometime even a fair deal. Any "off-balance sheet" type subsidy therefore requires careful scrutiny.

Government Participation

In some instances, a transport infrastructure project, on a stand-alone basis, may not pass the acid test of financial viability analysis. Some form of government participation would be necessary to make the project a viable commercial venture. For example:

- the Government granting associated property development rights and other operating rights, such as connected franchises in urban rail stations, service stations on expressways etc.;
- hybrid public-private partnership in the early years to counter the risk of low traffic volume and to lend confidence to lenders;
- the Government shares or contributes to part of the civil works costs and/or land appropriation should the up-front construction/land acquisition cost be too high; and
- the Government grants a subsidy toward those essential but nonviable services, such as public transport service to low population, remote/rural areas.

Land as a Form of Subsidy

The property market boom in China in recent years has led to an upsurge in the demand of land, especially those either at prime locations or areas of great potential growth. Many foreign and local investors are looking for opportunities to build up their land bank.

For many years, the Chinese government has endorsed the policy that land may be used as a form of cross-subsidy for financially less-attractive projects. Land has also been used to enhance the attraction of a project, for example, the prospect of a higher return with revenue from property and to shorten the payback period.

In the mid- and late 1980s, land was an attractive component of the BOT deals. In some cases, the investors may see the BOT project as a vehicle for obtaining land at a bargain. The situation is gradually changing. First, fewer attractive sites in prime locations are available. Second, the lack of a good secondary market means foreign investors are unable to dispose of the property easily. This restricted the cash turnaround and is not popular with investors who cannot afford having capital tied up for a long time. Third, the property market has started to level off and the size of surplus housing stock is building up.

Indiscriminate injection of land as a means to enhance the attraction of a transport project is not recommended. Each case should be carefully reviewed and its merits, financial and economic implications vigorously appraised. The following points are relevant:

(a) Investments on land and transport have distinctly different characteristics. The former is traditionally a speculative, short-term investment. Its characteristics are high risk and high return, whereas the typical characteristic of a transport infrastructure project is a long-term investment. Compared with property investment, it is less vulnerable to short-term economic fluctuations and provides a low but stable return over a long period.

(b) The property market is, by nature, vulnerable to short-term economic changes. If the market sentiment is good, the income from property development during the construction period of a transport project could help to reduce the loan required. This will reduce the financing cost of the transport project and improves its viability. However, any downturn in the property market could result in cash flow difficulties and seriously threaten the investor's ability to complete both the development and the transport projects. Thus, in structuring the deal, the Government must separate the development risk from the transport project and ensure that satisfactory completion of the transport project would not be affected by the ups and downs of the property market. The developer (the investor holding the development right) should be required to underwrite the "anticipated contribution" from the land development, that is, underwriting the "subsidy" or "injection" to the transport project.

(c) The property market in China has just begun to flourish. It will be some time before a structured system is available to appraise and regulate land and property prices. There is no system or technique available that allows the Government to determine systematically and scientifically the "true market value" of land. Against such a background, it would be almost impossible to evaluate the value of a subsidy, the gain or revenue forgone of the Government. The lack of price references and management system on land administration within the government would also easily lead to abuses.

(d) If the land to be included in the project is a prime site, the Government could consider the option of separately disposing of the land directly through public auction and using the proceeds to subsidize the transport project.

(e) Land development is a highly speculative investment. It would inevitably be more attractive to some investors than a transport project. In structuring the package, the Government must ensure the concessionaire's attention and investment on the transport project would not be diverted by the land development. Under no circumstances should the concessionaire be permitted to give priority to land development and to make the transport project only an "affiliated" project. They must be treated as two completely independent projects.

(f) The transaction and the subsidy should be as transparent as possible to avoid abuse by either investor or any connected agents.

Summary

Getting long-term concessionary financing is still difficult in China, especially if no acceptable guarantee is provided by the major Chinese banks or central/provincial government. Most of the commercial loans bear floating rates of interest, which create uncertainties in the cash flow projection and resulted a much shorter repayment period. It is difficult to secure commercial loans with a tenure exceeding five years in developing countries without some form

of government guarantee or equivalent. China suffers, like other developing countries, from the general lack of a risk-taking local capital market.

Most foreign investors and financiers who have little experience working in China still perceive a high risk in investing in transport projects in China. To protect themselves against such risk, they often seek assurances/guarantees in the form of :

- limiting the construction cost to an agreed fixed price;
- a minimum revenue or traffic guarantee;
- preferential dispersion of dividend/interests to foreign investors;
- subordinate loans from local government if the project runs into unexpected an adverse cash flow situation.

Such concerns have adversely affected the pace of private investment in infrastructure projects in developing countries. In recognition of this, the World Bank has developed a Contingency Guarantee Program, which would provide cover to the investors and lenders on part of the project risk. This could help to greatly increase the confidence of foreign investors and lenders. In this arrangement, the World Bank is acting principally as an intermediary. It will require a back-to-back guarantee from the host government. The Asia Development Bank (ADB) also has some similar facilities. It offers official and commercial cofinancing to ADB-assisted projects. In addition to providing direct loans, ADB also allows other lenders to share the same privileges and immunities of the bank. ADB also provides partial credit guarantees for the public sector and partial risk guarantees for private sector borrowings, especially for BOT projects. Like the World Bank, ADB will also require a back-to-back guarantee from the government of the host country.

8. PROJECT RISKS

Introduction

Main Categories of Risks. The risks in undertaking a transport infrastructure project on a BOT basis include:

- construction risks,
- financing risks,
- traffic and revenue risks, and
- political risks

Impact on the Parties Involved. These risks apply both to the public and private sectors, although the implication might be different. Take the example of construction risks. The risks, as perceived by the different parties, are as follow:

(a) the public sector:

(i) a delay in completion means a delay in the provision of the transport service, which could have serious traffic and land development implications. Also, there may be political implications and public complaints.

(ii) an increase in construction costs might be recovered through a higher level of toll. This would mean the consequence of a financial loss arising from project delay and a cost overrun could eventually be passed to the innocent public.

(b) the concessionaire (investors):

(i) cost and time overruns means higher-than-expected capital outlays, an increase in project risks and a reduction in revenue. The rate of return will suffer unless such a loss can be absorbed by others. This could also create cash flow difficulties for the project, such as difficulties in raising additional finance to cover the cost overrun. The revenue from tolls or other tariffs during the initial period may not be able to meet the increased debt service requirements.

(c) the lenders:

(i) in the case of limited recourse financing, the lenders face the highest risk during the construction period. The concessionaire will not be able to service the debt until the work has been completed and revenue operation has commenced. Often, lenders have little alternative but make available additional loans to tide the concessionaire over the difficulties; this will increase the lenders' debt exposure. Learned from bitter experience in BOT projects in the 1980s, lenders are more reluctant to carry such risks now. They would demand such risks to be underwritten by other parties such as the contractors, investor and the public sector.

Risk Mitigation and Allocation

It would be difficult to completely eliminate the project risks. The nature and impact of such risks vary from project to project. The key to success lies with the identification of the nature and sources of risks in a project and to allocate them to the parties most experienced and capable of managing them. The ability to properly address these risks and to contain them to an acceptable level is fundamental to the success of a BOT project.

Construction Risks

Construction risks are those risks that may prevent a project from being completed on time, to specification and within budget. Main construction risks include completion risk, cost and time overrun risks.

Completion Risk. The worst that can happen to a BOT project is the contractor's inability to complete the work within the specified contract period and/or the budget price. Such failure may be attributable to the lack of expertise, poor management or adverse financial conditions. The investor must satisfy the Government that the work would be carried out by reputable contractors with relevant experience and a good performance record. Also, the investor must employ a team of suitably qualified and experienced professional engineers to manage the works program, supervise and monitor the performance of the contractor. In addition, the investor could take the following measures to minimize, mitigate or allocate the risks to the contractor:

- a specially devised payment schedule that provides incentives to program compliance;
- an "on-demand" performance bond to guard against contractor default; the investor may also seek parent company guarantees as an additional assurance;
- unconditional assignment of subcontractors, consultants and subconsultants, etc., this would allow the investors to continue with the work with the least amount of disruption in the event of a material default and reentry of the construction contract;
- a realistic level of liquidated damages to deter unacceptable delays and to partially compensate the financial losses to the project owner;
- tough and watertight contract conditions limiting the contractor's rights to extensions of time to only variations by the employer and Force Majeure, which would be narrowly defined in the contract.

A delay in completion means also a delay in the commencement of the revenue operation. The investor would suffer from significant losses in terms of revenue and could even face default under the loan agreement if they could not raise alternative funds to meet the additional construction costs and debt servicing obligations during the delay period. In some cases, contractors may be asked to share or undertake such risks by assuming part of the debt servicing obligations in the event of a delay in completion, in addition to other contractual provisions, such as liquidated damages. Insurance for advanced loss of profit could be an alternative, but it is very expensive and not easily available on the market.

Also, an unreasonable delay in the completion of works could trigger a default provision in the concession agreement, with the risk of the concession being revoked.

Cost Overrun Risks. This could be a result of the inadequacy and/or errors in the design, unreliable cost estimation, poor project management, unexpected problems arising from social, environment impacts, unforeseen ground conditions, inclement weather, technology risks (normally associated with new, untried technology), accidents and Force Majeure.

A reasonably competent and experienced contractor should be capable of managing most of these risks with possible exception of Force Majeure. The contractor can insure those risks that would result in "hard damages" through insurance, such as "contractor's all risk" insurance, third-party insurance, professional indemnity insurance, etc.

Neither the investor nor the lenders would be willing to share or undertake the cost overrun risks. They would pass these risks on to the contractor by insisting on fixed-price lump-sum, turnkey contract.

Even so, the investor will have to bear some construction-related risks, such as cost increases due to changes in project requirements, delays, political and/or other additional requirements arising from (delay in government) approvals and costs arising from work beyond reasonable control of the contractor. The investor should seek standby facilities built into the financing plan to cover such risks. It has become increasingly difficult to obtain such facilities, especially in developing economies.

Hong Kong Experience. The Hong Kong BOT projects adopt the following measures to tackle the completion risks. These could be useful to the packaging and managing of similar projects in China.

(a) The construction period is included in the concession period. Any delay in completion would reduce the revenue period. This forms an effective deterrent to contract delay, as well as providing an incentive for early completion. For both the Eastern Harbor Crossing and Tate's Cairn Tunnel, the construction contracts were completed several months ahead of schedule. The concessionaire achieved this through good project management and attractive bonuses for early completion. A huge bonus is a temptation that is difficult for any contractor to resist. The concessionaire would also benefit from the early completion—a longer revenue operation period.

(b) Since the Tate's Cairn Tunnel BOT Project in 1987, investors are required to provide a guarantee on project cost overrun. The cost overrun would initially be met by the guarantors (the original investors) who will later be reimbursed by the concessionaire after the retirement of the principal debt. Such cost overrun will not be included in the calculation of the rate of return on investment and thus will not affect the level of road toll. The public's interest is therefore protected.

(c) All concessions are conferred by an enabling ordinance. The ordinance specifies the construction period and the power of government officials to inspect the works during the construction period and to monitor the quality of service during the operation period. Failure to complete the construction work and to commence service to the public within the specified period could result in revocation of the concession (without any compensation). The Government may call on the performance guarantee requiring the original investors to complete the work and to meet the cost of completing the work.

Construction Risks—Summary Remarks. These tough conditions are welcomed by the lenders who also share the benefit of the protection. The concessionaire would transfer most of such risk to the contractors through the use of fixed-price lump-sum, turnkey contracts, tough delay penalty provision and guarantees from parent companies of the contractors, subcontractors and suppliers.

There could be practical difficulties in introducing such successfully tried arrangements in BOT projects in China. In China, the ownership of transport infrastructure is still tightly guarded. In most cases, the concessionaire for a toll road is a Cooperative Joint Venture between a foreign investor and a local partner, which often is a local highway development corporation, a state enterprise specially set up to take charge of the project. The construction work may be undertaken by this highway development corporation, its subsidiary, or a construction company that is, again, a state-owned enterprise. The contract is often awarded through direct negotiation and the price is established according to unit rates set in manuals produced by the Price Bureau. Competitive bidding is uncommon in China. The loose contract conditions used also make it very difficult to implement and enforce a genuine lump-sum fixed-price contract. Most disputes and variations are settled by direct negotiation or, failing that, a compromise set by political leaders. Such relaxed management and contract arrangements create difficulties when limited recourse financing is sought for the project. Lenders will look to the investors and/or government to underwrite the cost risks. In some cases, the Chinese partner agrees to cap the construction and delay costs, for example, the proposed privatization of the Yongjian Tunnel in Ningbo. The strength would depend on the quality of the guarantee, which will have to be backed up by the local or central government or a major bank acceptable to the investor or its lenders. This would in fact be a guarantee provided by the Government but dressed in a different form. The common practice in Hong Kong and many Western countries is to pass on such construction risks substantially to the contractor as a commercial risk and the cost of assuming such risks is generally reflected in the contract price.

Financing Risks

General. Typical financial risks include inadequacy of the loan financing to meet the contract payments, interest rate and exchange rate fluctuations, and project administration costs. The revenue risk will be dealt with in the next section—traffic and revenue risks.

A reliable project cost estimate is essential in assessing the amount of loan financing required. The loan arrangement should include contingencies to cater for unexpected but unavoidable cost increases, as well as shortfalls in working capital or revenue during the initial operation period.

Control Financing Costs. Low and stable financing costs are essential to the success of a BOT project. It does not only ensure a low and stable user charge throughout the concession period, but also ensures an agreed target return to investors. It is therefore important to seek maximum protection against any significant variations in interest and foreign exchange rates. This could be achieved by having part of the loan under a long-term fixed or "capped" interest rate arrangement. The remaining portion could be protected using interest swap or other hedging tools. Unfortunately, such hedging tools may not be readily available in China's financial market, which is still young and unsophisticated.

A significant part of the loan could be in foreign currencies. However, the revenue will be in local currencies. Thus, investors face an exchange rate risk for the entire period of the principal debt. The volatility in exchange rates could significantly affect the project's economics. The means to mitigate such risk depends on the currency structure of the loans and the type and amount of foreign currencies required during the construction period. Applicable

methods include hedging through swap, future and options markets. However these could be difficult to arrange as the renminbi is not a hard currency and has limited circulation overseas. Refinancing of foreign loan components of the principal loan upon the completion of the constructions works may be a feasible alternative in some instances.

Repatriation of Funds. Investors are concerned about their ability to repatriate funds, for debt servicing as well as dividends. With the gradual opening up of the foreign exchange market in China, it is hoped that most of the currency restrictions will be removed in the near future. Before that, investors would need government assurance on the handling of foreign exchange. Some of such assurance would need to be secured during the setting up of the foreign joint-venture company and seeking Ministry of Foreign Trade and Economic Relations (MOFTEC) approval.

Traffic and Revenue Risk

The debt servicing ability of a BOT project is dependent principally on its future earning potential. For a transport infrastructure project, these would be toll or fare box revenues. A comprehensive demand forecast projection is necessary to determine future patronage of the facility. Particular attention should be paid to the effect of competition from alternative routes or transport services and price elasticity. It is possible to project the future usage of a transport facility, within an acceptable level of certainty, up to 15 years ahead using modern demand forecast computer modeling techniques. However, the accuracy of such predictions is critically dependent on the availability of reliable transport-related statistical data, planning data and well-considered socioeconomic assumptions. It is crucial to the credibility of the forecast that the transport study is carried out by an unbiased, independent and experienced transport consultant. Often, an investor will commission a transport consultant to carry out an independent patronage. The study will be managed by the potential lead bank (the institution that will organize the loan syndication) to ensure its independence. For large projects, lenders may seek annual updates of the traffic and revenue projections using the latest socioeconomic data available in order to monitor their exposure continuously.

The economics of the project is most vulnerable during the initial three to five years of operation. If, for any reason, the revenue falls significantly below the expected level, the operating surplus may not be sufficient to service the debt (interest and repayment of principal) and, technically, the concessionaire could be in serious financial difficulties or become insolvent. Often, lenders will demand a guarantee from the private investors of the project (sometimes, their parent companies too) to make up any shortfall in operating cost and debt servicing in the first five years of operation and restrict the distribution of dividends until a specified debt coverage ratio is met. Such a guarantee is sometimes called a cash deficiency guarantee.

Political Risk

Stable Government. Political risks could arise from instability of the government. Since a BOT project is a long-term investment, its ability to provide long-term stable returns relies critically on the stability of the government and the presence of long-term stable social and economic policies. It would be very difficult to package a BOT project or to obtain project

financing for projects in a country where there are frequent changes in government or no clear, affirmative policy directions.

Government Policy Changes. Most lenders and investors are worried about "policy-induced" risks. Government policies may change any time for reasons that may or may not be rational or logical. There is no shortage of examples of "U turns" in government policies. Such changes could pose threats to the viability of a BOT project. For example, the Government may, due to purely political considerations, "renationalize" industries that were divested (that is, privatization of a nationalized industry) a short while ago. Or, solely for political considerations, the Government may change its mind and refuses the collection of user charge (such as the Huanggan Cross-Border Complex at Shenzhen) or intervene in granting adjustments to the toll/ tariffs to offset the effect of inflation or as per a contract agreement (Bangkok Expressway). This could seriously affect the debt servicing ability of a project and put lenders at risk. During this transition period of moving from a planned economy to a market economy, some of the economic policies could inevitably be wobbly. This could become a serious concern for some investors; they would seek a higher rate of return to compensate for such risks.

Competing Transport Infrastructure. There is still no formalized long-term transport planning mechanism in China. A transport project could be implemented because of an ad-hoc decision. A municipal government may, for reasons other than genuine transport planning or operation, build an alternative route or provide competing transport services prematurely. This would lead to an oversupply in capacity, wasteful competition and, eventually, reduction in the revenue of an existing BOT project and undermine its ability to pay back the debt. For example, the Government may decide to build a new river crossing parallel to an existing crossing that has just been put into operation. This is not an uncommon phenomenon in China. In BOT projects overseas, investors often demand assurance from government on the timing and construction of competing transport infrastructure.

9. Initiating BOT Projects

Prerequisites

The prerequisites for a BOT project are:

(a) there is a genuine demand for the services provided by the project;

(b) the Government needs nontax-based funds to finance it;

(c) there is a market for the service provided by the project and the future revenue potential of the project is sufficient to service at least a substantial portion of the debt raised to build it;

(d) the project is ready.

In summary, a dream project cannot be implemented as a BOT project.

Preparatory Works

BOT is only a method of financing a project. The transport project remains part of the Government's overall transport infrastructure investment program. Therefore, the Government still carries the responsibility for the planning and evaluation of the project in the same way as other Government-funded projects. The priority of the project should be determined by the real transport needs and economic benefits to the community and not by the interest or availability of potential investors.

The Government must establish that the project is technically feasible and financially viable before deciding on inviting proposals from private investors. As a first step, it is necessary to conduct a series of feasibility studies. These include: engineering feasibility study, transport study and financial viability study.

At present, China is fully capable of undertaking the engineering feasibility study for most road projects. However, there are still inadequate experience and knowledge at the municipal level to undertake the transport studies to the level of detail required by the financial community. This will have to be carried out by, or with the assistance of, external advisors.

Engineering Feasibility Studies

A proper **engineering feasibility study** should be carried out:

- to ensure the project is technically feasible;
- to arrive at an accurate cost estimate and implementation schedule;
- to identify the extent and timing of land requirements;
- to provide bidders with adequate information for the preparation of a realistic BOT proposal; and
- to establish the technical specifications for construction, operation and maintenance of the facility.

Transport Study

The purpose of the transport study is to evaluate the transport and economic need of the project and to assess its future patronage and revenue potential. The transport study will forecast the future volume and composition of the traffic using the facilities against the backdrop of known planning data and policy (land use, population, work distribution and economic growth). Sensitivity tests would be carried out to assess the upside potential and downside risks. It will also look into the implication of possible competing roads. The traffic and revenue forecasts will be input to the financial model for financial viability analysis.

Preferably, such study should be conducted by an independent consultant of international repute and reach a standard that would be acceptable for international project financing purposes.

Financial Viability Study

A financial viability study must be conducted to fully assess the financial viability of the project. This would include examining the likely return on investment, payback period and the benefits and risks to the investors and government. The study will, based on the financial analysis, recommend the outline commercial conditions for the concession and develop a strategy for marketing the project. If the project is only marginally viable, it would examine ways to turn it into a viable proposition, including evaluating the need and extent of government injection, subsidies or cross-subsidies required. Although the study would not examine in detail the methods of financing of the project, it should take into consideration the commonly available sources of funds in the domestic and international capital markets in the financial model analysis.

The financial viability study will have to rely on external support as the expertise required does not normally reside in the Government. The study may be carried out by financial advisors from a merchant bank, commercial bank or specialist financial institution with hands-on BOT experience (accounting firms, security firms, etc.)

Packaging

Having satisfied the above basic technical and financial requirements, the next step is to examine the commercial and market aspects and package the project in a way which would render it attractive to potential investors and lenders. Unlike a conventional procurement or construction contract, BOT is a business venture and a substantial investment; investors will only participate in a project if they are attracted by its conditions and prospects. The package would principally examine the following key issues:

- commercial viability;
- assurance over political risks;
- certainty in revenue stream;
- sharing of the completion risks;
- prevailing financial climate (local and international), and
- the image of an understanding and considerate public sector client (usually the municipal or provincial body).

Competitive Tender

At present, Chinese authorities make no distinction between the invitation of private foreign investment in manufacturing industry, property development or transport infrastructure. They are treated equally as investment opportunities in China and interested foreign investors are welcomed to approach and negotiate directly with the relevant government departments or agents.

Transport infrastructure investment is a long-term investment with a long payback period. It has a strong social component and directly affects the public at large. Also, the investment would be very susceptible to the effect of government policy and economic changes. Accordingly, it should be treated differently from private investment on property or manufacturing.

Competitive tendering is the preferred approach for the implementation of a BOT transport project. The drawback, or indeed the advantage, of this approach is that the client, that is, the government (municipal or provincial), will have to complete the detailed planning beforehand, including all the engineering and financial feasibility studies. The commercial and technical conditions must be clearly specified in the bid document. This will also help the Government to develop a clear picture of what it wants to achieve. Similarly, interested investors would have in writing the details of the project, and the technical and commercial requirements. He can then structure his bid accordingly. Competitive bidding offers the client a better chance to get a fair deal.

The preparation of BOT bid submission is a very expensive exercise because of the large number of consultants and advisors required and the time involved. Thus, investors would only respond to a bid invitation if they consider the investment opportunity is good and they have a reasonable chance of getting the project. Most important of all, the investor is convinced that the owner, that is, the government, is serious and sincere in the tender action and there will be fair competition.

Invitation of Tenders or Calling for Proposals

Tender invitation is normally used when the goods or services to be procured are well defined. Fully detailed specifications are provided in the tender document. The focus of competition and therefore the evaluation will be on tender price. In the case of BOT projects, the Government only defines in the bid document a framework of commercial and technical requirements upon which bidders may develop a creative solution. It involves also a bargaining process and the Government is looking for a partnership. In practice, the proposals (or bid) submitted for a BOT project provide a starting point of negotiation. The concession conditions would have to emerge subsequently through negotiation.

Bid Document

The preparation of a bid document is a complex and specialized task. BOT bid documents are very different from those for conventional construction work tender documents. A BOT bid document provides a framework of commercial and technical requirements. It should give enough room and flexibility for bidders to exercise their innovative thinking, to make the best application of their experience and capabilities. On the other hand, the bid document should contain basic rules and requirements that will be adhered to and place some limitations on the range and types of proposal to be submitted to ensure a "like" with "like" comparison is possible. Most municipal governments in China, like their counterparts in South Asia, are accustomed to conventional construction or procurement contracts. They do not have the experience or in-house expertise to prepare such documents. External expert assistance would be necessary.

Typically, a BOT bid document comprises two parts: Project Brief and Technical Specifications. The Project Brief concerns mainly the instructions to bidders, rules on preparation and submission of a BOT proposal, an outline of the legal and commercial conditions for the concession. Where possible, it should also include a draft concession agreement. The Technical Specifications, as the name implies, concerns the technical requirements of the project. It would include a design memorandum, design approval procedures, quality assurance requirements, operation and maintenance requirements, etc.

The contents and structure of a typical BOT bid document are illustrated in Annex 2.

Evaluation of Proposals

The evaluation of BOT proposals is a very complex process. Essentially, it would analyze:

(a) the technical feasibility of the proposal;

(b) the credibility of the cost estimates;

(c) the experience, capability and management structure of the bidder (and the project company), its technical team, designers, contractors and, in particular, their ability to satisfactorily complete the work on time;

(d) soundness of the financial proposal;

(e) comparison of the proponent's revenue and cash flow projections with those of the government;

(f) the risk allocation structure, in particular the potential risks to government, and the ability of the different parties to the BOT project to take onboard the risks allocated to them;

(g) quality of the lenders' support;

(h) quality of the support from shareholders (the original investors), for example, against delay, cost overruns, and cash deficiency, etc.

The analysis would involve a presentation by each proponent and written clarification on technical and commercial issues. As pointed out earlier, the proposal is merely the starting point of contract negotiation. Often, experienced bidders may purposely be vague in certain aspects of the proposal. It is a recommended practice not to start any face-to-face negotiations until most of the qualifications and ambiguities are resolved in writing to the satisfaction of the Government and its advisors.

Negotiation

The BOT bid assessment and negotiation are time-consuming processes. It could also be very exciting, stressful, tiring and frustrating. Bid negotiation should be conducted only with a short list of two or three bidders.

Prior to the commencement of negotiations, the Government must first establish a negotiation strategy that would provide clear statements on targets and objectives of the negotiation, points the negotiation team may concede and treat as not negotiable. Also, the negotiation team must have a full understanding of the bids before starting the negotiation. Clearly defined discipline should be set for the team members—who will be the leader and spokesman and who will play the supporting roles, etc. Internal notes should be prepared for each round of negotiation. Any agreement reached in a round of negotiation must be recorded and endorsed by both parties in writing immediately.

A BOT project should be viewed as a joint undertaking between the government and the private sector. Its success relies heavily on mutual understanding, mutual respect, cooperation and readiness to share the risk, if logically and equitably distributed between the parties. The project can only be successful if it is a viable business venture and provides a reasonable service to the public at an acceptable price. The government should acknowledge and appreciate the profit motives of the bidder while standing firm on its transport policy and protecting the public's interest. Also, it should not easily concede to unreasonable desires of the investor.

BOT is a marriage for a long period—20- to 30-year franchise period. Thus, it would be in the best interest of the parties to have a frank and sincere negotiation and reach a conclusion both parties would be happy to honor afterward. Negotiation by secrecy or trick is unlikely to foster a win-win result.

Contract Document

The contract document involved is also very complex. This includes a concession agreement (or implementation agreement), a construction agreement, a wide range of loan agreements, a shareholders' agreement and a large number of warranties and guarantees. All documents must properly and correctly reflect the agreement reached during negotiation. The finalization of these documents involves not only the government and the investors, but also the lenders, contractors and their financial and legal representatives. The complex legal documentation alone could easily run into hundreds of pages. They would have to take into account the laws and regulations of China, as well as some international practices that may need to be included in the legal documentation in order to provide comfort to the key lenders. Many of these documents would have to be in both Chinese and a foreign language. The government must have adequate preparation in order to avoid any unnecessary delay to the project. To maintain progress at this stage, all the participants, including their representatives and advisors, must be suitably experienced. There would be no time to learn as you go along.

10. Concluding Remarks

Parties Involved

There are three parties to a BOT project: government, investors and lenders. Although the lenders are not a party to the concession agreement, they provide most of the funds for the project and share a large portion of the project risk. Therefore, in planning and developing a BOT project, the government should take into consideration the concerns and expectations of lenders, for example, allocation of project risks, credibility and reliability of future revenue and debt servicing potential.

Possible BOT Project and Prerequisite

A dream project cannot be implemented as a BOT project. There must be a genuine need for the proposed transport infrastructure, a real demand for the service and the existence of a market for the service the project provides. The project must be ready, that is, the necessary government approval obtained and the support services and infrastructure available upon completion of the BOT project.

A BOT project must be able to generate a net operating revenue that would pay back the loan used to build it and provide a reasonable return to the investors. Urban transport infrastructure projects that may fulfill this requirement include toll highways, car parks, freight stations and public transit systems. Designed properly, it would also be possible to implement a modern automatic electronic toll system as a private sector venture.

Profit Motives

Private investors are profit motivated. The profit motive is not evil as long it seeks no more than a reasonable return on the capital employed and a fair compensation for the commercial risks undertaken. The profit margin should be a measure of efficiency and skill and, as such, it can be encouraged.

User Charges

In spite of the economic reform that has been going on in China since 1978, transport prices of most public services are still below cost. This is in conflict with the "user pay" concept and adversely affects the revenue of a project. The ability to adjust tolls or tariffs during the concession period has always been a major concern to investors and any uncertainty in this respect would be perceived by foreign investors as a serious political risk.

BOT is a Joint Undertaking

A BOT project should be viewed as a joint undertaking between the government and a private investor. Often, the project must work within a very tight budget and program in order to ensure its commercial viability. During the course of project implementation, the investor will rely heavily on support from the government to liaise, coordinate and resolve conflicts between different authorities, agencies, and to obtain speedy design and statutory approvals, permits and licenses. Any heavy-handed bureaucracy in these processes could affect cash flow and the project itself. The government should appreciate the problem confronted by investor and do its best to help overcome them, as a partner and not as a referee.

Institutional Issues

There is a high level of centralized control under the current institutional structure of municipal governments in China. Also, in many municipalities, the line of command and division of responsibilities between (and within) the government departments and agents are not clear. All these create confusion for the investor and increase the risk of project delay. Few investors can understand the complex municipal government structure. Often, they have difficulties identifying the right party/agent to talk to when they need information or when the

project runs into problems. These are major disincentives and hurdles for foreign investors, especially those who do not have good connections. The government should streamline its operation and decision-making process and try to match the tempo of the private sector. This could include setting up a task force with clearly defined authority and responsibility, appointing a "champion" for the project and making some of the decision-making process and procedures more transparent.

Legal and Regulatory Framework

The existence of clearly stipulated legal and regulatory frameworks for the implementation of a BOT project will help to remove part of the "country" risk perceived by foreign investors. It will also help to remove most of the uncertainties and anxiety of bidders and set the scene for successful competitive tendering. Clear implementation guidelines will help to prevent misunderstandings and/or misrepresentations. Guidelines and regulatory framework should also include procedures for bid assessment and negotiation.

Project Financing

Few investors would be prepared to borrow against their balance sheet for a transport project. Project financing is different from traditional financing, which is asset-or "balance sheet"-based. Project financing is also known as nonrecourse or limited recourse financing. In this form of financing, the future debt servicing expectation is limited primarily to the future revenue potential of the project. That is, the project would become the borrower, not the investor as in the case of traditional financing. The ability to reliably assess the potential future revenue and to secure it is crucial to the success of a BOT project.

Specialist Knowledge Requirements

The financial mechanisms and operations of a capital market are highly sophisticated. Even for those civil servants in the more highly developed Western countries, to understand the subtleties involved and appreciate the difficulties and concerns facing lenders, security agents and investors is a severe challenge. This situation could be more acute in China. This inability to comprehend the complexity involved in such projects could lead to mistrust between the private and public sector. This would prolong the contract negotiation period and generate conflicts during the construction and operating stages, adding to the cost of a project.

Finally the legal documentation involved is very complex. The total documentation of legal contracts, warranties, guarantees, loan documents, security document and assignment agreements can easily run up to several hundred pages. Officials in the municipal governments would need external professional and specialist support.

Preparation Works

BOT is only a means of financing. The Government must complete its own transport planning and determine the priority of projects in the usual way. Private investors' interest should not be allowed to bias the Government's transport strategy. The Government should carry out appropriate feasibility studies to confirm the technical and financial viability of the project prior to inviting bids from the private sector.

Bid Evaluation and Negotiation

The bidding process should be well-defined and transparent. Where possible, it should also include a schedule for bid evaluation and bid negotiation.

The information contained in a submitted BOT proposal is highly confidential and any leakage could affect the process of evaluation and negotiation, or even result in unfair competition. This would have an adverse effect on the image and credibility of the Government. The Government must ensure that the confidentiality of proposals are rigorously observed throughout the evaluation and negotiation period.

In a BOT project, the Government is looking for a partner, not a contractor. The success of the negotiation relies, to a large extent, on mutual understanding, mutual respect and cooperation between the parties and readiness of the Government to share the project risks with other parties. The Government should have a good understanding of the project, the investor's rightful expectation in terms of return and risk exposure and be sympathetic toward investors' and lenders' genuine concerns. The Government should also be consistent in its requirements.

Project Risks

The main categories of risks include construction risks, financial risks, revenue risks and political risks. Risk allocation is important to the structuring of a BOT project. BOT projects require complicated structures to allocate the projects risks and responsibilities among the many parties involved. The most practical way is to allocate risks to those parties that are most experienced and capable of managing and containing them.

Prospect for Private Funding for Urban Transport Projects

There will be a gradual increase in the incidence of private-sector participation in transport infrastructure projects in China. However, a higher level of private-sector participation, as is currently in the manufacturing and industrial sectors, would only come about when the learning period is over. Also urban transport projects will have to compete with the large number of interurban highway projects that are more attractive to foreign investors; many such projects are under active discussions. Thus, the private sector is unlikely to make a large contribution to urban transport infrastructure funding in the short term; most urban projects will still have to be funded by the public sector.

Municipal governments should carefully review their projects in hand and identify those projects that would be suitable and attractive for private investment. They should employ the assistance of experienced international professionals to package them with target investors in mind and before putting them to the market.

THEME PAPER 10: SHAPING THE FUTURE: GETTING PRICES RIGHT

KENNETH GWILLIAM [1]

1. INTRODUCTION

Determining social or economic objectives is a national prerogative. It is not the purpose of this paper to infringe upon that prerogative. But it is assumed that there is a desire in China to harness market forces to achieve the national objectives. The purpose of this paper is to examine how the use of the price mechanism might be used to address the critical issues that are likely to confront the urban transport sector in China in future years.

China is growing rapidly. With that growth will come an increase in the demand for transport, both for business and for leisure purposes. And with that growth China will inevitably have to face similar problems of traffic congestion and environmental impact which have affected currently more wealthy economies in the process of growth. Using the market process does not mean that social welfare interests have to be abandoned. Whatever the social objectives and priorities, market processes can help to achieve them. Prices are the primary instruments through which markets work. In the transport sector, prices affect how people behave and, hence, how much and what type of transport is demanded. They also generate revenue and, hence, can be used to improve services offered or to invest in new facilities. But both the factors affecting what people demand and the structure of the costs of supplying transport service are very complex. Understanding how prices work in the sector, and what is necessary to make the best use of the price mechanism, is therefore central to the introduction of more market-oriented approaches to social and economic policy.

Section 2 briefly characterizes the current urban transport situation in China and identifies some respects in which current pricing and financing arrangements may be giving wrong signals for individual and institutional behavior. Section 3 refers to the experience of countries that have already achieved higher income and development levels to identify a range of problems that those countries have encountered, and that China will almost certainly have to face in the future. Section 4 outlines, in general, the functions that are performed by prices in market systems as a basis for the subsequent discussion of how prices and the market mechanism might be used in China to confront the incipient problems. Sections 5 and 6 discuss how consumers and suppliers typically behave in market-based urban transport systems. Section 7 outlines the important tasks that still fall to government in making the market system work. Sections 8, 9 and 10 discuss how prices and markets can contribute to better achievement of economic

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efficiency, distributional equity and environmental acceptability of urban transport. Section 11 considers the role of fuel prices, which has impacts over a broad range of decisions and dimensions of impact. Finally, Section 12 draws some conclusions and makes some suggestions concerning the actions that would be of the highest priority for a Chinese government wishing to move in the direction of greater use of prices and market incentives in urban transport.

2. How is Urban Transport Provided in China at Present?

There are a number of specific characteristics of urban transport in China at present that will affect the way in which the pressures of increasing national and personal wealth will influence the decisions that have to be made.

- **Bicycles** are relatively cheap by international standards; the cost of a new standard bicycle is about one month's average urban income per capita. Though this appears to be more than double the proportion for industrialized countries such as the Netherlands or Japan, it actually is very comparable when allowance is made for the much higher costs of housing in those countries and the greater state provision of some other services in China. The proportion is much lower than that for most African countries. There is a nominal registration charge and some low parking charges in specific locations. The bicycle is, therefore, currently the affordable means of mechanized transport for the mass of people and dominates road traffic. Even as incomes and car ownership increase, it is likely to remain the dominant mode for a long time.

- **Buses** are the next most common mechanized mode of urban transport after the bicycle. They are owned by the municipalities and are organized under the Bureau of Public Utilities Division Of Urban Public Transport. They receive separate annual budgets for capital expenditures and operating deficit. The municipal government determines routes, frequencies, fares, and wages. In some cities (for example, in Guangzhou but not Shanghai), labor can now be employed with market wage rates below that for full-time state employees. Bus fares are regulated at a low-level flat fare that varies somewhat from city to city, but is approximately Y 0.4 for journeys of 4 kilometers and Y 0.5 for journeys of 8 kilometers. The Government takes some share of the revenue for reinvestment and subsidizes the operating cost. Surplus over the planned revenue is viewed as "profit" to be used at the discretion of the company—including bonuses to employees. "Extra" services above quota can be supplied by the company. Where premium service (for example, limited stop) is provided, premium prices can be charged. There also appears to be a possibility for employees to jointly own vehicles purchased from surplus. There is some private operation by a Hong Kong investor in Guangzhou.

- **Motorcycles** are an increasing proportion of the total vehicle fleet. Although there are still only six motorcycles per 1,000 people in Chengdu, there are already two per 100 people in Jinan and six per 100 in Guangzhou (where incomes are about 50 percent higher). There are still twice as many motorcycles as motor cars in Chengdu and seven times as many motorcycles as cars in Guangzhou. It therefore appears likely that, as incomes grow, the first step into private motorized transport could be a

massive and rapid increase in the motorcycle population (see the companion paper on "Motorization").

- **Private automobile ownership** is currently low. The basic domestically produced vehicle costs over Y 90,000, and there are tariffs on imported vehicles varying between 70 and 230 percent, depending on vehicle type and the preference rating of the purchaser. A consumption tax of 3 to 10 percent is charged on the base price plus tariff. On this total sum a further purchase tax of 17 percent is levied. These taxes accrue to the central government. In addition, there are some further charges or fees, the receipts of which accrue to the local government or line ministries. These include an Added Vehicle Purchase Fee of 10 percent of the retail price and a Road Maintenance Fee (RMF) of 12 to 15 percent of the total business revenues for specialist transport enterprises and Y 100 to Y 230 per ton or 10-seat capacity for all other vehicles. At present, the basic domestically produced car costs between 20 and 30 years' earnings at the average urban income levels, compared with 6 months in the United States, and about one year in many European countries. By international standards, ownership is a little below what is normal for countries of similar income level. Initial expansion of car ownership will inevitably be restricted to the relatively rich.

- **Taxi services** are important in all of the cities with populations over 2 million, as well as in most of the smaller cities in the rich coastal areas. They are supplied under a wide range of ownership including state-owned, collectively-owned, privately-owned, and joint venture between domestic and domestic/foreign partners. Typically, the companies rent the vehicles at a flat monthly rate to drivers who pay for gasoline and maintenance. There is a high incentive to work long hours. Some cabs are rented on a two-shift basis. Fares are subject to control, but differential fares are charged according to vehicle type.

- **Urban rail** is at present only a small contributor to movement in most cities. There is little suburban rail service. Beijing, Shanghai, and Tianjin have subways, and that of Guangzhou is under construction. Several cities have streetcars.

The construction and maintenance of the urban road infrastructure is the responsibility of the Urban Construction Commission in each municipality, which reports to the Ministry of Construction in Beijing. Work is financed through local revenue sources, mostly unconnected to the transport sector. The main source of revenues for major road building in the large cities is land leasing. For rural roads, the Communications Commissions of both municipalities and provinces are responsible. Work is funded through the Road Maintenance Fee and by grants from the Ministry of Communications.

The lack of any link between the cost of provision of infrastructure and the cost of its use is exemplified by the approach to the supply and pricing of transport fuels. Two aspects are most notable:

- **Gasoline** has, in the past, been allocated to companies at subsidized prices on a quota related to the calculated needs of the company. Extra fuel could be purchased

on the market at the administered market rate. The dual pricing system is generally being superseded, but still appears to continue in special cases such as public bus company allocations of "planned" price quotas. The relationship between the administered price and the real costs are not clear. At the moment, most cars are used for business purposes: on standard reasoning, this is an intermediate input and, therefore, not appropriate to use as a base for sumptuary taxation. But this should change as the proportion of cars used privately increases—especially as in the near future, it is likely to be the very rich who have cars.

- **Fuel taxation** is not explicitly levied as such because the Government has, historically, obtained revenue primarily from remissions of surplus from companies. Fuel comes from domestic sources and now, increasingly, from imports. The price of fuel was fixed on a calculation ostensibly based on the labor theory of value. Now a "market" price is set, based on the international purchase cost (the "border price") plus the distribution and handling cost margin of the government agency. Imported fuels are now charged duties varying between 6 and 14 percent, and there is a consumption tax levied at Y 0.1 per liter for diesel and Y 0.2 for gasoline. The market price is currently much closer to the border price than in most countries (see Figure 4 below).

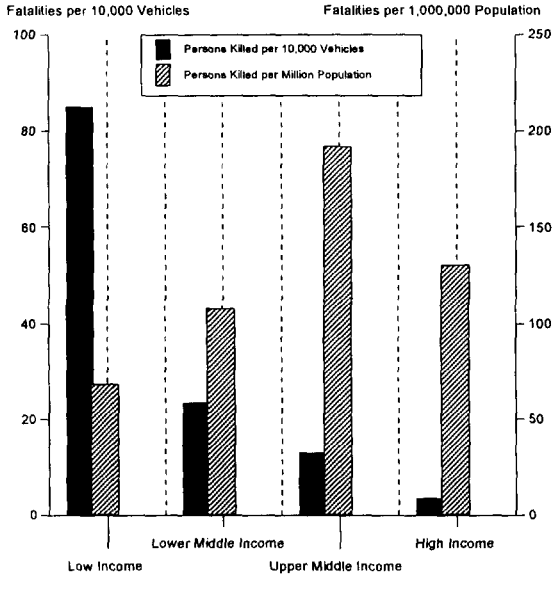
This existing arrangement involves, as in most countries, a division of responsibility for management of transport regulation and associated taxing and pricing between levels of government and agencies.

3. WHAT ARE THE INCIPIENT PROBLEMS?

The incipient problems that emerge as incomes and car ownership increase can be identified from the experience of other nations—even those in Southeast Asia—that have gone through that process. The major issues that China will certainly have to face are the following:

- **Road accidents**. Associated with the increase in traffic volume is a likely increase in traffic accidents. Experience throughout the developing world has shown that while injury accident and fatality rates per vehicle decrease steadily as car ownership rises the rates per person tend to increase until very high car ownership rates are achieved and associated with very strong safety programs (see

Figure 1: ACCIDENT RATES



Source:: International Road Federation. 1993. *World Road Statistics*

Figure 1). In the early stages of development the impact is predominantly on pedestrians and cyclists who are particularly vulnerable in mixed traffic.

- **Road congestion**. Increasing mobility associated with increased ownership of private automobiles is an understandable aspiration in a rapidly growing economy. It is important to recognize, however, that expansion of the car stock without adequate road infrastructure can be very damaging. Both in Bangkok and in Seoul very serious traffic congestion has occurred at relatively low levels of car ownership because of the inadequacy of infrastructure availability (only 11 percent of the land area of Bangkok is devoted to roads compared with 20 to 25 percent in most European cities). The most significant problem that is likely to arise in China concerns the existence of low levels of fuel taxation, which give a high incentive to the development of private transport, unrelated to the way in which public transport is priced and financed. At present, this does not create a serious distortion because of the high costs (relative to income) and consequently low level of private car ownership. But, as incomes and car ownership increase, the need for a comprehensive strategy that reconciles the desire to increase the private mobility of Chinese citizens with the maintenance of other legitimate aspirations on the quality of urban life will become more apparent (see paper on motorization).

- **A deteriorating urban environment**. Air pollution caused by transport is worse in the growing cities of the developing world than in major cities in industrialized countries (see Figure 2). While some technical actions can be taken to counter this (for example, catalytic converters to reduce NO_x and CO, elimination of lead from gasoline and sulfur from diesel), the problem is not one that can solely be managed by technology regulation.

Figure 2: AMBIENT AIR QUALITY INDICATORS FOR SELECTED CITIES, AVERAGE MEAN CONCENTRATION, 1987-90

% Range Transport Sources	Pb 90-100	CO 80-100	NO_2 60-70	O_3
Bangkok	●	○	○	○
Beijing	○	NA	○	●
Bombay	○	○	○	NA
Cairo	●	●	NA	NA
Jakarta	●	●	○	●
London	○	●	○	○
Los Angeles	○	●	●	●
Mexico City	●	●	●	●
Moscow	○	●	●	NA
New York	○	●	○	●
São Paulo	●	●	●	●
Seoul	○	○	○	○
Tokyo	NA	○	○	●

● WHO guidelines exceeded by more than a factor of two.
● WHO guidelines exceeded by a factor of up to two.
○ WHO guidelines normally

Source: World Health Organization and United Environment Programme. 1992. *Urban Air Pollution in Megacities of the World.* Oxford:

- **Conflict between motorized and nonmotorized transport**. Motorized vehicles tend to dominate nonmotorized vehicles in mixed traffic situations, even when they only constitute a minority of the total traffic. High cyclist accident and death rates may result (as in India where only 5 percent of fatalities occur to motor vehicle drivers or occupants). It will be important to remember the continuing high level of dependence on the bicycle in the planning and management of infrastructure.

- **Failure of public transport to supply the poor in a nonsubsidized commercial market**. The reliance on the commercial sector for the provision of public transport service can increase supply efficiency, but means that services which are not remunerative will not be provided. Historically people have lived close to their workplaces in China and the bicycle has functioned as the basic mode of transport for the poor. Not only has it been cheaper than public transport for the typical journey to work, but it has also been quicker for the typically relatively short journeys undertaken. As incomes increase, car ownership and road congestion will increase. Bicycles are likely to prove relatively less convenient for many trips. It is therefore important to ensure that there are adequate institutional and financial arrangements to ensure public transport for those still not able to afford a private car. In many countries that have been dependent on private-sector provision of public transport supply to the poor has either had to be subsidized (which many poor countries have not been able to afford) or left to the informal sector using smaller, cheaper, vehicles but taking advantage of the availability of the pool of labor available for employment at low cost. It is important that Chinese cities confront this issue.

4. WHAT ARE THE GENERAL FUNCTIONS OF PRICES WITHIN MARKET SYSTEMS?

Within a market economy, prices perform a number of different functions.

- **Giving signals to affect consumers' decisions**. Where income is limited, and goods and services are not physically rationed, consumers will attempt to obtain the highest level of satisfaction that they can from allocating their income. Prices will thus affect the allocation of consumer expenditures, both between and within sectors of the economy. The greater the degree of freedom of consumer choice across the whole economy, the greater the benefit to be obtained from making any one sector more commercial.

- **Giving signals to affect producers' decisions**. Within a commercial market, producers are concerned to maximize the surplus of revenue over cost. Market prices will thus affect decisions about what to produce, quantities to produce, and input resources to use.

- **Generating revenues to fund production by enterprises**. Private enterprises can only continue in production, without subsidy, if they generate enough revenue to maintain their capital assets and to pay for their current inputs.

- **Generating revenues to government** for infrastructure provision and maintenance. Taxes or fees and charges for the use of publicly provided infrastructure also yields revenues with which that infrastructure can be maintained.

- **Giving signals on investment decisions**. The level of prices is also important for capital investment decisions. If prices are too low, demand appears high and congestion of facilities will occur. This will give the appearance of a need for extra capacity that would not be necessary if prices for use of infrastructure or services were set to cover costs. In terms of cost-benefit rate of return calculations, a higher

rate of return appears to be obtainable if current prices are set below costs. In this way, undercharging for the use of transport infrastructure and services not only leads to an excessive level of current expenditure, but also leads to overinvestment.

The key advantages of using the market mechanism more extensively in the transport sector are that excess demand is restrained, financial deficits are avoided for both public and private sector undertakings, and socially beneficial transport investments and improvements are identified and funded.

In order that the market signals can have their effect on all of these dimensions, a number of general conditions must exist, namely:

- **Consumers must be free to choose**. In order to make the best of their limited incomes, consumers must be as free as possible to allocate their income between alternative forms of consumption. Quantitative rationing of the amount that consumers may, or must, consume of any product will reduce their welfare.

- **Prices must reflect relative marginal costs**. For free individual choice to result in the maximum welfare, the prices at which they are able to buy commodities must reflect the extra cost that society incurs in producing goods. This is the marginal cost of production.

- **Prices must reflect real costs (including externalities)**. The costs that should be covered by the purchaser of a commodity should include all costs imposed, including such elements as the cost of any environmental pollution caused by the production or consumption of the good or service. It is important to note, however, that this assumes that there is some competitive pressure to make firms efficient. If production is not efficient, prices set to cover total real costs would be in excess of economically efficient prices.

We now turn to the application of these general principles to the specific problems likely to be confronted in the transport sector. In a number of ways, the particular characteristics of the transport sector make the application of general market principles both complex and difficult. We can approach these complexities by looking in turn at the peculiar problems facing consumers, suppliers of services, and government (as supplier of infrastructure as well as in its role as general regulator of market conditions).

5. How do Consumers Behave in Market-Based Transport Systems?

Four considerations are most critical for consumer decisions in the transport sector.

Perceived Costs. These are costs that the consumer is immediately and directly aware of, and that the consumer takes into account in making his/her decisions. Many of the costs that the individual incurs in running an auto, for example, only arise periodically (fuel once a week, costs of maintaining his/her vehicle once a month, costs of registration or insurance once a year, etc.) are not immediately perceived by the transport user in making an individual trip and, hence, are not taken into account in making decisions. Even more significantly, the consumer imposes substantial costs on others which he/she does not perceive and, hence, does not take into account

in making his/her decisions.. In order to discourage individuals from making trips for which the social cost exceeds the private benefit, it is desirable for the costs that the individual incurs privately should reflect the total social cost that he/she is imposing. Environmental impacts are also for the most part also ignored in private decision-making if they are not reflected in the prices that users of transport services or infrastructure have to pay.

Generalized Cost of Transport. This is the sum of the money price that a consumer has to pay for a good or service and the money value of the time that is involved in making the trip and any other inconvenience (discomfort, etc.) involved. Consumers will normally select the means of making a trip that offers the lowest generalized cost. As incomes increase, so will the valuation that transport users put on time, comfort, convenience and flexibility of service, with the effect that the money price tends to become less important as a determinant of consumer choice and the quality of the alternatives more important. That is why richer people tend to use faster, more comfortable modes of transport. It is the reason why the quality of service provided by public transport modes should be progressively upgraded as the economy, and the people within it, get richer. But the converse is also true: it does not improve welfare to provide a higher quality of service than users wish to pay for.

Marginal Private Cost. This is the extra cost that a user incurs as a result of a decision to consume one extra unit of a service. For a public transport service, it will be the fare that he/she pays together with the time that the journey takes. For a car trip, the marginal cost may be perceived as only the fuel cost. Charges not related to level of usage (such as license fees) or paid only occasionally (such as maintenance and insurance charges) tend to be ignored by the consumer in making marginal choices.

Marginal Social Cost. When there is congestion on the roads, every extra vehicle not only incurs a certain time cost to make a journey, but also contributes to slowing down all of the vehicles already on the road. The cost that the extra vehicle user incurs is the *marginal private cost* (described above); the cost that the extra vehicle user imposes on others is the *marginal external cost*. The sum of these two is the *marginal social cost*.

Consumers are likely to make their decisions on the basis of the costs that they perceive themselves to incur as a consequence of any decision. In terms of the definitions above, this means that private decisions reflect the perceived, marginal, generalized cost of alternatives. Where there are very substantial costs imposed by an action that does not enter this private calculation, significant biases or distortions can result. That is the reason why it is so important to try to *get the prices right*, that is, ensure that individuals do perceive, as private marginal costs, all of the costs that they impose on society as a consequence of their private decisions.

Transport consumers' decisions have many dimensions. All of these dimensions of choice have resource-use implications, and all can be affected by transport prices.

- **Number of trips**. People will only make a trip if the benefits of the trip exceed the time and money costs of making the trip. In some cases, such as the journey to work, the trip is of such importance that it is likely to be made at almost any price. The same applies to a lesser extent to trips for health and educational purposes. But leisure trips are likely to be more price-sensitive. Prices can thus discourage some

less highly valued trips, cause people to economize by making multipurpose trips, and have the effect of allocating scarce space to those trips that are more highly valued by users.

- **Choice of transport mode**. The choice of mode will depend on the relative generalized costs of the alternatives. The significance of this is that public transport service quality must be maintained if it is to be an effective alternative to the bicycle or the private auto.

- **Time of travel**. While some trips, such as those for the journey to work, are strictly determined by the timing of activities (working times, shop opening times, etc.), others are not so constrained. Individuals may be discouraged from traveling at peak hours because of peak-hour surcharges, particularly on the use of congested roads by private cars. Such time-of-day differentials may also encourage enterprises to vary their times of business to avoid peak hour travel ("staggering" of working hours).

- **Destination choice (trip length)**. For walking or bicycle trips, the length of trip is very constrained by the time taken and the physical capacity of individuals to make longer trips. That is not so for public transport or for the private automobile. Low and flatly-structured public transport fares, and low effective prices for use of the automobile, encourage long trips and increase total demand and congestion

- **Route choice**. This can be affected particularly by road tolls. It is particularly important to ensure that tolls are not set in such a way as to produce high levels of congestion on untolled facilities.

- **Choice of vehicle type**. One of the most important effects of increasing the price of fuel (through fuel taxation) is to encourage people to use fuel-efficient vehicles. This is particularly important for freight vehicles. The level and structure of taxation on freight vehicles is a particularly important determination of the structure of the freight vehicle stock in many countries.

The great complexity of the determinants of user preference, and the large number of dimensions over which that preference is exercised, is very difficult to include in a centrally determined and administered plan. The consequence is that simple quantitative controls over what transport can be supplied to the market are likely to produce outcomes that differ significantly from those that consumers would choose if they were able to have direct impact on supply. The central reason for trying to make urban transport more market-oriented, and to use the price mechanism to guide decisions, is to allow consumers to have greater influence on what transport is provided.

6. How do Suppliers of Transport Service Behave in Market-Based Systems?

A clear distinction needs to be made between "public transport," which is transport service available to any member of the public on demand; and "public sector supply," which is the provision of public transport service by a public, as opposed to private, agency. These are not the same thing. In many parts of the world, public transport service is provided predominantly by private companies. Moreover, it is not necessarily the case that subsidized

service can only be provided by public enterprises. Again, in many parts of the world, public authorities who wish to provide services to consumers below cost do so through supply contracts with private companies. Thus, whether a service should be provided by a public or private agency depends not on whether it is desired to subsidize the service, but on which type of agency is able to give the best value in providing the service (whether subsidized or not). In all cases, producers need to cover costs to survive, to respond to consumer demand to thrive, and to manage their businesses efficiently.

Covering Costs

Creating a more market-oriented urban transport sector also requires an understanding of how suppliers are likely to behave in commercial market situations. For private companies or commercialized publicly-owned companies operating in commercial markets, competition enforces two essential requirements:

- **Total revenues must cover total costs to stay in business.** Any commercial enterprise must be able to obtain enough revenue from its users to cover all of its costs; otherwise it will go bankrupt and be unable to stay in business. This gives suppliers of service an incentive to identify those activities that will yield them the greatest possible revenue for a given level of input, and price their services in the way that maximizes the revenue that they obtain. For these reasons, private enterprises tend to be more inventive in finding ways, including price discrimination, to attract patronage and secure revenue. They are also likely to be most sensitive to changes in what consumers want, including responsiveness to emerging new needs.

- **Attributable revenues must cover costs for separate items of production.** In order to be able to achieve any profit, which is a necessary condition for survival in a highly competitive market, producers must ensure also that *each service* that they provide generates enough extra revenue to cover the extra costs incurred in its provision. Cross-subsidy is not possible. That does not mean that all services or schedules for which demand is relatively low will disappear. In some cases, the introduction of a new link or route will not only generate traffic on that service, but also generate extra traffic for other services. In that case, the excess of increased revenue over increased cost on existing routes to which traffic is served should be treated as part of the attributable revenue to the new route. This same logic also applies to the provision of services at some times of day (for example, late night services), which only carry one half of a return trip that would not otherwise have occurred.

Responding to Demand

Given this general requirement to cover costs, in seeking to develop a viably profitable operating strategy, companies supplying service in a competitive market must adapt flexibly in a number of dimensions:

- **What service to provide.** As consumer needs and demands change, either because their incomes are growing, or because tastes have changed for some other reason, the mix of products supplied to the market should change accordingly. The way in

which this is achieved in a market economy is through suppliers adjusting price in response to excess demand, and expanding or contracting supply in order to maximize their profit. Thus, if customers want more of a given service than is being provided at the current price, a profit-maximizing supplier will either increase supply at the existing price or increase price. If he/she increases the price, this will attract new entrants to the market and hence increase supply that will, in turn, drive prices down again. Either process will result in an increase in supply. The market process will also give the enterprise an incentive to innovate, providing services that have never been provided before, but for which a potential demand is believed to exist. For example, changes in the location of activities or in the incomes of consumers may generate desired trip patterns may make it possible to provide new services that can attract sufficient revenue to cover their costs. In a commercial market, a profit-oriented supplier would be always searching for such possibilities of increasing his/her level of activity.

- **What technology to use**. The same considerations apply to the way in which services are supplied. New services may differ not only in routing, but also in other characteristics, (express, air-conditioned, etc.) that require a change in the types of vehicle used. Other dimensions of technology that should ideally respond to demand through the commercial process are vehicle size (which affects the balance between fares and frequency of service), fare collection equipment, etc.

- **What prices to charge**. The prices charged for different products or services within a market economy should reflect the costs of production. Thus, new products should be charged at levels that, once they are established, allow them to be profitable. Because users of public transport may have different valuations of time, comfort, flexibility, etc., it is both to the advantage of the supplier and of the user if different types of service, operated at different costs per seat mile and different load factors, and hence at different costs per passenger-mile, are made available at differentiated prices. For example, if express buses or air-conditioned buses can be operated profitably at a premium price, that indicates that both suppliers and users are gaining from it. The only circumstance in which that has any disadvantage is if it diverts sufficient traffic from the basic services that basic frequencies are reduced, and the waiting time of the users of the basic service are increased. This is unlikely to be a significant issue, particularly where the higher-quality service is serving a section of the population that would not be using the basic services in any case because they have private automobiles.

Managing the Enterprise Commercially

Efficient operation in a market context requires that operators have a range of commercial skills that have not traditionally been required in a more centrally commanded transport system. The following capabilities are necessary.

- **Understanding of market demand characteristics** is essential in order for managers to know what kind of transport service is likely to attract patronage. This is not simply a matter of knowing where people want to go to and from, but also

knowing how they value (and hence what they are willing to pay for) different characteristics such as speed, comfort, reliability, air conditioning, etc.).

- **Knowledge of the enterprise cost structure** is essential in order for managers to make the appropriate adjustments to their inputs and outputs in response to market changes. For the transport enterprise, this means not only must they know the costs of specific inputs, but they also must know what outputs are responsible for those costs being incurred. On this basis, they will be able to compare the revenues that they receive from the production of a specific line or service with its costs in order to be able to decide whether that output is worth producing or not. That is quite a complicated matter for a transport enterprise as some costs are independent of the level of output produced (licenses or insurance premiums); some vary with the number of hours over which a service is provided (labor costs); and others vary with the vehicle mileage performed (fuel).

- **Market pricing skills** can be employed to combine knowledge of market characteristics and cost characteristics in order to improve both the finances of the operator and the welfare of transport users. For example, where there is spare capacity on vehicles operating in off-peak periods, it may be possible to increase the total revenue derived from that service by offering an off-peak fare. Or, alternatively, it may be possible to obtain extra patronage and revenue by offering cheaper fares to particular categories of traveler who would not be willing to travel if they paid the "full" price. This involves charging different prices for what appears to be the same physical product, often referred to as "price discrimination" or "yield management". The importance of such price discrimination is that it enables capacity to be more fully used and, by so doing, reduces the average cost per passenger and leads to optimum use of public transport. The critical issue in determining how far price discrimination can be pursued is the ability of the operator to *segment the market.* There are a number of different bases on which price discrimination can be implemented, for example, person type (pensioners or children), time of travel (off-peak promotional fares) or quality of service (premium qualities or speeds). If price discrimination can be practiced in such a way as to attract new users at lower prices, without a disproportionate loss of users who would be willing to pay the higher charge, the revenues of the enterprise are increased and even passengers paying the "full" fare may benefit as a consequence.

All of these new skills require training.

7. WHAT MUST GOVERNMENT DO TO MAKE BEST USE OF MARKET POSSIBILITIES?

It follows from the earlier analysis that there are certain basic conditions which must exist if market processes are to result in efficient use of resources, and to contribute to cost efficient achievement of social and environmental objectives. The two basic conditions are that the prices must be right, and the market must operate in a fair, competitive manner.

Getting The Prices Right

- **Input factor prices must reflect real costs.** As in the case of consumers, producers will only make socially optimal decisions in a market framework if the prices that they pay for each of their inputs covers the true cost to society (including the cost of externalities) of their inputs.

- **Infrastructure use must be properly charged for.** In the transport sector, it is particularly important that suppliers are charged the full and proper costs for the use of publicly provided infrastructure.

Market Behavior

- **Producers must have freedom to make decisions** on output mix, choice of technology, etc. Any restriction on the freedom of producers to choose what they will produce, and how they will do so, will lead either to higher costs of production or to an inferior quality product than could have been produced.

- **Anticompetitive behavior must be controlled.** The profitability of a firm will be greater if it can exclude competition. Where this is done by producing more efficiently, giving higher quality of service or lower prices, the consumer benefits. But enterprises can also attempt to achieve this by predatory behavior (such as the use of physical intimidation or the temporary adoption of prices that are unsustainable in the long run to deter new entrants). There must be some procedure for overseeing the market to ensure that these forms of predatory action do not occur.

- **Private monopoly must be avoided.** The benefits of market process to the consumer arise primarily from competition. The profits to the supplier are greatest when there is no competition. It is, therefore, in the interest of suppliers to develop monopoly positions both by structural actions (such as the formation of cartels or mergers). There must be some procedure for assessing the acceptability of any market associations or proposals of companies to merge, which will create private monopolies.

8. How can Prices Increase Efficiency in Resource Allocation in Urban Transport

The fundamental nature of the economic problems of urban transport in China appears to be rather similar to those of many countries. At the heart of the problem is the fact that road infrastructure is publicly provided as a free good: this leads to the first problem of *road congestion* due to excessive demand for that free infrastructure. In the absence of any pricing mechanism to limit this excessive demand, it is common for governments to use proxy or surrogate instruments such as parking policy; this leads to the second problem of *designing efficient traffic restraint policy.* Within the urban system, some modes of transport are more efficient users of road space than others; without there being any mechanism to reflect this relative efficiency in individual choices; this generates the third problem of *securing efficient mode choice.* The existence of peaks in demand during the day is typically associated with a

fourth problem of *securing efficient utilization of capacity.* Even within individual modes, there is often no mechanism to ensure that more efficient technologies are preferred to less efficient ones; this generates the fifth problem of *securing efficient technology choice.* Finally, the combination of inefficiencies in the use of infrastructure, mode and technology choice together with the acceptance of a public responsibility to provide transport at an acceptable price to the user typically involves large public expenditures and subsidies; this raises the problem of *avoiding excessive fiscal burden,* which can have very adverse effects on the availability of funds for other sectors and may distort the allocation of resources between the sectors.

The adoption of more market-oriented approaches to the urban transport market can make a important contribution to solving each of these problems (also considered in the paper on motorization).

- **Road congestion** can be addressed by direct road-charging mechanisms. Many different approaches have been used to introducing such a charging structure. The simplest approach is the imposition of some kind of tax on vehicles entering into areas where there is high congestion. This was the approach adopted in the Area Licensing Scheme in Singapore where a supplementary daily license had to be paid to enter the crowded Central Business District in the peak period. More complex systems can now be introduced. The experiment in Hong Kong in the mid-1980s involved a system of vehicle recognition through which central records were kept of all vehicle movements in the congested area, with prices charged and bills issued based on the number of "pricing points" the vehicle was observed passing. More recent research has concentrated on "off-vehicle" charging systems in which the vehicle itself carries some "smart card" or other payment recording or direct charging device. Such a technology is now in the process of introduction in Singapore. In the short term, the simplest way to charge users roughly in proportion to the amount of external cost that they are imposing is through fuel taxation. Fuel is consumed roughly in proportion to the amount of distance traveled: if congestion is widely spread throughout the area and throughout the day, it may therefore be a rough proxy both for congestion effects and for environmental impacts

- **Efficient traffic restraint**. Most private vehicle trips involve parking the vehicle at the destination in order to undertake the activity that is the purpose of the trip. Use of road space for driving and use of on- or off-road space for parking are thus jointly consumed.. Two policy conclusions follow from this. First, even if road space is properly charged for excess, demand for road space may emerge if parking, with which it is jointly consumed, is underpriced. Hence, parking should never be subsidized. This not only means that public authorities should not provide subsidized parking, but also that private enterprises should normally be required to charge a market price (covering the opportunity cost of the land consumed for parking space) for parking spaces that they provide. Second, in the absence of efficient prices for driving space, charges for parking in congested areas should be set at a level that covers not only the resource cost of the parking space itself, but also the marginal social cost of the congestion associated with the cars parked. Calculating those optimal parking charges is a complex issue and inevitably involves some elements of judgment. Moreover, where parking is privately provided, there

may need to be some taxation structure to ensure that the excess of revenues over costs in private parking, resulting from the use of parking charges as a proxy for congestion charges, accrues to the government and not to the supplier. But the principle is clear; *urban parking charges should always cover the otherwise unrecouped marginal social costs imposed by the parked cars.*

- **Efficient mode choice**. The level and structures of direct congestion charges, fuel taxation, or parking charges will all affect the choice of individuals between different modes of transport by making private transport less attractive and public transport more attractive. Particularly if an unsubsidized private sector is supplying public transport efficient mode choice depends on the implementation of efficient charges for road use or their proxies in fuel taxation or parking charges.

- **Efficient use of public transport capacity**. Because many of the costs of provision of public transport service are determined by the peak demand (certainly the case for capital costs, and also often the case for labor costs where labor laws or agreements require payment for some minimum working day), the marginal costs of the public transport passenger may be low off peak.. Price discrimination may be used by suppliers of public transport to attract traffic at these periods of low cost and, hence, increase the efficiency of utilization of the capacity.

- **Efficient technology choice**. Where fuel is underpriced, neither private individuals nor companies supplying public transport services will have adequate incentive to save fuel by selecting vehicles of optimal size or fuel consumption characteristics.

- **Reducing the fiscal burden**. In principle, some of the internal distortions within the transport sector can be countervailed by subsidy to public transport. That will still reduce the costs of transport by all modes, and distort the choice between transport and other goods and services. More importantly, however, it will create a fiscal burden that will be increasingly intolerable as city size and the level of "second best optimum" subsidies rises. In contrast to this, attacking the problem at its heart by introducing efficient charges for the use of scarce road space will generate revenues for the public authorities that can be used to improve facilities (roads or public transport) wherever the return is greatest.

- **Contributing to safe operation**. Maintaining safe operation is very largely a matter of having appropriate safety regulations and enforcing them effectively. But market processes can assist this in some ways. High fines can be a very strong deterrent to unsafe driving. Compulsory third-party insurance requirements, together with substantial discounts for drivers not making claims over a period of years, are also inducements to care on the roads.

9. How Can The Transport Needs Of The Poor Be Assured In A Market Economy?

Transport expenditure can be a significant item in the expenditure patterns of the poor. In some countries, inability to afford the costs of transport may limit access to health, welfare, and education activities, and even to work. It is, therefore, important to the fight against poverty

that affordable transport is available for the poor. The conclusion that is often drawn from this is that government should intervene to ensure that suppliers keep prices down to levels that are considered affordable to the poor. This is most usually done by imposing *price controls* on suppliers and relying on them to use surpluses from more heavily-demanded and profitable activities to *cross-subsidize* less profitable ones

Price controls within a commercial transport sector may have effects on the poor that are entirely the opposite of those intended. For example, in many African cities (such as Dakar in Senegal), restricting the prices that public transport operators are able to charge has had the effect that they could not afford to maintain their vehicles. The number of vehicles out of operation has therefore increased and service frequencies and quality of service has declined. Even in very well-managed countries like Korea, where vehicle maintenance is sustained, the effect of price controls has been that suppliers needed higher levels of occupancy of vehicles to cover their costs and have, therefore, reduced frequencies to achieve this. Because the money cost is only one part of the generalized cost of transport, controls on prices may actually increase the total generalized cost as perceived by users if the effect of the price control is to reduce frequencies and increase waiting and queuing time disproportionately. The lesson to be learned from that experience is that great care must be used in imposing general price controls in commercially provided public transport, unless an alternative source of funding is provided for the costs of operations.

Internal cross-subsidy is often relied upon as the basis for maintaining control on fares. Cross-subsidy occurs when one user is supplied at a price below the marginal cost that he/she imposes, and this deficit of price below marginal cost is recouped from surpluses derived from other passengers. If it happens to be the case that surpluses are being earned on some services, and that those services are primarily used by richer people, cross-subsidy may indeed be a means of assisting the poor. Unfortunately, it is frequently the case that the most profitable services are those that have many poorer users. Requiring those services to generate surpluses to support other parts of the network means that either prices are higher, or frequencies lower, on those services than would otherwise need be the case. The distributional consequences of this are then perverse, with the poorer users of public transport subsidizing the richer users. This is particularly likely to occur in cities where richer people live further from the city center, at lower residential densities, and with higher car ownership (and, hence, lower level of dependence on public transport) than the poor. Those may not be conditions that are presently very apparent in China, but they may increasingly emerge as incomes and freedom to select residential locations increase.

In order to avoid these difficulties of price control and cross-subsidy, it is desirable to provide channels of finance that have the effect of targeting the groups whom it is intended to assist without distorting the decision processes of service suppliers.

The preferred outcome is for those who are considered to be in need of help to be identified directly and assisted by a general income transfer, which might be used on transport or for any other purpose. By doing this, there is no question of distortion arising in transport markets, and no need for any subsidy specific to transport provision or use.

Transport subsidies should only be resorted to insofar as it is not considered possible to target direct income transfers effectively. They can be administered in three main ways, all involving some use of the price mechanism.

- **Service contracts and public service obligations**. Where the group of people who are significantly disadvantaged by lack of adequate, affordable, transport is well identified geographically , as for example it was in the black townships in South Africa under apartheid, then it may be appropriate for the subsidy to be channeled through direct financial support to the operators providing public transport service to these localities. The problem about this approach is that so long as the operators have an automatic recourse to public finance, they have incentives to maximize the amount of service provided (rather than the benefit to users) and to load as much of the costs of the organization as possible on to the subsidized services. Careful auditing of the accounts of the operators may give some protection against these tendencies.

- **Person-related subsidy mechanisms**. This involves channeling support directly through the groups that it is intended to support (for example, schoolchildren, the aged, the infirm, etc.), and allowing suppliers to compete for the business of these subsidized passengers. The administration of such a scheme could be through tokens distributed to the beneficiaries, spent with the transport operators, and recompensed in cash by the public authority on presentation. That system gives the maximum incentive to service operators to provide the service that people really want, and is quite compatible with the competitive provision of different qualities of service at different prices (the token would always be cashed in for the same amount, but operators could decide whether they wished to make it cashable on premium services on payment of a supplement). It has been argued earlier that this is best done in terms of money transfers to them that give them the freedom to decide what extra consumption benefits them most. Only in cases where there is no adequate administrative procedure to handle these direct transfers is assistance-in-kind sensible. When applied to the journey to work, and administered through employers, (as in the case of the "vale de transport" in Brazil), this system has the disadvantage that it does not get to those working in the informal sector, who are often among the very poorest workers.

- **Competitive franchising**. The experience in many countries is that the public subsidy costs, and hence the fiscal burden, of providing any given level of subsidized service can be reduced by the introduction of competition in the subsidy process. Competitive franchising is very similar to the service contract arrangement except that suppliers compete for the right to supply. The public authority specifies the kind of service that it requires including the prices to be charged (which may be zero for some categories of person) and gives a contract to provide that service By breaking down the franchises into relatively small "packages," it is possible for such a system to operate with many individual operators. This approach has been adopted successfully in several countries which wished to reduce the costs of subsidies (New Zealand, United Kingdom, Sweden, Denmark).

10. HOW CAN THE MARKET CONTRIBUTE TO ENVIRONMENTAL IMPROVEMENT?

The level of motorization in major Chinese cities is still relatively low in comparison with those of equivalent size in other Asian countries. But the pace of development in China is so fast that it is important to consider what might be the situation in a few years time: for that purpose, the current experience of other Asian cities such as Bangkok or Seoul is relevant. The Chinese aim will no doubt be to try to handle the process of increasing development of the transport sector more successfully than other cities that have recently gone through the same process.

Observation of those other cities indicates that rapidly developing cities are among the most environmentally polluted by their transport systems in the world. This occurs for a number of reasons:

- High exposure of population living close to the roadside;
- High proportion of very polluting vehicles (such as two-stroke motorcycles);
- Low proportions of road space devoted to traffic movement;
- High average age and low level of maintenance of vehicles;
- Lack of effective mitigation measures.

The main local environmental impacts generated by transport operations in urban areas are:

- lead;
- suspended particulate matter;
- noise; and
- danger of physical injury in traffic accidents.

In addition, there are some local pollutants emitted from the tailpipes of vehicles as the products of combustion that have adverse effects, but which can be effectively suppressed by the use of modern techniques of catalytic conversion (including carbon monoxide, oxides of nitrogen, and unburned hydrocarbon). Other products of combustion, such as carbon dioxide (and to some extent oxides of nitrogen), have global warming effects that are more diffuse in time and space. The extent of these environmental impacts will depend on the amount of traffic, the mode of transport used, the type of vehicles used (including the way in which they are fueled), the way in which those vehicles are maintained, and, to some extent, the manner in which they are operated. The nature and extent of these pollutants in Chinese cities, and some considerations for a general strategy for progress toward dealing with them in China, are contained in Michael Walsh's paper.

One critical question in a market-based transport sector is the extent to which price structures and levels give the appropriate incentives to individuals and companies to take private decisions that are consistent with maximizing social welfare in this respect. Price instruments can be used in a number of ways to mold individual behavior to the social good.

There are a range of ways in which the environmental impact of transport in urban areas can be influenced. The main ones are:

- total amount of motorized travel;
- choice of mode;
- choice of vehicle type; and
- choice of fuel.

Theoretically, the best way in which environmental impacts could be affected is by directly charging polluters in proportion to the amount of pollution that they cause, and at rates that represent the social valuation of the damage that they do. In practice, individual vehicle emissions are difficult to measure at the point of emission, and there are currently no means of imposing such a precise form of pricing. As a consequence, a range of less direct forms of pricing can be used to have an impact on the various dimensions in which environmental impact can be influenced. The main "proxy charge" instruments that can be used are as follows.

- **Vehicle Prices**. High vehicle prices are a disincentive to vehicle ownership and can reduce total vehicle use. In many countries, discouraging ownership is a policy objective, pursued through high taxation on vehicles, and particularly through high import duties. Such policies are not always successful as the effect of high new car prices may encourage users to keep old cars in operation. As older cars are usually less efficient in terms of fuel consumption and gaseous emissions, and often less well-maintained than newer cars, the net effect may be an increase in total environmental impact. To overcome this effect, Singapore operates a scheme whereby the government decides how many cars are to be in operation and auctions permits to own a car. Because the price of these permits is very high, and associated with strong regulations on emission characteristics of cars, there is little inducement to save on the capital cost of car purchase and the cars bought are both modern and well maintained.

- **Fuel Prices**. For the private car, and for the commercial operator of buses and taxis, the use of environmentally less-damaging fuels can also be encouraged by price structure. For example, taxation differentials between leaded and unleaded fuel have resulted in the rapid replacement of leaded by unleaded fuel in Europe. In contrast, in Mexico the availability of leaded fuel at a price below unleaded fuel not only resulted in continued use of leaded fuel but also severely impeded the introduction of catalytic converters to eliminate other environmental impacts. The general level of fuel prices can also affect the amount of vehicular transport undertaken, the choice of mode and the choice of vehicle type (for example, the increase in the price of fuel in the first fuel crisis in 1973 on led to very significant changes in the average size of the American car, and the relatively high price of fuel in Europe has had significant effects both on car size and on fuel efficiency). However, fuel taxation also acts as a proxy for other resource uses, including the costs of road provision and maintenance. We, therefore, consider it in more detail in the next section.

- **Congestion Charges**. The emissions of carbon dioxide, the primary global warming gas, is directly proportional to the amount of fuel consumed. Fuel tax is, therefore, a good instrument for pricing this emission. The same is not true for other environmental impacts such as noise and local air pollution. The significance of these impacts is much more dependent on the time and place at which they occur.

Because both congestion and some of these local environmental impacts are most significant where the amount of traffic is greatest, a congestion pricing system probably reflects them better than does a fuel price. But loading an environmental charge on to a congestion charge would still, at best, be a very rough proxy indeed.

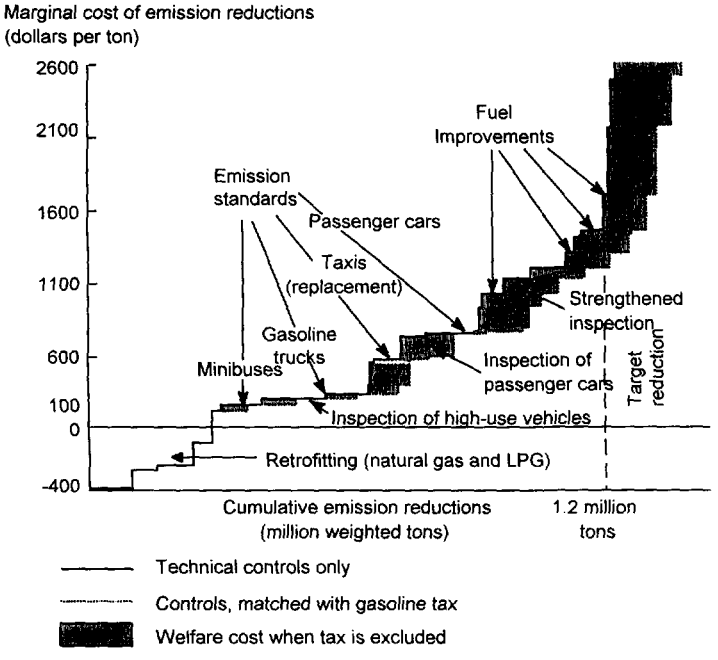
- **Public Transport Fares.** Because public transport modes usually create less pollution per passenger-kilometer than private transport modes, it is often argued that public transport should be subsidized–especially when the full costs are not being charged to private transport modes. There are a number of reasons why this is not a very good instrument for the purpose. First, not all public transport modes, or vehicles, are nonpolluting, so that the level of subsidy would, in principle, have to be differentiated between vehicles that might make the fare system extremely complex. Second, the extent to which public transport usage leads to a reduction of environmental impact depends on the load factor of the vehicle: a bus carrying two passengers creates more pollution than a car carrying two passengers, though a bus carrying 50 passengers almost certainly creates less pollution per person than a car carrying two people. Third, the environmental benefit depends on what is the alternative mode; transferring passengers from car to bus (with adequate load factors) probably reduces pollution, whereas transferring passengers from bicycles to car does not.

Because it is not easy to differentiate public transport fares to reflect these factors, and because the impact on public transport fares on the use of cars once a car is owned is very low, manipulation of public transport fares for environmental reasons is unlikely to be effective. Insofar as it involved charging below cost, it might also generate some extra trips for which the benefits did not exceed the real costs it might even have a perverse effect. The main area where something less than full cost coverage may be justifiable is in the case of the capital costs of metros, where the purpose of the metro is to sustain a higher density of central city activity than would be the case without the metro and, hence, where the existence of the metro may obviate the need for other social infrastructure expenditures in newly developed locations.

Selecting Remedial Strategies

Because of difficulties both in attributing a precise money value to environmental impacts, and of finding charging mechanisms that properly reflect marginal environmental impacts in marginal user charges, it may be necessary to define politically, and specify administratively, some environmental standards that are to be met. Even though this is not a market process using prices, the method of implementing such an approach to environmental control could be. For example, if a range of alternative instruments were identified, these could be costed using market prices for their inputs and ranked according to their cost effectiveness in reducing the environmental impact. This would give a ranking for action and also identify which instruments were cost effective and which were not in achieving any given environmental standard. This sort of exercise has been undertaken in looking at a strategy for reducing transport generated air pollution in Mexico City (see Figure 3).

Figure 3: COST-EFFECTIVE AIR POLLUTION STRATEGIES IN MEXICO



Note: Calculations are based on -0.8 elasticity of demand for gasoline

Source: Gunnar S. Eskeland, 1994. "A Presumptive Pigovian Tax on Gasoline: Complementing Regulation to Mimic an Emission Fee." *World Bank Economic Review* 8 (3):373-94.

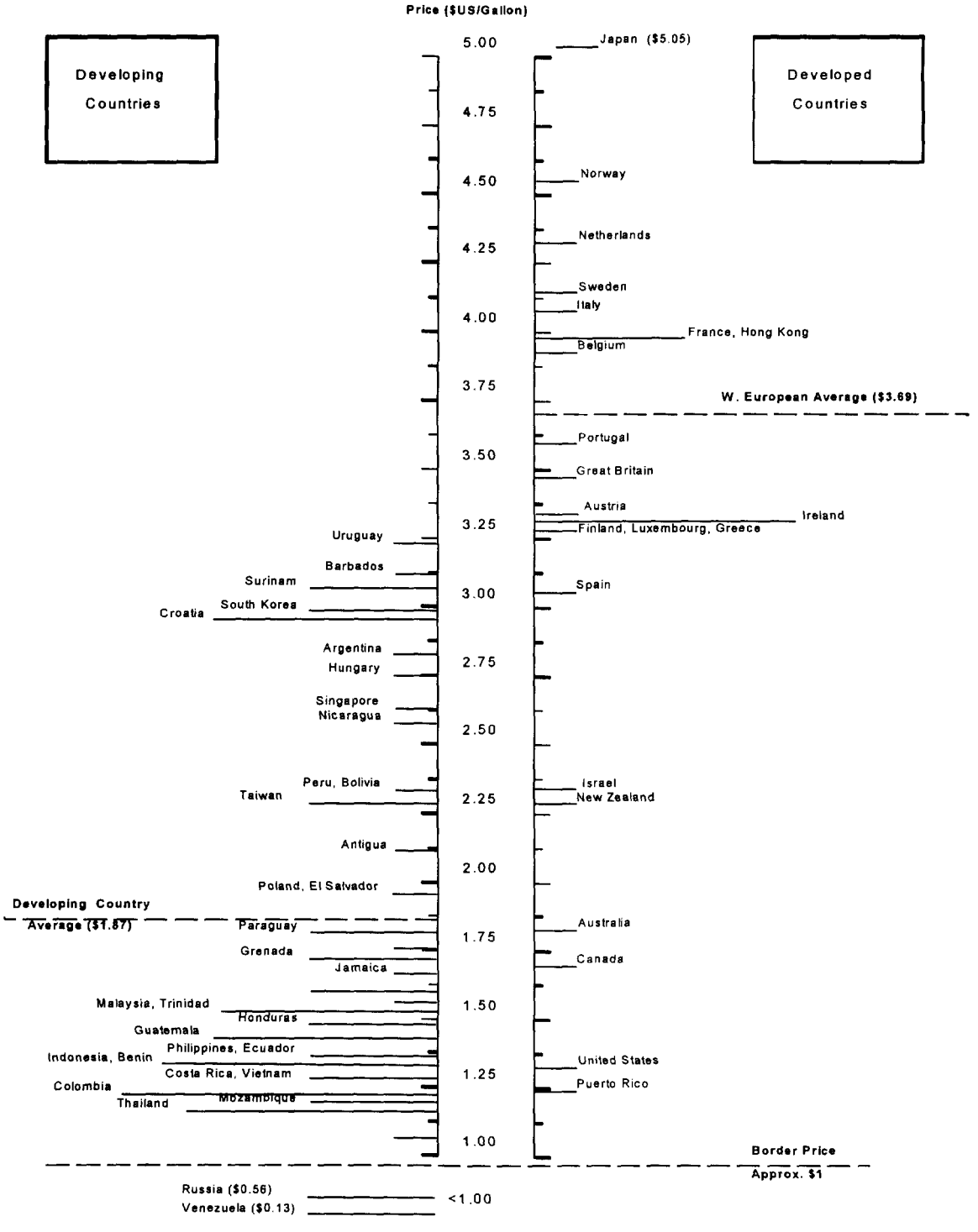
The general principle on which the price of any resource should be set in a market economy is that it should reflect the real costs to society of the use of that resource. When fuel is being consumed in road vehicles, there are three different component elements in the real costs to society that should be taken into account.

The first component in a fuel charge should be the *resource costs of the fuel* itself. This is represented by the price at which fuel is imported (or for producing countries the price at which it could be exported). In some countries (Russia, for example), fuel is priced below the border price, and in Venezuela, price is even below local production cost (see Figure 4).

The second component to be addressed is the *cost of road infrastructure use.* While there still remains much controversy over the allocation of total "joint" costs among vehicle categories and, hence, over the "right" structure of user charges *within the road mode,* a key principle is that no vehicle category should pay less than the incremental or attributable costs that it causes. The first requirement for this purpose is that total road cost accounts should be compiled, accompanied by an analysis of how these costs can be attributed to different vehicle categories. Good examples of how this can be done include the studies undertaken for the Bank in Ghana, Zimbabwe, and Tunisia. Some general guidelines for tax and charging policies can also be derived from these studies. The most germane conclusions are the following:

- Where road damage by heavy vehicles is the primary problem and heavy but not light vehicles are predominantly diesel-powered, diesel taxes should be set at levels that reflect the marginal costs imposed by light goods vehicles and buses. These marginal costs can be assessed either in the form of increased operating costs associated with increased road roughness or in the form of the increased capital costs necessary to forestall that cost. The precise figures will depend, of course, on the nature of the roads and the volume of traffic. However, the Ghana and Zimbabwe studies suggested diesel taxes of between $0.035 and $0.05 per liter of fuel.

Figure 4: PREMIUM GASOLINE PUMP PRICES



Source: *Energy Detente* (February 1994) and World Bank Data.

- This level of diesel taxation will not yield sufficient revenues to cover total maintenance costs, both because a proportion of the deterioration of roads is not related to use but is associated with, for example, weather and subgrade conditions and because the extra costs caused by very heavy vehicles are greater than the extra diesel taxes they pay as a consequence of their higher fuel consumption. In the absence of distance-related axle-load taxes, which would be the best way of imposing the charge, *differential annual vehicle taxes related to gross vehicle weight and axle loads should recover the full maintenance costs in a way that creates incentives for consumers to choose vehicle types that minimize the total cost of road and vehicle use.*

The third component in setting fuel prices, *environmental impacts*, are also presently not directly priced. Gasoline taxation should be set at a level that acts as a proxy for environmental effects. If future studies show high environmental costs related to the use of diesel fuel, higher charges on diesel may also be justified (beyond their role as a proxy for road damage charges).

In countries with a weak direct tax base, there is often a heavy reliance on gasoline taxation for general revenue. Sumptuary taxation on gasoline is politically acceptable, both because the insensitivity of demand for gasoline to its price may limit the distortion it causes and because it is consumed disproportionately by higher-income groups. These considerations may justify tax/cost ratios considerably higher than unity, particularly for the private car. Where fuel taxation is being used as a primary source of general tax revenue, care must be exercised to ensure that it is not creating major distortions within the transport sector itself (as happens in some countries where the imposition of lower tax on diesel than on gasoline leads to the use of diesel engines in smaller vehicles than is economically or environmentally desirable).

Broad orders of magnitude may now be put on these components. The border price of fuel is about $1 per gallon. Road use costs may add about $0.50 to this. Including both accident costs and global environmental impacts, a slightly less conservative calculation suggested that existing fuel taxes in Europe were between 40 and 70 percent of the levels necessary to internalize environmental externalities. For countries with high levels of urban congestion a further $1 per gallon would be consistent with the environmental evidence. Taken all together these numbers suggest that the *European levels of gasoline taxation may be a more appropriate benchmark for fuel taxation in developing countries that those of the United States, to which Chinese gasoline prices are more closely aligned.*

The appropriate policy for a country that wishes to make it possible for its citizens to enjoy the benefits of increased mobility associated with the ownership of a private car, but also wishes to protect its environment against the adverse environmental consequences, would seem to be a combination of fuel taxes sufficiently high to cover the border price of the fuel plus the road infrastructure costs and the fuel consumption related environmental costs associated with the use of the car, together with urban road prices to cover the congestion effects and the location specific environmental effects.

12. What Are The Main Messages?

A number of messages emerge from the foregoing consideration of how market systems work in the transport sector in market economies.

- Incorrect pricing leads to distortions in behavior and creates unnecessary financing burdens for the municipality.

- Pricing of the use of scarce road space can be used to manage reconcile the desired growth of motorized mobility for the people of China with the maintenance of an acceptable urban environment.

- Road use charges, or their proxies such as parking charges and taxation on car ownership and use, can help finance the provision of urban infrastructure, reducing the dependence on land leasing.

- If the use of road infrastructure is correctly priced, bus companies can operate commercially and be totally self-financing, thus also reducing the burden on the municipalities.

Some priority actions would also be called for in terms of direct executive actions of government, regulatory and institutional reform, and development of the skills of operating agencies in support of the development of a more market-oriented transport sector. The main items would be as follows:

Legislative actions would be necessary to create:

- private operating companies; and
- a legal framework for competition in bus service supply.

Direct executive actions of government would be necessary to:

- set gasoline fuel prices at an appropriate level; and
- create administrative agencies to manage the public sectors role as customer for public transport services.

Action of operating agencies would be necessary to develop appropriate

- management information systems;
- skills in assessing market demands; and
- commercial skills in price setting.

THEME PAPER 11: LAND USE AND TRANSPORT PLANNING IN CHINA

LI XIAOJIANG AND YU LI [1]

Rapid socioeconomic development and the transition of economic system have triggered great changes in the land-use and transport patterns in Chinese cities. The urban and transport planning system is also undergoing considerable changes accordingly. While discussing the land-use and transport models as well as the planning system in urban China, it is important to understand the history and its inertia effect in this sector, as well as the significance of the ongoing changes. Our purpose of evaluating the current urban land development and planning practice is not only to criticize, but also to see if these ongoing changes are moving in the same direction as that of future urban dynamics. More important, this evaluation aims at a better understanding of the trends of urban development, which hopefully will help us improve planning practices.

1. THE EXISTING URBAN PLANNING SYSTEM

The Urban Planning Administrative System

Urban planning in China started in the 1950s and was demolished in the 1960s for various political reasons. The existing urban planning administrative system was reestablished in the late 1970s when the urban planning administrative departments at the central, provincial and municipal levels were reinstalled and established. Since then, the urban planning and design research institutes as well as urban planning programs in higher education have also been resumed gradually.

In 1984, the State Council promulgated "The Regulations of City Planning." In 1989, "The City Planning Act" was approved by the People's Congress. The nationwide implementation of the Act began on April 1, 1990. The Act is applicable to all development and construction activities within the planning area designated by municipal governments. Provincial and municipal governments are authorized to formulate implementation measures and detailed regulations under the framework established by the Act. These become legal guidelines for the implementation of the Act at the local government level.

The urban planning administrative authority of a municipal government has three major functions. They are: (a) to prepare, or designate relevant institutions to prepare, urban plans of

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different levels; (b) to approve various plans under the Master Plan; and (c) to manage land use and civil construction (development and management).

Preparation of Urban Plans

The Act requires the formulation of urban plans be divided into two stages: the master planning and the detailed planning. To strengthen the link between the two stages, medium- and large-size cities can carry out district planning in between these two stages.

The Act also requires that the urban master plan of a city be first approved by the municipal people's congress, and then submitted to the higher-level government for ratification. Urban master plans of the centrally directly administered cities, provincial capitals, and large cities with more than 1 million population must be submitted to the State Council for ratification. District plans and detailed plans only need the ratification of the municipal governments. At present, urban master planning has the widest scope and touches the most issues among all levels of urban planning. Its preparation and approval procedure is also the most complex. Once approved, it becomes a statutory plan with legal and regulatory power.

An urban master plan includes the following tasks: defining the functions of the city, development objectives and scale; setting construction norms, quotas and index; planning urban land use, transport network, water supply, sewage, urban greenery and other municipal facilities; making short-term construction implementation plans; and planning the town and settlement system within the municipal government's jurisdiction.

It should be pointed out that as a component of the master plan, transport system planning focuses on physical plans for road networks and land-use plans for transport facilities. It is not as comprehensive as what is known as transport planning in the West. In master planning, planners plan the transport system based on the layout of land use, instead of the other way around where the land-use plan is formulated based on the transport forecast and analysis.

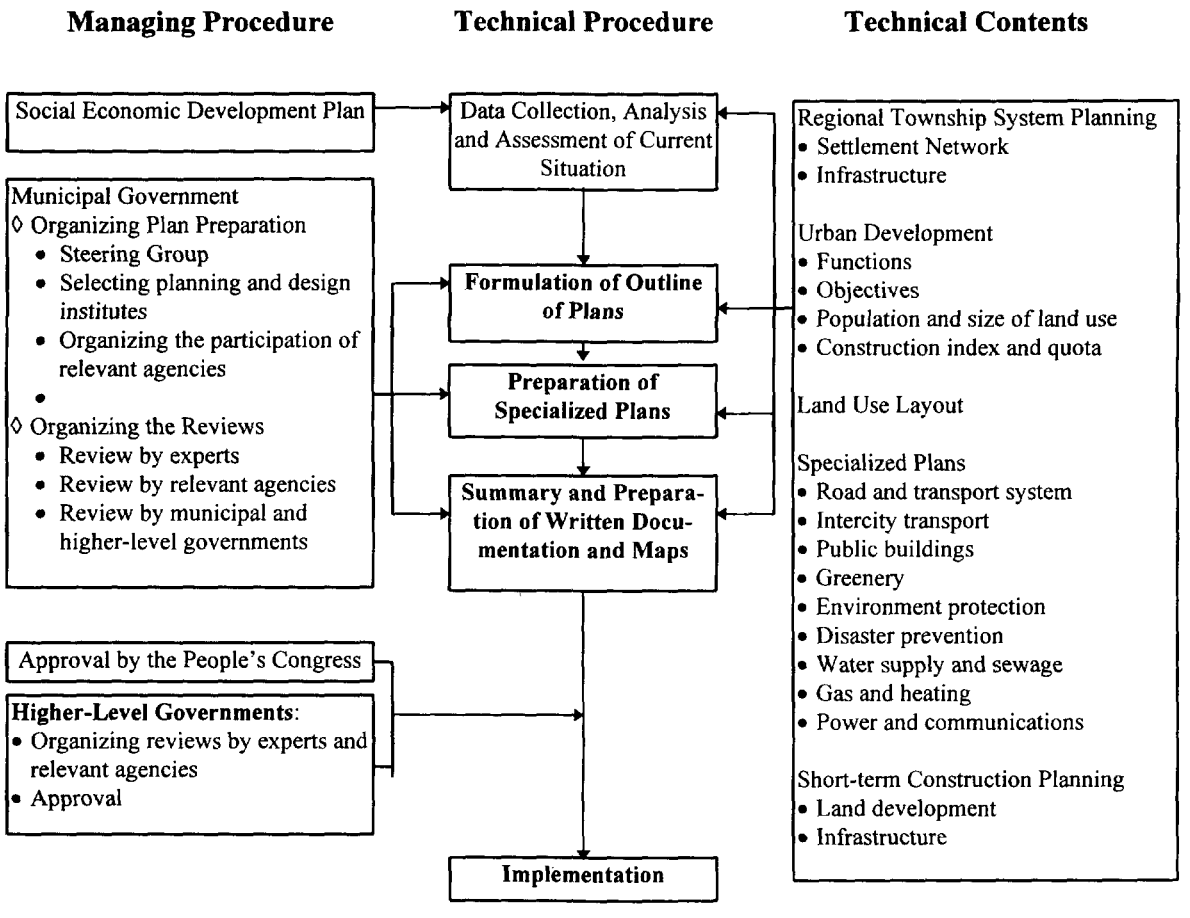
The municipal government often assigns, or entrusts, urban planning and design institutes to prepare the master plan. The municipal government also sets up a steering office (or a permanent government agency in some cities) with members from relevant departments within the government to direct the preparation of the master plan. Under this steering office, there is often an organization that is responsible for planning administration to work together with the planning institutes. During the plan preparation, there are also several consulting and advisory meetings with relevant departments and experts both from the local area and elsewhere. Figure 1.1 presents a typical procedure of urban master planning for larger cities in China.

In addition to the master plan, the municipal governments have increasingly emphasized other plans. In large cities, district planning has been widely adopted and practiced. Some of the district plans have the similar scope of a master plan.

In the last few years, the detailed control plans have attracted growing attention and been increasingly adopted. The detailed control plans are prepared for the important areas of a city. Different from traditional physical planning, the detailed control planning mainly sets up targets and indices to control land development, but also keeps some degree of flexibility and room for

future adjustment. A detailed control plan requires approval from the municipal government, and once approved, becomes a statutory plan with legal power.

FIGURE 1.1: THE PROCEDURE OF PREPARING AN URBAN MASTER PLAN IN LARGE CITIES



In order to better guide and control urban construction, many cities increasingly emphasize the formulation of specialized plans based on the master plan. These specialized plans include the environment protection plan, disaster prevention plan, transport system plan, water supply and sewage plan, gas supply plan and so on.

Implementation of Urban Plans

According to the City Planning Act, permission from the planning administrative authority is required for any development activities within the planning areas. Specifically:

- When a construction project proposal is submitted to the government for approval, a siting recommendation issued by the planning administrative authority must accompany the proposal documents;

- Only after obtaining the planning permit for the construction site, issued by the planning administrative authority, can a developer start to apply for land acquisition from the government;
- Only after obtaining the planning permit for construction work can a developer start the construction procedure.

From these regulations we can see clearly that urban development and construction activities are under the control of the planning administrative authorities. However, the Planning Act has not dealt with issues related to the changes in uses of buildings and facilities. We can then say that the planning control in China mainly involves control of construction and development. During the implementation of plans, planning administrative authorities, facing pressures from many parties, often have to make concessions to changes in type of land use, increases in construction floor area ratios (FAR) and building density, and reductions in the level of required indices for matching the capacity of social service facilities and infrastructure. Especially during the redevelopment of old city-center areas, great conflicts exist between development and control, and between development and conservation. Because of poor solutions to these problems, some cities have lost their own characteristics; some development even brought damages to the environment and adversely affected the daily life of the residents.

Functions of the Urban Planning System

Within the planned economy system, urban planning is to formulate land and infrastructure development plans beneficial to social and economic development, ensuring a rational allocation of land resources and protecting environment. At the macro level, urban physical planning is broadly consistent with economic planning, for several reasons.

First, an economic development plan guides and controls urban economic development. Therefore, it lays a quite reliable foundation for urban planning. However, when mistakes are made in the economic development plan, urban planning will be adversely affected, resulting in the departure of urban planning targets and measures from the needs of actual social and economic development.

Second, a master plan requires clarity and simplicity, but this also cause rigidity. Despite its weakness in adjusting itself over time, a master plan is easy to operate and control, in particular for rapid economic development and large-scale construction. This characteristic is very important as China is now experiencing high economic growth, rapid urban land expansion and large-scale urban construction.

Finally, although the urban planning system in China is still far from perfect as problems do exist in the preparation and implementation of plans, it has played its due role considering the lack of urban planning expertise and the weak technical strength of planners at present. With the present organizations and human resources available in urban planning departments, it can help at least to prevent the worst scenario in urban development from happening.

Urban Transport Planning

The City Planning Act has not made a detailed requirement for urban transport planning. Nevertheless, in their "Implementation Measures for the City Planning Act," some provincial and municipal governments require their large cities to formulate urban transport plans.

Urban transport planning in China started in the early 1980s. In 1985, the China Academy of Urban Planning and Design (CAUPD) prepared a transport plan for Shenzhen. This was the first transport plan in China. By 1995, about 50 cities had formulated urban transport plans.

Usually, the urban planning administrative authorities are responsible for preparing and implementing urban transport plans. In most cities, urban transport plans were formulated after the completion of the master plans, missing an opportunity to improve and substantiate the master plan from the perspective of transport development.

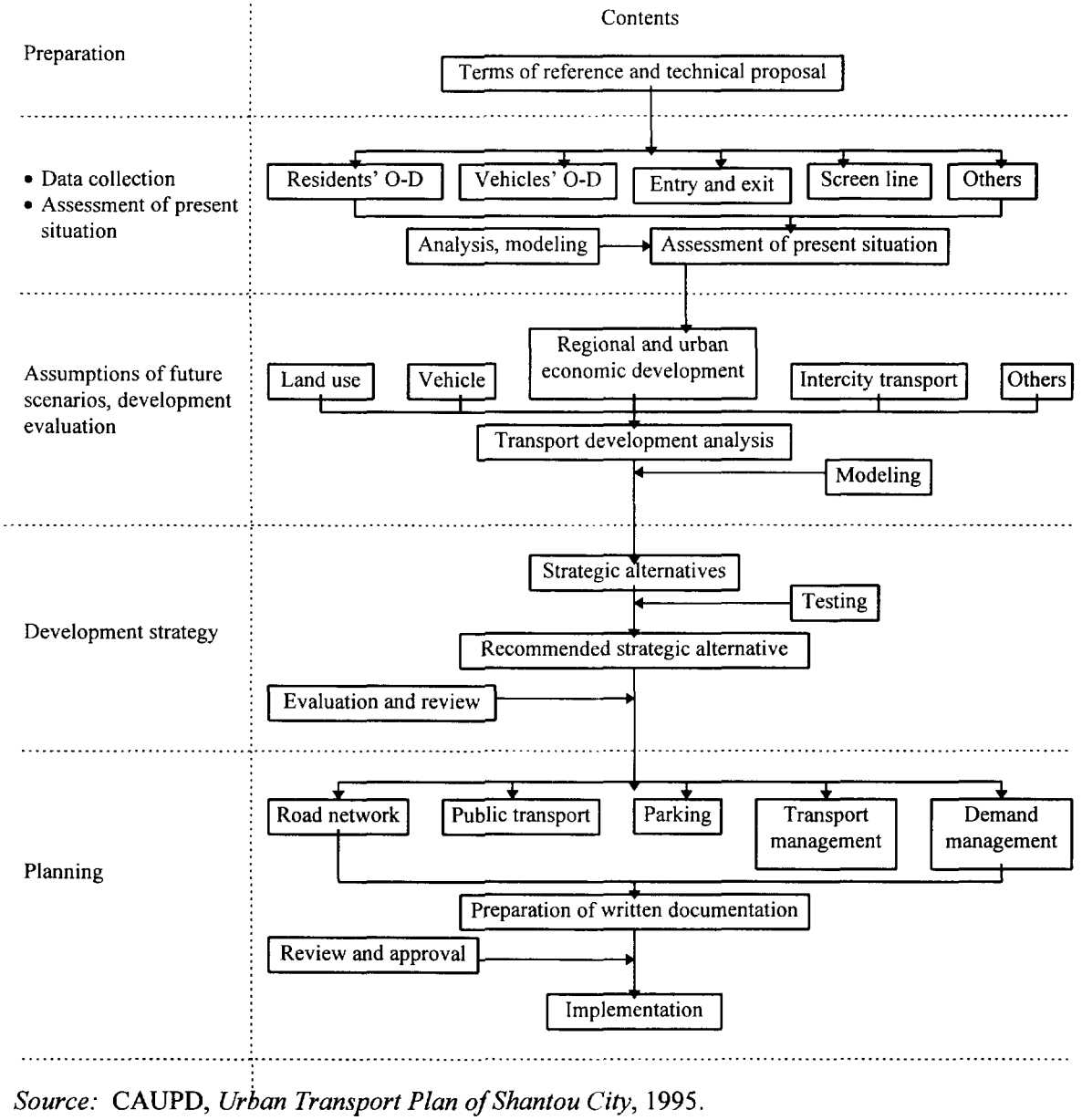
The techniques now used in transport planning in China originated from developed countries. The methodologies are similar to that of United States and Britain. It normally consists of the following contents (or procedures):

- Travel survey and data collection;
- Proposing transport development targets;
- Travel demand modeling and forecasting;
- Preparing transport development alternatives, including road network and public transport network;
- Proposing construction projects for the transport network; and
- Proposing transport management strategies and policies.

There are no clearly defined and continuing transport policies, nor a well-developed system to ensure the implementation of transport policies. As a result, in the 1980s there were no studies on transport development strategies and policies. Instead, emphasis was placed on the analysis of road network and planning, as well as the construction targets of transport infrastructures. In addition, due to the compartmentalization of the administrative system, the municipal governments were unable to adjust transport demand effectively through pricing. Furthermore, transport planning makes little effort to find low-cost solutions to the transport problems, nor does it carry studies on improving the efficiency of existing infrastructure and facilities against the shortage of financial resources.

The further worsening of urban transport has forced the municipal governments to focus on transport planning, and to deal with the transport problems with comprehensive methodologies. In the last few years, the urban transport planning has been strengthened in the following aspects (as illustrated by an example shown in Figure 1.2):

FIGURE 1.2: THE PROCEDURE CHART FOR THE SHANTOU TRANSPORT PLAN, CHINA ACADEMY OF URBAN PLANNING & DESIGN, 1994



Source: CAUPD, *Urban Transport Plan of Shantou City*, 1995.

- Studies on urban transport development strategies and development policies;
- Studies on how to control the growth of motor vehicles;
- Studies on public transport development;
- Evaluation of transport development strategies and transport network schemes from the point of view of environment, economy and finance.

At present, many municipal governments have realized that transport planning is a major foundation for, and an important component of, city master planning. In some cities, the budget for transport planning is higher than that of master planning. Some cities have integrated the process of master planning with transport planning. In 1995, for example, Shanghai revised both its master plan and transport plan, and Luoyang prepared these two plans simultaneously.

Historical Problems in the Existing Planning System

Because the existing urban planning system in China was reestablished under the centrally planned economy and during a period of slow social and economic development, it has certain limitations to meet the demands of the present economic system, as well as the rapid social and economic development. It is important to carefully examine these limitations and problems if we want to improve the existing planning system. The historical problems of urban planning system are discussed as follows.

The Concept of the Centrally Planned Economy. Under the centrally planned economy, there was only one source of investment funds, that is from the government. Consequently urban planning was understood as an extension and a physical aspect of the economic planning. The long-term planning overemphasized the quantitative relationship among the urban population, land development and the economic targets. The short-term planning only aimed at materializing the objectives of economic development through construction projects in urban plans. As a result of the total dependence on economic planning, methodologies used in urban planning are highly simplified, and lack a long-term vision, as well as the ability to adapt to new development.

Under the centrally planned economy, urban development and land use were not influenced and adjusted by a market economy. Economic rationales play no role in urban planning. It was therefore difficult to incorporate the actual demands of urban social and economic development in physical planning. The professional urban planners concentrated much of their efforts on the materialization of their idealized city models. Sometimes the idealized models dictated the planning practice. Just as often seen in a centrally planned economy, the favored planning thoughts or academic schools greatly affected the planning practice. During the first half of the 1980s, some Western schools and urban development models in favor of the satellite town, linear city, and urban clusters had been introduced into the planning practice in many Chinese cities. However, the background that had prompted the birth of these theories and models as well as the assumptions on which these theories and models are based have been largely overlooked. In fact, most of these theories and models do not fit China's reality. They therefore had not been realized and, as a matter of fact, cannot be realized in China's development.

In sum, the influence of the centrally planned economy system on urban planning was twofold. On the one hand, urban planning blindly followed economic planning. On the other hand, it unrealistically sought perfection.

Planners often overlooked the financial constraint imposed by the shortage of funds as they were administratively allocated by the economic planning departments. The budget needed for the development proposed by physical plans was often beyond a city's economic capacity.

Furthermore, an overambitious plan was also used by the urban planning and construction departments as one of the tools for bargaining for more funds from the economic planning departments.

City-Size Control Policy. It was about the same time as the reestablishment of the urban planning system in China that the Central Government proposed the city-size control policy. The City Planning Act asks for "strict control of large-size cities and active development of medium- and small-size cities" (City Planning Act, Article 4, 1991). This policy, no doubt, contributed to the reduction of blind expansion of the large cities and has already achieved some positive results. It, however, has sometimes been understood and adopted lopsidedly in the formulation of master plans. As a result, this kind of practice has damaged some cities' rational development and the effectiveness of urban planning.

In the 1980s, due to the lopsided understanding and ill application of this policy, some cities lowered the population growth target to a unreasonable level. The land-use and infrastructure plan lacked or intentionally avoided long-term considerations. Therefore, these cities encountered many situations where urban plans conflicted with development reality. The function of control by the plan was weakened.

The Blueprint Planning Model. The city master plan has the characteristics of a "blueprint plan." This plan formulates a clearly defined and rigid land-use layout and land-use model. The result of this model is similar to that in United Kingdom before its change of planning system in 1968.

Because China has a very low level of urbanization, the urban population and land use are currently experiencing rapid expansion. But the urban planning management capability is still weak. Under this circumstance, the "blueprint" plan shows some advantages because of its simplicity and clarity. In particular, under the planned economy system, the "blueprint plan" enabled the urban plan to coordinate better with the economic plans.

This "blueprint" planning model, however, has some obvious weaknesses. It causes the urban plan to lose its ability to adjust to a dynamic development process. In particular, during the period of fast economic development and transition of economic system, the "blueprint" planning may deviate from the course of urban development and the principle of a market economy, and/or even contribute to runaway development in areas beyond the urban planning area.

Physical Planning that is not Supported by Relevant Policies Studies. In the government administrative system, urban planning authorities and economic planning authorities are separated. Traditionally, urban planning is within the construction departments. Urban planning is then a kind of physical planning. During the procedure of plan formulation, urban planners are unable to study the most basic problem in urban development—demand and supply—and find rational solutions in a comprehensive manner. The planners are unable to participate in social and economic development policy-making and implementation to achieve balanced urban development. Although the urban planning departments are responsible for studying and defining the functions of a city, the number of residents, city-town system and other development targets, their functions in and influence on the actual policy and decision-making

are very limited. They are unable to participate in the making of urban social and economic policies, to carry out thorough studies on land and infrastructure development policies, and to formulate and implement urban transport development policies.

The disconnection of the physical plan from the development policy, and the fragmentation of administrative departments between those responsible for formulating urban plans and those for management make the physical plan irrational. The physical plan often lacks a long-term vision and forecast. It focuses on the long-term plan targets but overlooks the dynamic nature of development. It often starts with big issues that lack support from studies of crucial and detailed issues. Finally, it emphasizes new infrastructure development but neglects the potential of existing facilities.

In addition, there are also problems in demand forecasting, evaluation of development alternatives, and public participation in the preparation in the planning process. All these problems have adversely affected the formulation and implementation of plans.

Recent Improvements in Urban Planning

In recent practices, some of the problems mentioned above have been improved. This is reflected in several aspects.

First, the time interval for periodical revision of the master plan has been shortened. Some megacities almost adjust their master plans to meet the demand of development on a continuous basis. Some large cities review their master plans every three to five years. These frequent revisions have gradually transformed plans formulated under the planned economy into plans suitable for a market economy. The problems in the "blueprint" planning model have been partly solved.

Second, during the preparation of master plans, the urban development targets are now set to meet the demand of social and economic development. A number of large cities' master plans, especially those of coastal cities and provincial capital cities with high economic growth rates, have incorporated a long-term vision and have the ability to adjust themselves to new development. There are, however, a number of cities too optimistic about their future development, setting up a much higher than realistic target for their population growth.

Third, the urban plan's function in controlling land development has been strengthened. The district plan and detailed plan for control had been institutionalized in the last decade, with rapidly increasing acceptance. These two levels of planning have land development intensity (building density and FAR) control as their objectives, guiding and controlling land development and infrastructure construction in a detailed manner. Although there are cases where the indices required by the plans have been modified at discretion during the plans' implementation, overall the plan's control function has been greatly enhanced.

The municipal governments are no longer satisfied with the original plan formulation at different administrative levels. After completion of the master plan, they often make in-depth specialized plans that cover a wide range of elements, such as transport, disaster prevention, environment protection, sewage and drainage, gas supply, etc. These plans not only supplement the master plan with depth and details, but also compensate for the master plan's weaknesses in

setting development targets, population size, land-use pattern, etc. These specialized plans also have compensated for the weakness of the existing planning system to a large extent and increased its comprehensive capability, contributing to coordination among urban social and economic development, land development, and infrastructure construction for balanced development. In some megacities, the important specialized plans are prepared at the same time as the master plan. For example, Shanghai, Xiamen and Shantou have combined the master plan and transport planning studies in many different ways. They have achieved good results.

Finally, while improving the planning techniques and methodology, some cities have also started experimental institutional reforms in their planning organizations. These experiments and efforts have the objective of integrating the urban plan into urban social and economic development at a higher level, thus enabling the urban planning departments to participate more actively in the decision-making process for social and economic development, and helping urban planning to break away from only serving physical construction targets. These reforms have some success in a few cities such as Beijing and Shanghai. These, however, have only occurred in a small number of cities and their development perspective is not clear.

2. FACTORS CONTRIBUTING TO URBAN SOCIAL AND ECONOMIC DEVELOPMENT AND THEIR IMPACTS

Urbanization and the Floating Population

Urbanization. China's strict urban resident registration system and family planning policy greatly control the growth of the nonagricultural population in Chinese cities. According to China's conventional definition of nonagricultural population used in statistics, the level of urbanization in China is low, especially compared with other developing countries (Table 2.1).[2]

The Floating Population. The economic reform has vitalized the economy in both urban and rural areas of China. There are great changes in the urban employment system. Enterprises are now relatively free to hire contracted workers. There is a great demand for labor in urban industry and the retail and service sectors. And the rural area has a large number of redundant laborers and many of them migrate to urban areas for urban jobs (Table 2.2). Therefore, during the last decade, the floating population in large- and medium-size cities in China has been fast-growing, totaling about 80 million in 1994.[3] They live and work in cities, and some even bring their families with them (see Box 2.1). They are the de facto urban population. According to scattered statistics, the size of the floating population is about 20 to 40 percent of the nonagricultural population in large cities. This ratio is even higher in the coastal megacities, reaching 30 to 50 percent. In some large- and medium-size cities in the Pearl River

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2 Yan Mingfu, "Modern Civilization and Urbanization Towards 21st Century in China," *Urban Development Studies*, No. 3, 1995. By correlating the levels of GNP with the degree of urbanization, the author argues that the actual urbanization in China is about 6 to 7 percent lower than it should be at its GDP level if using the world average as a yardstick. Gu Shengzhu, "A Study of Non-Agriculturalization and Urbanization," *Population Studies*, Vol. 15, No. 3, 1991. Yu Depeng, "A Quantitative Comparison of Urbanization Between China and Other Countries," *Population Studies*, Vol. 18, No. 2, 1994. These two papers suggest that the urbanization level in China is 10 to 12 percent lower than that of countries with large populations. Since 1981, urbanization in China has slowed down, instead of accelerated as some other researchers argued.

3 *Economic Daily*, July 9, 1995.

Delta, the floating population is larger than the registered urban population.[4] The urban population, therefore, is composed of the registered as well as the floating population. The urbanization level should be calculated based on this definition.

TABLE 2.1: THE PROCESS OF URBANIZATION IN CHINA

Year	Urban population ('000)	Urban population over total population (%)	Annual growth rate of urban population (%)	Urban non-agricultural population ('000)	Urban nonagricultural population over total population (%)	Year	Urban population ('000)	Urban population over total population (%)	Annual growth rate of urban population (%)	Urban non-agricultural population ('000)	Urban nonagricultural population over total population (%)
1949	57,650	10.60				1972	149350	17.10	_0.2	106,240	12.2
1950	61,690	11.20	+0.6			1973	153450	17.20	+0.1	109,020	12.2
1951	66,320	11.80	+0.6			1974	155950	17.20	+0.0	110,086	12.1
1952	71,630	12.50	+0.7			1975	160360	17.30	+0.1	111,710	12.1
1953	78,620	13.30	+0.8			1976	163410	17.40	+0.1	113,420	12.1
1954	82,490	13.70	+0.4			1977	166690	17.6	+0.2	114,950	12.1
1955	82,850	13.50	_0.2			1978	172450	17.90	+0.3	119,940	12.5
1956	91,850	14.60	+1.1			1979	184950	19.00	+1.1	128,620	13.2
1957	99,490	15.40	+0.8			1980	191400	19.40	+0.4	134,130	13.6
1958	107,210	16.20	+0.8			1981	201710	20.20	+0.8	138,700	13.9
1959	123,710	18.40	+2.2			1982	211640	20.80	+0.6	142,910	14.1
1960	130,370	19.70	+1.5			1983	241280	21.60	+2.7	149,610	14.6
1961	127,070	19.30	_0.4			1984	330060	23.01	+8.4	163,010	15.7
1962	116,590	17.30	_8.0			1985	378200	23.71	+4.2	175,470	16.7
1963	116,460	16.80	_0.5			1986	434590	24.52	+5.1	182,110	17.3
1964	129,500	18.40	+1.6	98,850	14.0	1987	497770	25.32	+5.4	191,170	17.9
1965	130,450	17.98	_0.4	101,700	14.0	1988	540640	25.81	+3.2	200,810	18.5
1966	133,130	17.90	_0.1	99,650	13.4	1989	570628	26.21	+1.9	208,498	19.0
1967	135,480	17.70	_0.2	102,730	13.5	1990	594874	26.41	+1.0	214,135	19.0
1968	138,380	17.60	_0.1	103,600	13.2	1991	615677	26.37	+1.2	219,729	19.4
1969	141,170	17.50	_0.1	100,650	12.5	1992	709136	27.63	+7.6	230,918	20.0
1970	144,240	17.40	_0.1	100,750	12.1	1993	750192	28.14		242,916	20.9
1971	147,110	17.30	_0.1	102,450	12.0	1994	790453			256,198	21.8

Source: Xia Zonggan, "Bohai Bay Urban Development," CAUPD Report, 1994.

TABLE 2.2: THE MIGRATION OF RURAL LABORS IN GUANGDONG PROVINCE
(In percent)

	1988	1990	1991	1992	1993	1994
Migrated labor force over total labor force	7.6	3.7	4.5	5.0	9.2	10.1
Labor force migrated to the urban area over the total migrated labor force	-	57.6	52.3	49.1	57.9	62.9

Source: *Guangzhou Statistics Yearbook*, 1995.

4 Yao Shimo, "Regional Evolution of Urban Clusters in China," *Urban Economic Study*, No. 8, 1995. The floating population in Beijing was 0.3 million in 1978, 0.65 million in 1984 and 1.31 million in 1988. The floating population in Shanghai was 2.09 million in 1988 (1.8 times higher than the 1984 level), and 3 million in 1994.

Guangzhou Statistics Yearbook 1995. The floating population in Guangzhou in 1994 was 1.4 million, slightly lower than the 1993 level. Note that these may be the data of registered temporary population.

Sheng Chi, *Nanhai Master Plan*, CAUPD Report. Nanhai is located in the Pearl River Delta. The registered urban population in 1994 was 1.01 million, of which 24 percent was nonagricultural. In fact, 57 percent of the population is involved in nonagricultural activities. The registered temporary population was 560,000, but the actual temporary population was 800,000.

BOX 2.1: THE FLOATING POPULATION SURVEY IN BEIJING, NOVEMBER 10, 1994 (SUMMARIZED FROM A DATABASE STILL TO BE FINISHED)

- There are 3.3 million nonlocal residents in Beijing, among which 2.8 million come from other provinces and cities; 44,000 from overseas; and 41,800 transit population.
- Among the 2.9 million floating population living in Beijing, 82.7 percent (or 2.4 million) live in the urban area. There were 5.9 million nonagricultural persons in the city proper of Beijing in 1994, and the ratio between nonagricultural population and floating population was 2:1.
- The average age of the floating population is 27.7. The average male age is 28.5, and 26.4 for females. The ages between 0 and 14 accounted for about 10 percent of the floating population, the ages over 60, 2.2 percent.
- About 20.5 percent of the floating population was those coming to Beijing for visiting, tourism, holidays, training, conference and other nonemployment-related activities for a short time. Thus, it can be estimated that about 80 percent of the floating population was coming to Beijing for jobs.
- Among the floating population who worked, 34.9 percent were in business, retail, and services; 21.4 percent in the construction industry; 5 percent in the manufacturing industry; 1.9 percent in family nursing (service), and 0.9 percent in agriculture.

Source: *Beijing Evening News*, April 995.

According to the official estimate, there are now 450 million laborers in rural China, among which the redundant labor force is about 120 million. It is predicted that there will be more than 200 million redundant rural laborers by the end of the century. That is to say that there will be 80 million more rural laborers seeking employment in the urban area in the next five years.[5] Although the rural industrial sector will absorb a certain number of these laborers, most of them will migrate to cities, and they may also be accompanied by their dependents, estimated 80 million. This means that a total of 160 million floating population will be added to Chinese cities by the year 2000.

Except for a small percentage of the floating population involved in retail and services and having a relatively higher income, most of the floating population undertake heavy and low-pay physical work. Generally, the municipal governments do not provide them with housing, health and unemployment benefits and welfare subsidies. The floating population even has to pay higher fees for their children to go to school. Because the municipal governments have a policy of strictly controlling the construction of self-built simple housing units, most of the floating population have to stay in work shelters or rent their residences from farmers in the suburban area. As a result, their housing conditions are very poor. This practice has created, in urban China, two different classes with different entitlements to government welfare. In the megacities, the gap is even larger. In July 1995, a special conference on the management of the floating population was held by the Central Government. The conference focused only on the management of employment and public security, however, and failed to propose policies to deal with the urban population registration system, housing for the floating population, and other

[5] Wu Banguo, "Improving Floating Population Management and Promoting Reform, Development, and Stability," *Outlook*, No. 30, 1995.

social welfare problems. It is understandable that under the tremendous pressure of settling and managing surplus rural laborers, it is very difficult for the Government to propose a clear policy. The floating population as a special group will remain for a long time within Chinese cities.

Urban planning departments have not been involved in the management of, nor the formulation of, policies regarding the floating population. The traditional urban land-use control indices (such as per capita land use) and infrastructure construction indices only take the permanent nonagricultural residents into consideration. Urban planning departments deeply feel the pressure imposed by the floating population for land, transport and other infrastructure in recent years. It is almost impossible for a city to ignore its floating population in the formulation of its urban master plan since the floating population now increasingly accounts for a higher percentage of the total urban population. Large cities now start to forecast the growth of the floating population in their master planning and transport planning process. In addition, these cities attempt to raise a certain percentage of land, adjust the usage ratio of infrastructure facilities and add more planning indices to accommodate, to a certain degree, the floating population. There are, however, no clearly-defined policies concerning the floating population. More important, the floating population's migration is characterized by its blindness and unpredictability. As a result, the accuracy of forecasts in these plans and the suitability of these planning methodologies are dubious.

Land Market and Real Estate Development

The growth and establishment of an urban real estate market as well as the changes in urban real estate development have been synchronized with the rapid economic development and urban population expansion, and are closely related to the changes in the urban land-use and transport models.

Leasing and Transfer of Land-Use Rights. In the mid-1980s, the Chinese Government began to introduce and promote the paid land-use rights system through leasing (the lease period is usually 40 to 70 years), and allow the transfer of land-use rights. This policy has changed the practice of land allocation and land use at no cost that had lasted for the past 40 years. The formation of a land market has introduced market principles in land use, and resulted in differentiated land rents (prices).

Nongovernment Real Estate Development. Although urban real estate development was not entirely a government business before the economic reform, economic planning still strongly exercised control of the quantity and location of real estate development. All the activities of real estate development were defined by the economic plans. Under the new system, except government office buildings, housing for government employees, and the pilot, government-subsidized housing projects for low-income residents, which are totally or partially financed by governments, most of the housing, office buildings, business buildings are developed by enterprises and put on the market for sale. Profit is the major incentive for developers.

China's real estate market is still under formation. The market system itself as well as laws and regulations for market management are still far from perfect. As a result, instead of

benefiting from the newly established land market, Chinese cities first encounter many new problems.

Since the 1980s, there have had several "high tides" of economic development, which accompanied each time a disordered or even runaway real estate development. Because of the rapid rise in land prices and housing rents, as well as the abnormally high return rate in the real estate business, real estate became the "hot point" of investment activities. The municipal governments' unrealistically optimistic view of economic and real estate development resulted in oversupply of land compared to actual demands. Some coastal cities had practically no control in land leasing. From 1992 to 1993, the total leased land area was two or several times the built-up areas. Speculations in real estate development were so widespread that serious problems resulted. In some large cities, most of the leased land had been transferred many times and still not fully developed after these changes. A high proportion of leased land are undeveloped while infrastructure facilities, financed by the municipal governments through borrowed funds, cannot be fully utilized to their designed capacity and are unable to recover cost.

The land-leasing activities and related infrastructure development during these "high tide" periods often contradicted the objectives set by master plans and transport plans. Urban planners, thus, frequently confront situations where they have to formulate urban layout and land-use plans as well as plans for district functions for areas where the land-use rights had already been leased out and the land functions had been previously determined. Consequently, plans made under these circumstances become ineffective.

The speculation of land development also influenced the rural area. The rural collectives only have the right to use the agricultural land. The governments possess the right to procure land needed for development and then to lease or transfer land to developers. Because of the great difference between the compensation fee for procured land and the leasing price, many rural communes, towns and even villages have set up a large number of "development zones," or go beyond their authorized rights to lease the land directly to the developers. This phenomenon is widespread in the suburban areas of coastal and large cities. The result is not only the loss of government revenue from land transactions, but also the chaotic land use, urban layout and infrastructure development as well as the weakening of the urban plan's authoritative power in controlling urban development. In Shenzhen, for example, the total land area being leased out illegally or without the proper, higher-level government authorization is much larger than the planned urban land development specified by the master plan.

Because of the lack of market rules and the high risk, developers tend to seek extremely high short-term returns. Their development activities often seriously conflict with the urban plans in development location, density, capacity of infrastructure and facilities, etc., leading to chaotic urban layouts and higher tension between transport supply and demand in downtown areas.

During the periods of abnormal land development "high tides" and speculation, the urban planning authority often found itself playing a passive role and its efforts useless. First of all, the blind economic optimism is deeply rooted in the complex political and institutional systems. These factors are out of the control of a normal administrative system. Second, the municipal governments have not recognized the risks behind the fast economic and real estate

development. They do not understand the natural law governing the land market. Instead, they regard the control through planning as a factor hindering economic development. They, thus, intentionally weaken the role played by urban planning. Finally, the urban planning system developed within the traditional planned economy framework and the master plan based on the planned economy model are not suitable for the market economy system. The master plan is then unable to manage the land market supply and demand at the macro level. The conflicts between the new and old systems during the economic transition are therefore reflected in the planning system.

Housing Development and Housing System Reform

Housing Development. In order to improve the housing conditions, the municipal governments have invested heavily and undertaken urban housing construction on a large scale since the 1980s. As shown in Table 2.3, from 1984 to 1992, the newly completed housing stock totaled 1 billion square meters (m^2), and per capita residence floor area increased from 9.1 m^2 to 14.8 m^2. During the same period, 10 Chinese cities increased their housing construction floor area by 190 million m^2, and per capita residence floor area increased from 9.4 m^2 to 13.3 m^2. Annual housing construction accounted for more than 50 percent of the total building construction in urban areas.[6]

TABLE 2.3: TOTAL AREA OF BUILDING AND HOUSING CONSTRUCTION, TOTAL AREA OF COMPLETED CONSTRUCTION, AND AVERAGE FAR IN CHINA AND CHINA'S 10 LARGE CITIES

	1984					1992					
	Construction Area ('000 m^2)		Completed Area ('000 m^2)			Construction Area ('000 m^2)		Completed Area ('000 m^2)			
	Total	of which Housing	Total	of which Housing	Average FAR	Total	of which Housing	Total	of which Housing	Average FAR	Change in FAR (%)
National	**1,995,920**	**964,530**	**126,374**	**73,724**	**0.24**	**4,620,680**	**2,395,490**	**218,084**	**129,168**	**0.33**	**+37.5**
Beijing	129,960	65,380	8,240	4,470	0.36	190,900	95,700	9,425	5,846	0.45	+25.0
Tianjin	66,600	34,630	4,429	3,020	0.28	117,430	58,570	3,699	1,997	0.35	+10.7
Shenyang	48,820	25,260	2,811	1,791	0.30	83,420	42,320	3,952	2,463	0.44	+46.7
Harbin	31,190	17,270	1,787	1,379	0.22	58,130	28,790	2,900	1,810	0.38	+72.7
Shanghai	107,380	55,090	4,728	3,168	0.66	182,110	94,470	5,966	3,462	0.50	-24.2
Nanjing	41,970	20,910	2,501	1,499	0.42	61,760	30,860	2,633	1,646	0.50	+31.0
Wuhan	64,480	28,260	6,416	2,828	0.36	90,080	45,160	3,713	1,923	0.46	+27.8
Guangzhou	44,010	21,820	3,916	2,211	0.26	82,880	43,800	4,357	2,335	0.44	+69.2
Chongqing	34,560	15,360	2,076	1,256	0.55	49,760	24,280	2,373	1,211	0.49	-10.9
Xian	30,840	13,930	2,032	1,270	0.30	56,370	25,100	1,800	910	0.43	+43.3
Total	**599,810**	**297,910**	**38,936**	**22,892**	**0.35**	**972,840**	**489,050**	**41,818**	**23,603**	**0.44**	**+25.7**

Source: City Construction Statistics Annual Report, 1984, 1994.

In the last 10 years, a large percentage of the increased urban land use was for housing development. Most of the new housing stocks are located at city peripheries. In large cities, the renovation and redevelopment of old housing units in the old city areas gradually started in the 1990s. Large-scale housing construction in city peripheries permits the urban population to move from the inner city to city peripheries or suburban areas. As a result, many residential

6 *Urban Construction Statistical Yearbook*, years from 1984 to 1993.

communities were formed in suburban areas and the land-use model changed.[7] During the construction of new housing units around city peripheries, not enough attention was paid to transport, in particular, the provision of convenient public transport means.[8] The accessibility of public transport to these areas is low. The construction of new residential areas in city peripheries lacking convenient public transport is one of the reasons for an increased share of people using bicycles and company buses in some large cities, such as Shanghai, Tianjin and Beijing.

Reform of Housing System. Under the centrally planned economic system, housing was regarded as one part of employee income because it was assigned by work units to their workers. Workers could not select the location of their housing, however. When selecting the location to build or to purchase housing units, the work units often chose those that were concentrated together and near the workplace, to reduce job-related personal trips. In doing so, it was also convenient for the work units to provide company bus service when public transport services were poor and the traffic was congested. The objective of housing reform, which started 10 years ago, is housing commercialization and privatization. Under this new system, it is possible for urban residents to buy their houses with their incomes and give them more freedom to choose. The reform introduces the market and price mechanism to urban housing supply and demand. In general, it permits the urban land-use pattern to be developed on economic principles. The changes in the housing system will result in longer commuting distances and changes in spatial relationship between residences and workplaces. High-income groups may prefer to live in the suburban area with an excellent environment, or in luxury flats in the city center. The low-income group, which used to live in the high-density city center and now prompted by the high housing price that is beyond their reach, will have to move out of the city center to city peripheries during the renovation of old-city areas. This phenomenon has already occurred in some large cities like Beijing, Shanghai and Guangzhou.

Changes in the City's External Relationships

Relationship Between Cities. With the transition of planned economy to market economy, the economic relationship among neighboring cities is becoming closer. This is especially so when development in large cities is hindered by government controls or lack of resources; some of their economic activities will move to the nearby medium- and small-size cities. Benefiting from this movement and spared from the government city-size control policies, a number of medium- and small-size cities have developed very rapidly. This has created and intensified the economic relationships among cities, including not only the exchanges of funds, information, and materials, but also exchange of jobs for workers and managers.

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7 Chen Yewei, "Renovation Strategies for the Old Town of Shanghai," *City Planning Review*, No .5, 1995. There have been 4 million m^2 of old houses demolished, 120,000 households resettled at a rate of 10,000 households per year from 1979 to 1990. Between 1992 to 1994, 8.596 m^2 of houses were demolished, and 210,000 households resettled at a rate of 70,000 households per year.

8 Shanghai Urban Comprehensive Transport Planning Research Institute, *Shanghai City Comprehensive Transport Plan*, 1993. The average walking time to bus stops is 4.3 minutes in the old city proper, and 7.8 minutes in the 10 newly developed residential neighborhoods.

At the same time, the reform of the administrative system has created more and more administratively designated cities (there were 622 cities in 1994 as opposed to only 236 in 1982). Some cities, which used to be subordinated to other cities in administration, now have a parallel position as their formerly superior cities and have been granted similar powers in independent decision-making and management.

Relationship between the Urban Area and the Rural Area. Under the planned economy, there was hardly any direct economic relationship between the urban and rural areas. Even the exchange of goods was realized through the planned allocation system. Because agricultural reform was ahead of reform in the urban area, the redundant rural workers from large cities' rural peripheries became the first group of urban floating population. Then, some private entrepreneurs from the rural areas, who have accumulated wealth through many different ways, infiltrated into the urban areas. At the same time, various economic activities have been expanded from urban areas to their neighboring rural areas. This two-direction movement has created a very closed relationship between urban areas and rural areas. Because of the restrictions imposed by the permanent-resident registration system and housing system, a number of urban enterprises' employees, in particular the industrial sector employees, have to live in the nearby rural areas. These employees include former farmers from suburban areas and floating population who are unable to find suitable places to live in cities. The low costs of land and labor as well as the loose control in the rural areas have also attracted a number of urban enterprises to set up factories in the rural area, further strengthening the economic relationship between urban and rural areas. According to the traffic survey in some coastal areas, short-distance (10 to 20 km) intercity traffic account for about 70 percent of the total intercity traffic on roads. This tendency becomes one of the catalysts that encourage urbanization and suburbanization.

The Formation of Metropolitan Areas. Metropolitan areas or highly urbanized areas have emerged in regions with superior geographical location and fast economic growth, such as the Pear River Delta (see Box 2.2), Shanghai-Southern Jiangsu Region, Central Liaoning Province Region, and Beijing-Tianjin Region. Cities within these areas rely on each other and have very close economic relationships and networks. They have, however, from time to time, conflicting interests because of strong competition and lack of coordination. The relationship among cities within a metropolitan area has significant influence over each individual city's urban land layout, urban spatial pattern and transport system; this is especially true for the smaller cities.

The changes in a city's external relationships ask for high-level coordination among cities, between the urban area and the rural area, and within the metropolitan region. They especially require unified planning for infrastructure, environment, energy and land use. Although the relatively equalized administrative status and the independent decision-making and management power of each city will provide more economic development incentives, they also cause problems for much needed coordination and balance. In some regions, a number of newly constructed airports, seaports and highways have very low economic efficiency because of the fragmented administrative system. In the recent two to three years, regional planning has received renewed attention. Cities in the Pearl River Delta and the Central Liaoning Region have strengthened their coordination and unified planning of infrastructure facilities. However,

cities in the Yangtze River Delta and the Beijing-Tianjin Region still lack coordination because each of these two areas covers different provinces or megacities.

The existing urban planning system in China requires the preparation of a city-town system plan at the regional level within the municipality jurisdiction. But with further subdivision of the municipal administrative system and the increased number of administratively designated cities, the jurisdictional area of each municipality has been increasingly reduced. Consequently, the significance and functions of city-town system planning have been weakened.

BOX 2.2: URBAN CHARACTERISTICS OF THE PEARL RIVER DELTA REGION (THE CORE AREA), 1994

- The region has an area of 18,682 km^2 and a total registered population of 13.6 million, of which 7 million (or 51.4 percent) are nonagricultural people. The floating population accounts for 6 to 8 million. If the floating population was included, the population density reached 1,100 person/km^2, and the proportion of nonagricultural population was 70 percent.
- There were 15 municipalities and 203 towns in the region. The town density was 11.7 towns per 1,000 km^2.
- The agriculture land in the region was 3,487 km^2 and 255.7 m^2 for every registered person. The total built-up area of the 15 cities was about 800 km^2, while the 203 towns had a total of more than 100 km^2 built-up area.
- The GDP of this region totaled Y 243 billion in 1994, an increase of 15.9 percent from 1993. Based on the registered population, per capita GDP was Y 17,837. It would be Y 12,000 if the floating population was included.
- Of total GDP, the primary sector accounted for 6.7 percent; the secondary sector, 51.8 percent; and the tertiary sector, 41.5 percent. The number of workers in the tertiary sector in every municipality in the region ranged from 30 to 44 percent of the total number of workers.
- The region had 577,000 registered trucks and cars, and 1.4 million registered motorcycles. Based on the registered population, it was 42.3 trucks and cars, and 101.8 motorcycles per 1,000 persons, respectively.

Sources: *Guangzhou Statistics Yearbook 1995*; *Guangdong Statistics Yearbook 1995*; *China City Statistics Yearbook 1993-94*; and Yang Hongshan, "Rural Laborer Influx in Pearl River Delta: Investigation and Analysis," *Population Studies*, Vol. 19, No. 2, 1995.

The Tendency Toward Decentralization in the Urban Plan's Control Power

Although the function and authorization of urban planning have been increased in the legislation and control procedure, there is a tendency to weaken them as economic growth and system reform progress.

Usually, the power of urban planning is centralized in the municipal governments. As a general direction of the reform, power decentralization and increasing autonomy of lower-level governments have affected the planning power. For example, a number of large cities such as Shanghai and Guangzhou have decentralized planning management and development control power to district governments. In some cities, the management authorities for development

zones have quite independent planning control power. As district governments and management authorities in development zones focus on their own development, they often have weaker planning control and development management.

In order to attract investment, some cities make too many concessions to the developers who demand sharp increases in the density of development or changes in land-use function; some cities even allow developers to carry out development outside the planned areas. Such serious cases have happened in Beijing, Shanghai, Guangzhou and some other large cities. In the developed coastal medium and small cities, these happen even more frequently. In Shanghai, because the profits from land transactions are shared between the municipal and district governments, the district governments have increased the FAR in order to raise their financial income (the price of land is calculated based on the construction floor space).

In addition to the lack of necessary market regulations during the economic system transition and economic development, which has adversely affected the effectiveness of urban planning, the shortage of professional urban planners and poor technical capability of planners also contribute to the weakening of urban planning. In the last 15 years, the number of professional urban planners and designers has increased to 37,000 from 6,000,[9] but they are still far from enough to satisfy the demand if we are to have effective urban planning and urban management to meet the rapid growth of municipalities.

3. Changes in Urban Land Use-Transport Models

Increases in Urban Land Use and Urban Sprawl

Increases in Urban Land Use. Due to the rapid growth of the population and the urban economy, urban land used for construction increased by 64 percent in China during the period 1984-92. During the same period, the urban nonagricultural population increased by 41.1 percent. Many cities have now surpassed the construction land-use target set in the mid-1980s for the year 2000. From 1990 to 1992, China's 10 largest cities increased their urban construction land use by 510.4 km^2, that is a 30.0 percent increase.[10] During the same period, the urban nonagricultural population grew by 15.7 percent (Table 3.1). The sharp increase in urban land use and the conversion of a large quantity of cultivated land with comprehensive irrigation facilities and potential for high agricultural productivity to urban construction use have consequently provoked strong criticism from the agriculture departments and land administration authorities.[11]

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9 According to a presentation given by Zhou Ganzi (Department of Urban Planning, the Ministry of Construction) in Hong Kong in 1994, the professional urban planners in the whole country (including staffs both in management and design) were 6,000 in 1980 and 37,000 in 1993, among which 18,000 are design staff; moreover, there are 962 urban planning and design units (academy, institute, or division) in China.

10 *Urban Construction Statistical Yearbook*, 1990, 1991, 1992.

11 *Economic Daily*, June 17, 1995. It was pointed out in the National Cultivated Land Protection Conference that 1.1 million mu (733.3 km^2) of cultivated land has been taken by 10 large cities from 1990 to 1992 . The figure was different from that in *Urban Construction Statistical Yearbook*. It was also pointed out that the large- and medium size cities were still expanding with little restraint.

The reductions of cultivated land are mainly caused by the need for: (a) intercity transport (railway and highway), energy and irrigation construction; (b) urban development; and (c) rural housing and township enterprises. In recent years, the use of cultivated areas for urban development has taken an increasingly high share.[12]

For a long period of time, China's land policy has been, on one hand, to give priority in land allocation to transport, energy, irrigation, and key industrial projects with national significance, and on the other hand, restrict land use for urban and rural housing and industrial development. The fact is that the amount of land for urban use in Chinese cities is still very low. Even during the period 1984-92, per capita land use index had had only a small increase (about 7 percent). If we take into consideration the sharp increase in floating population and its high ratio over the total urban population, the per capita land-use index has actually decreased sharply during this period of time. As a result, the urban population density is still increasing (Table 3.1).

TABLE 3.1: THE POPULATION, CONSTRUCTION LAND USE AND POPULATION DENSITY IN CHINA AND 10 CITIES OF CHINA

	Urban Nonagricultural Population ('000)		Urban Construction Land Use (km^2)		Per Capita Land Use for Construction (m^2)		Population Density ('000 persons/km^2)	
	1992	1984	1992	1984	1992	1984	1992	1984
National	**154,594**	**109,569**	**13,918.1**	**8,480.4**	**90.0**	**77.4**	**11.1**	**12.9**
Beijing	5,659	4,985	429.4	365.9	75.9	73.4	13.2	13.6
Tianjin	4,491	4,123	334.7	240.3	74.5	58.3	13.4	17.2
Shenyang	3,687	3,173	189.2	162.1	51.3	51.1	19.5	19.6
Harbin	2,469	2,217	153.0	141.8	62.0	64.0	16.1	15.6
Shanghai	7,561	6,726	365.2	171.1	48.3	25.5	20.7	39.2
Nanjing	2,140	1,865	123.2	99.7	57.6	53.5	17.4	18.7
Wuhan	3,354	2,899	193.9	178.0	57.8	61.4	17.3	16.3
Guangzhou	2,996	2,486	188.2	172.2	62.8	69.3	15.9	14.4
Chongqing	2,307	1,523	101.5	62.9	44.0	36.1	22.7	27.7
Xian	2,006	1,686	131.0	104.3	65.3	61.9	15.3	16.2
Total	**36,670**	**31,683**	**2,209.3**	**1,698.9**	**60.2**	**53.6**	**16.6**	**18.6**

Sources: *City Construction Statistics Annual Report*, 1984, 1992.

While increases in the amount of urban land have received strong criticism, problems caused by the high urban population density have not drawn enough attention from the Government. These problems include the worsening quality of life and environment, rapidly rising real estate prices, and declining urban efficiency.

The urban planning authorities often face pressure from two directions. When formulating urban plans or during the "high waves" of development, the governments usually

[12] Ibid.

ask urban planning authorities to set high targets for urban population and land development, and designate more land for development (the major stated motive is to promote the municipality's economic development rather than to improve the quality of life and environment). However, when examining their policy on land resource management in the face of criticism, the governments often blame the urban planning authorities for their ineffective management of land resources.

There are four factors that cause the urban planning authority difficulties in controlling the growth of urban land use. First, forecasting results produced in the planning process are not robust because it is difficult to predict the rapidly growing economy with precision. But more importantly, the urban planning authorities lack a sound understanding of urban development dynamics and do not have experience and theory to guide their forecasting.

Second, when setting targets for land use and population growth, urban planning authorities often face too much political interference. Opinions from top leadership of the municipal governments inevitably influence the planning process.

Third, the urban land supply plan, developed by the land management authorities that are independent of the urban planning authorities (in some cities, however, these two departments are integrated into one), often contradicts the urban master plan. Sometimes, problems arising in the formulation and implementation of the land supply plan are even worse than those of the urban master plan.

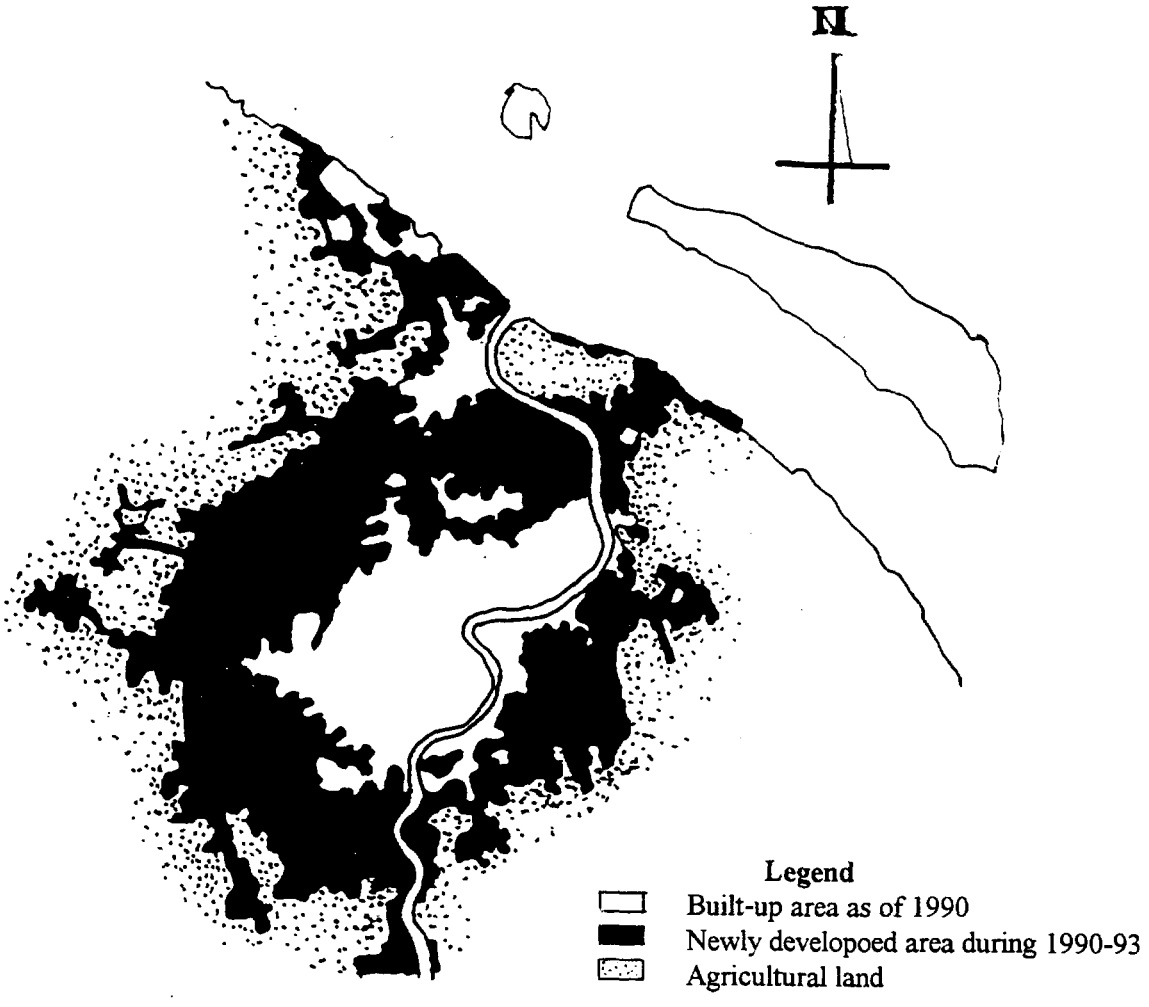
Finally, suburban rural land management is not well coordinated with urban land management. It is therefore difficult for the urban planning authorities to effectively control town and village land development for housing and industrial use. In more developed regions, towns and villages governments, driven by financial benefits, directly lease land to developers or investors.

Land Expansion Models. In the last 15 years, almost all the large cities have expanded geographically in concentric circles and increased the amount of urban land use; this is especially true in the plain areas where urban land use is not constrained by geographical barriers (see Figure 3.1). Several factors contribute to this pattern of land expansion.

First, the master plan formulated in the mid-1980s had abandoned the unrealistic planning models such as satellite cities; it favored the centralized urban land development. In the same period, a number of megacities, such as Beijing, proposed a road network comprising several high-speed ring roads and radial roads. With a tendency to imitate each other, a number of cities, without careful analysis of their cities' characteristics, blindly adopted similar road networks, even though they lacked the technical and financial capacity to support such development. The ring-road network has naturally led to land expansion in concentric circles.

Second, municipalities have limited financial resources to invest in urban infrastructure. Therefore, the supply of urban transport services is, in general, always lower than the demand. Urban expansion in concentric circles has an advantage in enabling a city to maximize the use of existing infrastructure, but even it has already been seriously overloaded.

FIGURE 3.1: MAP OF SHANGHAI'S URBAN DEVELOPMENT AND EXPANSION SINCE 1990



Source: French satellite remote-sensing map, provided by Shanghai Urban Planning and Research Institute.

Third, an overall change in the urban transport structure has yet to happen and the motorization level is still low. Urban expansion in concentric circles enables a city to maintain reasonable accessibility in the urban area and therefore reduce travel costs. Industrial entrepreneurs and real estate developers naturally prefer areas with good accessibility. Up to 1992, large cities had few high-grade arterial roads connecting areas beyond the city, which could have been their transport corridors and served as the backbone for urban expansion.

Fourth, due to the strict urban resident registration administration system and prohibition of self-built shelters by the floating population, there are no slums or self-built residential areas in city peripheries. In other developing countries, this kind of self-built residential areas is usually constructed along a city's major regional roads.

Finally, during the expansion of urban land use, the development control exercised by the planning authority has been generally effective. Although land use in some big cities has surpassed planned boundaries, the expansion orientation has been generally in accordance with the master plan.

Composition of Urban Land Use by Function

Land Use by Function. According to the National Urban Land-Use Standard Categorization, there are now 10 different categories of urban land use. Because of the differences between the new and the old statistical methodologies, it is difficult for us to make a comprehensive and historical analysis of the composition of different types of land use.

Traditionally, industrial land use took up a high percentage of urban land in Chinese cities (see Table 3.2), which was closely related to the urban economic structure, land-use policies formulated under the planned economy, and the governments' emphasis on industrial development. In 1984, industrial land use took 27 percent of China's urban land; it decreased to 22.3 percent in 1993, a large reduction in share as compared to other land-use categories. During the same period, in most of the 10 largest cities, the share of industrial land use had reduced by 1 to 4 percent, except for Shenyang and Nanjing,[13] whose share of industrial land use actually increased. In a number of cities, the recent statistics on the share of industrial land use cannot reflect the actual situations. For example, some newly developed industrial land has not been used. In a broad sense, the decreasing trend in the share of industrial land use is consistent with changes in urban economic structure and the need to increase land-use efficiency.

TABLE 3.2: LAND USE IN CHENGDU IN 1980 AND 1994

		1994		1980	
Order	Category	Area (ha)	%	Area (ha)	%
1	Residential	3,514.2	34.7	1,518.8	29.1
2	Public Facilities	1,870.2	18.5	1,051.8	20.2
3	Industry	2,739.2	27.1	1,500.0	28.8
4	Warehouse	305.2	3.0	243.6	4.7
5	Intercity Transport	381.0	3.8	172.4	3.3
6	Roads and Public Squares	863.4	8.5	442.3	8.5
7	Civil Public Facilities	275.3	2.7	171.4	3.3
8	Greenery	175.3	1.7	114.9	2.2
Total		**10,123.6**	**100.0**	**5,215.2**	**100.0**

Sources: Master Plan of Chengdu City, 1982, 1995, Chengdu Urban Planning Bureau.

[13] *Urban Construction Statistical Yearbook*, 1984, 1993.

The share of land used for public facilities (including retail and business facilities) and civil service facilities increased by 15 and 30 percent, respectively, while the share of land used for residential areas remained the same.[14]

The share of land used for urban roads (excluding service roads in residential areas) has always been too low. The central government's recommended standard is 8 to 15 percent, but few cities have reached this level. In 1993, the total land used for roads was only 6.5 percent of total urban land on national average, and an even smaller 6 percent on average for the 10 largest cities, except for Beijing, Tianjin, Guangzhou and Shenyang where land used for roads reached 8 percent.[15]

Spatial Distribution of Land Use. Although the division of districts by function in land use has been one of the main principles in urban planning, the phenomenon that land uses of different natures are mixed together is common in large cities, especially the mixture of industrial land use and residential land use, which has directly influenced the urban travel pattern. Except for a number of key industrial cities built in the 1950s, industrial sites in most of the Chinese cities are relatively scattered; even in city centers there are many medium- or small-size factories. Before the 1980s, there was little urban residential construction. As a result, the urban population was increasingly concentrated in the city-center area and its population density became extremely high. Under the planned economy, residential houses were usually built as to "match" industrial and administration development; cities are therefore characterized by mixed residential housing and other facilities. It was only in the 1980s that industrial enterprises in large cities began to move to city peripheries in relatively large numbers and large-scale residential areas were built at city peripheries.[16]

Changes in Urban Densities

Population Density. From 1984 to 1992, as the urban land use increased, the national per capital urban construction land for the nonagricultural population rose to 90.0 m^2 from 77.4 m^2, a 16.2 percent increase. At the same time, per capita urban construction land use in the 10 largest cities was up from 53.6 m^2 to 60.2 m^2, an increase of 12.3 percent. China's urban nonagricultural population density decreased from 12,900 persons/km^2 to 11,100 persons/km^2; the same density dropped from 18,600 persons/km^2 to 16,600 persons/km^2 in the 10 largest cities (see Table 3.1). Even so, Chinese cities, especially large cities, still have quite a high population density. Table 3.1 indicates that only in three of the 10 largest cities, i.e. Shanghai, Tianjin and Chongqing, the population density based on urban permanent residents had substantially decrease (population densities in Shanghai and Chongqing were 39,200 and 27,700 persons/km^2

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[14] *Urban Construction Statistical Yearbook*, 1984, 1993. It should be noted that this is a very crude comparison because the methods of counting land area for public facilities in these two years are different.

[15] *Urban Construction Statistical Yearbook*, 1984, 1993.

[16] Xinhua News Agency, October 1995. According to a survey of 10 industrial sectors in Shanghai, 319 industrial enterprises and 455 production units have been relocated to suburban areas from the inner urban area.

Chen Yewei, "Renovation Strategies for the Old Town of Shanghai," *City Planning Review*, No. 5, 1995. The industrial land area within the inner ring road in Shanghai in the 1980s took about 25 percent of the total area. This was reduced to 20 percent in the 1990s.

in 1984, respectively). If we consider the rapidly increasing floating population in the last 10 years (20 to 40 percent for most of cities, or 50 percent for Beijing as we mentioned previously), the effective per capita urban land area has actually decreased, while the effective population density has increased. This trend is still continuing and it is estimated that in the 10 largest cities, the effective population density now is over 20,000 persons/km^2!

The current national urban land-use standards stipulate that per capita urban construction land use should be around 100 m^2. In other words, the urban population density should be 10,000 persons/km^2. Indeed, almost all the cities desire to reduce their high population density, and have actually established a target for population density reduction and improvement of quality of life in their master plans. Some favorable results have been realized. Especially in large cities with high economic growth, the municipal governments have used a number of compromising policies to weaken the control of land management agencies in order to increase the amount of urban land.

Building Density. Urban buildings grow faster than the expansion of urban land. As a result, the average urban building floor area density (or FAR) is increasing. In 1984, the urban per capita building area for the nonagricultural population was 18.2 m^2 per person, and the average FAR was 0.235; and in 1992 these increased to 29.9 m^2 per person and 0.332, respectively. During the same period, per capita building area in China's 10 largest cities increased from 18.9 to 26.5 m^2; and the average FAR was up from 0.353 to 0.440, a 25 percent increase. Except in the highly densely populated Shanghai and Chongqing where the average FAR actually decreased, the FAR in the other eight largest cities increased rapidly. Guangzhou, for example, raised its FAR by 72.5 percent (see Table 2.3).

Due to the lack of detailed data on the floating population, we cannot give good estimates of the actual population density in large cities. Nevertheless, we can infer that growth of the urban population density is slower than that of the urban building density, which is consistent with evidence found in other countries.[17] The increase of urban building density in big cities implies that people now have more residential floor area, working space and other service facility spaces.

For urban planning authorities, controlling the urban building density is a much more difficult task than increasing urban land and reducing the urban population density. In many cases, the actual building density in new development is much higher than the planned density. Because of this experience, some municipalities have replaced the detailed density indices with a control range in principle when planning land development in the sensitive urban center.

The continuing increases in urban building density can be attributed to several factors. The first factor is the profit-maximizing behavior of developers. In good locations, raising the FAR is the most effective way for developers to realize extra profits. Especially in the high-risk market, developers tend to increase the FAR to materialize short-run high investment returns.

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[17] John F. Kain and Liu Zhi, "Avoiding Common Errors in Transport and Urban Development Policy," Harvard University, paper presented at the International Symposium: "Guangzhou Striving for a Modern International Metropolis in the 21st Century," 1993.

The second factor is the highly strict land supply policy. The shortage of land supply surely leads to the rise of land prices, inducing developers to increase the building density to lower unit construction cost.

Rising development costs is another factor. In addition to land price increases due to a land shortage, the rising development costs, caused by high density in old town and poor infrastructure in newly developed areas, also prompts an increase in building density. In the old city-center areas of Shanghai, Guangzhou and Beijing, the profitability for renovation of old housing units usually requires 3 to 54 m^2 of new construction for every 1 m^2 demolished. In large cities, infrastructure construction fees paid by developers, which are often calculated separately, become increasingly high. In some cities, the fees reach Y 100 to Y 200/m^2.[18] Consequently, developers have to raise the building density to shoulder these costs.

The fourth factor is the short-run behavior of the governments. Municipal governments often raise the FAR limit and lower land prices to attract investment, especially for big developers with deep pockets. This kind of short-run behavior directly contributes to the rising building density.

Finally, the disorder in the municipal governments' public finance system also contributes to the rising building density. The municipal government often requires developers to directly undertake construction of the infrastructure and service facilities as a precondition to increasing the FAR. This is actually an in-kind land rent imposed on developers. However, this in-kind land rent is difficult to quantify, which creates loopholes for developers to further raise the FAR to realize higher profits, and opens doors for bribes and corruption.

Under pressure from many parties, urban planning authorities often find it very difficult to control the FAR, especially in city centers and old town areas. Furthermore, few cities have ever, from an economic or financial point of view, undertaken studies to evaluate and then select appropriate FARs as control indices. Nonetheless, there were some research results and recommendations. They have not been adopted by the governments, and it is still unknown how well these studies could be used to guide practice. It is clear that increases in the FAR lead to highly concentrated transport volumes. As for the real estate developers, who are responsible for causing this increase, they have not paid their due share to the social cost of the needed infrastructure facilities in land development.

The Function of a City's Center Area

Under the planned economy system, a city center accommodated functions like retail, business, and government administrations. Due to the absence of a land market and market adjustment of land use, the city center maintained a high residential population density. It also contained a large number of factories and warehouses. The city center therefore had not become a central business district (CBD) typical in developed countries. With establishment of the market system, the geographic advantage of the city center brings about changes in its land-use

[18] This happens in Shanghai, Guangzhou and Beijing. The fees do not include the construction fee for social public service facilities. Similar fees in the new city center of Shenzhen run as high as Y 400 to Y 500.

functions. In large cities, the city center's function, which was weakened under the planned economy system, is now being rebuilt and enhanced. The following changes are clear indications of this trend.

First, retail business in the city center is growing rapidly, leading to expansion of shopping areas and commercial development areas. In the past 10 years, the construction floor area for commerce in major retailing centers in Shanghai and Beijing increased more than 50 percent. The number of workers working for and shoppers attracted by the city center's retail services are rapidly growing.

Second, financial institutions, business organizations and other tertiary-sector firms are rapidly concentrating into the city center. The rate of new office and hotel construction is higher than that of retail business. Although the intensity of land use for offices and hotels still cannot match that in developed countries, an early stage of CBD development has apparently formed.

Third, the numbers of residents and jobs in administrative agencies in the city center are decreasing. During the redevelopment of old town areas, a large number of houses had been demolished and were replaced by shops, office blocks and hotels. According to population statistics in some cities, the resident population in city centers decreased at least 10 to 20 percent during the last decade.[19] In Shanghai, a large number of office buildings in the city center were used as residential houses, factories and warehouses in 1950s and 1960s.[20] Now, the city is converting some of the traditional office buildings built in 1920s and 1930s to commercial use.

Finally, under market forces, factories in the city center and inner city are actively seeking opportunities to move out of the city center. In particular, financially strained enterprises try to raise urgently needed funds by selling their rights for the use of land and buildings they currently occupy. Some factories are directly involved in real estate development and operation with the land they now occupy, or switch to retail or service industries for higher profits in order to compensate for their losses in manufacturing.

At the same time as the city center's function is strengthened in big cities, some service functions have demonstrated a trend of moving away from the center. In large cities, the resident population density in city centers is very high; demolition of old buildings, relocation of old enterprises, resettlement of residents from the city center are expensive; infrastructure facilities are seriously overloaded and have little potential for improvement. They make the costs of redevelopment of the city center in big cities prohibitively high (prices of office buildings and hotels in the city centers of Beijing, Shanghai and Guangzhou rank in the top 10 in the world), hindering redevelopment in the city centers. Meanwhile, as infrastructure in the peripheries of

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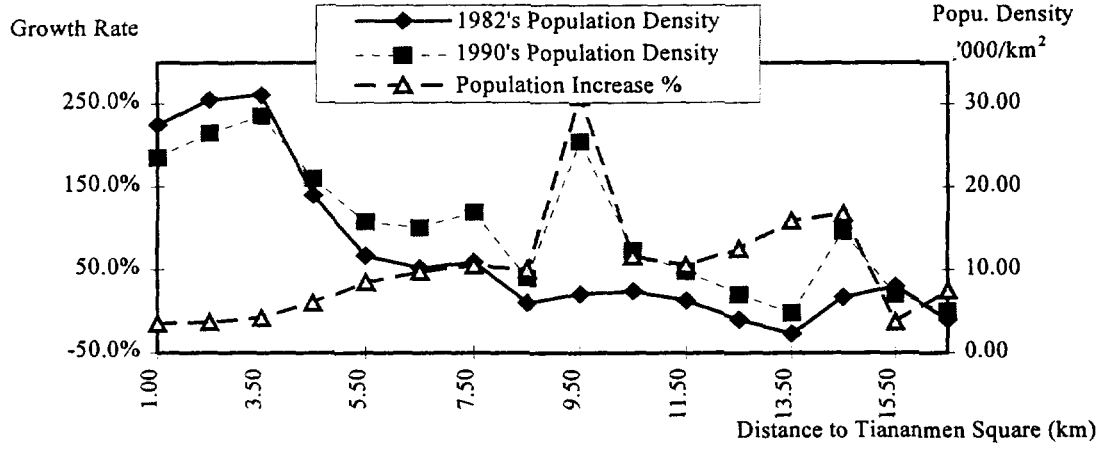
[19] According to incomplete data, population in Huangpu and Jinan Districts in Shanghai have been declining. *Guangzhou Statistical Yearbook 1995* also shows a slow increase in registered population in the four inner city districts. The population in Yuexiu District is declining. According to information provided by Guangzhou Municipal Planning Administration Bureau, a certain percentage of the registered urban population now lives outside the city proper.

[20] *City Herald*, July 24, 1995, reported that Shanghai Municipal Government established a special organization to deal with the conversion of buildings from government offices and residences to business offices in Waitan Area (the Bund). Thirty-seven buildings were initially selected for conversion and the first 18 buildings will be used by domestic and overseas businesses.

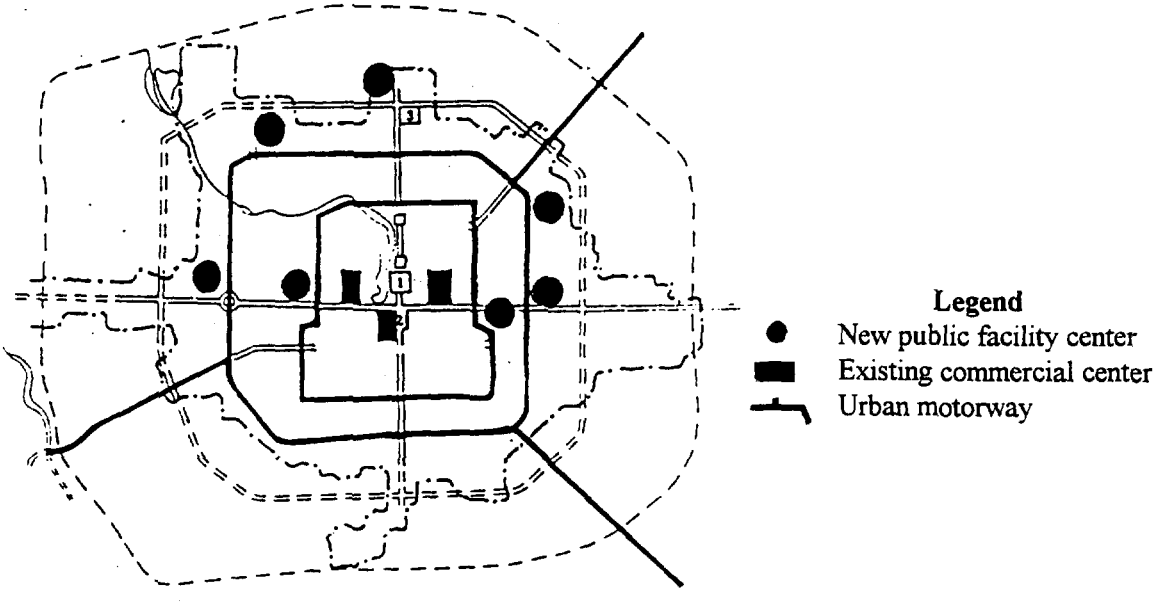
large cities improves, locations with high accessibility become new hot points of development. They have attracted a number of high-level and large-scale commerce, retail and service businesses. Examples are areas along the Second and the Third Ring Roads in Beijing, and the Hongqiao and Pudong Districts in Shanghai. These areas probably will develop into secondary centers, thereby decentralizing city centers' functions and lowering the degree of concentration in city centers (see Figures 3.2 and 3.3).

FIGURE 3.2: CHANGES OF POPULATION DENSITY IN BEIJING



Source: Sun Yinshe, "The Diffusion and Evolution of Urban Spatial Structure: Theory and Case Study," *City Planning Review*, No. 5, 1994.

FIGURE 3.3: THE LAYOUT OF NEWLY BUILT PUBLIC FACILITIES CENTERS IN THE PERIPHERIES OF BEIJING WITH HIGH ACCESSIBILITY



In their master plans, many cities have proposed developing new city centers outside the current built-up area or at the city peripheries where the density is low. The basic idea is to avoid difficulties in redevelopment of the old city center, or hope that the new city center can give birth to new growth and promote development of the tertiary sector. In some cases, it is only a symbolic gesture (for example, "building the world metropolis") to reflect the planners' idealized development goals.

These newly planned city centers are often bigger than the existing ones, with more functions, usually including CBD, retail center, administrative center, cultural center, etc. In some rapidly developing cities, this new development has started. Speaking from recent practices, some traditionally small-size cities, or cities whose city center had moved with the city expansion (such as Shantou), have succeeded. Unfortunately, in large cities, development of new city center is not very successful. The failure has many reasons, including those relating to market demand, investment capacity, location, accessibility, etc. Generally speaking, plans for new city centers are often made blindly, lacking economic justification.

Urban Transport Characteristics and Their Changes

Under the economic system and land-use models specific to Chinese cities, urban transport has developed its special characteristics accordingly. Following changes in the economy and land-use patterns, urban transport characteristics have also experienced changes, although at a slower pace than those of the economy and land-use patterns. Because of the sharp increase in the share of passenger transport relative to freight transport in recent years, we focus on passenger transport here.

Travel Characteristics. Because Chinese cities generally have high population densities, a mixed land-use pattern, and a special residence-employment model formulated under the old housing system, residents have relatively short travel distances but make more trips. According to the data on resident trips in the last 10 years, travel distances in big cities have increased. Table 3.3 compares the survey results of Tianjin residents' person-trips in 1982 and 1993.

Because the definitions of resident trip are different in the two surveys, the actual increase in travel distance is lower than that reported by the survey.[21] Almost in the same period, the urban built-up area of Tianjin had increased to 350 km^2 from 150 km^2. The travel distance had, however, a much small increase. We can thus infer that the land-use model has not yet changed dramatically.

In medium-size cities, because the distance between workplace and home is short and the noon break is long, peak hours thus occur at both ends of noon, which inevitably increases the number of work-related trips. In some cities, many people live, work, shop and go to school within one big compound. Zero trips were thus reported in travel surveys (it is certainly related

[21] Li Yaming, *China Urban Transport Database*, CAUPD Draft Report, 1995. Personal O-D trip in Tianjin's 1981 O-D survey was defined as a travel for one purpose from place A to B; and the city's 1991 O-D survey it was limited to the trip with a distance of 500 m or longer, or 8 minutes on foot.

to the definition of trip); for example, in Beijing, the average resident made only 1.6 trips per day in 1986.

TABLE 3.3: RESIDENT TRAVEL CHARACTERISTICS IN TIANJIN IN 1982 AND 1993

Travel Characteristics	1981	1993
Average Number of Trips	2.44 Trips/day	2.02 Trips/day
Average Trip Duration	22.3 Minutes	27 Minutes
Average Trip Distance	3.78 km	4.18 km
Trip Mode		
Walk	42.6%	28.01%
Bicycle	44.6%	60.48%
Bus	10.3%	4.06%
Motorcycles	n/a	2.00%
Company Bus	n/a	3.06%
Others	n/a	2.40%

Source: Fong Rong et al., *Resident Travel Characteristics in Tianjin and the Analysis of Transport Demand and Supply*, 1994.

Origin-Destination (O-D) Distribution. If we could say that the characteristics of urban resident travel and mode choice are indirectly influenced by the land-use pattern, then the O-D distribution of urban residents is directly related to the land-use pattern. Because the functional uses of urban land are highly mixed, especially in old industrial cities like Shanghai and Tianjin, residential areas are dotted within working places. Areas with the highest population density and employment density are always located in city centers. The population and employment densities decrease gradually with distance away from the center. There are few exclusively residential or employment areas formed. Therefore, person-trips are characterized by short travel distances. Due to the mixed residential and job locations, there are no clear directions in road transport flows; and traffic volume is relatively balanced on both directions of arterial roads.[22]

4. TRANSPORT DEVELOPMENT AND THE ROLE OF PLANNING

Travel Modes

Urban residents' travel mode choice is not only influenced by the land-use pattern, but also affected by transport policies, and the supply of public transport and road infrastructure.

Walk. Obviously, the high population and employment densities, the mixed functional uses of land, and the housing policy implemented under the planned economy have all

[22] Shanghai Urban Comprehensive Transport Planning Research Institute, *Shanghai City Comprehensive Transport Plan*, 1993. It was only in the last few years that the tidal traffic flow pattern appeared in the arterial roads in Shanghai.

contributed to the short resident travel distances. It is convenient to travel by walking and walk-trips take up a large percentage of total person-trips. However, due to the popular use of bicycles, part of the trips that need 10 to 15 minutes' walk have been taken with bicycles. Even so, walk-trips generally account for 30 to 40 percent of total resident trips in large-size cities.

Bicycle. Obviously, the bicycle plays a very important role in China's big cities. Bicycle travel takes up a large share of person-trips. It is very common in the urban area that trips by public transport only represent a small share in total resident trips.

In addition to the low level of economic development, several main factors contribute to the high share of bicycle trips. First, it is acceptable for bicycle users to make trips of 3 to 4 km long, in terms of time or physical demand. Second, the "Three Boards Roads" (those with motor vehicle lanes, bicycle lanes and pedestrian sidewalks with simple physical separations), built in large quantities since the 1970s, provide good road conditions for bicycle users. Third, traffic congestion has little effect on bicycle travel speed. Especially in recent years, as the delays in public transport increase and speeds decrease, traveling by bicycle has a better chance of making trips on time. Finally, the financial cost of bicycle trips is still lower than that of using public transit, although in recent years financial cost is no longer the most important factor determining the choice of travel mode between bicycle and bus. In the 1960s and 1970s, the transport subsidy policy gave clear economic incentives to bicycle users (a bicycle user could save the transport subsides, which were given in cash; and the saving of about three or four years is equivalent to a bicycle's price). This policy had a long-lasting effect on the development of bicycle ownership and bicycle trips.[23] Even today, the financial cost of bicycle trips is still lower than that of bus trips.

We could see that trips by bicycle have been encouraged by government policies in road use and prices. Since the 1980s, the share of bicycle trips in total resident trips in big cities has been up to 50 to 60 percent, which is near the saturation level.[24] The total traffic volume of bicycle transport is expected to increase as the urban population grows.

Bus. In the past 10 years, the share of bus transport has been rather low and has continued to decline. The existing land-use model in China favors the development of buses. However, due to many external and internal factors, bus services in big cities are now in a vicious cycle and difficult to improve. It is important to note that buses take up 75 percent of total passenger volume of public transport. In addition, bus enterprises are mostly owned by the state. The factors contributing to the low share of trips on public buses over total resident trips are as follows:

- Low-level service, including low network density, low service frequency and inconvenient transfers. In some cities, for trips less than 5 km, traveling by bicycle is faster than by bus. Buses are neither attractive nor competitive.

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[23] Li Xiaojiang and Yang Zhonghua, "Private Car Ownership and Urban Transport Development," *Urban Development Studies*, No. 3, 1995.

[24] Yang Zhonghua, *Urban Bicycle Transport*, background paper on bicycle transport in China, prepared for the World Bank's South Asia Region, 1994.

- Poor management capability in bus companies. With the loss of passengers and the resulting loss of revenues, bus companies experience serious financial losses. As a result, their service levels are lowered even further.

- The government policy of giving public transport priority is reflected only in the subsidy policy. It has never given priority to buses in road use. Traffic congestion is an important factor contributing to the decrease of bus services. In big cities the average speed of public transport is about 10 km/h.

- The last, but not the least important, reason is that the municipal governments have implemented the below-cost fare policy for many years. As a result, bus enterprises have lost the mechanism for self-development. The subsidy policy and the methods used for giving away subsidies also have many problems.[25]

Motorcycle. In the last 10 years, the growth of motorcycle ownership has been dramatic. In some cities, motorcycle ownership now reaches 100 to 150 vehicles per 1,000 persons.[26] As a transport means, the motorcycle has played two important roles: first, it has replaced a number of bicycles, taking up an increasingly higher share in total trip modes;[27] second, it becomes the convenient transport means for suburban dwellers to enter the city for employment and business, promoting integration of the urban and rural economies. Compared with the automobile, the motorcycle has advantages in price, energy consumption and road occupation; compared with the bicycle, it has advantages in speed and comfort. It therefore has strong potential competing against all other kinds of transport means in Chinese cities. However, the growth of motorcycle ownership is strictly restricted by the municipal governments for environment protection and safety reasons.

Other Modes. In last 10 years, another notable change in urban passenger transport was the rapid development of high-priced minibus and taxi transport, which do not receive government subsidies. In recent years, minibus transport and taxi transport have taken 3 to 5 percent and 5 to 10 percent of total urban public transport passenger trips, respectively. In Beijing, taxi transport is responsible for 15 percent of total urban public transport passenger trips. Certainly these numbers result from the low level of public transit services. The development of minibuses and taxis, on the other hand, also provide residents with more choices for transport modes and reflects a diversified demand for urban passenger transport.

The company bus, unique in Chinese cities, has a complex background. Its operation, to a large extent, reflects the inefficient use of economic resources. For example, in some cities, there are more company buses than buses for public transit. Nonetheless, company buses

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[25] Zhou Gangzi, Xu Juzhou, and Ma Lin, *The Study of Urban Transport Development in China: Summary Report*, CAUPD, 199x.

[26] This mainly happens in large cities that have less than 1 million population and are located in the more developed regions, such as Foshan and Shantou. Motorcycle ownership in some inland cities, such as Luoyang, reached 50 motorcycles per 1,000 persons.

[27] *Shantou Urban Transport Plan*, Urban Transport Institute, CAUPD, 1995.

supplement the insufficient public transport services. At the same time, they also hinder public transport development by taking away passengers from the latter.

Urban Road System

The definition of urban road land use is different from that of urban road area in official statistics. While the former includes parking garages and land for public squares, and excludes the service roads within residential areas, the latter includes all roads that are 3.5 m wide or wider and exclude pedestrian sidewalks and public squares. The difference in statistical definition makes our analysis more difficult. Table 4.1 gives several road statistics for 10 cities.

TABLE 4.1: ROAD LENGTH, AREAS, AND DENSITY, CHINA AND THE 10 LARGEST CITIES

City	1984			1994		
	Length (km)	Area ('000 m^2)	Density (km/km^2)	Length (km)	Area ('000 m^2)	Density (km/km^2)
China	36,410	330,190	4.29	96,689	951,710	6.95
Beijing	2,656	2,110	7.26	2,642	26,320	8.85
Tianjin	933	9,940	3.88	2,963	31,300	9.06
Shenyang	1,062	9,470	6.55	1,715	17,030	10.47
Harbin	711	8,480	5.01	1,603	13,210	4.59
Shanghai	1,030	10,170	6.00	1,677	18,410	8.25
Nanjing	2,368	15,340	23.75	1,016	10,050	6.48
Wuhan	1,222	7,410	6.87	1,257	11,500	5.12
Guangzhou	404	4,120	2.35	964	11,180	11.89
Chongqing	909	5,800	14.45	1,207	7,960	8.56
Xian	461	4,620	4.41	1,121	11,230	7.31
Total	**11,756**	**96,450**	**6.92**	**16,165**	**158,190**	**6.95**

Note: The roads mentioned in this table include those with a width of 3.5 m or more. It is not possible to illustrate the arterial road network. According to statistics from a number of cities, the density of arterial roads is generally 2 to 3 km/km^2. *Source for note: Annual Statistical Report of Urban Construction, 1994.* Between 1993 and 1994, the road area in Guangzhou increased 7 percent, but the length of road increased only 1.8 percent. This is also commonly seen in other large cities in recent years.

Source: *Urban Construction Statistical Yearbook*, 1984, 1992.

Road Land Use and Road Area. In Chapter 3, we mentioned that the national average of urban road land use is only 6.5 percent of total urban land area, and in the 10 largest cities it is 5 to 8 percent. These numbers also imply that per capita land area for roads is 4 to 6 m^2. From 1984 to 1992 the national average urban road area per capita increased from 3.04 m^2 to 6.16 m^2; during the same period, the statistic rose from 3.04 m^2 to 4.31 m^2 in the 10 big cities.

In the last decade, both road land use and road area remarkably increased. At the same time, bicycle ownership doubled, and the number of automobiles increased by two to four times. The growth of transport infrastructure cannot keep up with the growth of transport demand. In addition, per capita road land use and road area are still very low. There is little possibility that

these two indices, like the urban land-use index, will have significant increases in the next 10 to 15 years.

Road Density. According to available data (which may not be very accurate because of the differences in statistical methods used by different municipalities), urban road density is gradually increasing. If excluding service roads and small pedestrian streets in residential areas, the density of roads with two or more vehicle-lanes is about 3 to 4 km/km^2, indicating the distance between two parallel roads is about 300 to 400 m. Actually, the average distance between two parallel arterial roads in the areas developed in the 1960s and 1970s is up to 800 to 1,000 m. Since the 1950s, urban planning in China has followed the small-size residential district model (usually 20 to 40 ha), which led to low road density in the arterial road network plan. The low arterial road density led to a concentration of traffic flows. Because of motorized as well as nonmotorized vehicles operating on the same roads, moreover, arterial roads and intersections were overloaded. In recent years, some cities have still failed to make efforts to increase the road density.

Road Network. The main problem in the road network is the absence of a nonmotorized-vehicle road network, which would meet the needs of nonmotorized transport with a large share of bicycle transport. Although physical separations between motor vehicles and bicycles are often seen, motor vehicles and nonmotorized vehicles are still obstructing each other at most of the intersections, greatly lowering the capacity of the road network and its safety.

The urban planning departments have made efforts to promote a nonmotorized-vehicle road system. However, their recommendations have seldom been accepted by the municipal governments, although Shanghai has carried out some successful experiments in recent years. Even in new cities like Shenzhen, the proposed experiments to establish two separate motorized and nonmotorized road systems have not been carried out.[28] The municipal governments are more interested in solutions such as construction of multilevel flyovers and bicycle ban on arterial roads.

Another problem in the road network is the unbalanced ratio of arterial roads to service roads, and the traffic flow is overly concentrated on the main roads. Many large- or medium-size cities have recently constructed 60 to 100 m-wide major arterial roads, expressways and big flyovers, improving the transport situation in certain areas. The construction of those projects is an effective way to form a certain number of highly accessible areas. It could not, however, improve the overall transport conditions of a city.

Infrastructure Investment

Infrastructure investment mechanism and government investment policies have considerable effect on the efficiency of and the return to infrastructure investment. At present, investment of urban transport infrastructure comes from government finance, publicly raised capitals (sponsored by the governments), and developers (including the state as well as private

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[28] *Motor Vehicle and Nonmotorized Vehicle Traffic Separation System Planning for Futian District of Shenzhen*, Urban Transport Institute, CAUPD, 1992.

developers). The developers invest in transport infrastructure and facilities in order to improve the accessibility of their own development area. These investment projects are rather scattered. Investments from the overseas developers are mainly concentrated on toll roads, toll bridges, and profitable services such as taxi and minibus. Their investments could not solve the fundamental problem in transport infrastructure investment and meet the demand of transport infrastructure development.[29]

Infrastructure investment has three problems. First, the focus is on new construction projects, and maintenance and renovation of existing infrastructure facilities are largely neglected. In recent years, some municipal governments in big cities have paid great attention to investing in flyovers, expressways, rail transport system and other capital-intensive projects, hoping the construction of these projects could dramatically improve urban transport conditions.

Second, the construction of new roads is emphasized, but efficiency improvement in transport operation is overlooked. While investing a large amount of money in construction of new roads, the municipal governments have not put sufficient effort on public transport development and transport demand management.

Finally, investment directions are not consistent with urban transport plans. Some high-cost projects are not recommended by transport plans; sometimes they are even in opposition to transport plans. Some cities have invested in projects that actually encourage the development of private motor vehicle transport and constrain the development of public transport. Some investment projects have contributed to the departure of land-use patterns from the master plan.

All in all, the key problem in transport infrastructure investment is the lack of rational investment policy-making procedures, and the policymakers have not had a good understanding of transport development.

The Role of Transport Planning

Urban transport planning has received quite a lot of attention in the last decade. Almost every big city with more than 1 million population has formulated its transport development plan. What roles have these transport plans played in the construction of urban transport infrastructure and the policy-making process? The answer is very disappointing.

The transport plan per se has its weaknesses. The techniques are still immature. The planners have not fully understood the laws governing urban transport development, and underestimated the growth rate of development and the demand for transport. As a result, the plans' scientific foundation and rationality have been weakened. Only a few megacities are fully equipped with urban transport planning professionals and institutions. Relying on their own technical force, these cities are able to continuously improve and complete their data base, adjust the demand forecasting and revise the plans, making the transport plans helpful to transport

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[29] *Annual Statistical Report of Urban Construction, 1994.* In 1994, the total urban construction investment in China amounted to Y 66.6 billion, of which Y 6.42 billion (or 9.6 percent) were from foreign sources. Foreign investments were mainly for infrastructure projects that would impose user charges.

development.[30] However, the majority of cities can only rely on consulting organizations to formulate a "once and for all" transport plan.

Although urban planners wish to influence urban development policy on many issues, including population, land, real estate development, social services, construction of infrastructure, etc., the existing planning system limits its function to physical planning. The municipal governments still expect to have a "blueprint" plan guiding the city's physical construction. Therefore, city officials are most interested in the road network plan and short-term construction projects. They have never given due attention to transport development strategies, supply-demand policy, public transport development and transport management.

Transport supply should be based on a rational comprehensive strategy and multilevel and multisided policy studies. It should be consistent with the municipal government's policies on social and economic development, industry, land use and investment. In China, the state-owned economy has a large share in the national economy. Urban planners think themselves better than other departments in maintaining a neutral position to balance city development and the environment, the economic benefits and social fairness. In effect, the urban planning agencies are different from the state-owned retail sector and manufacturing sector; they have no direct economic interests in the outcome of urban plans. Unfortunately, they have not participated in the making of industry policy, land development policy and investment policy. Or they only have some weak effect on the making of these policies.

The separation of physical planning from policy-making has also put constraints on the development of methods and technology in transport planning, especially the development of transport strategy and policy research capability. Even when the physical aspect of transport planning receives a lot of attention, there is still no assurance that urban road construction will follow the transport plan. Therefore, at present, it is difficult for the transport plan to have any significant effect on the rapidly growing society, economy and transport demands, if we do not reform the planning system and the policy-making system, and fully understand and recognize the fundamental role of transport planning.

5. THE EXPECTED LAND USE-TRANSPORT MODELS

After a discussion of the characteristics of land use-transport models as well as the role of planning in big cities in the last few years, we should analyze the tendency of changes in these models in order to identify and build up a foundation for planning and policy-making.

Factors Promoting the Change of Current Model

The following factors will continue to affect the changes of land-use and transport models in large cities:

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[30] Shanghai's urban transport planning started in 1985 and a series of reports were completed by the end of 1992. The city just completed a new round of O-D survey for further research and planning. Some other cities, such as Beijing and Guangzhou, have experienced a similar process.

- **The strengthening of the market economic system.** The market economy will release great economic forces, promote urban and rural economic development, and help the growth of urbanization and the concentration of urban population. Urban land-use and transport development in a market economy will closely follow economic principles. With diminishing government interference, economic activities in the urban society tend to decentralize and disperse as they are influenced and adjusted by prices.

- **Continuous growth of personal incomes.** Rising personal incomes will give people more choices, bring about and accelerate the changes of residential area locations and the development of suburban areas. People will value speed, convenience and comfort when selecting transport modes; this will lead to changes in travel patterns.[31]

- **Changes in economic structure.** The fast development of the urban tertiary sector will change the sector composition of the urban economy, and the location of employment, as well as travel O-D distribution and travel distance. This will change the transport structure.[32]

- **The impact of planning control.** With the transition of economic system, planning techniques and economic policies, as part of government function, will follow market economic principles. The local governments will increasingly put more emphasis on economic development of their own cities and areas. Urban planning will move from the rigid physical planning model to a more adaptable model. These changes will help to increase urban land use and modify the land use model.

Factors Restricting the Change of Current Model

The following factors will restrict dramatic changes in land use and transport patterns in large cities in the short run. Some of them will have long-term effects.

- **Process of urbanization.** The urbanization level in China will continue to rise. Large cities in China will face increasingly high population pressure. It is doubtful that the current policy on the floating population can last for a long time. In large cities, enormous population pressure will keep the supply of land and transport short of demand for a long time.

- **Serious shortage of land resources.** In the last decade, total cultivated land and per capita land experienced a continuous decline. In 1993, the total area of cultivated land in China was 951,000 km^2, per capita cultivated land was 802 m^2. The cultivable unused land was 354,000 km^2, and 300 m^2 per capita.[33] Therefore, land

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[31] *China Economic Statistical Yearbook.* Annual growth rate of personal incomes for Chinese residents has maintained at 5 to 8 percent in the last 10 years.

[32] *China Economic Statistical Yearbook.* The tertiary sectoral share of GDP in China has increased approximately 1 percent a year in recent years.

[33] *China Economic Statistical Yearbook, 1993.*

administrative departments will continue to implement the policy of protecting cultivated land, formulating and implementing strict land supply policy. The conflict between urban development and the conservation of cultivated land resources will increasingly aggravate. Shanghai, Guangzhou, Wuhan, Chongqing, Shenyang and some other major cities will increase land use at a relatively large scale to raise the seriously low per capita land area. Nonetheless, these cities will keep their high-density development model for a long period of time in the future. For most of the cities, per capita land use will not exceed 100 to 120 m^2 per person.

- **Shortage of investment capital in infrastructure.** Rapid economic development brings more funds, but also stimulates demand for funds. Employment and housing have many problems to be solved, which are more important than problems in transport. In addition, demands for education, better environment, and cultural and recreational activities are increasing. These sectors are in great need of funds. Therefore, it is very difficult for the municipal governments to invest a large percentage of their funds in transport for a long period of time.[34] Private investors will not make big investments unless they have clearly-defined laws and policies to protect their interests. Therefore, cities are unable to attract a large amount of private investment funds, in particular the investment on roads where it is difficult to collect tolls and surcharges.

- **Inertia of urban development.** Under specific historical, social and economic conditions, large cities have already formulated their development models, which are characterized by the compact city pattern, high densities and highly mixed land use. They have also formed specific transport models and structures, management system and life style. All these characteristics in physical as well as cultural models will continue to affect urban development in the future.

- **Serious conflicts among groups of different interests.** During market economic development, conflicting interests among individuals (or individually owned enterprises), and between individuals and society will be aggravated. They include conflicts between the developers and society in urban land development, conflicts between developers and old residents in the renovation of the old city, conflicts between the urban area and rural area in expansion of land, and conflicts between individuals' demand for comfort and the social cost, etc. It is still difficult to say what kind of effect the aggravation of these conflicts will have on the urban land use and transport models. Nevertheless, the aggravation of conflicts in a society needs urban planning to adjust and balance the interests of different social groups.

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[34] *Annual Report of Urban Construction Statistical Yearbook, 1994*, and *China Urban Construction Statistical Yearbook, 1993, 1994*. Urban construction investments in Guangzhou and Shanghai in 1994 (including road, public transport and other municipal infrastructure) took about 8 and 7 percent of GNP, respectively; 60 percent of which was for road transport. This is obviously a high percentage.

Future Land Use-Transport Models in Large Cities

Based on the analysis of both favorable and restrictive factors affecting the change of land-use and transport models, we could predict that there will be no dramatic changes in land-use and transport models in large cities in the next 10 to 15 years. Nevertheless, there will be gradual changes following the current trends, and the changes will gradually speed up.

Urban Population Density. In the large cities, it is not possible to raise the urban construction land use index by a large percentage or to reduce the population density by a large percentage.

It can be seen that the large cities in China will maintain their high population density in the future. As for the density of residents, it is possible that the luxurious residential areas with low resident density will continue to build up in suburban and city peripheries. In old-town areas, the resident density, which is now extremely high, will be reduced by a large percentage. As for the building density, there will be more buildings in the city center, resulting in the rise of building density. The rise of building density will be lower in suburban and city peripheries. A large number of big cities in the world have experienced a shift of "density curve" from steep to relatively flat. That is a process of gradual reduction of densities in city centers along with the economic development. Based on China's current stage of development, the city centers' density curve in big cities will now rise for a period of time, and will gradually level-off later.

City Models. In general, there are four types of city models to follow in urban land expansion.

- **Expansion in concentric circles.** Cities expanding in this fashion usually have strictly controlled land supply. They maintain a single but strong urban center, have a high population density, need relatively smaller investment for construction of infrastructure and have lower operation costs.

- **Unrestricted suburbanization.** This model needs abundant land supply, even unlimited land supply. The urban area has multiple city centers and subcenters and low population density. It needs enormous investment for infrastructure.

- **Urban cluster.** It divides a large city into a number of independent city groups, which are relatively independent of each other. This model needs strong policy control, and relatively large investments for infrastructure. It provides a high-quality urban environment and permits balanced development.

- **Satellite-town model.** Building up a number of sizable satellite towns in suburban areas of large cities will alleviate the pressure of housing and employment facing the urban nucleus area. This model needs strong control and policy guidance as well as large investments.

The need for land supply and investment in infrastructure and transport make the unrestricted suburbanization model beyond the reach of developing countries. The urban cluster model and satellite-town model are ideal and rational. They have, however, not achieved much

success, in particular, in developing countries. A large number of big cities in China tried these two models in last 30 years and failed.

Due to the pressure of land, population, and investment for infrastructure, all large cities in China have, by and large, followed the concentric-circle expansion model. In China, the high density and concentric-circle expansion will be the basic development model for big cities for a long time to come. It is also possible that in big cities with rapid economic development and high population density, a well-coordinated and therefore balanced development between the city and suburban villages will produce a modified concentric-circle model with a certain degree of suburbanization.

Suburbanization. Because of the constraints of limited land resources and low economic development level, suburbanization with large-scale outward relocation of urban residents, which has happened in developed countries, will not happen in China's large cities in the near future. On the contrary, suburbanization in China will be largely the result of relocation of urban secondary and tertiary sectors to the suburban areas and the related migration of workers. It is therefore quite different from that of developed countries.[35]

In addition, another model of suburbanization may be born in a number of big cities, due to the high agricultural population density and the rapid growth of the nonagricultural sector (including township and village industry and commerce) in rural districts adjacent to the city area. That is, the city peripheral area will transform from rural area into low-density urban area. This model of suburbanization may give us (actually, it has already happened in a number of cities) some unwanted results. For example, the relatively independent development based on the old residential centers in city peripheries lacks much-needed coordination, planning and effective control, resulting in low-standard development of infrastructure in suburban areas. Take another example: land-use rights in rural areas are collectively owned. Land used by the collectives usually are not subject to the control of an urban planning authority. This land-use system permits the geographical dispersion of town and village industries in the suburban area, and the mixing of industrial and residential land uses, lowering the environment quality and quality of life as well as the efficiency of the industrial sector.

At the same time, the normal process of suburbanization—the outward relocation of both urban residences and jobs—will also happen to a certain degree. These are outward migration of high-income groups pursuing better environment and quality of life; and the outward relocation of industries under market pressures.

Possibly, a mixed suburbanization model comprising the two phenomena mentioned above will be a typical model for large cities in China.

Urban Space Structure. Large cities will maintain a single strong center. The CBD and CRD (central retail district), with relatively exclusive functions similar to those in developed countries, are difficult to establish. The city center will maintain its multiple functions, including business, retailing, administration and housing. Nevertheless, the residential density in

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[35] Zu Junming, "Population Growth and Industrial Spatial Expansion," *China Population Studies*, No. 4, 1994.

the city center will continue to decline as living conditions improve and land prices increase. The tertiary sector will create a large number of jobs in the city center, which will attract more business people and shoppers.

The development of businesses and retails in highly accessible peripheral areas might take away and therefore decentralize some functions of the city center. These areas have the possibility of developing into sizable subcenters and thus promoting suburbanization.

Residents and land for housing will move to peripheries from the city center and inner city. The move, however, will be on a limited scale.

Facing pressures from the land market, transport and environment control, industries and warehouses in the city center will undoubtedly move out to areas farther than the residential areas, at a relatively high rate. For China's big cities with high population densities, however, it is rational, in terms of land use and transport efficiency, to keep a number of nonpolluting factories and retain a certain ratio of industrial jobs in the inner city.[36]

Generally speaking, the large cities in China will maintain mixed land use. But the level of the mix, especially the obviously irrational (economically or environmentally) mix in land use, will be reduced. Urban jobs will concentrate in both the city center and some peripheries. Urban residents will move to the middle areas and the city peripheries. Concentrated development and a certain degree of suburbanization, the high urban population density and the gradual decrease of the density will happen at the same time. The function of the city center will first continue to be strengthened and then gradually decline.

As the land-use pattern changes, transport will change as well, although at a slower pace and taking a longer time. It is not the changes in the numbers and distances of person-trips but in the modes and the traffic structure that will have the biggest impact on the urban transport system. The growth of personal incomes as well as society's wealth, the growth of individualized transport, and motorization will put great pressure on urban transport development.

6. Recommendations about the Land-Use and Transport Pattern Management in Large Cities

Urban Planning and Land Development Management

We should have a thorough and in-depth understanding about the effect of the market economy on the growth of the urban economy and urban land development and study the characteristics of urban land use under the market mechanism. We should understand the way market affects land development, and use legal procedures, instead of government interference by administrative means, to guide urban land use and transport toward rational development.

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[36] Chen Yewei, "Renovation Strategies for the Old Town of Shanghai," *City Planning Review*, No. 5, 1995. Shanghai Municipal Government planned to relocate annually 50 large- and medium-size factories from within to outside the inner ring road by the year 2010. This would result in a decline in industrial land use from 20 percent in 1994 to 5 percent in 2000. It is worth further studies to see whether or not this plan is feasible and necessary.

Land-use and transport patterns are the products of the economic system and the level of economic development. They are also subject to the influence of history and present conditions. They have their internal laws governing change. It is therefore important for urban land-use planning to take into consideration the need of social and economic development, and respect the market principles of land supply. Through urban planning and development management, the municipal governments should usher the land-use and transport models toward rational changes, especially on the following issues.

- **Appropriate control of population and economic growth rates in big cities.** Megacities, such as Shanghai, Beijing, Tianjin and Guangzhou, should control the population to avoid problems associated with large metropolises. Big cities with more than 1 million population should maintain a reasonable growth of population in order to play the central-city role as development cores, to stimulate regional economic development. Cities under this category are usually experiencing structural changes. They should thus pay special attention to management of land-use and transport patterns.

- We should control the pace of suburbanization and the land expansion pattern in megacities, keeping them relatively compact shaped. This will conserve limited land resources and construction funds. This policy will also help to preserve the conditions for developing low-cost bus and bicycle transport, achieving high efficiency in urban transport.

- We should make, to a reasonable degree, the control of urban land expansion less strict for large cities, reducing the population density and improving urban housing conditions, and avoiding the overcrowdedness of traffic. At the same time, we should also prevent a too fast reduction of population density from happening, minimizing the conflicts in infrastructure supply and demand caused by rapid urban expansion.

- The mixed use of land in megacities is not entirely against market principles. In particular, allowing a number of nonpolluting manufacturing factories in the inner city is beneficial to balancing residence and job, shortening travel distance, and reducing transport demand.

- The population and building densities in the city center should be kept at a reasonable level. This level will support the strengthening of the city center's function on the one hand; on the other, it will help to prevent the city center from attracting too much automobile traffic, ensuring the normal functioning of the city center.

- We should exercise prudence in the construction of new centers or new CBDs. It is important to realize that not all large cities need or have the capacity to build up a large and strong CBD. For megacities such as Shanghai, Beijing and Guangzhou, the construction of secondary centers in highly accessible city peripheries will help to share the city center's function, alleviate transport pressure of old-town areas, and promote the rational expansion of urban land.

Urban land development must be effectively controlled by the urban planning authorities. For intensive, large-scale, land development projects that will attract a large passenger and freight transport flows, the urban planning authorities should carry out locational and development intensity appraisals, and undertake transport impact evaluations. At the same time, a standard tax and financial management in land transfers should be established. The developers should be required to shoulder the relevant social costs of development, and provide stable funds for urban transport infrastructure development.

The urban transport network, including road network, public transport network and rail transport system, is an important tool to guide and control land development, and the distribution of residences and jobs. Therefore, the transport network plan and its recommendations should be well coordinated and consistent with the land-use plan, permitting the rationalization of urban land-use and transport patterns. The large cities should select their transport models based on their own specifics, geographic features and economic development levels. To reduce the risk of misguiding land development, they should not blindly copy another city's model.

Intercity coordination in land-use development and transport network planning, especially among highly urbanized areas (megacity areas), should be strengthened. Regional planning for megacity areas should be strengthened. Vehicles for carrying out the coordination should be set up using administrative and legal instruments, striving for balanced regional development and permitting regions and cities to follow a rational land-use model.

Management of Urban Transport Development

We should continue to emphasize the supply of urban transport infrastructure and maintain the scale of transport investment, reducing the levels of infrastructure shortage in large cities. Meanwhile, comprehensive measures should be taken to control and adjust transport demand to achieve balanced development of urban transport and urban society and economy.

We should realize that bicycle transport is a transport mode suitable for the existing land-use pattern and development level in Chinese large cities. It will continue to be one of the major transport means in large cities for a long period of time. Separating motor vehicle and bicycle traffic by lanes on the same roads does not solve problems at intersections. It is necessary to provide a special bicycle transport network to protect the interests of bicycle users. In the meantime, we should increase the capacity of the road network. In megacities, long-distance bicycle transport should be replaced gradually by public transport; a rapid shift to motorcycles and cars, which would incur higher social cost, should be avoided.

Bus transport, which is an appropriate transport mode for the land-use pattern and economic development level in Chinese large cities, should become the main transport means in Chinese large cities for a long time. With the rapid increase in urban motor vehicles, a shortage of transport construction funds, and the huge potential for private car ownership growth, large cities and megacities should develop a bus network and system offering high-quality services. Policies encouraging the development of public transport should not mean only government subsidy. They should be focused more on road use, investment and other comprehensive development policies, giving priority to buses. For highly densely populated megacities like Shanghai, Guangzhou and Beijing, construction of a road network exclusively for bus use should

become a major tool solving urban transport problems and promoting public transport development.

Although there are many advantages in mass rail transit, the enormous construction investments, high operating costs, and long construction cycle make it beyond the reach of many large cities. It is safe to say that in the next 20 to 30 years, rail transit could not become the major passenger transport means in large cities, and its development will achieve a certain scale only in a few megacities. For large cities with more than 1 million population, we should leave room for rail transit development in the long run, rather than make it a immediate solution to the current transport problem.

We should be realistic and prudent on the issue of private car ownership development. On the one hand, we should realize the inevitability of car development; on the other hand, we should restrict, to a reasonable degree, the use of cars to prevent a sharp and sudden worsening of the urban transport condition. During infrastructure planning and construction, the impact of private car ownership development on the urban land-use pattern should be brought to our attention. We should leave room in the urban plan and suburban development plan to accommodate possible changes in land-use patterns caused by the development of private car ownership in the future.

The key point in transport construction is the increase in total road length and road density, especially road construction in the city center and at city entries and exits, which will help a balanced distribution of traffic flows. We must emphasize the justification for transport investment, maximizing transport benefits for a given amount of investment. Special attention should be paid to low-cost schemes of urban transport. Prudence should be exercised in the construction of rail transit, flyovers and expressway investment projects.

We should strengthen road use management; reduce the use of roads for nontransport activities; and effectively control development along the two sides of urban arterial roads; achieve a balance between land use and transport at the micro level, and increase road transport efficiency.

Improving the Planning System

We should establish a comprehensive urban development strategy plan and formulate a comprehensive planning system. The city development strategy should include the objectives of social and economic development; environment, land use and transport targets, and studies as well as the making of other infrastructure development objectives. Different from the physical planning, strategy planning should focus on policies and measures, and should not be limited to the area under the city administration's jurisdiction. The strategic plan should be used as the foundation for the land-use master plan, transport plan and other specialized plans, making it possible for these plans to be formulated at the same time and to interact effectively.

It is necessary to establish a multilevel urban transport planning and research system. The existing single-level transport planning system is unable to meet the demand of transport development. There should be transport research and planning at each level of the urban planning system, including strategic planning, master planning, subarea planning, sensitive area planning, etc. Evaluation of impact of large-scale and high-intensity land development projects

on transport patterns should be promoted, and be used as evidence in the approval and issuance of urban land planning certificates.

It is necessary to strengthen the study of urban and transport planning theory, methodologies, and land use-transport models in order to understand urban transport issues in China, to improve urban transport planning, and to guide the development of land use-transport models. We should also promote the progress of transport forecasting techniques, and carry out studies on transport economy, transport environment and other related issues.

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THEME PAPER 12: SHAPING THE FUTURE: THE ROLE OF URBAN TRANSPORT PLANNING

RALPH GAKENHEIMER [1]

AN URGENT AND BASIC NEED DURING ECONOMIC GROWTH

Transportation has several characteristics that make planning it very important. Transportation facilities are very expensive. They account for a large part of the capital investment of local governments. They are long-lasting; highway alignments endure for centuries. Once construction is begun, a highway project is an inescapable commitment, so it is important to make the right decision. Most transport investments cannot be tried in small increments. Transportation investments can either be important in solving problems or can make them worse. Inadequate solutions mean the loss of time and economic efficiency. Finally, the options in transport planning are numerous and often difficult to compare.

All these points together mean that advance planning for urban transportation is extremely important. Across the world, most large cities (and many small ones) have transportation plans that express their long-term vision and guide their annual investments in the sector.

Current circumstances in China make planning all the more important. With 5 percent per year increases in urban population, the current rapid increase in vehicles, and forthcoming increases responsive to the Government's policy to promote the automotive industry, local governments must prepare to take decisive action. Increasing travel demand is all the more problematic because of (a) the limited urban land devoted to streets, (b) reduced capacity with urban street lanes divided between motor vehicles and bicycles, and because of (c) extraordinarily high residential densities. Very serious access problems are brewing.

URBAN TRANSPORTATION PLANNING

The planning process requires focused attention to the problems while preparing basic data and information to be used in testing the solutions. It requires careful survey and analysis of trip generation, existing and future uses of urban land, trends in vehicle registration growth, the performance and conditions of existing infrastructure, and environmental conditions. In the end, it is important to examine the performance and the costs of proposed solutions in the light of available financial resources.

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Transportation planning must be *comprehensive*. Many aspects of economy, society and environment are at the foundations of the current transport behavior and influence the prospects for solution of problems. Planning should be *quantitative*. It is important to estimate the dimensions of future demand because that is the measure of required performance of the solutions. The planning must also be *financially realistic and economically sound*. Like so many problems, paths of solution would be different if resources were unlimited. In fact, available funding is likely to be very limited. Interactions among the components of costs/revenues and supply/demand for transportation interact in surprising ways. The difficulties of assuring public agency responsibility under these circumstances as China emerges from a planning economy are emphasized in Theme Paper 11. Further, the planning needs to be *continuous over time* because the problems will continue to evolve in the future—some of them in ways very difficult to foresee—so the data need to be updated, and analysts must be continually vigilant about the effects of past solutions and early warnings of new problems. Planning must *change institutions and create new ones* in order to do this new job of planning (viz. Theme Paper 11). Its foundations in governance and its form of decision-making are a new departure for Chinese local government. Finally, the planning process needs to *develop professional skills*. There is a great deal of basic technique in transportation economics and planning that professionals need to know. Further, the technique of the international profession needs to be adapted to use in the Chinese city.

The focus of planning is to inform important decisions. These decisions take place at different levels, metropolitan and local, and in agencies with different parallel responsibilities—transit, highways, water supply, land development, etc. An important purpose is to integrate government and private decisions around agreed objectives. Planning should inform the design and selection of major highway and transit facilities projects. It should inform policies on how these facilities are to be managed and used. That includes financial and operations management and the service pattern of public transit. It includes the traffic management of streets and highways , as well as related systems such as parking. These functions also include user pricing of facilities and a program for financing them.

Further, the planning should inform understanding of the behavior of tripmakers and other behavior important to future plans. That includes vehicle registrations, mode and destination choices of trips, land development trends and other phenomena that are important to the future of transportation. One of the important jobs in organizing transportation planning is to identify the issues that need to be carefully examined, at the same time avoiding excessive attention to inessential research.

The output of urban transportation planning is based on several important documents. The principal plans among these are (a) the urban development plan, (b) the transport strategy plan, (c) short-term transport action plans, and (d) major facility evaluation plans. The urban development plan is an important public commitment and a baseline for many subsequent reports on transportation. It is a particularly important input to the transport strategy plan. The urban development plan may be prepared before or in connection with the transport strategy plan. The transport strategy plan process, in turn, is a centerpiece for identifying the phasing represented in the short-term transport action plans and for identifying the projects to be examined in the facility evaluation plans.

In further detail, the *urban development plan* is based on anticipated levels of growth in economic activities and residential establishments. Through a combination of forecast and policy, this plan produces a future vision of land use, infrastructure requirements, and major institutional locations (such as parks, health and education complexes, etc.). This is normally done for an approximately 15-year horizon. It may be presented at the metropolitan level, and with more detailed plans for the individual localities. It includes an introductory picture of transportation facilities that will be considerably refined during the transportation planning process. The urban development plan should also include attention to implementation, through management of district negotiations with land developers, for example, as well as a program for interagency coordination with the utilities agencies and other involved services.

While the *transport strategy plan* is the centerpiece of a mature transportation planning process, it may take time and resources to fully develop. There is no need to wait until its completion before acting. During strategic planning, it is possible to use parts of it that are completed, or abbreviated forms of it. Later, with fuller information, parts of it may be replaced with more advanced versions. One way or the other, thoughtful transportation planning needs to start soon.

This plan also is based on a 15-year horizon. It is based on economic and travel forecasts, and the information provided from the urban development plan. Its outputs include (a) a program of major transportation facility development, (b) estimates of future equipment requirements for public transit, (c) basic policies for traffic management and transportation pricing (often neglected in China, as noted in Theme Paper 11), (d) basic policies for project financing, (e) a program of institutional management for planning, financial management and operations management, and (f) professional training in transportation planning.

Transport action plans are to phase and detail the overall decisions of the strategy plan. They present elements for implementation that are more detailed in level of design preparation, more specified as to financial plan, and introduce more detailed actions of demand management based on policies concluded in the strategy plan.

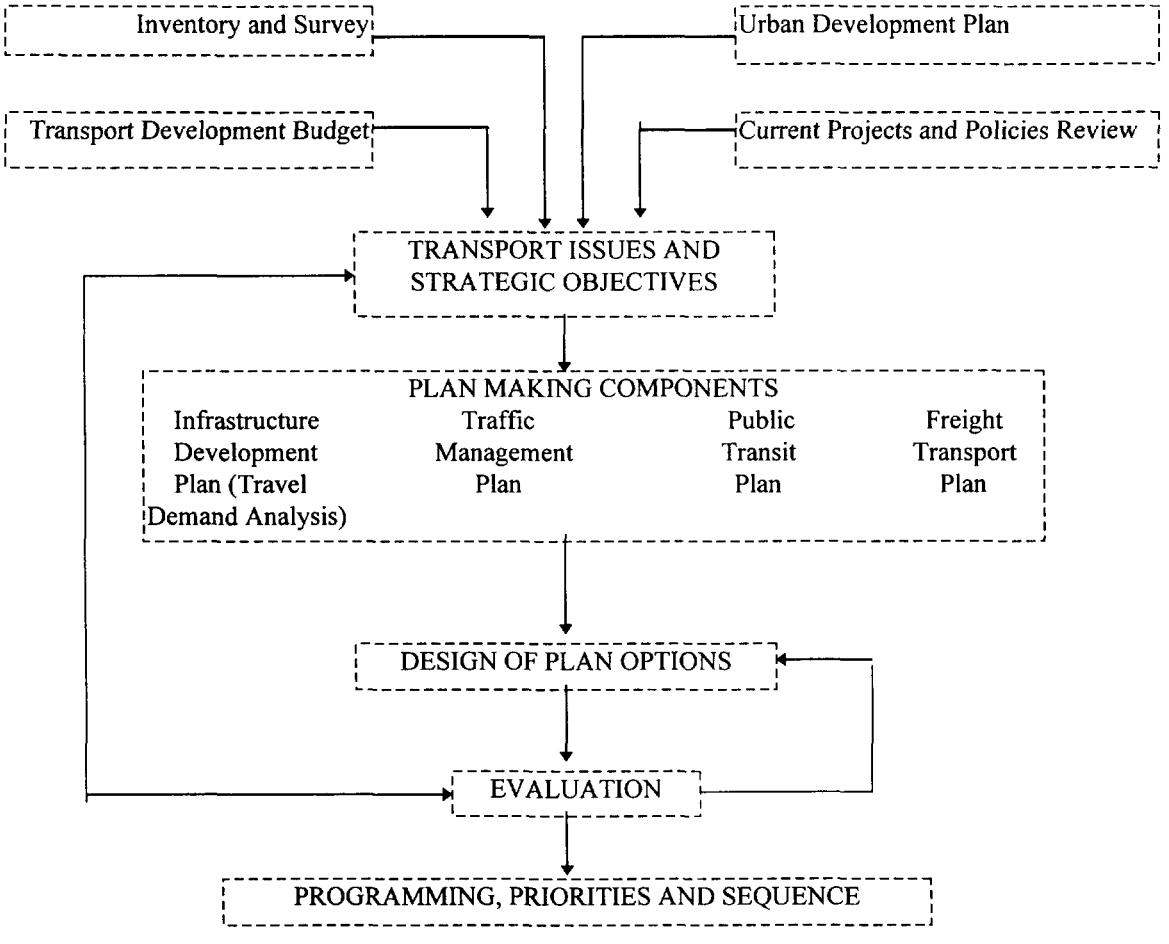
The level of *major facility evaluation* is one of the closest scrutiny of the projects. Based on complete designs, it deals with systems considerations and also economic concerns. On the systems side, it deals with impacts on traffic flows, parking demand, sufficiency of transit service, and so forth. It also concerns impacts on land and water ecologies, as well as air pollution. It deals with displacement and relocation requirements. On the economic side, the evaluation includes some form of concern for the externalities of the project. But considerable attention is focused on financial viability by careful consideration of the costs and revenues of the facility.

Evaluation also best proceeds by constantly searching for opportunities to make the interface between the project and its environment yet more positive, for example by such means as joint design. It is a procedure that stimulates redesign of the project to improve these relationships.

THE TRANSPORTATION PLANNING PROCESS

A prototype approach to producing reports that inform transportation decisions is summarized by the flow chart. The paragraphs that follow describe the steps in this flow chart. This is not a manual. It is only a sketch of each phase to indicate the kinds of technical activities that are required. At the early stages of skill development each cell of the chart can be accomplished by simple means, at the same time incorporating an educational component. Then, each cell can be replaced by a more refined and expanded version as skills develop.

Flow Chart: THE URBAN TRANSPORTATION PLANNING PROCESS



Inventory and Survey

It is important to emphasize the need for good transportation planning data in the explosively growing cities and economy of China. There is much that is difficult to predict in the future, so the observation of trends is important. As usefully emphasized in Theme Paper 11, the alteration of China's housing and land system is going to make a big difference in transportation patterns. How will the scale, location and density of new housing evolve as the liberalizing land market gives birth to increasing numbers of land development companies and the districts begin to standardize the agreements they make with these companies? The answer is

important because it locates new traffic generators. Who will buy (or receive the use of) new cars and where will they live? How will the liberalization of the state-owned enterprises and urban redevelopment affect the length of work trips? Will large-scale parking garages be built in the cities? Will large-scale decentralization take place? These are some of questions to which answers may be suggested by early warnings in the data if it is watched carefully. Of course, planning does not depend entirely on forecast, but an understanding of future trends is very important as a baseline for decision. This is true even when circumstances are so unpredictable, as in today's China, that reliable forecasts may be difficult (see Theme Paper 11).

The information ultimately needed by transportation planning is quite demanding. It is important to realize that planning must start with the information available and with intelligent estimates, perhaps some time before a full set of data is available. The information required by the mature process can be sketched as follows:

Background economic and demographic data. Though hopefully collected by other agencies rather than by the transportation planning process, these items are important to have in usable form. It would not be surprising if they are found in form less than usable for transportation planning because they are not collected frequently enough or in appropriate spatial units. So it may be necessary to persuade the responsible agencies to change their practices or for the transport planning process to adapt or supplement them. The data include changes in numbers and types of jobs, increases or reductions in residential population, changes in personal income, relevant national aggregate and sectoral economic indicators, and local government revenue trends.

Transportation inventory. This includes survey of the roads and transportation facilities (including their capacity and their physical condition). The survey includes transit facilities and rolling stock. The survey also records the parking stock and its administration. It analyzes the experience in traffic management—what actions have been taken, their effect on congestion and their consequences to the economy. The experience with vehicle registration controls is also included.

Transportation conditions. This information category includes speed and delay studies (measures of congestion), general tracking of traffic volumes, and the costs of transportation (including out of pocket costs, fares, permit costs, etc.).

Land use inventory. Since local governments have not kept good records of land development, a survey of land use is likely to be necessary for transportation planning. This is a basis of estimating travel demand and for understanding the development process. In the absence of adequate demographic data, it can be used to estimate population.

Environmental conditions. The effect of the growing use of motor vehicles on air quality is the subject of survey information that ought to be collected periodically. Basic information should also be on hand that records the conditions of water courses and valued land uses (encompassing historical sites, valued features of the natural environment and productive agricultural land). This is a background for examining the environmental impacts of newly proposed projects and policies.

The Transportation Development Budget

Budgetary realism is important. Throughout the world, there is an inclination for governments, when they are desperate to meet the rising demand for trip-making capacity, to make proposals that considerably exceed their financial possibilities. It is important not to do this because false hopes generated by big projects often hide the possibilities for achievement at more modest cost. For example, there are many overly optimistic cities that are continually planning on a metro, the cost of which is clearly out of their reach, meanwhile letting their bus systems deteriorate because of a belief that the metro will eventually be the main source of transit improvement. Although every effort should be made to expand traffic capacity of transit and highway facilities in the cities of China during the coming years, as a matter of unavoidable fact, most of the achievement of the cities in confronting the motorization challenge, if successful, is going to be more the result of travel demand management.

It is important to account for all sources of income to the municipality that is potentially usable for transportation investment. That encompasses urban development fees, tolls, fares and fees of all sorts. It is clearly not possible to forecast the full amount due to the transportation sector in advance, but a sense of the magnitude of municipal income provides a picture of the rough level of investment possibilities. The portion of the total local budget occupied by transportation commitments is a matter of negotiation. Though it is instructive to consider the amount of revenue received from transportation sources, we do not recommend the simple ear-marking of this or other revenue sources for transportation investment.

Revenue level estimates must be supplemented by a knowledge of prior commitments to approved projects and to repair/maintenance obligations, and transit subsidies. Realistic estimates of the costs and direct revenue of proposed new projects will be the focus of attention further on in this paper. The planning process should appraise the possibilities of privatization through close acquaintance with potentially interested entrepreneurs. The process should survey sources of loans against revenues and the terms on which capital can be raised in this manner.

This analysis should be based on real numbers, even though it includes a number of unknowns. The purpose is to generate estimates that instill realism into the expectations of officials who will be under great pressure to provide new transportation facilities.

The Urban Development Plan

Land planning is important to providing a manageable future of urban development for purposes of mobility. If projections are mistaken the transportation facilities provided may be very uneconomically used. From the point of view of this process the main purpose of the urban development plan is to assure efficient mobility. In doing so, the plan will provide an overall pattern for land development within which other purposes of land use planning can also be engaged (for example, observance of environmental holding capacity or the mix of land uses at micro level), usually at a smaller scale.

Up to now, metropolitan development planning has been routinely performed in China, but it has not been taken seriously. This is probably because mobility has not been a major problem, and land use planning has been seen as a more micro-level exercise primarily focused on assuring the economic success of state owned enterprises. In Theme Paper 11, however, Li

and Yu note recent strengthening of the local planning process in China. Only recently has population growth, increased motorization, and economic liberalization begun to produce significant forces that play across the whole structure of the metropolitan area—these forces include impending congestion from higher vehicle use, longer work trips, large scale peripheral urbanization, and rebuilding of city centers as examples. Li and Yu refer to these circumstances of rapid change in Theme Paper 11. As a result, now it is urgently necessary to think about the guidance of development at a larger scale than before. It is going to be difficult because of the inherent problems of taking more seriously a practice that has been widely performed but disregarded at the level of implementation. The job is to guide urban structure toward a form that is amenable to mobility through means available to the population, especially assuring that new development is served by public transit even though it may be under strong pressures toward decentralization.

Current Projects and Policies Review

Decisions in the past have already set a path for improvement of urban mobility. Some of these decisions may be unchangeable, but others are subject to reconsideration after which they might be altered or replaced based on new thinking or evaluation of their performance up to the present time.

As regards capital improvements that are not yet under construction, we should ask whether they are the most efficient elements to add mobility to the present system, whether they build systems with good levels of connectivity, and whether they are the highest priority elements, given the most recent information about needs. Most importantly, this review examines whether the list of forthcoming projects is realistic from the point of view of budgetary reality. Can the city afford them?

Traffic and vehicle registration management are more easily changed on the basis of evaluation. The review should consider whether actions in these categories are having suitable effect on the system. Are they raising mobility? If they are effective, and at whose cost? It may make sense, for example, to examine different alternatives for the management of traffic than the substantial confinement of truck travel, since trucks are closely related to economic development.

A final component of the review is consideration of the pricing of all elements of the transportation system. Transit, parking, auto use and ownership, and highway use are all priced at some level. In many cases, the pricing has arisen in separate contexts, so they may be very disparate in their effect on travel behavior and the extent to which they reflect the costs entailed. Initial conclusions on current policies and practices is a beginning for designing the purposes of the studies in the transportation planning process.

Transport Issues and Strategic Objectives

The analytic exercise of travel demand forecast that follows below is important as a means of gauging locations and magnitudes of need for transportation actions. However, in general, it will not reveal issues that have not been discovered by experienced observers of the transportation system, and it will not throw up solutions. Neither will it clarify the objectives of transportation planning very much. Both these matters should be carefully discussed and shaped

before the analytic process begins. The reason for this is that the way of performing the study can be adjusted to illuminate these issues and objectives more than otherwise would be the case. As examples, if a rail line is envisioned, the modal split modeling can be handled in a way that clarifies demand for it. If the redevelopment of certain parts of the central city are a concern, it is possible to isolate them for analysis by appropriately placing the zonal lines for data collection.

The idea of identifying the objectives of transportation planning may at first seem trivial. The overall purpose is simply to improve mobility. But it is not possible to increase mobility uniformly for all places, modes, people and trip purposes. Planners must make choices among the beneficiaries. Accordingly, it is important to consider the ultimate purposes for which the mobility is to be increased.

The following items are listed just as examples of the kinds of objectives that might well interest stakeholders in a Chinese city. The objectives are:

(a) to advance urban economic productivity by emphasizing trip-making that is the most critical to the economy;

(b) to maximize trip-making opportunities by whatever modes are the most effective in doing so (that is, to provide the most trip-making possible for a given, limited public investment, or to provide a targeted amount of trip making for a minimum summed public and private cost);

(c) to expand urban transport facilities as quickly as possible subject to the constraints of the preservation of valued land uses (such as historical sites), relocation problems and financial limitations;

(d) to facilitate the increase of housing stock through increasing the amount of serviced land. Extended access provided by transportation investments is an important part of increasing land available for housing;

(e) to assure that all new development be accessible to effective public transit service. Since the Chinese city is quite dense this might seem to require no special effort. In fact, however, as cities grow at the periphery access to central parts by transit will deteriorate without special modes or special rights of way;

(f) to reassert micro planning of land use with mixes of uses that induce short urban trip lengths;

(g) to privatize transportation facilities and services to every extent possible, knowing that the prospects are limited in the transportation sector;

(h) to commercialize transportation facilities and services as close to full cost as possible;

(i) to restructure the roles of different urban modes—auto, truck, motorcycle, bicycle, bus—to maximize their joint potential; and

(j) to control urban street congestion to a specific level through some combination of vehicle registration control, traffic management and facility expansion. The targets would be specific minimum speeds for the different transportation modes and facility types.

There are many possible alternative objectives. They are not mutually exclusive. It is important to select and prioritize objectives for purposes of guiding the planning in order to assure that the following phases will address them and will produce a coherent plan.

Urban Plan-Making Components

Infrastructure Development Plan. This phase of the planning process is to forecast future demands for travel by mode and by individual links in the transportation network for the purpose of planning roads and transit infrastructure. It requires the preparation of computerized representations of the modal networks and also a survey of personal trip-making by individuals recording the origins, destinations, modes and times of trips as well as other information that facilitates projection into the future. Then, specialized computer software is used to project this activity into the future in order to estimate travel demand.

Due to the amount of data collection and computational work required, this part of the study traditionally accounts for a substantial part of its total time and cost, possibly well over half the entire study budget. The value of these forecasts rests also on adequately projecting the future levels of auto ownership, vehicle use, and the locations of future land development.

Although they are important, the results of these forecasts will be subject to considerable error. It is very difficult to predict future land development patterns (even in the presence of a strong plan), or to know future kind and effect of travel demand management measures (such as odd-even day use restrictions on trucks) that will be enacted. Travel demand measures are currently stringent in Chinese cities and likely to become more so. The revealed future demand for trips depends very much on which ones will be in force. The intrinsic demand for transport, which would not depend on these measures that modify the supply, is not something our tools are able to measure.

Methods for demand forecasting can be borrowed from agents in countries with advanced experience, but it is very important to adapt them to the needs of Chinese cities. For example, equations that simulate the generation of trips would need to be estimated specifically for Chinese cities. It may be possible to estimate prototype measures of trip generation for Chinese cities rather than having to do so for each city. Similarly, it is important to examine the elasticities among the modes in use in Chinese cities—that is, the consequences of changes in cost and convenience among modes that would cause some users to switch from one mode to another. This cannot be provided from international experience.

It is important to choose demand models that permit easy use for comparing alternative contingent assumptions about the future different use patterns, different levels of auto use, different transit fare levels, etc. This is important because of the many unknowns in Chinese future urban development. Relatively speaking, this flexibility is much more important than the capability of the analysis to predict future traffic very accurately based on specific assumptions. The assumptions will never be that reliable.

Many portrayals of the urban transport planning process would have presented this travel demand component as its central element. Here it is portrayed as one of four streams of analysis and planning. This serves to remind us that the other three streams of planning are also very important and do not depend greatly on travel demand. This is the case because they deal primarily with actions in the short run. Demand forecast is required only for long-range, high-capital investments.

Traffic Management Planning. Traffic management is the menu of techniques that control the number of vehicles in the street and the street capacity. These techniques are much used in China during the recent few years. Work should begin with a study of the current use of these techniques to assure they are accomplishing what is intended. During very rapid motorization, traffic management is the principal tool of public policy to confront explosive congestion.

Traffic management planning requires survey of local conditions through traffic counts and speed-and-delay studies, the evaluation of traffic regulation enforcement and driver discipline, and the survey of incidents such as breakdowns and accidents (which are responsible for as much as half of congestion). This element also requires study of the mode separation problem between bicycles and motor vehicles.

The techniques of traffic management are a box full of numerous tools increasingly tried in many places throughout the world. Planners must review them to choose promising techniques and then examine their possibilities in the corridor or city under study. In some cases, pilot projects would be advisable. As new highway proposals emerge from the planning process, they should be incorporated into the network for traffic management planning. It may be advisable to make them smart corridors, wired for several traffic management functions. The final product of the traffic management planning is a coordinated set of actions, mostly for short-range implementation. This plan can be largely completed long before the laborious travel demand analysis and projection have been completed.

Public Transit Planning. This stream of technical activity is to improve and extend the physical system of public transport, and to assist its institutional and financial conditions. (Possible attention to new rail transit or other heavy construction for transit belongs in the Infrastructure Development Planning Stream rather than in this one because of the need for travel demand forecasts when planning large-scale project investment.)

Study of this element requires passenger surveys, routing and scheduling surveys, examination of terminal problems for buses, tariff study, system administrative efficiency, and also the financial circumstances of the system and its means of getting new equipment. There is also a bus traffic survey that combines this stream with that of traffic management.

The objectives of the transit plan are to rationalize the routing and scheduling system, improve the administrative management of the mode, and to strengthen its financial situation.

Freight Transportation Planning: Freight planning is very important to the Chinese city because, with the growth of competition for street space among vehicles, freight transport is disproportionately affected because of its intensive use of street space in movement and also for loading and unloading operations. There is a tendency, definitely apparent in Chinese cities, for

public authority to especially disadvantage trucks because of a sense that auto drivers and buses are more important. Yet it is the trucks that are the most closely related to the creation of employment and the enhancement of economic development. Indeed, there might be good justification in restricting passenger vehicles from the truck lanes, rather than vice versa.

Freight studies should include the traffic management arrangements that confine truck operations. (For example, how much extra cost is imposed on industry by requiring truck deliveries to be made only at night, or for trucks to operate only on odd for even days?) Issues include also the routing of freight movement. Another important matter is the availability of freight terminals and warehousing. In many cities, congestion and other inefficiency is caused by the fact that the trucks mostly transload cargo while parked in the streets.

Design of Plan Options

This phase is the confluence of many of the previous ones. We have reviewed pending policies and projects, considered the budget available for the transportation sector, committed ourselves to a land use plan and refined objectives of transport actions in the coming years, and become aware of the demands for transport anticipated for those years. Then we prepared four streams of planning—for highways, traffic management, public transport and freight. The next step is to mold the resulting action recommendations into an internally consistent plan.

The first step is to consider the realistic implications of strategic options that arise from the conclusions about strategic objectives above. It would be appropriate to lay out sets of policies and projects consistent with some of the generically different strategic objectives that may have arisen as commitments. For example, it would be informing to lay out the policies and projects that would most advance the goal of economic development–the best management of cargo and work vehicles, even sometimes at the disadvantage of personal travel, and the optimal location of new industrial investment. A second outline of policies would be implied by maximizing the role of transportation in making new housing available to the burgeoning urban population—presumably inferring a decentralization to rapidly increase housing sites and lower their cost. A third display might emphasize the maximization of trip making opportunities—emphasizing high volume modes and the successful resolution of the multimodal use of the streets by bicycles and other vehicles. Eventually, a combined strategy will arise out of merging commitments to each of the strategic objectives and the projects/policies that represent them.

In the course of policy and project identification, it is important that the objectives be present, that budgetary constraints be in mind, and that the magnitude of the achievement of the options be a consideration in the light of the level of demand in view for the coming years. One thing that will emerge from this awareness is the importance of policies in contrast with capital projects. One should not deny the importance of infrastructure projects, but means are limited. The use of rail transit will surely be limited to only a few cities. And again, it is clear that with limited financial resources and an urban structure that is ill equipped to receive large numbers of new vehicles, traffic management policies will be very important.

The components of these strategies need to be assembled into scenarios at different time horizons. Comprehensive transport plans often use 20 to 25 years as their horizon dates in more stable circumstances. Due to the rapid changes in technology and economy in China, however,

probably a shorter horizon is more appropriate, perhaps 15 years. That matter should be discussed. Then there should be a nearer horizon for purposes of more detailed planning, perhaps five years. Finally, local government should prepare a program of actions for execution during each year as an annual segment of the plan.

Evaluation

This phase is very important because pressures on the planning process are likely to result in pushing the process away from its strategic intent. For example, a group of stakeholders committed to the value of rail transit may refine it in directions that fail to recall its original context in the objectives of mobility efficiency and budget constraint.

One level of evaluation is detailed review of the emerged plan by the full set of participants and stakeholders. We do not expect that they will agree on all components of the scenarios as developed, but it is an opportunity for municipal leadership to confirm that the purposes originally intended for each of the plan components are in fact served by those components, that the parts fit together productively, and that the whole is affordable.

The technical evaluation is also very important. *This is the point in the entire process where technical detail and accuracy are the most important.* Evaluation requires the best available estimates of facility demand and estimated revenue, its costs in full detail, its impact on surrounding traffic, its environmental effects, its dislocation impacts and all the other elements that affect its physical and financial feasibility. During evaluation, the planning process should anticipate significant project redesign as a means of reducing its negative impacts and taking more advantage of positive ones.

Programming: Priorities and Sequence

Project and policy programming is a very important part of the process. Within the plan scenario chosen for implementation, individual actions have to be selected and sequenced with attention to a number of factors:

(a) There are inevitably many more viable, attractive actions than can possibly be implemented. The programming process was created in the United States during the development of the Interstate Highway System when this was dramatically true, but it characterizes nearly every planning process. Many actions are proposed. They are examined and designed to further consider their viability. This results in further staff commitment to them. The result in many countries is excessively numerous projects that are implemented too slowly. We need to select the most important ones

(b) The timing of projects needs to stay within the stream of revenue available to the sector.

(c) At the same time, programmers must keep an eye on the growth of demand in order to complement new road projects with policies that assure their usefulness rather than permitting them to be swamped in excess demand.

(d) The programming should strive to make use of the installed capacity of the various participant agencies in urban transportation rather than to overburden some and deprive others of participation.

(e) It is important to avoid construction conflicts that result from building projects in the same locality or that multiply impact on the same streams of traffic.

In essence, programming is the timing of actions, and timing is the basic issue in transportation policies during rapid motorization. Level of motorization alone is not a very significant measure of the problem. After all, Chinese cities are incipiently congested at the present time with one of the lowest rates of auto ownership in the world. It is a matter of the relationship over time between growth of vehicle registrations, levels of use restraint policies, adjustments in the structure of the city, and expansion of infrastructure capacity.

URBAN TRANSPORTATION PLANNING IN THE DEVELOPED WORLD

Most large cities in the West prepared transportation plans based on travel demand forecasts during the decade of the 1960s and some in the 1970s. These studies were a large scale commitment, typically taking some two or three years to complete, and employing a total staff of approximately 150 people. Most of those people were involved with the survey and data preparation. The core analysis and planning staff was typically about 50. In the course of this activity a permanent agency was usually created. Most of these agencies continue to exist at the present time and are responsible for the periodic updating of those studies as well as detailing and revisions on account of changed requirements for plans by central government.

Governments continue to revise urban transportation planning as a process and as a technical procedure. In the United States, the most recent set of metropolitan transportation planning requirements are in the Intermodal Surface Transportation Efficiency Act (ISTEA) of December 1991. They emphasize 15 important elements that should be included in urban transportation plans, paraphrased as follows:

(a) Preservation of existing transportation facilities and their more efficient use as a means of economically meeting transportation needs.

(b) Consistency of transportation plans with government energy conservation plans.

(c) The need to relieve congestion, and to prevent it before it occurs.

(d) Consistency of transportation plans with land use plans, and concern for the impacts of transportation actions on land use.

(e) Need for the programming of transportation facilities.

(f) Attention to the effects of all transportation projects in the metropolitan area with special concern for the requirements in the United States on the effects of publicly funded projects.

(g) Attention to project impacts on major mode change points (such as airports and seaports) and valued land uses (such a monuments and historic sites).

(h) The need for connectivity of roads in the metropolitan area with those outside the area.

(i) The transportation needs inferred by the use of traffic management actions.

(j) The preservation of rights of way for the construction of future projects, including identification of unused rights of way that may be needed for future corridors, and corridors in which action is needed to prevent destruction or loss in future right of way acquisition.

(k) Methods to enhance the efficient movement of freight.

(l) The use of analyses of facility life cycles in the design of bridges, tunnels, and pavement.

(m) The overall social, economic, energy and environmental effects of transportation decisions.

(n) Methods to expand and enhance transit service and to increase the use of transit service.

(o) Capital investment that would result in increased security in transit systems.

These elements serve only as an example of the current concerns of one government experienced in the transportation planning process.

For a specific study of a transportation planning in the Boston area, the metropolitan agency assembled a series of study elements in the following form:

(a) Study management—the guidance of the full set of activities of the study.

(b) Community liaison and technical assistance—discovering the ideas and preferences of local stakeholders.

(c) Design and evaluation criteria—the creation of a series of standards by which actions should be designed and evaluated.

(d) Transportation system design—the activity of engineering the options selected for pursuit in the plan.

(e) Joint development—designing the relationship between transportation facilities and their abutting land uses.

(f) Land use and travel forecasting—the large element including adoption of a land use plan as well as the travel demand survey and analysis procedure.

(g) Special mobility studies—the problems of people with special access problems on account of income, location or available modes.

(h) Technology planning—considering the choices available for transport technologies not yet used in the metropolitan area.

(i) Administrative and legal studies—attention to aspects of planned actions that have to keep within specified bounds of law and administrative practice.

(j) Environmental and conservation studies—examining conditions of air, watercourses and flora as they are currently impacted by transportation and would be impacted in the case of implementation of specific proposals.

(k) Effects of alternatives on the regional economy—seeking options that have positive effects on economic development

(l) Replacement housing and family location—management of the needs of people displaced by transportation actions.

(m) Business relation and employment—management of business relocation from the point of view of the needs of the businesses impacted and also for the loss of local employment.

(n) Neighborhood cohesion and transportation needs—the consequences of severance in the case of communities that lose part of their area to transportation projects.

This set of study elements was the basis for organizing a staff for a study of the transportation problems of Boston during a period of 18 months that included professionals seconded by several public agencies responsible for planning and transportation services as well as several consulting firms.

One lesson emerging from the United States experience is that careful monitoring and assistance of methodological development in transportation planning is important. During the roughly three decades of development of these methods in the United States, there has been a great deal of guidance by the responsible national government agency and by the principal membership organization of transportation planning and engineering professionals, the Transportation Research Board. Between these two groups, a great deal of attention has been given to the development of methods, the dissemination of best practice achievements, and the standardization of methodologies that have made planning studies easier and more economical to accomplish. There needs to be similar guidance in China.

Accordingly, professional training and the creation of institutions that promote and assist the achievement of quality in transportation planning practice are very important (see Theme Paper 11).

CONCLUSION

This is an exciting time in Chinese urban history. It is a time when an enormous challenge is presented to the cities. They need to take advantage of new opportunities for a level of mobility that has never before been possible, even during the very long and distinguished history of Chinese urbanism. But to do so requires thoughtful and vigorous efforts to adapt urban development and urban infrastructure to make that mobility possible. Much depends on the determination of the municipalities to rise to this challenge.

CLOSING REMARKS: TOWARD THE NEW CENTURY

MAO RUBAI [1]

Honorable Mr. Chairperson, Ladies and Gentlemen

After three days of hard work, the China 1995 Urban Transport Symposium is now concluding with success and fruitfulness. Experts from home and abroad have discussed in-depth strategies for China's future urban transport development, and presented many excellent ideas and strong arguments. The major issues touched upon during the symposium include China's urban transport development strategies, policies, institutional reforms, infrastructure-funding channels, city planning and land use, the role of public transport, urban transport management, the relationship between urban transport and the environment, passenger car development, bicycle transport, and sustainable development. The findings that are specific to China will be a valuable contribution to the formulation of China's future urban transport development policy.

Ms. Sierra just delivered the symposium's Concluding Statement. She expressed her favorable endorsement to the role of the symposium. She pointed out that China's urban transport should be developed under the guidance of a comprehensive strategy. She also outlined the principles that should be applied to areas such as operation and management system reforms, legislation improvement, public transit priority, urban transport infrastructure financing, and international cooperation. All municipal leaders should take these proposed principles into consideration and tailor them to meet local conditions when formulating and implementing your urban transport development strategies.

In 1992, the Central Government set the objective to establish a socialist market economy system. This marked a new era for China's reforms. To create markets under socialist conditions is a new initiative in the world history of social and economic development. The policy of reforms and opening-up has greatly promoted China's economic development, and stimulated the growth of gross national product (GNP) at an annual rate of 13.1 percent over the last three years. Living conditions have generally been improved and the demand for urban transport has also increased because of the rapid increases in GNP. Many participating experts here stressed that from now on, China's cities will be facing not only the challenges of fully establishing a socialist market economy system and of further economic development, but also the challenge of rapid increases in transport pressure arising from this process.

With the realization of the objective of tripling the 1980 GNP level by the end of the century and with continuing urbanization, the urban population will remarkably increase. The development of urban industries and the booming of commercial activities will also cause rapid

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[1] Mao Rubai is Vice-Minister, Ministry of Construction.

increases in urban freight transport. The increase of private-car ownership and rapid development of car transport will dangerously threaten the normal functioning of urban transport in China's cities, particularly in large cities. This will be further devastated by the shortage crisis of urban land, which imposes constraints on urban transport. Environment pollution, like air pollution and noise in cities, will be getting worse. Unless correct strategy and countermeasures are formulated and implemented, China's urban, and even national, economic and social development will be adversely affected by these threats.

Ladies and Gentlemen:

China is ready to implement its Ninth Five-Year Plan. We should recognize the vigorous economic development and social progress brought about by the reform policy, and the bright future of rapid development of China's urban transport sector and the positive impacts of a series of relevant measures adopted in the sector. More importantly, we should focus on the difficulties and problems that would arise from the tremendous demand for urban transport. The symposium has intensively examined and discussed the problems that we are likely to come across in urban transport development. Some of the successful international experiences have also been introduced. There is no doubt that all of these will be of great help for us to explore ways of developing urban transport in accordance with China's specific situation.

By summing up the past experience and looking forward to the future, we understand that China's urban transport sector has made considerable progress and that the development is still speeding up. I would like to thank you all for your valuable and constructive contributions to this process. I hope that our government officials, entrepreneurs, bankers, and experts will continue their efforts in the development of China's urban transport. I am confident that when we stride toward the new century, with our joint effort, China's urban transport sector will develop more rapidly for the benefit of China's economic growth and social development. Ultimately, we will make a positive contribution to human civilization.

Thank you.

ANNEX: URBAN TRANSPORT STATISTICS

LI YAMING [1]

This annex presents urban transport statistics for a number of mostly large or mega Chinese cities. The following text includes an explanatory note on the definitions of urban area and urban population, and the description of the data sources for the statistics presented.

URBAN POPULATION AND URBAN AREA

Currently there are over 600 municipalities in China. They can be classified into three groups according to their administration status, that is, provincial level (i.e., centrally administered), prefectural level, or county level. In general, each municipality has the following administrative subdivisions:

- Municipality with provincial or prefectural level status:
    - Urban (i.e. the city proper):
      City district(s)
      Suburban district(s)
    - Rural: Suburban counties (for some large or medium size cities only).
- Municipality with county level status:
    - Urban: City district
    - Rural: Rural villages.

China's official annual statistical publications use several population definitions. They are nonagricultural population, agricultural population, total municipal population, and urban population. *Total municipal population* is total resident population (both nonagricultural and agricultural) within the municipality boundary, including all suburban counties. *Urban Population* (or *City proper population*) is the sum of both nonagricultural and agricultural resident population in the city proper area, excluding suburban counties. Obviously, the city proper nonagricultural population, which can be found from most official statistical publications, appears to be the closest estimate of registered urban resident population, even though a small number of agricultural population may live in the same area.

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[1] The statistics included in this annex were compiled by Li Yaming, Chief Engineer, Urban Transport Institute, China Academy of Urban Planning and Design (CAUPD).

Similarly to the population definitions, the area definitions also correspond to the administrative subdivisions of a municipality. Urban area, for example, includes both the city proper and suburban districts, but excludes suburban counties. Two other area definitions that are often used by the urban construction sector are urban planning area and urban built-up area. These are self-explanatory.

The official statistical publications provide two gross resident population density measures, i.e., at the municipal and at the city-proper level. Due to the large rural area included, however, the municipal population density can be misleading if the indicator is used to describe urban population density. City-proper population density has its problem too, for it includes agricultural population. The best measure for the purpose of urban studies appears to be built-up area population density, but population data are not gathered for the built-up area.[2] CAUPD researchers suggest to use city-proper nonagricultural population as a proxy for built-up area resident population in estimating the built-up area resident population density. The data of city proper population, area, and the proxy of built-up area population density for 31 largest cities are shown in Annex Table 3.1.

Currently, nonagricultural population living in all city proper areas accounts for a total of slightly over 300 million, or 28 percent of the nation's total population. The use of nonagricultural population, which is defined primarily for urban population management purpose, however, leads to an underestimation of the actual degree of urbanization. This is because a large number of *floating population* comprising mostly rural laborers and their families coming for urban jobs live in urban areas quite permanently. The size of floating population varies city by city, but is generally larger in bigger, richer cities, especially those in the southeastern coastal areas. It is estimated that there are 3 million floating population in Beijing, 1.7 million in Guangzhou, 0.8 million in Chengdu, and 0.7 million in Shenyang. The ratios of floating population over resident population in most large cities are estimated around 25 to 30 percent.

DATA SOURCES

Urban Transport Statistics for 10 Selected Cities (Annex Tables 1 and 2)

These statistics were collected during the preparation of the 12 theme papers presented in the symposium. A joint MCon, IBRD, ADB, and CAUPD urban transport sector mission visited five (Beijing, Shanghai, Guangzhou, Chengdu, and Jinan) of these 10 cities in April 1995. The tables are arranged to cover five aspects: (1) urban socioeconomic characteristics; (2) urban transport prices, revenues, and expenditures; (3) road network and vehicle fleet; (4) public transit system and operation; and (5) travel demands by mode.

The Year 1993 Urban Construction Statistics (Annex Tables 3.1 through 3.5)

These tables present selected statistics relating to urban transport sector and their derived indicators for all 31 largest cities (with city-proper area nonagriculture population over 1

[2] For urban planning purpose, some large cities estimate resident population in their built-up areas.

million), and Shenzhen and Shantou. These statistics are obtained from a single source, *1993 Urban Construction Statistical Report*, published by the Ministry of Construction (1994) for all Chinese municipalities.

O-D Survey Data (Annex Tables 4.1 through 4.5)

These data are obtained from a number of individual cities that have conducted person-trip O-D surveys during the last decade. Annex Tables 4.1 to 4.5 summarize the key statistics so that urban travel characteristics can be compared across cities.

ANNEX TABLE 1: URBAN STATISTICS FOR SELECTED CITIES

PART I. SOCIOECONOMIC DATA

Indicator	Year(s)	Beijing	Shanghai	Guangzhou	Chengdu	Jinan
1. Population ('000)						
Municipal total	1993	10,510	12,950	6,240	9,470	5,340
of which, nonagriculture population	1993	6,690	8,930	3,750	2,760	2,150
City-proper total	1993	8,408	9,480	3,696	2,934	2,397
of which, nonagriculture population	1993	5,748	8,935	3,036	1,835	1,437
Built-up area population	1994	na	na	3,000	1,815	na
Floating population	1993	3,000	na	1,700	830	na
2. Population Growth Rate (%)						
City proper : nonagriculture population	1989-93	1.25	4.71	1.29	8.83	1.63
Built-up area	1989-93	na	na	na	na	na
Floating	1989-93	na	na	na	na	na
3. Area (square kilometers)						
Municipality	1991	16,808	6,341	7,434	12,930	8,227
City proper	1993	2,701	793	1,444	1,382	2,127
Build-up area	1993	454	300	207	92	110
4. Average Household Size (persons)	1991	3.0	3.0	3.4	3.4	3.3
5. Employment (% of total)						
City proper: nonagri. employment share	1991	57.8	55.9	58.6	66.5	57.8
of Which: Service	1991	52.8	38.6	51.7	42.7	40.3
Manufacture	1991	47.2	61.4	48.3	57.3	59.7
City proper: Jobless	1991	0.2	1.5	1.6	1.0	3.3
6. Per Capita Income (Y/person)						
Average disposable income	1991	2,040	2,334	2,906	1,925	1,753
Low income (second dec.)	1991	na	na	na	na	na
7. Per Capita Income Growth (%)	1989-91	13.0	12.0	11.2	10.9	11.6
8. Inflation: consumer goods (%)	1992-93	16.9	17.5	19.8	13.7	10.3

ANNEX TABLE 1: (CONT'D)

PART II. TRANSPORT PRICES, REVENUES AND EXPENDITURES

Indicator	Beijing	Shanghai	Guangzhou	Chengdu	Jinan
1. Vehicle Prices ('000 Yuan)					
Car: Santana 1800cc	160-170	160-170	160-170	160-170	160-170
Xia Li 700cc	90-100	90-100	90-100	90-100	90-100
Motorcycle: Xing Fu 125cc	7-8	7-8	7-8	7-8	7-8
Mu Lan 70cc	4-5	4-5	4-5	4-5	4-5
Bicycle 28": Standard	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Luxury (with gears)	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.0
Bus: Double Deck	41.8	41.8	41.8	41.8	41.8
Articulated	158.4~242	158.4~242	158.4~242	158.4~242	158.4~242
Luxury	352~484	352~484	352~484	352~484	352~484
Standard	123.2~187	123.2~187	123.2~187	123.2~187	123.2~187
Minibus	64.9~220	64.9~220	64.9~220	64.9~220	64.9~220
Trolley bus (one ~combination)	121~253	121~253	121~253	121~253	121~253
2. Fuel Prices (Yuan/ton)					
Gasoline	3,125	2,838	2,400	2,450	2,775
Diesel	2,444	na	2,100	2,129	2,600
3. Transport Fares (Yuan)					
Metro: 4 km/8 km trip	0.5	1.00/200	na	na	na
Premium: 4 km/8 km trip	na	1.00/1.50	1.00/1.20	na	na
Standard: 4 km/8 km trip	na	0.50/0.50	0.60/0.60	0.40/0.50	0.30/0.40
Minibus: 4 km/8 km trip	1.00/2.00	1.00/2.00	1.00/2.00	0.70/1.00	1.00/1.50
Taxi: 4 km/8 km trip					
by Santana	12.00/20:00	14.40/21.60		10.00/16.00	10.00/18.00
by Xia Li	10.40/16.80	10.80/16.40		na	8.40/14.80
by Yellow "bread loaf"	10.00/10.00	na	na	na	6.00/10.00
% of full bus fare paid by students			43		20-24
4. Annual Fee (Yuan/month)					
Car	437			300-500	
Motorcycle				50-100	
Bicycle: Standard/Luxury				5-10	
5. Parking Charges at Daytime					
Car (Yuan/hour)				1.00-3.00	5.00/day
Motorcycle (Yuan per lot)				0.5	2.00/day
Bicycle: Standard/Luxury (Yuan per lot)	0.1			0.1	0.30/day
6. Revenues ('millions of Yuan)					
Public Transit enterprise (1994)	3,000	971	500	10	59
7. Operating Costs (millions of Yuan)					
Public Transit enterprise (1994)	11,200	1,800	630	120	81

ANNEX TABLE 1: (CONT'D)

PART III. ROAD NETWORK AND VEHICLE FLEET

Indicator	Beijing	Shanghai	Guangzhou	Chengdu	Jinan
1. Built-up Area Land for Roads (km^2)					
Total	27.75	28.29	13.78	7.73	15.01
of which: high & subhigh quality pavement	25.12	24.89	11.87	7.51	13.91
2. Vehicle Fleet					
Motor Vehicles			76,257	73,400	74,458
Tractor			23,603		36,118
Large Passenger Vehicles	17,776		10,178	4,477	
Small Passenger Vehicles	118,743		54,773	27,378	
Motorcycles	89,124		373,865	60,000	129,292
Trucks: Large	72,355		51,662	19,598	
Small	125,407		61,398	18,350	
Other Vehicles				3,597	14,730
Subtotal	423,405		551,876	133,400	144,022
Bicycles	7,885,188			1,580,000	1,500,000
Total	8,308,593		551,876	1,713,400	1,644,022

ANNEX TABLE 1: (CONT'D)

PART IV. PUBLIC TRANSPORT SYSTEM AND OPERATION, 1993

Indicator	Beijing	Shanghai	Guangzhou	Chengdu	Jinan
1. Bus					
Number of Buses	4,229	5,627	2,222	1,189	746
Route-kilometers	3,240	3,950	3,165	2,183	1,281
Bus-kilometers ('000)	216,390	276,000	94,700	37,910	37,790
2. Trolleybus					
Number of Trolleybuses	519	853	116	81	83
Route-kilometers	151	168	54	34	45
Vehicle-kilometers ('000)	27,770	49,460	4,640	3,140	4,500
3. Taxi					
Number of Taxis	46,022	30,433	12,825	3,812	1,915
Taxi-kilometers ('000)					
4. Metro					
Number of Trains	323	na	na	na	na
Route-kilometers	42	na	na	na	na
Car-kilometers ('000)	3,253	na	na	na	na

ANNEX TABLE 1: (CONT'D)

PART V. TRAVEL DEMANDS BY MODE

Indicator	Beijing	Shanghai	Guangzhou	Chengdu	Jinan
1. Year of Data Collection	1986.6	1986.11	1984.6	1987.9	1988.11
2. Demands ('000 trips per day)	8,404	14,374	5,680	3,478	2,184
Walk	1,156	5,492	2,224	1,252	508
Bicycle	4,541	4,913	1,932	1,897	1,393
Bus and Trolleybus	2,044	3,454	1,068	202	147
Motorcycle		26	21	na	17
Company Bus	366	318	259	na	84
Taxi	25	22	15	na	0.7
Others	272	149	161	124	33

ANNEX TABLE 1: (CONT'D)

PART VI. KEY INDICATORS

Indicator	Year(s)	Beijing	Shanghai	Guangzhou	Chengdu	Jinan
1. Built-up Area Population Growth Rate (%)	1989-94	na	na	na	na	na
City Proper: nonagriculture population growth	1989-94	1.29	4.71	8.83	1.25	1.63
2. Floating Population in Built-Up Area ('000)	1994	na	na	na	830	na
3. Built-up Area Population Density (persons/km^2)		na	na	14,493	19,685	na
4. Percent Population Employed (%)		na	40.27	na	42.74	na
5. Average Income per Person (Yuan)	1989-91					
Average disposable income	1991	2,906	2,334	1,925	2,040	1,753
6. Annual Per Capita Income Growth Rate (%)	1989-91	na	11.62	na	10.91	na
7. Bus Fare for 4km/8km (Yuan)	1994	0.20/0.30	0.50/0.50	0.60/0.60	0.40/0.50	0.30/0.40
8. Bus Monthly Pass (Yuan)	1994	7-18	25-35	35	na	20-25
9. Public Transport Subsidy (millions of Yuan)	1994	820	800	130	na	22
10. % Change in Public Transport Subsidy	1989-94	na	na	na	na	na
11. Vehicle Ownership Per Person	1994					
--Car						
--Motorcycle		0.01		0.10	0.02	0.05
--Other Motor Vehicle						
--Bicycle		0.94			0.54	0.63
12. Vehicle Fleet Annual Growth Rate	1990-94	15			21	18
13. Road Length Per Persons (m)		0.47	0.3	0.45	0.39	0.85
14. Trip Rate (trips per person per day)						
--Buses		0.39	0.43	0.98	0.13	0.11
--Minibuses						
--Company buses		0.07	0.04	0.10		0.06
--Taxi		0.00	0.03	0.01		0.00
--Car						
--Motorcycle			0.00	0.01		0.00
--Other Motor Vehicle						
--Bicycles		0.87	0.61	0.78	1.18	1.07
--Tricycle						
--Total		1.61	1.79	2.28	2.16	1.68
15. Traffic Accident Fatalities	1994				897/3,393	
16. % Change in Fatal Accidents	1989-94				0.6	
17. Bus Company Performance	1995					
% Availability		93.4	85.6		93.0	87.0
Monthly Driver Wages (Yuan)		10,072	12,000	12,000	4,617	6,000
Employees Per Bus		12.47	7.84		10.00	7.86
Kilometers Per Bus Per Day		158	136		129	150
Passengers Per Bus Per Day		1,840	2,023		695	1,093
Fuel Consumed Per 100 Vehicle-km (liter)		21-30	24.20		27.00	24.70

ANNEX TABLE 2: URBAN STATISTICS FOR SELECTED CITIES

PART I. SOCIOECONOMIC DATA

Indicator	Year	Tianjin	Wuhan	Urumqi	Qingdao	Fuzhou
1. Population ('000)						
Municipal total	1993	8,827	6,845	1,366	6,731	5,447
of which, nonagriculture population	1993	4,968	3,857	1,112	2,241	1,290
City-proper total	1993	5,847	3,872	1,222	2,121	1,338
of which, nonagriculture population	1993	4,580	3,346	1,108	1,401	927
Built-up area population	1994	na	na	na	na	na
Floating population	1993	na	na	na	na	na
2. Population Growth Rate (%)						
City proper : nonagriculture population	1989-93	1.08	1.08	1.51	1.88	1.74
Built-up area	1989-93	na	na	na	na	na
Floating	1989-93	na	na	na	na	na
3. Area (square kilometers)						
Municipality	1991	11,305	8,467	11,444	10,654	11,968
City proper	1993	4,276	1,627	835	1,102	1,043
Built-up area	1993	339	211	67	100	61
4. Average Household Size (persons)	1991	3.20	3.38	3.80	3.09	3.43
5. Employment (% of total)						
City proper: nonagri. employment share	1991	60.0	60.8	63.7	53.4	59.1
of Which: Service	1991	37.4	41.9	48.8	38.5	43.0
Manufacture	1991	62.7	58.1	51.2	61.5	57.0
City proper: Jobless	1991	1.0	1.5	0.2	1.6	3.3
6. Per Capita Income (Y/person)						
Average disposable income	1991	1,699	1,661	1,780	1,859	1,820
Low income (second dec.)	1991	na	na	na	na	na
7. Per Capita Income Growth (%)	1989-91	11.81	12.01	10.48	12.95	11.02
8. Inflation: consumer goods (%)	1992-93	8.6	6.7	7.6	6.8	7.4

ANNEX TABLE 2: (CONT'D)

PART II. TRANSPORT PRICES, REVENUES AND EXPENDITURES

Indicator	Tianjin	Wuhan	Urumqi	Qingdao	Fuzhou
1. Vehicle Prices ('000 Yuan)					
Car: Santana 1800cc	160-170	160-170	160-170	160-170	160-170
Xia Li 700cc	90-100	90-100	90-100	90-100	90-100
Motorcycle: Xing Fu 125cc	7-8	7-8	7-8	7-8	7-8
Mu Lan 70cc	4-5	4-5	4-5	4-5	4-5
Bicycle 28": Standard	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Luxury (with gears)	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.0
Bus: Double Deck	41.8	41.8	41.8	41.8	41.8
Articulated	158.4~242	158.4~242	158.4~242	158.4~242	158.4~242
Luxury	352~484	352~484	352~484	352~484	352~484
Standard	123.2~187	123.2~187	123.2~187	123.2~187	123.2~187
Minibus	64.9~220	64.9~220	64.9~220	64.9~220	64.9~220
Trolley bus (one ~combination)	121~253	121~253	121~253	121~253	121~253

ANNEX TABLE 2: (CONT'D)

PART III. ROAD NETWORK AND VEHICLE FLEET

Indicator	Tianjin	Wuhan	Urumqi	Qingdao	Fuzhou
1. Built-up Area Land for Roads (km^2)					
Total	32.5	12.1	5.4	9.4	5.9
of which: high & subhigh quality pavement	32.1	11.6	5	8.1	4.9

ANNEX TABLE 2: (CONT'D)

PART IV. PUBLIC TRANSPORT SYSTEM AND OPERATION, 1993

Indicators	Tianjin	Wuhan	Urumqi	Qingdao	Fuzhou
1. Bus					
Number of Buses	2,134	1,422	662	918	380
Route-kilometers	3,144	1,167	697	987	766
Bus-kilometers ('000)	104,610	86,310	33,440	40,630	17,990
2. Trolleybus					
Number of Trolleybuses	53	235	0	136	25
Route-kilometers	17	85	0	30	8
Vehicle-kilometers ('000)	1,370	14,320	0	7,940	790
3. Taxi					
Number of Taxis	11,484	6,459	4,135	4,874	2,975
Taxi-kilometers ('000)					
4. Metro					
Number of Trains	21	na	na	na	na
Route-kilometers	7	na	na	na	na
Car-kilometers ('000)	900	na	na	na	na

ANNEX TABLE 2: (CONT'D)

PART V. TRAVEL DEMANDS BY MODE

Indicator	Tianjin	Wuhan	Urumqi	Qingdao	Fuzhou
1. Year of Data Collection	1993.6	1987	1993.9	1993.6	1993.1
2. Demands ('000 trips per day)	9,252	5,724	2,958	2,753	2,253
Walk	2,591	1,867	1,441	1,296	572
Bicycle	5,595	1,865	648	494	1,372
Bus and Trolleybus	376	1,404	550	603	54
Motorcycle	185	14		21	97
Company Bus	283	269	207	257	34
Taxi		6		10	7
Others	222	301	112	72	117

ANNEX TABLE 2: (CONT'D)

PART VI. KEY INDICATORS

Indicator	Year(s)	Tianjin	Wuhan	Urumqi	Qingdao	Fuzhou
1. Built-up Area Population Growth Rate (%)	1989-94	na	na	na	na	na
City Proper: nonagriculture population growth	1989-94	1.08	1.08	1.51	1.88	1.74
2. Floating Population in Built-Up Area ('000)	1994	na	na	na	na	na
3. Built-up Area Population Density (persons/km^2)		na	na	na	na	na
4. Percent Population Employed (%)		37.36	41.88	48.79	38.51	43
5. Average Income per Person (Yuan)	1989-91					
Average disposable income	1991	1,699	1,661	1,780	1,859	1,820
6. Annual Per Capita Income Growth Rate (%)	1989-91	11.81	12.01	10.48	12.95	11.02
14. Road Length Per Persons (m)		0.69	0.38	0.44	0.55	0.86
15. Trip Rate (trips per person per day)						
--Buses		0.08	0.44	0.50	0.43	0.06
--Minibuses					0.02	
--Company buses		0.06	0.08	0.19	0.18	0.04
--Taxi			0.00		0.01	0.01
--Car						
--Motorcycle		0.04	0.04		0.02	0.10
--Other Motor Vehicle						
--Bicycles		1.22	0.59	0.58	0.35	1.48
--Tricycle						
--Total		2.02	1.80	2.67	1.97	2.43
18. Bus Company Performance	1995					
Employees Per Bus		10.20	16.50	10.20	12.97	8.70
Kilometers Per Bus Per Day		134	166	138	121	130
Passengers Per Bus Per Day		749	1,969	1,798	2,109	1,156

ANNEX TABLE 3.1: URBAN POPULATION, POPULATION DENSITY, AND PER CAPITA GDP FOR 33 LARGE CITIES

City	City Proper Area km^2)	City Proper Total Population ('000)	City Proper Nonagri. Population ('000)	Built-up Area (km^2)	Built-up Area Density (persons/ km^2)	GDP Per Capita in 1992 Yuan
Shanghai	793	9,480	8,935	300	29,783	7,766
Beijing	2,701	6,408	5,748	454	12,658	7,025
Tianjin	4,276	5,847	4,580	339	13,518	4,836
Shenyang	3,595	6,577	3,724	189	19,683	4,380
Wuhan	1,627	3,872	3,346	211	15,865	4,070
Guangzhou	1,444	3,696	3,036	207	14,695	8,837
Harbin	1,658	3,121	2,576	156	16,513	4,083
Chongqing	1,534	3,064	2,344	106	22,051	3,549
Nanjing	947	2,585	2,174	148	14,650	5,918
Xian	1,066	2,885	2,060	148	13,919	3,211
Chengdu	1,382	2,934	1,835	92	19,902	4,197
Dalian	2,415	2,487	1,818	200	9,072	6,143
Changchun	1,116	2,188	1,757	114	15,412	2,950
Taiyuan	1,460	2,040	1,601	168	9,530	4,242
Jinan	2,127	2,397	1,437	110	13,087	4,466
Qingdao	1,102	2,121	1,401	100	14,024	5,022
Lanzhou	1,632	1,576	1,253	163	7,711	4,223
Anshan	622	1,422	1,240	90	13,855	5,933
Fushun	675	1,376	1,233	110	11,168	4,491
Kunming	2,081	1,577	1,200	98	12,245	5,319
Zhengzhou	1,010	1,742	1,177	100	11,829	2,834
Changsha	367	1,391	1,160	101	11,485	4,325
Hanzhou	430	1,383	1,151	90	12,761	7,318
Nanchang	561	1,422	1,136	65	17,477	3,001
Shijiazhuang	307	1,380	1,126	90	12,511	4,632
Urumqi	835	1,222	1,108	67	16,612	5,708
Jilin	1,755	1,352	1,099	105	10,467	4,742
Qiqiharer	4,365	1,404	1,092	102	10,706	2,542
Guiyang	2,436	1,622	1,077	86	12,567	3,329
Tangshan	1,090	1,530	1,062	117	9,054	3,928
Baotao	2,153	1,231	1,013	145	6,981	3,526
Shenzhen	327	877	877	81	10,841	32,752
Shantou	246	915	674	41	16,642	4,307

Source: Ministry of Construction (1994), *1993 Urban Construction Statistical Report.*

ANNEX TABLE 3.2: URBAN ROAD LENGTH AND AREA IN 33 LARGE CITIES

City	Total Road Length (km)	Total Road Area ('000 m^2)	Average Road Width (m)	Per Capita Road Length (m)	Per Capita Road Area (m^2)
Shanghai	2,722	28,290	10.4	0.30	3.2
Beijing	2,713	27,750	10.2	0.47	4.8
Tianjin	3,148	32,500	10.3	0.69	7.1
Shenyang	1,731	17,370	10.0	0.46	4.7
Wuhan	1,278	12,060	9.4	0.38	3.6
Guangzhou	1,379	13,780	10.0	0.45	4.5
Harbin	1,626	13,640	8.4	0.63	5.3
Chongqing	1,215	9,460	7.8	0.52	4.0
Nanjing	1,033	10,460	10.1	0.48	4.8
Xian	1,123	11,300	10.1	0.55	5.5
Chengdu	712	7,730	10.9	0.39	4.2
Dalian	856	12,680	14.8	0.47	7.0
Changchun	752	8,830	11.7	0.43	5.0
Taiyuan	1,170	10,510	9.0	0.73	6.6
Jinan	1,220	15,010	12.3	0.85	10.4
Qingdao	764	9,440	12.4	0.55	6.7
Lanzhou	503	5,200	10.3	0.40	4.2
Anshan	526	5,830	11.1	0.42	4.7
Fushun	439	3,980	9.1	0.36	3.2
Kunming	331	3,500	10.6	0.28	2.9
Zhengzhou	490	5,830	11.9	0.42	5.0
Changsha	622	5,010	8.1	0.54	4.3
Hanzhou	737	5,700	7.7	0.64	5.0
Nanchang	284	3,310	11.7	0.25	2.9
Shijiazhuang	654	6,780	10.4	0.58	6.0
Urumqi	492	5,350	10.9	0.44	4.8
Jilin	503	3,850	7.7	0.46	3.5
Qiqiharer	849	6,450	7.6	0.78	5.9
Guiyang	290	2,600	9.0	0.27	2.4
Tangshan	524	5,280	10.1	0.49	5.0
Baotao	442	4,570	10.3	0.44	4.5
Shenzhen	296	6,510	22.0	0.34	7.4
Shantou	283	2,720	9.6	0.42	4.0

Note: Only the urban paved roads with a width of 3.5 meters or wider are counted in these statistics.

Source: Ministry of Construction (1994), *1993 Urban Construction Statistical Report*.

ANNEX TABLE 3.3: PUBLIC TRANSPORT STATISTICS: BOTH PUBLIC AND PRIVATE SECTORS, 33 LARGE CITIES

	Public Transit							Taxis	
City	Number of Standard Vehicle Equivalents	Total Route-km	Total Psgrs. Carried (million)	Standard Vehicles Per 1000 Pop.	Rides Per Person	Rides Per Std. Vehicle ('000)	Rides Per Route-km ('000)	Number of Taxis	Taxis Per 1000 Pop.
Shanghai	11,783	12,470	5,627	1.32	630	478	451	30,433	3.41
Beijing	8,058	3,533	3,354	1.40	583	416	949	46,022	8.01
Tianjin	2,731	3,181	610	0.60	133	223	192	11,484	2.51
Shenyang	2,777	3,720	537	0.75	144	193	144	4,407	1.18
Wuhan	2,951	1,315	1,251	0.88	374	424	951	6,459	1.93
Guangzhou	2,731	3,219	664	0.90	219	243	206	12,825	4.22
Harbin	1,882	1,144	612	0.73	238	325	535	4,111	1.60
Chongqing	2,090	5,038	753	0.89	321	360	149	4,092	1.75
Nanjing	2,389	2,683	500	1.10	230	209	186	3,957	1.82
Xian	1,266	733	355	0.61	172	280	484	7,487	3.63
Chengdu	1,482	2,494	268	0.81	146	181	108	2,812	1.53
Dalian	2,420	531	1,045	1.33	575	432	1,968	4,956	2.73
Changchun	1,196	791	310	0.68	176	259	391	6,377	3.63
Taiyuan	965	786	212	0.60	133	220	270	4,490	2.80
Jinan	1,092	1,326	337	0.76	235	309	254	1,915	1.33
Qingdao	1,963	1,094	724	1.40	517	369	662	4,874	3.48
Lanzhou	857	599	292	0.68	233	341	488	2,226	1.78
Anshan	659	405	252	0.53	203	383	623	2,518	2.03
Fushun	1,310	1,643	371	1.06	301	283	226	777	0.63
Qunming	918	1,616	218	0.77	181	237	135	2,557	2.13
Zhengzhou	663	376	127	0.56	108	192	339	3,745	3.18
Changsha	963	468	256	0.83	221	266	547	1,231	1.06
Hanzhou	1,100	866	385	0.96	335	350	445	3,817	3.32
Nanchang	517	912	115	0.46	102	223	127	1,660	1.46
Shijiazhuang	663	564	116	0.59	103	174	205	2,000	1.78
Urumqi	864	708	440	0.78	397	510	622	4,135	3.73
Jilin	659	570	178	0.60	162	270	312	2,836	2.58
Qiqiharer	355	1,176	82	0.33	75	230	69	711	0.65
Guiyang	1,049	1,969	321	0.97	298	306	163	1,253	1.16
Tangshan	434	303	79	0.41	74	181	260	500	0.47
Baotao	586	1,070	59	0.58	58	101	55	515	0.51
Shenzhen	1,561	1,010	319	1.78	364	205	316	7,016	8.00
Shantou	94	100	17	0.14	25	178	167	2,074	3.08

Source: Ministry of Construction (1994), *1993 Urban Construction Statistical Report.*

ANNEX TABLE 3.4: STATE-OWNED PUBLIC TRANSIT SYSTEM PERFORMANCE INDICATORS, 33 LARGE CITIES

City	Number of Standard Vehicle Equivalents	Number of Workers	Total Veh-km (million)	Total Route-km	Total Pasgrs. Carried (million)	Operating Subsidies (Y million)	Average Workers Per Std. Veh.	Veh-km Per Std. Veh. ('000)	Psgrs. Per Veh-km	Operating Subsidies Per Psgr. (Y)
Shanghai	9,998	79,887	325	4,118	5,518	520.0	8.0	32.6	17.0	0.09
Beijing	7,252	53,665	244	3,391	2,824	521.0	7.4	33.7	11.6	0.18
Tianjin	2,681	21,665	106	3,161	601	100.1	8.1	39.5	5.7	0.17
Shenyang	1,897	17,632	52	1,798	483	42.8	9.3	27.4	9.3	0.09
Wuhan	2,544	28,036	101	1,252	1,237	79.4	11.0	39.6	12.3	0.06
Guangzhou	2,731	20,128	99	3,219	664	0.0	7.4	36.4	6.7	0.00
Harbin	1,479	14,883	44	725	506	49.5	10.1	29.4	11.6	0.10
Chongqing	2,090	16,221	97	5,038	753	18.4	7.8	46.2	7.8	0.02
Nanjing	1,612	13,937	70	1,637	445	39.0	8.6	43.3	6.4	0.09
Xian	1,259	10,075	37	725	355	7.0	8.0	29.1	9.7	0.02
Chengdu	1,357	9,676	41	2,217	262	0.0	7.1	30.3	6.4	0.00
Dalian	1,578	12,780	50	346	762	33.5	8.1	31.4	15.4	0.04
Changchun	1,118	7,415	38	778	287	0.0	6.6	34.1	7.5	0.00
Taiyuan	895	4,939	34	786	207	37.0	5.5	37.7	6.1	0.18
Jinan	1,092	7,307	42	1,326	337	22.0	6.7	38.7	8.0	0.07
Qingdao	1,527	11,903	49	1,017	707	20.0	7.8	31.8	14.5	0.03
Lanzhou	857	5,328	31	599	292	2.5	6.2	35.7	9.6	0.01
Anshan	578	7,004	19	392	202	0.0	12.1	33.1	10.6	0.00
Fushun	855	6,769	33	577	361	8.0	7.9	38.9	10.9	0.02
Qunming	918	4,988	25	1,616	218	8.0	5.4	27.6	8.6	0.04
Zhengzhou	538	4,221	18	283	121	7.0	7.8	33.8	6.7	0.06
Changsha	963	6,276	32	468	256	3.0	6.5	33.1	8.0	0.01
Hanzhou	1,100	9,499	48	866	385	20.0	8.6	43.6	8.0	0.05
Nanchang	517	4,457	14	912	115	3.3	8.6	27.9	8.0	0.03
Shijiazhuang	663	4,966	17	504	115	8.0	7.5	26.2	6.6	0.07
Urumqi	848	6,780	33	697	434	2.0	8.0	39.4	13.0	0.00
Jilin	659	3,265	21	570	178	4.1	5.0	32.4	8.3	0.02
Qiqiharer	355	4,042	15	1,176	82	9.2	11.4	41.0	5.6	0.11
Guiyang	536	5,213	21	802	225	0.0	9.7	38.9	10.8	0.00
Tangshan	434	3,770	14	303	79	10.4	8.7	31.9	5.7	0.13
Baotao	474	2,973	15	710	55	5.0	6.3	32.6	3.5	0.09
Shenzhen	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Shantou	94	725	4	100	17	1.2	7.7	38.5	4.6	0.07

Note: These statistics are not applicable to Shenzhen.

Source: Ministry of Construction (1994), *1993 Urban Construction Statistical Report*.

ANNEX TABLE 3.5: URBAN MAINTENANCE AND CONSTRUCTION (M&C) REVENUES AND EXPENDITURES, 33 LARGE CITIES

City	Revenues (Y million)		Expenditures (Y million)			Per Capita Revenues (Y)		Per Capita Expenditures (Y)		
				Of which					Of which	
	M&C Rev.	M&C Tax and PU/a Surcharge	M&C Total	Public Transit	Roads & Bridges	M&C Rev.	M&C Tax and PU Surcharge	M&C Total	Public Transit	Roads & Bridges
Shanghai	10,367	756	10,368	702	4,474	1,160	85	1,160	79	501
Beijing	3,654	815	3,241	476	850	636	142	564	83	148
Tianjin	1,386	370	1,351	14	210	303	81	295	3	46
Shenyang	842	218	674	40	130	226	59	181	11	35
Wuhan	974	261	974	17	263	291	78	291	5	79
Guangzhou	3,060	551	3,041	97	2,516	1,008	182	1,002	32	829
Harbin	1,230	148	1,230	0	0	478	58	478	0	0
Chongqing	560	203	551	73	143	239	87	235	31	61
Nanjing	891	269	916	13	234	410	124	421	6	108
Xian	1,014	87	586	15	223	492	42	285	7	108
Chengdu	1,094	132	1,072	54	376	596	72	584	29	205
Dalian	882	194	881	7	77	485	107	485	4	42
Changchun	589	110	609	8	50	335	62	347	5	28
Taiyuan	391	134	348	0	0	244	84	217	0	0
Jinan	625	151	625	19	9	435	105	435	14	6
Qingdao	614	169	618	47	146	438	121	441	34	104
Lanzhou	210	138	210	8	13	168	110	168	6	10
Anshan	479	218	493	8	22	387	176	397	6	18
Fushun	234	132	234	10	38	189	107	189	8	31
Qunming	447	252	398	25	76	373	210	332	21	64
Zhengzhou	359	98	368	6	156	305	83	312	5	133
Changsha	465	112	469	15	107	401	96	405	13	92
Hanzhou	523	190	436	27	99	454	165	379	23	86
Nanchang	284	46	489	24	343	250	41	431	22	302
Shijiazhuang	246	125	196	5	16	218	111	174	4	14
Urumqi	340	100	337	37	126	307	90	304	33	114
Jilin	144	59	142	1	5	131	54	129	1	5
Qiqiharer	157	51	157	0	46	144	47	144	0	42
Guiyang	175	80	150	4	76	163	74	139	4	70
Tangshan	279	159	227	7	24	263	150	214	6	22
Baotao	241	115	202	2	33	238	113	200	2	33
Shenzhen	142	121	140	0	0	162	138	160	0	0
Shantou	376	82	370	5	118	558	121	548	8	175

/a PU: public utility.

Source: Ministry of Construction (1994), *1993 Urban Construction Statistical Report*.

ANNEX TABLE 4.1: DAILY TRIP RATES BY CITY

City and Survey Year	Year 1993 Population ('000)	Average Daily Trips Per Person	
		Resident Population	Floating Population
Tianjin, 1993	4,671	2.02	1.98
Wuhan, 1993	3,459	1.80	na
Guangzhou, 1984	3,037	2.28	3.22
Chengdu, 1987	1,835	2.16	2.63
Jinan, 1988	1,604	1.68	1.77
Qingdao, 1993	1,571	1.73	2.49
Zibo, 1989	1,270	na	na
Fushun, 1995	1,233	2.73	2.56
Fuzhou, 1993	930	2.40	4.00
Nanning, 1993	802	2.53	na
Shantou, 1994	674	2.75	na
Zhongshan, 1995	329	2.90	4.00
Wuzhou, 1993	229	2.12	na

ANNEX TABLE 4.2: MODAL SPLITS BY RESIDENT POPULATION, 18 CHINESE CITIES

City and Survey Year	Year 1993 Population ('000)	Modal Splits by Resident Population (%)							
					Others				
		Public Transit	Bicycle	Walk	Company Vehicle	Taxi	Motor-cycle	All	Total
Shanghai, 1986	8,104	24.0	34.2	38.2	2.2	0.2	0.2	3.6	100.0
Beijing, 1986	5,983	24.3	54.0	13.8	4.4	0.3	na	7.9	100.0
Tianjin, 1993	4,671	4.1	60.5	28.0	3.1	na	2.0	7.5	100.0
Shenyang, 1990	3,724	8.0	60.2	28.7	na	na	na	3.1	100.0
Wuhan, 1987	3,459	24.5	32.6	32.6	4.7	0.1	0.2	10.3	100.0
Guangzhou, 1992	3,037	21.7	33.8	30.6	na	6.1	6.4	13.9	100.0
Chengdu, 1987	1,835	5.8	54.6	36.0	0.0	0.0	0.0	3.6	100.0
Jinan, 1988	1,604	6.7	63.8	23.3	3.8	0.0	0.8	6.2	100.0
Qingdao, 1993	1,571	21.9	17.9	47.1	9.3	0.4	0.8	13.1	100.0
Zibo, 1989	1,270	2.9	76.0	19.0	na	na	0.6	2.1	100.0
Anshan, 1995	1,240	12.1	57.4	22.7	4.6	0.9	1.4	7.8	100.0
Fushun, 1995	1,233	17.7	23.4	51.0	na	na	na	8.0	100.0
Urumqi, 1993	1,108	18.6	21.9	48.7	7.0	na	na	10.8	100.0
Fuzhou, 1993	930	2.4	60.9	25.4	1.5	0.3	4.3	11.3	100.0
Nanning, 1993	802	2.2	58.9	22.8	3.0	1.2	6.2	16.1	100.0
Shantou, 1994	674	0.5	52.5	32.6	1.0	0.8	11.4	14.4	100.0
Zhongshan, 1995	329	3.6	33.0	25.8	6.6	1.0	24.6	37.6	100.0
Wuzhou, 1993	229	4.7	50.9	31.4	2.3	0.3	1.5	13.0	100.0

ANNEX TABLE 4.3: MODAL SPLITS BY FLOATING POPULATION, SIX CITIES

City and Survey Year	Modal Splits by Floating Population (%)							
	Public Transit	Company Vehicle	Taxi	Motor-cycle	Bicycle	Walk	Other	Total
Tianjin, 1993	29.8	15.9	n/a	0.7	6.1	19.1	28.4	100.0
Guangzhou, 1993	45.9	1.9	17.0	0.2	2.0	24.5	8.4	100.0
Chengdu, 1987	40.0	n/a	6.0	n/a	n/a	28.0	26.0	100.0
Jinan, 1988	38.0	12.8	1.8	1.2	14.5	21.0	10.7	100.0
Qingdao, 1993	25.0	10.4	18.7	0.3	0.2	28.5	8.6	100.0
Fushun, 1995	26.3	5.2	2.3	0.0	18.4	38.1	9.7	100.0

ANNEX TABLE 4.4: AVERAGE TRAVEL TIME BY MODE, SELECTED CITIES

City and Survey Year	Year 1993 Population ('000)	Average Travel Time Per Trip (Minutes)						
		Walk	Bicycle	Bus & Trolleybus	Company Vehicle	Taxi	Motorcycle	Others
Wuhan, 1993	3,459	18	23	55	46	46	25	n/a
Guangzhou, 1993	3,037	15	23	44	48	n/a	n/a	n/a
Chengdu, 1987	1,835	16	22	46	n/a	n/a	n/a	n/a
Jinan, 1988	1,604	18	22	44	37	n/a	n/a	n/a
Zibo, 1989	1,270	14	16	23	n/a	n/a	17	24
Anshan, 1995	1,240	19	28	38	34	29	22	31
Fuzhou, 1993	930	15	23	38	39	32	20	26
Nanning, 1993	802	17	22	38	21	25	15	20
Shantou, 1994	674	15	18	47	27	38	15	n/a
Zhongshan, 1995	329	18	15	44	29	18	15	24
Wuzhou, 1993	229	19	23	31	28	25	19	37

ANNEX TABLE 4.5: PEAK-HOUR TRIP RATIOS BY MODE, 10 CITIES /a

City and Survey Year	Peak-Hour Trip Ratio (%)							
	Public Transit	Company Vehicle	Taxi	Motor-cycle	Bicycle	Walk	Other	All Modes
Wuhan, 1993	21.9	23.7	18.5	19.1	25.2	22.1	n/a	22.8
Guangzhou, 1993	20.6	22.3	12.0	13.8	24.2	19.1	n/a	21.2
Chengdu, 1987	n/a	n/a	n/a	n/a	n/a	n/a	n/a	18.3
Jinan, 1988	17.9	21.5	n/a	n/a	24.3	17.6	n/a	22.0
Zibo, 1989	11.7	n/a	n/a	4.5	11.1	9.9	8.5	n/a
Fuzhou, 1993	23.2	n/a	n/a	19.5	23.4	21.6	n/a	n/a
Nanning, 1993	16.0	16.0	12.0	14.0	12.0	19.0	n/a	n/a
Shantou, 1994	9.3	17.4	9.7	14.8	16.6	12.9	n/a	14.0
Zhongshan, 1995	23.9	21.2	3.9	17.6	18.7	14.4	25.4	n/a
Wuzhou, 1993	18.5	24.3	23.3	19.5	17.9	16.4	n/a	n/a

/a Peak-hour trip ratio is the share of trips generated during the AM peak hour over total daily trips.

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