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KOREA: OPTIONS FOR SECONDARY CITY URBAN TRANSPORT

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The views expressed are entirely those of the authors as is the responsibility for any errors.

PREFACE

i. The present report is one of five major reports prepared for the study of the Urban Sector in the Republic of Korea undertaken by the World Bank in 1977. In its present form it is just a working document which represents only the views of the authors and cannot be quoted as representing the official views of the World Bank nor its affiliated organizations. It will be used for the preparation of a more comprehensive document integrating the findings of various study teams. Because the preparation of this more comprehensive document will require additional time, and reviews, it has been thought useful to outline briefly and informally the nature and organization of this study of the Korean Urban Sector.

ii. Over the last twenty years the Republic of Korea has established one of the best records in terms of rapid economic growth. This growth has been accompanied by a similarly rapid rate of urbanization which by some measures has been the highest in the world for countries over 15 million people. These changes have now transformed South Korea into a society where urban policy issues are occupying a more and more conspicuous place. During the year 1977 it was decided that the World Bank should engage in a review of some of the major problems and opportunities created by urbanization in Korea for three main reasons. First, the review of the Korean experience would be of value to the Bank in its operations in Korea, second a large amount of the new investment based on foreign loans has a major direct impact on Korean cities. Finally, the Korea case is of particular interest because of the rapid evolution of the economy and the relatively large information base permitting a good documentation of this evolution. Documenting the Korean case in more detail would provide a very useful point of reference for the understanding of urbanization patterns in other countries.

iii. Given the time and resource constraints imposed on the review, selectivity was necessary. It was decided that the focus of the analysis should be on the urban problems of non-metropolitan cities, that is to say, the Korean cities other than the two major urban centers of Seoul and Busan. It was felt that the complexity of the problems in Seoul and Busan would require analyses of greater depth and larger scale than could be possible with the resources available. In addition, justification of the focus on the non-metropolitan Korean cities could be based on four broad arguments: (1) These cities are already experiencing a very rapid demographic growth, and will have to accommodate even more people in the future if the growth of the metropolitan cities is to slow down. (2) Quite a few of these cities have become capable of attracting new industries and need to guide their internal growth more effectively. (3) There have been serious debates on whether infrastructure and operating costs in these cities are not likely to be lower than in the metropolitan centers. (4) Non-metropolitan cities must play a greater role in reducing regional inequalities.

iv. The participants in the Korea Urban Sector Study listed by area of responsibility have been:

<u>Urban Transport</u>:

- Christopher Turner, Partner, Nathaniel Lichfield and Partners, London.
- Michael Beesley, Professor, University of London and Partner, Nathaniel Lichfield and Partners.
- Peter Gist, Nathaniel Lichfield and Partners.
- Whang, Kyu-Bok, Korea Institute of Science and Technology, Seoul, Korea.

Housing:	- Bertrand Renaud, World Bank.
	- James Follain, The Urban Institute, Washington, D.C.
	- Gil-Chin Lim, Princeton University, New Jersey.
Local Finance:	- Professor Roger Smith, University of Alberta, Canada.
	- Professor Kim, Chong-In, Sogang University, Seoul, Korea.
Land Use:	- Professor William Doebele, Harvard University.
	- Professor Hwang, Myong-Chan, Kon-Kuk University, Seoul, Korea.
Environment Law and Planning:	- Professor Julian Gresser, University of Hawaii, Honolulu, Hawaii.

v. In addition to these five major reports, Linda Lessner, Associate Researcher, Urban and Regional Economics Division, World Bank, prepared reports on the legal framework for urbanization in Korea, on the Korean System of Local Government and on the recent history of urban and regional policies in Korea. In anticipation of the beginning of the Korea Urban Sector Study, Professor Koichi Mera of Tsukuba University, Japan, had prepared a report on population distribution policies in the Republic of Korea in 1976.

vi. The organization and the management of the entire project has been the responsibility of Bertrand Renaud, Economist, Urban and Regional Economics Division, Development Economics Department, The World Bank. In addition to his general responsibilities for the entire project and to his more specific responsibility for the housing report, he also performed additional studies of aggregate patterns of urbanization in Korea.

1. INTRODUCTION

A. Background

1.1 This paper presents an assessment of existing urban transport problems and their possible solutions for rapidly growing secondary (provincial) Korean cities in which future Bank interest might be concentrated. The study is one of four such reviews being conducted as part of an overall secondary city urban sector mission. Other papers cover housing, land use and local public finance.

1.2 The detailed background to the transportation sector study is set out in the terms of reference, Appendix A to this report. It is however, important to report here that the study has departed from the original terms of reference (Appendix A) in two major respects. The first concerns the proposed analysis of Busan. Because of the acute shortage of urban transportation (and particularly travel) data for the secondary cities it had originally been intended to base the analysis on the City of Busan (for which a transport study has been carried out) 1/, and to draw inferences from this analysis for the secondary cities. However, Busan is itself not representative of all secondary cities. During discussions early in the study it was concluded that a more appropriate approach would be to develop and test policy alternatives specifically for a 'representative' city, an average of the main secondary cities. A simplified modelling procedure, developed to forecast future travel demand in response to alternative land use, ownership and use regulatory policies, was checked for consistency against the existing situation in Busan. It was then applied directly to

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1/ Busan Transportation Study, KIST 1974.

the analysis of alternative land use and regulatory policies. The 'average' secondary city was constructed, respectively, from the existing and forecast physical and socio-economic characteristics of the four cities of Daegu, Daejon, Gwangju and Jeonju. This method is set out in detail in Section 3.

1.3 The second departure concerns the omission of the goods movement sector from our analysis. It has not been possible to make such a study within the available resources.

B. Objectives

1.4 The essential purposes of the study, were first, to review existing transportation conditions in Korean secondary cities; second, to clarify the context and content of decision-making in urban transportation planning and its execution in Korea, as an initial step in the preparation of feasibility studies; and third, to provide appropriate tests of policies for future transportation planning activities.

1.5 The timing of the study is significant for the following reasons. Under the Five Yea. Plan, 1/ personal incomes are forecast to rise at a rate of 7% compound annually, over the period which, *ceteris paribus*, would inevitably lead to a major increase in the demand for car ownership. Further, the role of the Korean motor industry in the country's future industrial development programme is currently being reviewed. To date, the high taxes on car ownership and low personal incomes have tended to suppress the demand for private cars and the industry has been operating

1/ Korea's Fourth Five Year Economic Development Plan, March 1977. Economic Planning Board, Republic of Korea.

well below its capacity of 140-150,000 cars a year. It is considered that there is the possibility of a rapid expansion in the country's level of motorisation at low real costs in manufacturing terms which will be an important part of growth in the Korean economy as a whole. This, together with the personal advantages associated with car ownership, constitutes a pressing argument for a rapid expansion in motorisation. However, these private benefits to car ownership will involve public expenditures and costs, particularly in the cities.

1.6 Again, the new Decentralisation Strategy, 1/ announced in March 1977, is likely to place even more growth pressures on the four provincial cities that form the focus of the study, Daegu, Daejon, Gwangju and Jeonju. This is because these cities have been designated as target cities for the absorption of the Seoul surplus population, in addition to being designated as major growth centres under the previous policy.

1.7 Rising incomes and populations will result in a dramatic increase of demand for mechanised travel of all kinds - buses, taxis, other paratransit as well as cars. Over the time period of analyses to 1985, cars, though growing rapidly, will still constitute a relatively small part of total demand for travel. The substitution of walk trip demand is likely to provide an important source of future mechanised travel.

1.8 For these reasons in particular the study has concentrated on an analysis of the potential impact of rapidly increasing demand for mechanised trip-making on the transport planning problems of Korean non-metropolitan (secondary) cities, and within this the role potentially played by cars.

1/ Decentralisation Strategy, March 1977. Government of Korea.

Because cars represent a very space-consuming form of transport, as opposed to buses, rising car ownership has important implications for these solutions. Alternative sets of land use and pricing (of car ownership and use) assumptions have been postulated and tested.

1.9 To make these tests we have developed a simplified model to project the order of magnitude of total future personal citywide travel demand under alternative land use and pricing assumptions. For each policy, costs have been traced in terms of the stock of vehicles, new road construction and time spent travelling. While conscious of the limitations imposed by the small scale of the exercise, we consider the model to represent an innovation which, with further development, could provide an extremely useful strategic planning tool. We also believe that the magnitude of the projections made under the various policy options, and against which we have framed our recommendations, provide a reasonable indication of the scale of the future travel demand problem facing Korean secondary cities. This is borne out by the international comparison provided in para. 3.44.

C. Organization of Paper

1.10 This paper is set out as follows. Section 2 describes the significant elements in existing conditions, policies and institutional organisations in the urban transport sector which bear upon future transport developments and therefore policy choices. Where possible, comparisons are drawn with other developing countries.

1.11 Section 3 presents the analysis of the future car ownership problem and potential land use and pricing policy solutions to that problem. Section 4 draws together the recommendations which follow both from the analysis of the current situation in the urban transport section (Section 2), and the investigation of future strategic policy alternatives (Section 3).

2. APPRECIATION OF CURRENT SITUATION IN URBAN TRANSPORTATION SECTOR

A. Existing Conditions

(i) Structure of Personal Travel Demand and Forecasting 1/

2.1 The major source of secondary city data for travel demand is the City of Busan, for which a comprehensive transportation study was carried out in 1973. 2/ Given this scarcity of data, the approach taken in predicting likely future developments is to compare the main elements of travel demand recorded for both Seoul, for which data does exist, 3/ and Busan with those of other developing country cities at different stages of their development. The major source of secondary city data for travel demand is the City of Busan, for which a comprehensive transportation study was carried out in 1973. 2/ Seoul is the only other city for which such data exists, and its demand characteristics are compared with those of Busan in Table 1. While total person trip rates/person for Seoul and Busan are similar at the dates for which the information exists, Seoul has a higher level of mechanised person trips/person and a lower non-mechanised trip rate.

2.2 An important part of total person trip making is all walking trips, and to a lesser extent bicycle trips, comprising "non-mechanised" trips. Any prediction of mechanised trip-making must account for transference to mechanised modes. The potential importance of this for Korea is seen in Figure 1. This takes motorisation as a proxy for income and compares total person trips for different cities as motorisation increases.

1/ Note that this discussion relates to total daily trips.

2/ Busan Transportation Study, KIST 1974.

3/ Survey and analysis report on Seoul Urban Transportation, KIST 1970.

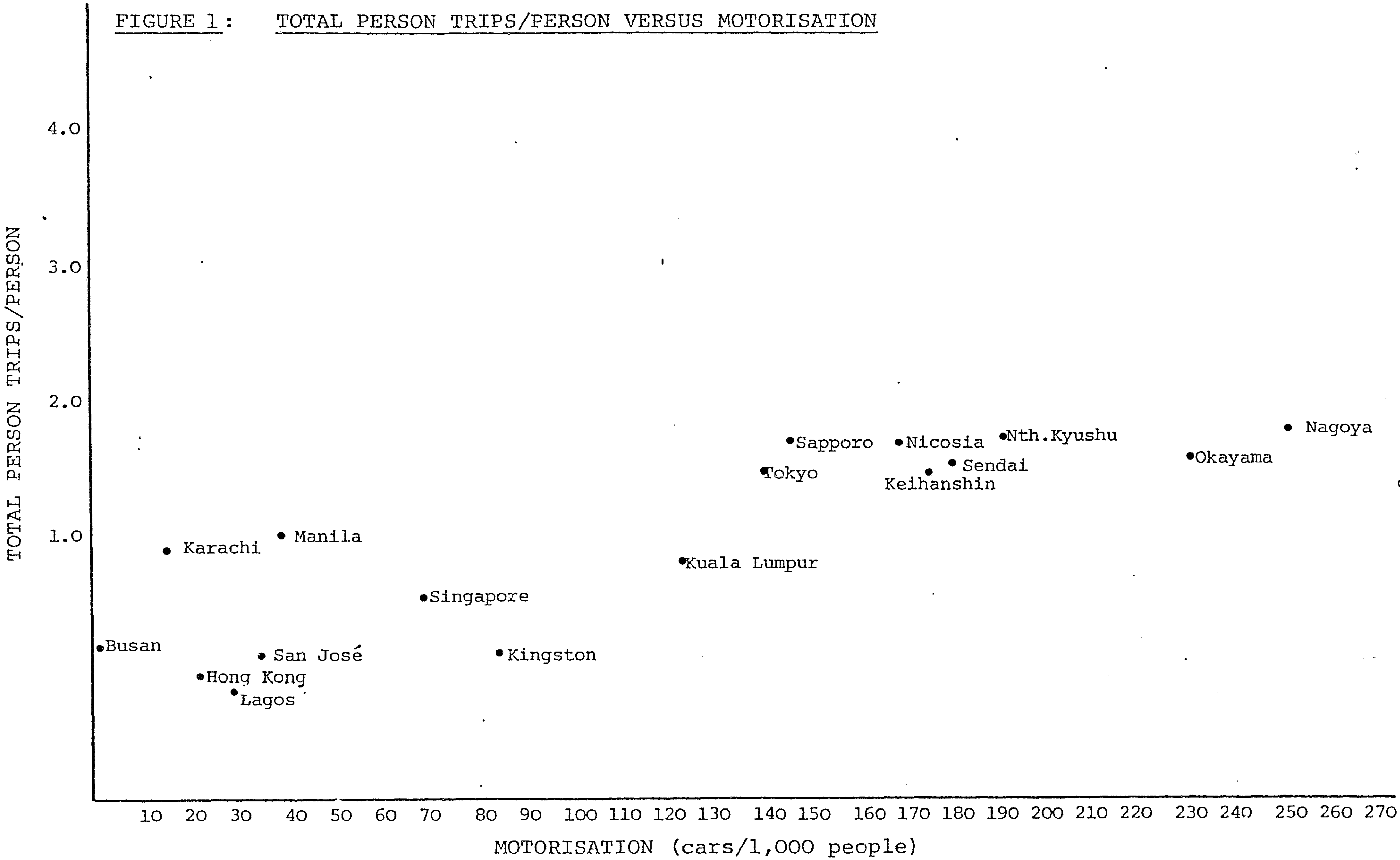
TABLE 1: COMPARISON OF TRAVEL DEMAND CHARACTERISTICS, SEOUL AND BUSAN

MODE	Seoul (1970) Person Trips/Person	Busan (1973) Person Trips/Person
Non mechanised trips	0.350	0.494
Private mechanised trips (Cars)	0.030	0.069
Public mechanised trips (buses and taxis)	0.864	0.720
Total mechanised trips	0.894	0.789
Other	0.045	0.000
TOTAL	1.289	1.283

Sources: Survey and Analysis Report on Seoul Urban Transportation, KIST (1970)

Busan Transportation Study; (KIST 1974)

FIGURE 1: TOTAL PERSON TRIPS/PERSON VERSUS MOTORISATION

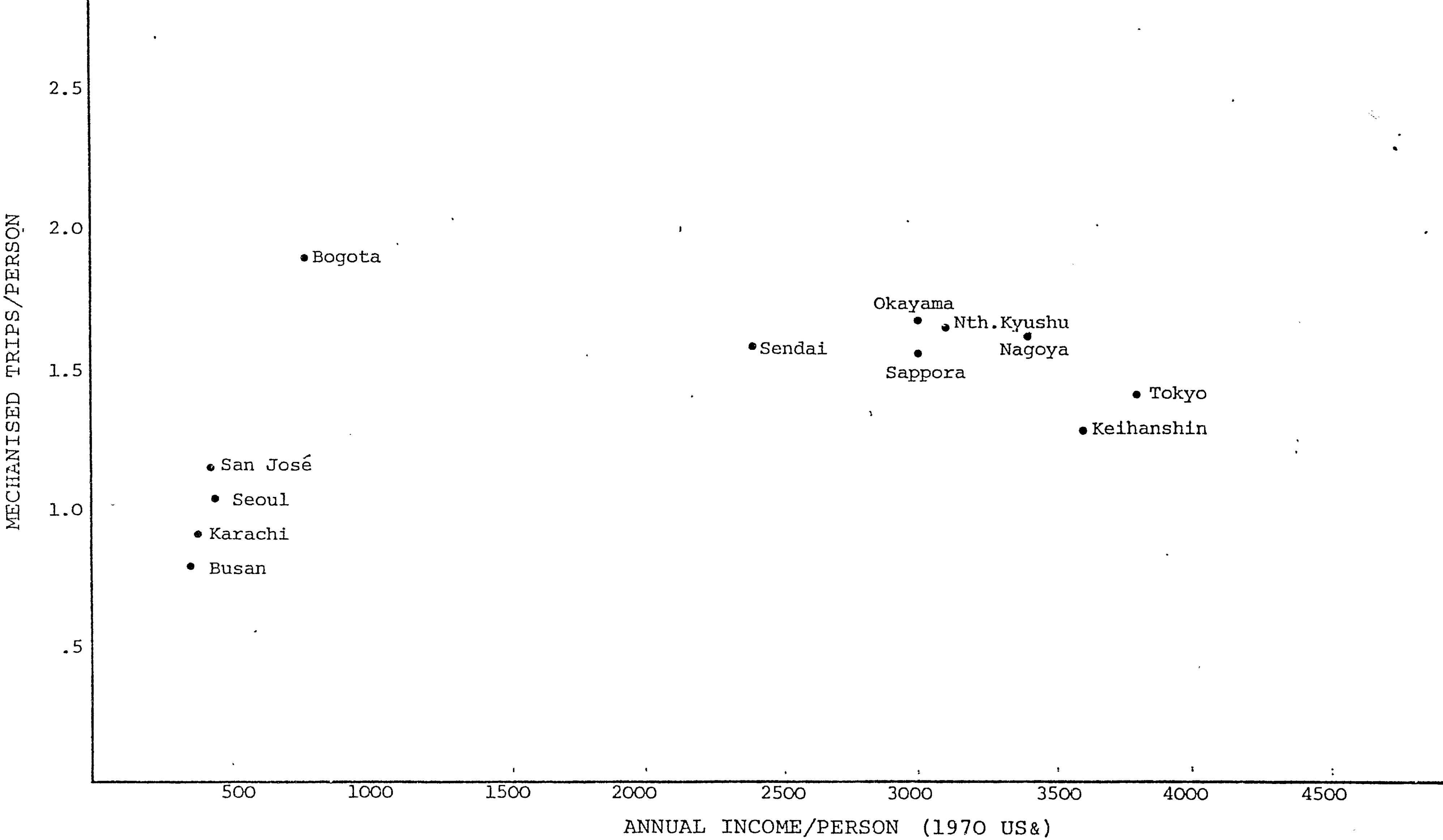


SOURCE: 1. Nathaniel Lichfield and Partners, 1977.
2. Annual Report of Roads 1975 - Japanese Road Association.

Busan's position is not far different from what one would expect allowing for its exceptionally low level of motorisation, because at that level, walking is in any case greatly affecting total person trip-making. We concentrate on mechanised trips of the various kinds here because walking trips are notoriously difficult to survey accurately. Longer walking trips are more likely to be observed and recorded than shorter, and are more likely to be substituted for by mechanised means when incomes increase. For forecasting purposes, then, figures for total person trips will be less reliable than figures for mechanised trips. Total person trips can be expected to grow with income more slowly than mechanised. We assume that non-mechanised trips will remain unaffected by income growth. The figures that are available do not appear to support this assumption (see Table 1.A, Appendix B). Indeed they show a relationship indicating that as income grows so do non-mechanised trips. This is likely to be due to differences in conditions for data collection and reportage. With higher incomes, the greater the chances of full reporting of trips. But differing densities can be expected to affect non-working trips and is taken account of later.

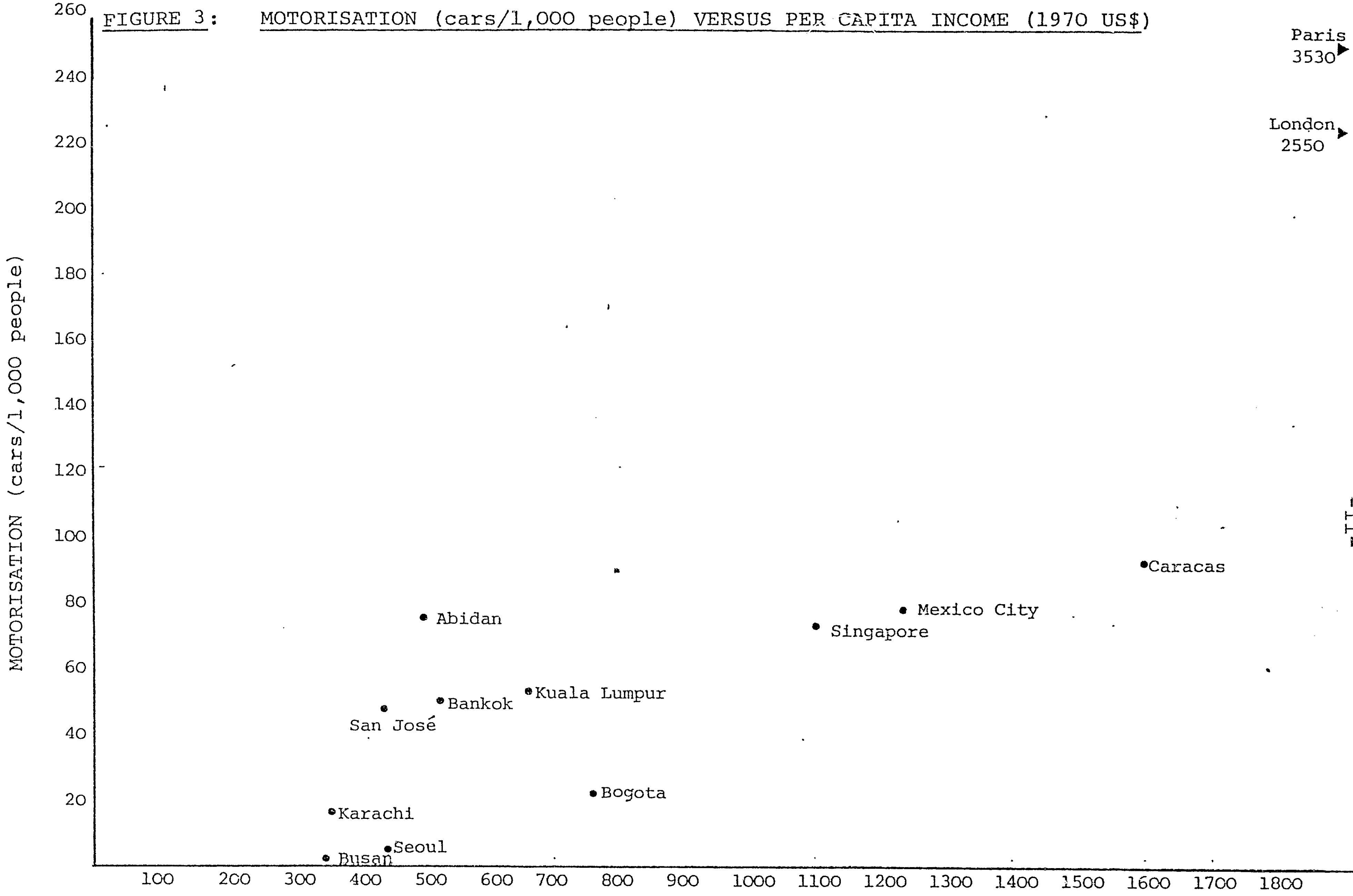
2.3 Judging by the position of Busan and Seoul, Korean cities do not display an exceptional position when mechanised trips per person are considered with respect to income levels (Figure 2). Busan falls little below its expected trip-making level. The striking feature of the current demand for travel in Korean cities is the extremely low level of car ownership ("motorisation") in comparison with non-Korean cities, again when income per head is taken into account (Figure 3).

FIGURE 2: MECHANISED TRIPS/PERSON VERSUS PER CAPITA INCOME (1970 US$)



SOURCES:
1. Nathaniel Lichfield and Partners, Phase I City Study, 1977; "Urban Transport", Sector Policy Paper, IBRD, 1975.
2. Annual Report of Roads, 1975, Japanese Road Association.

FIGURE 3: MOTORISATION (cars/1,000 people) VERSUS PER CAPITA INCOME (1970 US$)



SOURCES: 1. Zahavi "Travel Characteristics in Cities of Developing and Developed Countries" IBRD Staff Working Paper No.230.
2. Nathaniel Lichfield and Partners 1977.

2.4 Significant structural changes in the ownership of cars can be observed over time with rising incomes (Table 2). In particular, there has been a significant increase in the ownership of private and business cars and a parallel decline in the market share of taxis. These trends are consistent with those experienced in Japan at a rather later stage of its development (Table 3). 1/

2.5 It has been possible to break out the business and private market shares for Japan, and this reveals that while both shares increased rapidly initially, the proportion of business car stocks has subsequently levelled off while the private car ownership market share has continued to increase. It is entirely possible, and indeed to be anticipated, that a similar shift is currently taking place in Korea, although the data does not allow this to be estimated directly. For forecasting, it seems appropriate to focus on income per head.

2.6 One other point of interest concerning the mechanised market in Korea is the very small role played by motorcycles. In Seoul for example, this mode accounted for only 0.65% of all person trips in 1970. According to a six city study in Japan 2/ the figure varied between 8.2% and 22.5% in 1970. We assume that, principally for reasons of climate, motorcycles will not be an important mode fo: .ip making in our model.

2.7 Seoul has a greater r..te of public trip-making/person and a lower private trip/person rate than Busan (Table 1). The differences in non-mechanised/ mechanised trip rates are consistent with the income differential

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1/ In fact in terms of national income/capita, the 1957-1961 range for Japan was US$440-660; and for Korea (1970-75), US$230-403, in 1970 constant prices.

2/ Annual Report of Roads, Japanese Road Association, 1975.

TABLE 2: THE STRUCTURE OF KOREAN CAR OWNERSHIP

Breakdown of Total Car Stock by Type

Year	Official		Business and Private		Taxis		All Cars	
	Total	%	Total	%	Total	%	Total	%
1966	1,345	11	7,481	43	8,176	47	17,502	100
1967	2,247	10	9,871	42	11,117	48	23,235	100
1968	2,787	8	14,397	43	15,928	48	33,112	100
1969	3,128	6	23,690	47	23,475	47	50,299	100
1970	3,547	6	28,687	47	28,443	47	60,667	100
1971	3,961	6	33,994	50	29,627	44	67,582	100
1972	4,507	6	36,412	52	29,325	42	70,224	100
1973	5,046	6	43,400	55	29,885	38	78,334	100
1974	4,837	6	44,618	58	27,007	35	76,462	100
1975	5,023	6	50,093	59	29,090	35	84,212	100

Source: KIST 1977

TABLE 3: THE STRUCTURE OF THE JAPANESE CAR OWNERSHIP

% Breakdown of Total National Car Stock by Type

YEAR	OFFICIAL	BUSINESS	PRIVATE	BUSINESS & PRIVATE	TAXIS	TOTAL
1957	3.0	57.2	7.9	65.1	31.9	100
1958	3.5	56.9	12.3	69.2	27.4	100
1959	5.7	59.2	13.9	73.1	21.2	100
1960	3.7	59.4	16.0	75.4	20.9	100
1961	4.5	57.0	23.0	80.0	15.5	100

SOURCE: KIST 1977

that existed at the dates of the studies 1/ and the substitution of mechanised for non-mechanised trips in Seoul. The differences in the rate of private mechanised trips are more difficult to explain as one would expect the rates to be reversed, the differential could be in part attributable to the higher densities of the capital and a superior public transport system. The complete data sets and sources in this comparison are set out in Appendix B.

2.8 The likely future course for travel growth in Korea is, then, first a rapid increase in mechanised trip-making as income grows, as shown in Figure 2 and a decrease in non-mechanised trip-making. Were Korea to develop as have other nations, one would expect a rapidly growing share in total mechanised trip-making for private cars, the more marked because of the exceptionally low private ownership levels at which Korea starts. The potential of this increase is clearly brought out by Figure 4. Car ownership does more than create a substitute for trip-making, of course; it also generates more mechanised trips. 2/

2.9 This is basically because of the superiority of the motor car on all attributes concerning mechanised trip-making, except driving itself, once the car is owned (convenience, cheapness per head per trip etc.). Mechanised trip forecasts therefore include the implied trip-generating effect of car ownership.

2.10 Figure 5 summarizes the public transport (including taxi trips) share of the total mechanised market as against motorisation across a range

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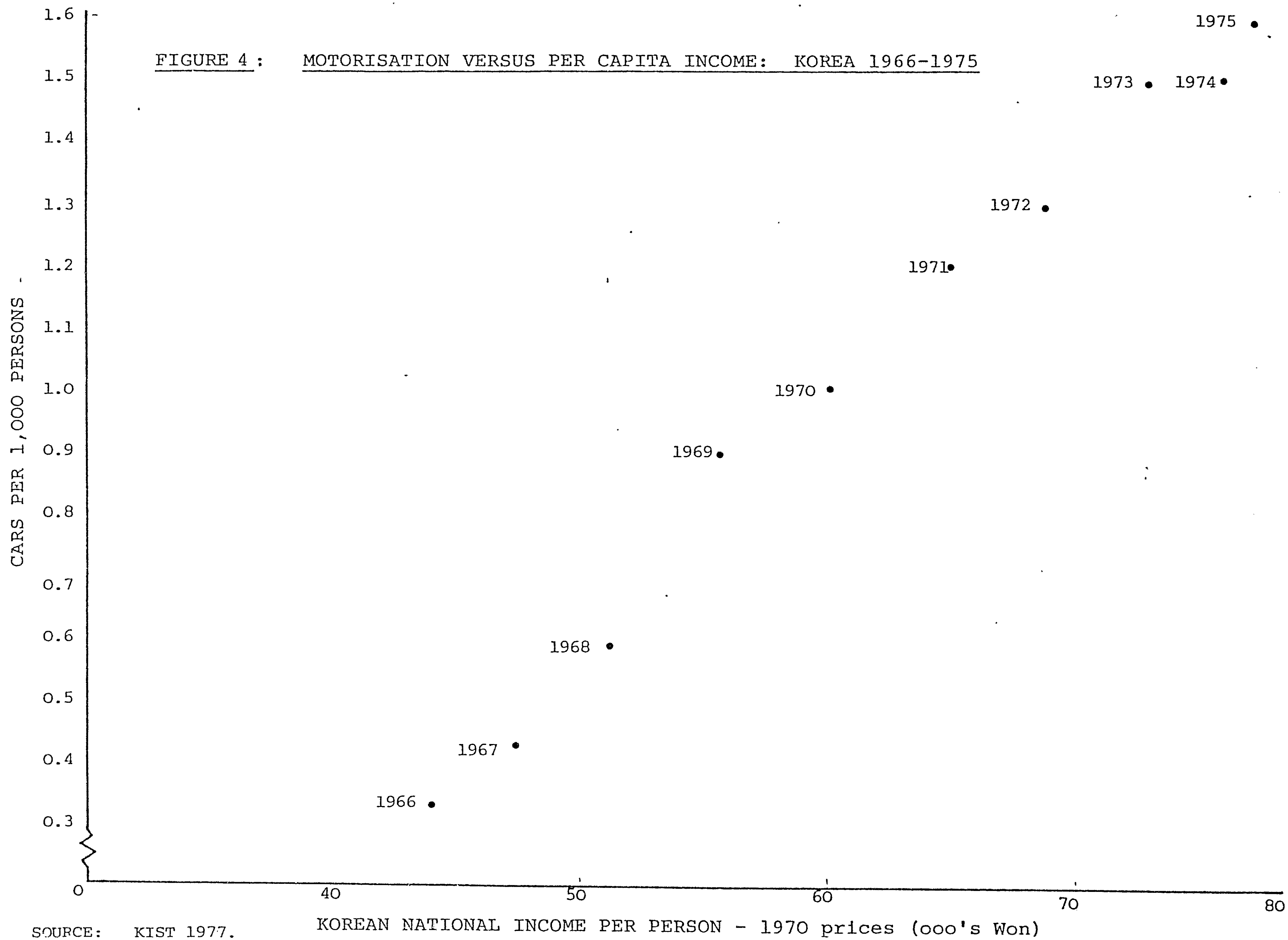
1/ \$440/person for Seoul in 1970, \$350/person for Busan in 1973, in 1970 US\$ national income per person.

2/ This effect can be very significant. In the Nagoya region of Japan for example, car owners made 3.56 trips for every 2.49 trips/person made by non-car owners in 1970, a 43% difference.

FIGURE 4 : MOTORISATION VERSUS PER CAPITA INCOME: KOREA 1966-1975



SOURCE: KIST 1977.

of developing and developed country cities. It brings out the point that by international standards Korean cities, as represented by Seoul, experience a very high proportion of public transport use. It is, however, the combination of high car taxes and relatively low income levels rather than the quality of public transportation in Korean cities, see Section 2.A(ii) which accounts for the current level of use. In this connection it is interesting to compare the level of car tax in Korea with that of Japan in 1976 (Table 4). This reveals that purchase taxes on the average car were about three-quarters of those levied in Korea. As seen later, these taxes account for less than half of Korean car taxes. Annual taxes in Japan were only about one-sixth of those in Korea. In 1976 Japan's income per head was about eight times that of Korea.

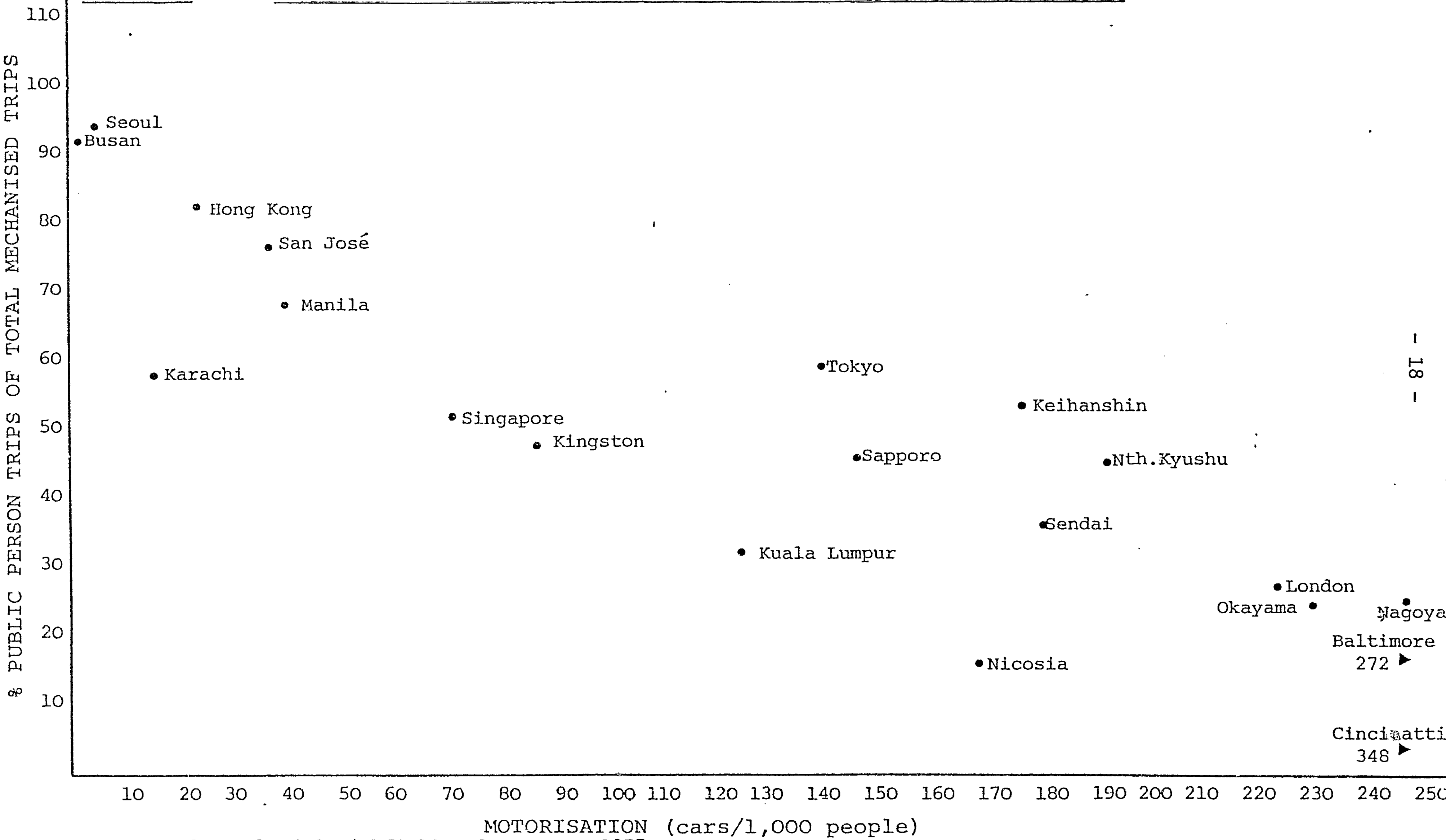
(ii) <u>Characteristics of Supply</u>

<u>Infrastructure</u>

<u>Urban Roads</u>

2.11 A relatively small proportion of the urban areas of Korean cities is given over to road space. This is brought out clearly by international comparisons presented in Table 5, in terms of the percentage of urban area used for roads. The secondary road system in particular is extremely poor and in some instances does not exist at all. Though levels of traffic are also comparatively low, there is considerable pressure on the primary road system both through the concentration of mixed land uses along the main corridors and the use of the major road system for highly localised journeys. Although quantitative figures are not available, facilities for both pedestrians and cyclists also appear small, particularly given the large proportion of the total travel market that they represent.

FIGURE 5: PUBLIC TRANSPORT SHARE OF MECHANISED TRIPS VERSUS MOTORISATION



SOURCE: 1. Nathaniel Lichfield and Partners 1977
2. Annual Report of Roads 1975 - Japanese Road Association

TABLE 4: COMPARISON OF AUTOMOBILE RELATED TAX RATES IN KOREA AND JAPAN FOR A STANDARD 1500 CC NON COMMERCIAL USE PASSENGER AUTOMOBILE 1976

(A = Commodity Value)

	Korea	Japan	Japan/Korea (%)
PURCHASE TAXES:-			
Commodity tax	$0.2A (A \times \frac{20}{100})$	$0.15A (A \times \frac{15}{100})$	
Defense tax	$0.04A (0.2A \times \frac{20}{100})$	-	
Acquisition tax	$0.0248A \left[(A+0.2A+0.04A) \times \frac{20}{1000}\right]$	$0.0575A \left[(A+0.15A) \times 0.05\right]$	
SUB TOTAL	0.2648 A	0.2075A	78.36%
YEARLY TAXES:-			
Licence tax	14,400 W/Yr	-	
Weight tax	-	17,000 W/Yr	
Auto tax	249,600 W/Yr	35,700 W/Yr	
Defense tax	74,880 W/yr	-	
SUB TOTAL	338,880 W/Yr	52,700 W/Yr	15.55%

SOURCE: "A study of the Automobile Industry Development Plan". The Korean Automobile Manufacturers Association 1977.

TABLE 5: INTERNATIONAL COMPARISONS OF % OF URBAN AREA USED FOR ROADS (PAVED, GRAVELLED, UNREPAIRED)

	% of urban area used for roads
KOREAN CITIES:-	
Seoul	6.3
Busan	3.4
Daejon	7.5
Jeougu	1.7
Gwangju	2.3
Daegue	4.8
OTHER CITIES:-	
Salisbury (Rhodesia)	38.0
Leiden (Netherlands)	16.0
Dublin (Ireland)	12.0
Lisbon (Portugal)	20.0
Tel Aviv (Israel)	12.0
Madrid (Spain)	17.0
Denver (USA)	26.0
Los Angeles (USA)	23.0
Hamburg (Germany)	19.0
Gothenburg (Sweden)	18.0

SOURCE: Korean Muncipal Yearbooks 1976; R.J. Smeed "Traffic Studies and Urban Congestion", Journal of Transport Economics and Policy January, 1968.

2.12 The relatively small area given over to road space in Korean cities should not, however, be regarded as a justification for a major road building programme. Indeed, one of the consequences of the successful suppresion of car ownership and private travel demand has been a lower investment requirement for urban road construction. While the pressures for new road construction will undoubtedly increase with rising mechanised trip-making, and within that, rapidly increasing car ownership, the extent to which such construction will be necessary becomes very much a function of the success of future policies in restraining private travel demand. This is taken up in Section 3.

2.13 Much the same applies to parking provision. In all cities, prospective growth in motorisation will lead to greatly increased demands for parking. Present provision, even when augmented by new measures which have been introduced to make new developments provide their own parking spaces, may not seem adequate. Moreover, the high price and great scarcity of parking, caused by the high opportunity costs of urban land, could well continue to act as a disincentive to the provision of substantial new parking space.

Public Transport

2.14 The supply of conventional public transport per person in Korean secondary cities is compared with that of other developing country cities in Table 6. The public transport share of the mechanised travel market is also summarized for those cities for which the data are available. As might be expected from our earlier discussion, the Korean cities have rather similar levels of bus and taxi provision (Tables 6 and 7), once allowance is made for their lower incomes per head.

TABLE 6: CHARACTERISTICS OF BUS PROVISION

No. Buses		Population	Buses/Person	Public Transport Share of Mechanised Market
Seoul	4,305	5,525,000	.0009	.92 (1970)
Busan	1,329	2,573,713	.0005	.89 (1973)
Daegu	702	1,359,040	.0005	
Daejon	217	522,439	.0004	
Jeonju	182	625,007	.0003	
Kwangju	201	322,020	.0006	
Calcutta	886	3,399,000	.0003 (1964)	
Hong Kong	1,920	3,068,000	.0006 (1966)	.82
Karachi	1,248	2,350,000	.0005 (1970)	.58
Kuala Lumpur	715	912,000	.0012 (1973)	.33
Manila	3,285	4,400,000	.0007 (1970)	.68
Singapore	3,300	2,150,000	.0015 (1972)	.52

Notes: 1. Korean figures for 1976 unless otherwise stated

Source: Korean source - Statistical Year Book 1976

Non-Korean source - Nathaniel Lichfield & Partners Phase 1 City Study "Urban Transport Sector Working Paper", Information Availability and Travel Characteristics in Developing Cities, 3rd June, 1977.

TABLE 7: CHARACTERISTICS OF TAXI PROVISION

		Population	Taxis	Taxis/ooo Persons
Seoul		6,541,500	11,964	1.8289
Busan		2,306,041	3,488	1.5125
Gaegue		1,266,233	2,099	1.6577
Kwanju		588,662	643	1.0923
Daejon		476,660	856	1.7958
Jeonju		303,261	314	1.0354
Calcutta	(1964)	3,399,000	4,000	1.1768
Hong Kong	(1966)	3,068,000	3,728	1.2151
Karachi	(1971)	2,350,000	3,582	1.5243
Kuala Lumpur	(1973)	912,490	1,610	1.7644
Singapore	(1972)	2,150,000	5,000	2.3256

NOTES: 1. Korean figures for 1976.

SOURCE: Korean source - Statistical Year Book 1976
Non-Korean source - Nathaniel Lichfield and Partners
Phase 1 City Study, "Urban Transport Sector Working Paper",
Information Availability and Travel Characteristics in
Developing Cities, 3rd June 1977.

2.15 Apart from taxis, conventional bus service is the only form of public transport provided in Korean secondary cities, and this service itself has four major characteristics. First there is an obvious overloading of vehicles with buses operating above their seating capacity even in the off-peak period on many routes. Second, the route structure in most cities is oriented towards the CBD, (137 of the 157 routes in Seoul cross the CBD), whilst many of the outlying areas have few buses. Third, the design capacity of Korean buses is high (average seat capacity of sixty and crush capacity of almost ninety). Given their secondary road access problems, many suburban residential neighbourhoods have low accessibility. Fourth, there is an absence of bus priority measures such as lane reversal, bus lanes, bus ramps at intersections, bus priority through signalisation, wider bus stop spacing and other such measures designed to use the existing road space and road improvements to the advantage of public transport users.

2.16 The bus services in Korea are provided by a large number of private bus companies, licensed to operate by the Ministry of Transportation. Fares are regulated nationally by the Ministry and routes are fixed by the Municipal Bureau of Transportation. Recent legislation has compelled bus operators to incorporate. Their decisions to change the sizes of their fleets are also subject to regulation.

2.17 Fares are uniform for the cities with which we are concerned. Since costs vary across cities, the operators of different cities vary in their profitability. Differences between operators of the various cities are reflected in Table 8. From it, some comparisons can be drawn between

TABLE 8: BUS OPERATING CHARACTERISTICS, 1976 (Cost, revenue data in Won)

	SEOUL	BUSAN	DAEGU	DAEJON	JEONJU	GWANGJU
No. of Bus Companies	91	22	13	4	4	6
No. of Buses	4,793	1,329	702	217	182	201
Av. No. of Buses per Company	52.67	60.41	54.00	54.25	45.50	33.50
Average Monthly Total Cost/Bus	1,389,914	1,481,505	1,201,618	1,077,326	1,112,343	1,114,344
Average Monthly Labour Cost/Bus	411,151	382,200	247,157	278,471	326,197	289,001
Average Monthly Revenue/Bus	1,118,513	1,065,501	1,030,585	1,108,502	1,074,039	1,117,208
Average Monthly Kilometres/Bus	9,041	9,015	10,696	9,370	8,924	8,394
Average Monthly Passengers/Bus	34,769	32,410	34,122	33,910	24,397	45,414
Average Monthly Labour/Total Cost Ratio/Bus	0.30	0.26	0.23	0.26	0.29	0.26
Total Monthly Revenue/Cost Ratio/Bus	0.80	0.72	0.86	1.03	0.97	1.06

SOURCE: KIST, 1977

the four cities of our study on the one hand and Seoul and Busan on the other. Each city has relatively few companies in total compared to Busan (and to Seoul in particular), although the number of buses/company varies considerably, with Gwangju having the lowest figure. In terms of service level provided, expressed by bus use, Gwangju is significantly worse off than the other five sample cities. On the whole, the four secondary cities have relatively more profitable companies, though on average the work done by buses, as represented by kilometres per bus and revenues, are broadly similar. It seems likely that the major distinction lies in the lower wages which the four have to pay.

2.18 Pricing and regulatory policies for taxis mirror those for public transport. Fares are set uniformly on a national basis, while the number of companies and vehicles in each city are regulated through a licensing policy which is applied and monitored in the same manner as bus transport. Shared rides are also currently prohibited in Korean cities to avoid what is regarded as excessive profiteering on the part of the taxi drivers.

B. Principal Existing Urban Transport Policies

(i) Investment Policies

2.19 Urban road proposals are usually generated through the statutory city master planning process, within the context of which each city must produce an annual programme of projects. These projects are then included in the city's budget proposals which are forwarded to the Provincial Government for approval and subsequently to the Ministry of Home Affairs.

2.20 In addition, major urban road projects can be funded in part by the Ministry of Construction. One example of this is the Busan Container

Road, which will link the port of Busan with the Seoul-Busan expressway. Fifty percent of the cost of this project is being met by the city of Busan and fifty percent by the Ministry of Construction.

2.21 Within the definition of existing functions little emphasis and indeed opportunity is given to public transport investment. This is to be expected, since investment in public transport has to date come almost exclusively through the private, and until recently, the informal sector. So, in the City of Busan's current annual budget, while 30% of the total is allocated to road construction (including the city's share of the new container road) no provision is made for investment in public transport.

2.22 The policies to be investigated imply needs for investment in public transport from whatever source is appropriate. A major priority of urban transportation policy will clearly be the formulation of a consistent public transport investment strategy for secondary cities. This would cover both the necessary infrastructure improvements and also investment in new vehicles, both conventional buses and smaller more flexible para-transit vehicle types. By 'para-transit' is meant forms of public transport spanning the range between conventional bus and taxi services, including jitneys, microbuses, hire cars, limousines and their various forms of organisation. This differentiation of public transport is, where permitted, a response to two main effects of income growth - diversifying demands and rising labour costs, which strongly influences total costs of operation.

2.23 Creating the conditions in which an appropriate investment in vehicles will take place involves a review of organisational arrangements and regulatory and fare control practices.

(ii) Pricing Policies

Car Ownership and Use

2.24 The pricing of car ownership has been the single most effective urban transport policy instrument to date in discouraging private travel demand in Korean cities. The taxes and other imposts together set an exceptionally high price on car ownership. In 1975 for example, the taxes payable on the purchase of an average car (e.g. a Pony), amounted to 42% of the factory price. Taxes levied annually (motor vehicle tax, defense surtax and licence) amounted to an additional 57% of the base factory price. A use tax is also levied on petrol. The time series structure of these ownership and use taxes is set out in Table 9 at constant 1970 prices for those years for which the data is available, for an average family car.

2.25 The Government also levies a National Highway Bond of ₩500,000 on the purchase of a car, on which the Government pays interest. The purchaser usually finances this bond through a loan raised on the commercial market, and on which he pays the difference between the Government and commercial rates of interest. Finally, this year the Government has imposed VAT at a rate of 10% on the factory price less input cost. This is in addition to the existing taxes on ownership.

2.26 However, while such policies have been effective in the past, maintaining checks on car ownership will imply dramatic increases in taxes given the expected increase in personal income levels. It is possible that the thrust of future pricing policies will have to shift progressively away from taxes on car ownership to taxes on use if future effectiveness is to be maintained. This is an issue to which we return in Section 3.

TABLE 9: TAXES ON OWNERSHIP AND USE FOR THE AVERAGE KOREAN CAR

YEAR	CURRENT FACTORY PRICE (WON)	FACTORY PRICE (1970) (PRICES)	TAXES INCLUDED IN FACTORY PRICE		REGISTRATION TAX (1970) (PRICES)	ANNUAL TAXES ON OWNERSHIP			FUEL	
			COMMODITY TAX (1970) (PRICES)	DEFENCE SURTAX (1970) (PRICES)		MOTOR VEHICLE TAX (1970) (PRICES)	DEFENCE SURTAX (1970) (PRICES)	LICENSE (1970) (PRICES)	RETAIL PRICE PER IMP.GALL (1970) (PRICES)	TAX PER IMP.GALL (1970) (PRICES)
1965	-	-	-	-	-	-	-	-	-	-
1966	967,000	1,296,247	129,625	-	25,925	278,820	-	48,257	-	-
1967	967,000	1,217,884	121,788	-	24,358	261,965	-	45,340	-	-
1968	872,000	1,016,317	101,632	-	20,326	193,939	-	41,958	-	-
1969	1,177,619	1,366,147	136,615	-	27,323	181,659	-	39,301	-	-
1970	1,400,374	1,400,374	323,163	-	28,008	166,400	-	36,000	30.16	16.58
1971	1,390,548	1,225,152	282,727	-	24,503	146,607	-	31,718	31.71	17.99
1972	1,784,260	1,407,145	324,726	-	28,143	131,230	-	28,391	40.22	22,57
1973	1,890,194	1,445,102	333,485	-	28,902	101,835	-	11,009	43.96	24.69
1974	2,416,439	1,386,125	342,951	-	29,723	81,919	-	8,856	111.00	65.32
1975	2,350,132	1,153,722	186,084	37,219	23,074	98,085	29,426	7,069	93.02	61.28
1976	-	-	-	-	-	93,906	28,172	6,787	96.82	63.80

SOURCE: KIST 1977.

C. Land Use Planning and Environmental Controls
Strategic Land Use Planning

2.27 To date the combination of land use policies, notably the green belt policy, and low mobility requirements which result from the low level of personal income has resulted in the evolution of a fairly compact secondary city land use pattern. Mobility requirements have been satisfied mainly by walk, taxi and conventional public transport trips. The current secondary city land use pattern appears to be consistent with the mix of transportation supplies provided (i.e. fairly concentrated development serviced by the walk and public transport modes).

2.28 This 'balance' between land use and transportation is threatened by a combination of factors. First, as we have seen, there is the potential impact of rapidly rising real incomes on the mobility and car ownership expectations of the population. This will inevitably increase the pressures for decentralisation as higher incomes and car ownership levels facilitate the purchase or rent of a greater amount of residential space at a lower cost and greater distance from place of work. Second, as also seen, the new decentralisation policy 1/ will put growth pressures on the secondary cities, and particularly Daegu, Daejon, Gwangju and Jeonju in addition to those which they would have experienced in any event as a result of the previous policy.

2.29 Clearly then there is a need to analyse the likely impact of these changes with a view to the establishment and analysis of consistent future land use and transportation policies. This is taken up in Section 3.

1/ Decentralisation Strategy, March 1977. Government of Korea.

Local Land Use Planning

2.30 Congestion of the road network itself has led some cities, notably Seoul and Busan, to take drastic measures aimed at reducing congestion by the relocation of major generators such as markets, intercity bus terminals and schools outside the CBD. As part of this policy, Seoul's population and employment is being encouraged to relocate at new urban centres south of the Han river, while in Busan, a new industrial centre is being created to the west of the city, and restrictions have been placed on new industrial development within the city.

2.31 In most, if not all, secondary cities there is an urgent need for more consideration to be given to the traffic implications of future local land use policy decisions, if the ad hoc and often ill thought out measures of expediency which are currently the norm, are to be improved upon.

Environmental Controls

2.32 Environmental controls on mobile sources (vehicles) are currently enforced through spot checks on vehicle emission levels rather than through legislation designed to make the combustion engine more efficient and hence less of a pollutant. As a result of this policy and the age of the bus and taxi fleet, there are a large number of recorded pollutant violations but little progress towards any improvement in environmental conditions.

2.33 Environmental conditions could potentially be improved in a number of ways, ranging from the production of a more efficient combustion engine to measures designed to reduce travel demand at source through integrated land use planning. A number of such solutions have been proposed for example, by the United States Environmental Protection Agency in their guidelines for the reduction of air pollution through transportation and land use planning. 1/ The potential application of such measures in the Korean context should be investigated.

D. Decision Making in the Urban Transportation Sector

(i) Road Investment

2.34 This is probably the most clearly defined function within the transportation sector, although there are some major points of uncertainty with respect to functional responsibilities and investment criteria. At the national level, the Economic Planning Board is responsible for the national budget proposal, allocation and dispersal. The budget proposal task itself is delegated to two national ministries, the Ministry of Home Affairs and the Ministry of Construction.

2.35 The Ministry of Home Affairs is responsible for the co-ordination and approval (but not formulation) of the budgets of the cities and provices which are presented for each sector, while the Ministry of Construction generates many of its own project and budget proposals at the national level.

2.36 The budget proposals of the cities reach the Ministry of Home Affairs by the following process. Proposals are generated by the City Masterplanning process, itself the responsiblity of the Bureau of City Planning. Depending upon city size these masterplans are then taken to the National Planning Review Committee or Provincial Planning Review Committee

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1/ "A Guide for Reducing Automotive Air Pollution", prepared for the Office of Air Programs, The Environmental Protection Agency, November 1971 by Alan M. Voorhees & Associates and Ryckman, Edgerley, Tomlinson and Associates.

for approval. Once approved the projects and an implementation programme are included in the City's annual budget proposals prepared by the City Bureau of Construction which are forwarded to the Provincial Government. The agreed city/provincial budget and the projects within each sector are then sent to the Ministry of Home Affairs, which is responsible for the co-ordination of city/provincial budgets at the central Government level. With respect to the allocation of investment across sectors, in Busan for example, approximately 52% of the City's current annual budget is given over to infrastructure and housing, 60% of which is devoted to new road construction. The self-sufficiency of secondary cities in respect of their budgets is in the order of 48%, although in the case of Busan the figure is close to 98%. The balance of each city's budget requirement is made up through a central government subsidy, but clearly there is considerable pressure on the cities to keep the level of this subsidy low.

2.37 The cities are totally responsible for the planning construction and maintenance of two of the three types of roads within their boundaries: provincial roads and city roads. National roads are the responsibility of the Ministry of Construction. Where a section of a national road crosses a city, although the project responsibility rests with the Ministry of Construction, its costs are met from three sources: Ministry of Construction subsidy, the City's own budget and a national tax subsidy (share of tax) allocation by the Ministry of Construction. In addition, the Ministry of Construction will occasionally contribute to major urban road projects, such as the Busan Container Road, where it is providing 50% of the project cost.

2.38 While the smaller cities raise less tax locally for their road building, they are more dependent upon the provincial Government for budget and project approval. This applies equally to all sectors, with less independent sources of funds; they have less freedom to opt for particular solutions to their problems.

(ii) Regulatory Policies

Car Ownership and Use

2.39 Taxes are levied on the purchase of cars by the Ministry of Finance, as are the annual usage taxes with the exception of license fees. Licenses are regulated by the municipalities. The basic regulatory tool is that of pricing and was discussed in Section 2.B(ii).

Public Transport and Taxis

2.40 The Ministry of Transportation has national responsibility for regulating the supply of and pricing policy for buses and taxis. The operation of the policy was discussed earlier in the sections on public transport and is not repeated here. The National Ministry delegates the responsibility for the implementation and monitoring of these policies to the Municipal Bureau of Transportation, while the selection of new operators is, in principle, delegated to the Provincial Governors.

2.41 Fare changes recommended by the Ministry of Transportation are subject to review by the Economic Planning Board, to ensure that they are consistent with national economic policy. Taxi operators applying for licenses have to give proof of assets e.g., office space.

(iii) Traffic Management

2.42 One of the major reasons for the ineffectiveness of traffic management in Korean secondary cities lies in the absence of clearly defined responsibilities for the planning and implementation of traffic management policy. At the municipal level, the responsibilities of the Bureau of Transportation include the monitoring of traffic conditions, regulation of bus and taxi licensing and fare policy, road maintenance and traffic management. The traffic police are responsible for traffic regulations, safety, traffic signals and enforcement. In practice, however, a good deal of confusion exists with respect to the specific responsibilities of the Bureau of Transportation and Traffic Police.

(iv) Land Use

2.43 Insofar as the urban transportation sector is concerned, the formulation of each city's land use policy is the responsibility of the Bureau of City Planning, which in turn receives its guidelines for the preparation of these plans (e.g., extension of the green belt to avoid urban sprawl) from the Planning Review Committee of the National City Planning Bureau of the Ministry of Construction. The Bureau of City planning is also responsible for the City's strategic transportation planning. However a number of land use decisions are also made outside this framework. In Busan, for example, there is a special urban planning committee to deal with short term problems. Their recommendations go direct to the Mayor for approval and then to the National Ministry of Construction. These short term problems and proposed solutions invariably relate to the reduction of special traffic generators, and the prohibition of new building permits.

3. THE ANALYSIS OF FUTURE TRAVEL DEMAND AND POTENTIAL STRATEGIC POLICY ALTERNATIVES

A. Introduction

3.1 The analysis of the existing characteristics of demand for mechanised travel, its likely future growth, and the policies and instruments used to influence it leads to a number of questions for future urban transportation policy making at the strategic level. A very large increase in mechanised trip-making can be foreseen. Despite the present high level of taxation levied on car ownership, the forecast growth of personal incomes is likely to bring about a shift in the existing structure of these trips towards the rapid growth of car ownership and use.

3.2 Such changes are likely to be influenced greatly by the future growth of the secondary cities and the consequential development pressures leading towards suburbanization. Korea will experience these pressures strongly. In other countries, similar pressures have further encouraged car ownership, and major investment in road construction. This has discouraged the use of public transport, the operators of which find themselves facing higher costs and a progressively diminishing share of the total mechanised travel market. A declining central area has usually been associated with these developments.

3.3 To date Korea has successfully avoided the problems which would follow from the progression of events described above, and which have afflicted almost all other developing countries of comparable income levels. However, because the pressures leading in the direction of such changes are certain to increase, it is essential that alternative means of meeting and influencing future travel demand are examined at a strategic (city wide) level.

3.4 The remainder of this section is concerned respectively, with specifying the alternative strategic policies that have been selected for analysis, describing the methodology on which the analysis has been based, and presenting the findings of the analysis. The detailed methodology workings and results of the analysis are presented in Appendix C.

3.5 The findings of this analysis, together with our conclusions on existing conditions, then provide the basis for our recommendations which are set out in Section 4.

B. Specifying the Strategic Policy Alternatives

3.6 Taking as a starting point the analysis of existing demand characteristics relative to the instruments that are used to meet and influence demand in Korean secondary cities, and anticipating the changing structure and greater magnitude of the future demand problem, we believe that the most effective strategic means of providing for and influencing future demand are as follows:

(a) manipulation of demand through regulatory and pricing policies (e.g. ownership and use taxes);

(b) organisation of the forms of supply which are to be encouraged (e.g. public transport);

(c) establishment of urban land use forms consistent with (a) and (b);

and it is on this basis that we set up and tested a range of policy alternatives.

3.7 It will be seen that, associated with each means of influencing demand are anticipated levels of trip-making, and corresponding investments in transport plant (roads) and equipment (vehicles) for the level of trip-making. Thus aggregate costs of transport provision, including the time costs trip-makers themselves expend in travelling, are generated. These different aggregate total costs and their associated trip-making characteristics comprise the transport implications of policy choices. They represent inputs to decisions which will concern far wider issues - housing policy for example - with which we are not concerned directly here. Judging how many trips to encourage, at the costs specified, must be accomplished when the other secondary city urban sector studies are set beside this one. In the sphere of transport itself, however, we are able to make judgements about the relative <u>efficiency</u> and <u>equity</u> of the alternatives.

3.8 We have forecast for 1985 for the 'average' city the outcomes of adopting alternative land use and car pricing policies in the context of growing incomes, demands for mechanised travel, and levels of car ownership. Four future land use policy assumptions have been examined, each of which distributes a given forecast increase in population in the 'average' city 1975-1985 across the city in such a way that a desired change in the average population density between 1975 and 1985 is achieved. The different densities imply different car ownership levels and trips.

3.9 The outcomes of these policies have been examined firstly in a situation in which the relative prices of transport have been kept at their 1975 levels and second in a situation in which the prices of car travel relative to other modes have been altered either by imposition of extra taxes upon car ownership or by altering the relative prices for the use of cars and public transport in the 'average' city. The implications of the latter have been examined more fully than the implications of increasing taxes on ownership simply because of the high levels of increase which we estimate will be necessary to achieve the postulated reduction in the forecast levels of ownership.

3.10 We assume that, in fixing taxes or prices, a target level of impact is aimed - e.g., to restrain trip-making to a lower level. One way to alter relative prices of car use and public transport is to impose taxes on car use. Under each alternative land use option this will lead to two effects - the suppression of some trips and the diversion of others to public transport, buses or taxis. To investigate the implications of differential pricing for cars and public transport, however, we have assumed that total trip-making will remain unchanged as between pricing policy alternatives <u>within</u> each land use option. Thus, those trips that would otherwise be made by car <u>all</u> appear on the public transport system. This is in order to allow for another policy option - to lower the prices of public transport to attract car users to it.

3.11 The practicality of these policies depends of course mainly on the quality of the public transport offered. For analysis purposes, we associate high quality with the introduction of a flexible, intermediate type of transit system e.g. microbuses. Currently, the taxi comes closest to such a system in Korea, despite its obvious shortcomings and bad image. In this report we continue to assume the use of taxis as a way of describing such an intermediate type of system. Lower level of service is associated with a conventional bus operation, although a reduction of 20% has been assumed in occupancy level, so as to allow far more comfortable future travel conditions.

3.12 Each of the policy alternatives is described briefly below, with the outcomes of the land use policies in 1985 in terms of population area and average density summarized in Table 10 and compared with the 'average' city characteristics in 1975.

(i) Land Use Policies

3.13 Policy of Maintaining 1975 Average Population Density ("Existing Density"). Under this policy the extent of the urban area in our average city is allowed to increase so that average density remains at its 1975 level in the face of the average forecast increase in population for the four cities.

3.14 Policy of Concentration. The existing land area of the city is assumed to absorb the forecast increase in population.

3.15 Policy of Dispersion. This policy assumes a decline in average population density with the area of the average city rising considerably under this policy in the face of the population growth forecast.

3.16 Green Belt Policy. This policy directs all forecast population growth into two new satellite cities of equal size outside the green belt, with the population and land area of the existing city remaining constant over the forecast period.

(ii) Pricing Policies

3.17 To explore the consequences of adopting different pricing policies we first nominate an aim common to the policies. A feasible aim for urban areas is to reduce trip-making by cars by an amount which might be achieved were these to be charged according to the congestion they may cause. Within the resources of the study we have no means of estimating this plausibly for Korea, but we can proceed by way of analogy. When improvements in city

TABLE 10: AVERAGE CITY 1975 AND 1985 UNDER LAND USE POLICIES - DENSITIES, AREAS, POPULATIONS

		1975 ALTERNATIVE POLICY OPTIONS					
					GREEN BELT		
	1975	EXISTING DENSITY	CONCENTRATION	DISPERSION	INNER CITY	TOTAL OF OUTER SATELLITES	TOTAL
		(1)	(2)	(3)	(4)		
Density persons/km^2	4,717	4,717	6,575	2,886	4,717	2,937	3,959
Area km^2	147	207	147	339	147	100	247
Population	684,068	977,750	977,750	977,750	684,068	293,682	977,750

SOURCE: Nathaniel Lichfield and Partners.

traffic conditions are sought, the target reduction in traffic is often in the range of 15-30%, as for example in the case of congestion pricing proposals for London, and in the practical case of imposing a central area licensing scheme on Singapore. 1/ Accordingly, benchmark reduction in car trips is set arbitrarily, but probably reasonably, at 25%.

3.18 With such a benchmark, we can represent the effects of two kinds of ways of approaching the task as outlined earlier - taxing car ownership, or altering the relative prices of the modes used in the urban area.

3.19 The first of these is an exercise in applying an own-price elasticity to a postulated price rise (in the form of a tax). We ask - what increase in tax is necessary to reduce ownership so that trip-making is reduced by 25%? The answer will depend, amongst other things, on the kind of urban densities involved. We have calculated the necessary increase in tax with three different own-price elasticities, -1.5, -1.0 and -0.5; the higher one assumed to prevail on the higher population density land use options ("Concentrated" and "Existing Density") where one would expect a more effective level of public transport service than in the less dense options. The "price" to which the theoretical tax is applied is calculated as total and running an average Korean car for five years, rather than simply the retail price, since all costs expected over the life of a car are relevant in the ownership decision.

3.20 Use Pricing. Altering the use of cars via pricing involves asking a similar question - what price (tax) differential would there have

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1/ A "Study of Supplementary Licensing" Greater London Council 1974; "Study of Traffic Restraints in Singapore" IBRD 1975.

to be to induce a 25% reduction in car trips and the transfer of the car passengers to public transport? This depends on the cross-elasticity of demands between cars and public transport, which in turn largely depends on the quality of the public transport alternatives. We have adopted two versions of this quality, the first, (high) appropriate to the availability of a para-transit option in public transport, and the second appropriate to an improved conventional bus system. The former cross-elasticity is set at 2.0 and the latter at 0.7. The liklihood of achieving such quality depends, inter alia, on the density of the urban area. We shall comment on this when comparing the results for the land use options.

3.21 The quality of the atlernative modes is of course one element in the own-price elasticity for car trips, so that when an appropriate use price change is made there will be an effect on car ownership itself. We trace this effect by relating the cross-price elasticity to an own-price elasticity. Because there is a systematic relationship between the two, we couple the higher own-price elasticities with the higher cross-price elasticities, and vice versa. Similarly, there is in principle a cross-price elasticity effect to be traced through to public transport when car ownership is taxed, but we have not followed this up because the first-round effects of the ownership tax turn out to be rather unattractive.

3.22 With a change in the relative prices of modes, there is a question of what happens to total trip-making. This, as pointed out earlier depends on whether the price differential is accomplished by taxing car trips or by lowering public transport prices. If the former is selected, total trips would be adversely affected. If the latter, total trips will increase. We have simply calculated for unchanged total trip-making. What happens in practice depends on the means adopted. For convenience we express the prices in terms of taxes on car use. We argue later in favour of taxing car use as the appropriate policy. If this option is adopted, total trips will be less than shown by the model.

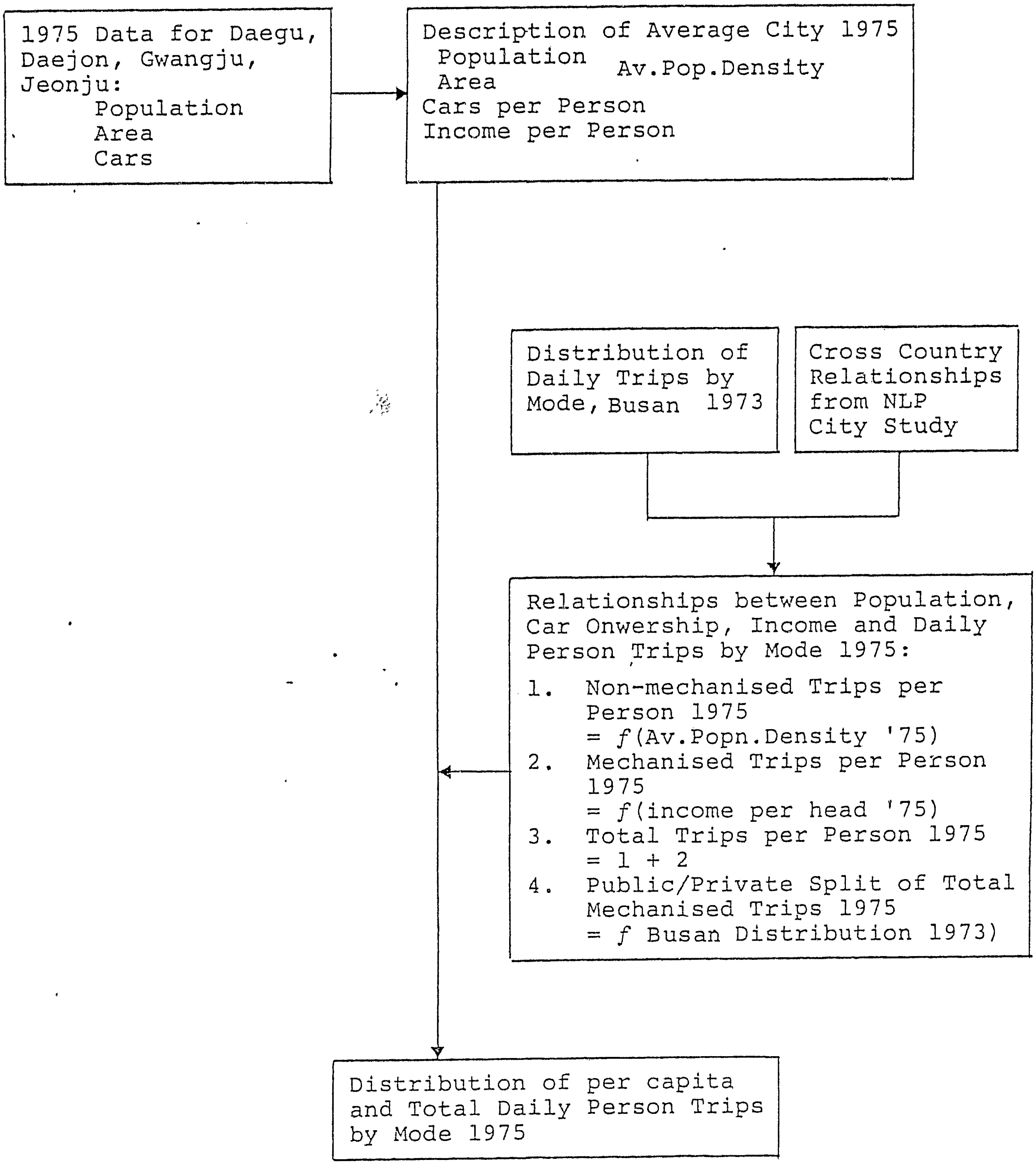
(iii) Summary of Model Procedure

3.23 We first establish the travel pattern by mode in the average city in 1975, divided between mechanised and non-mechanised trips, and within the mechanised trip market, the private and public shares. A summary of this procedure is given in Figure 6.

3.24 We then forecast total mechanised and non-mechanised trips separately, as a function of population and income change to 1985, holding density at the 1975 levels. Total trips are the addition of these two forecasts. We then consider the effect of the alternative land use policies on trip-making, holding expected population and incomes constant. These land uses are represented in the form of different densities, and we relate them to different levels of car ownership through empirical evidence on car ownership and residential density. This data, derived from a recent study of London 1/ indicates that the elasticity of car ownership with respect to changes in average population density is approximately -0.6. The lower the density, the higher the car ownership. Higher car ownership involves more mechanised trips, because of the association between car ownership and the generation of household travel. So the most dispersed land uses are expected to have the highest mechanised trip rates and the most concentrated the least. The green belt option represents an amalgamation of the effects of a relatively dense inner city and less dense satellites.

1/ A study of supplementary licensing, Greater London Council 1974.

FIGURE 6: 1975 AVERAGE KOREAN CITY



3.25 All four land use options - 'existing' densities at 1985 and other three alternatives, are then tested for the effect of use pricing. This, as explained earlier, assigns 25% of car trip-making to buses or taxis. The 'required' price differentials between cars and public transport are computed for buses and taxis assuming all the trips accrue to the one or the other. Corresponding costs to these options are then computed.

3.26 The 1985 model forecasting procedure is summarised in Figure 7.

C. Findings

(i) Forecast

Numbers of Person Trips and Vehicle Kilometres of Travel Without Pricing Policy

3.27 Table 11 summarises the estimates of daily person trips by mode and Table 12 the daily person kilometres of travel in the average city in 1975 and 1985 under each of the alternative land use options. These results relate to the effects of land use policies only, without pricing of use or ownership.

3.28 The number of daily non mechanised trips increases absolutely 1975-1985 under all options, but declines as a percentage of total trips in all cases.

3.29 In all cases the number of mechanised trips increases both absolutely and as a percentage of total trips reflecting the strong influence of growing incomes upon the demand for mechanised trips. The greatest increases occur under the policy of dispersion, under which mechanised trips increase from 558,540 per day in 1975 (64% of total trips) to 1,044,237 per

FIGURE 7 : 1985 AVERAGE KOREAN CITY

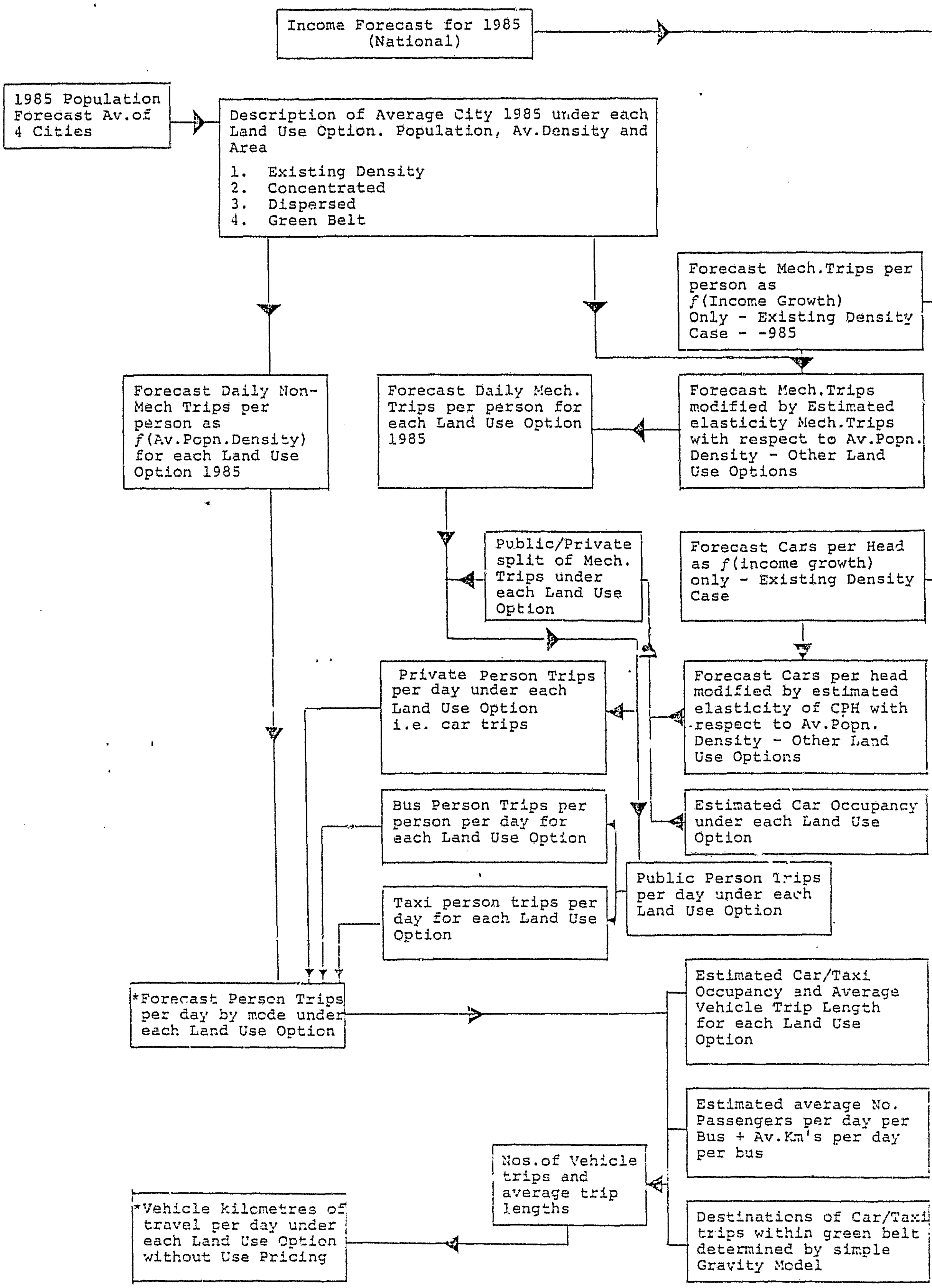


TABLE 11: SUMMARY: DAILY PERSON TRIPS BY MODE IN THE AVERAGE KOREAN CITY, 1975 and 1985 UNDER THE ALTERNATIVE LAND USE OPTIONS

DAILY PERSON TRIPS BY MODE	1975		1985 AVERAGE CITY: ALTERNATIVE LAND USE OPTIONS											
									GREEN BELT					
	AVERAGE CITY		EXISTING DENSITY		CONCENTRATED		DISPERSED		INNER CITY		OUTER SATELLITES		TOTAL	
		%	(1)	%	(3)	%	(4)	%		%	(4)	%		%
Non Mechanised Trips	318,692	36.0	455,511	30.8	531,758	34.5	380,372	26.7	318,692	36.8	114,879	26.8	433,571	29.6
Mechanised Trips Private	50,011	5.7	277,352	18.7	234,202	15.2	355,845	25.0	194,050	18.7	105,930	24.7	299,950	30.5
Mechanised Trips Public	508,529	58.0	747,027	50.4	776,792	50.3	688,392	48.3	555,853	50.5	207,722	48.5	730,575	49.9
Total Mecahnised Trips	558,540	63.7	1,024,379	69.2	1,010,994	65.5	1,044,237	73.3	716,903	69.2	313,652	73.2	1,030,555	70.4
Total Person Trips	877,232	100.0	1,479,890	100.0	1,542,752	100	1,424,609	100	1,035,595	100	428,531	100	1,464,126	100

SOURCE: Nathaniel Lichfield and Partners, 1977.

day in 1985 (73% of all trips). The smallest increase in total mechanised trips occurs in the concentrated policy case due to the restraining effect on demand of the higher population density and the relative ease with which non-mechanised trips are made. However, there are different implications for the division between trips on private and public modes of transport.

3.30 Both public and private trip-making increases strongly. Private trip-making, by 1985, reaches some 25% of total trips, in the dispersed case. Public transport, though increasing much less than car trips, still records about a 35% increase in each case over 1975. The variance of public transport trips across the options in 1985 is very much less than that of cars, the biggest difference (13%) occuring between the "dispersed" and "concentrated" options, compared with 52% difference between these options for car trips.

3.31 In important respects greater differencs occur between the options when put in terms of person kilometres of travel (Table 12).

3.32 In terms of total mechanised kilometres the difference between the "concentrated" and "dispersed" options become 36%. Private car kilometres become a greater proportion of total kilometres in all cases, being greatest in the dispersed case at 75%. Public transport kilometres in each case have a smaller share of the total than do public person trips, between 25% and 40% compared with 48% - 50%. And the variance of public transport experience becomes less - at 8% between the dispersed and concentrated options, while the private car variances become greater at 85%.

The Effects of Pricing Policies

3.33 Table 13 summarizes the estimates of increases in the total cost of owning a car necessary to reduce the level of car ownership under each

TABLE 12: PERSON KM'S OF TRAVEL IN THE AVERAGE CITY 1975 AND 1985 UNDER ALTERNATIVE LAND USE OPTIONS

	1975	1985: Alternative Land Use Options					
		Existing Density	Concentrated	Dispersed	Green Belt		
					Inner	Outer	Total
Non mechanised Km's	509,907	728,818	850,813	608,595	509,907	183,806	693,714
Private Car Km's	213,827	1,287,245	1,001,350	1,856,940	860,794	397,009	1,247,803
Public Km's	1,163,233	1,854,899	1,776,868	1,921,881	1,226,432	416,509	1,642,941
Total mechanised Km's	1,377,060	3,142,144	2,778,218	3,778,821	2,077,226	813,518	2,890,744
Total person Km's	1,886,967	3,870,962	3,629,031	4,387,416	2,587,133	997,324	3,584,458

SOURCE: Nathaniel Lichfield and Partners 1977.

TABLE 13: THE INCREASE IN CAR PRICES AND TAXES NECESSARY TO REDUCE CAR OWNERSHIP BY 25% UNDER EACH LAND USE OPTION

	1985 Average City: Alternative Land Use Options				
	Existing Density	Concentrated	Dispersed	Green Belt Inner	Green Belt Outer
Reduction in car stocks	25%	25%	25%	25%	25%
Assumed own price η^1	-1.0	-1.5	-0.5	-1.0	-0.5
% increase in price required	33%	21%	80%	33%	80%
% increase in taxes overall to achieve required price increases	91%	58%	222%	91%	222%

Source: Nathaniel Lichfield and Partners, 1977

Notes: [1] Varies directly with the expected extent of provision of alternative transport to the private car cars use option to secure a 25% reduction in car trips at 1985. Also shown are the tax increases over current levels needed to do this, assuming that taxes would constitute 36% of the total cost of owning and running an average car (Table 14) before the extra taxes were imposed.

3.34 Prices would need to rise by between 21% and 80%, according to land use, and taxes by 58% and 222% respectively. These substantial imposts can be compared with the measures necessary to discourage 25% of trips were use pricing adopted instead.

3.35 Imposing taxation so as to effect use, to reduce the number of car vehicle trips by 25% made under each option (rather than taxing car ownership per person), would require less dramatic percentage increase. Provided sufficient provision is made to allow ready transfer of trips from car to public transport (reflected by an elasticity of -2.0 rather than -0.7 for the response of trip-making to changes in trip costs) then an increase in trip costs of 15.4% is necessary under each land use option. If a poor public transport service is provided an increase of 51.3% in per trip costs is necessary. As noted earlier, the higher elasticity figure is likely to be more typical of a para-transit taxi-like level of service.

3.36 The contrasts between the approaches are that not only are substantially more severe taxes needed to achieve similar cuts in trip quantities in the ownership tax case, but also that the trips suppressed are trips made in all conditions and areas which the owner could otherwise make and not trips confined to urban areas. The effective impact on congestion would be much less, and there could in effect be an inefficient taxing of trips made in uncongested conditions, whereas use pricing can be made to

TABLE 14: TOTAL USER COST OF AVERAGE PRIVATE CAR (1975 PRICES)

		WON	% TOTAL	TAXES AS % TOTAL
Fixed Costs[1]	Factory Price of which	2,350,000	45	
	(a) Commodity Tax	470,000	9	9.0
	(b) Defence Tax	47,000	9	0.1
		2,350,000	45	
	Registration	47,000	1	1.0
		2,397,000	46	
Annual Fixed[1] Costs (5yr life)	Motor vehicle tax (199,880 pa)	999,000	19	19.0
	Defense Surtax (59,940 pa)	299,700	6	6.0
	License (14,400 pa)	72,000	1	1.0
		1,370,000	26	
Operating Costs[2]	50,000 K''s @ 30 WON per KM	1,500,000	28	
TOTAL		5,267,000	100	36

SOURCE: [1]Korean Institute of Science and Technology

[2]In the absence of data for Korea this is estimated on the basis of a 1975 average operating cost for a 1500 c.c. car in the UK supplied by the Automobile Association.

bear on relevant urban trips. We assume in what follows that this more effective policy would be pursued.

3.37 We also assume, for reasons given later, that of the two means of securing a transfer to public transport - raising car use tax or lowering public transport prices - the former would be adopted.

3.38 Forecast Stocks of Vehicles. Table 15 summarizes the total vehicle kilometres of travel, and Table 16 estimates the stocks of vehicles in the average city in 1975 and in 1985 under each of the land use options, before and after effective taxing of car use. Because an increase in trip costs will result in an increase in the relative costs of owning and running a car, the imposition of a tax to restrain use will also effect a reduction in car stocks. We cannot forecast the precise effects because the likely effect on car ownership is complex. Among other things, average car use (running both in towns and elsewhere) might well be effected. Further investigation is needed to predict the likely actual effects of alternative policies on car ownership. However, in the long run, less car use means that less stocks are needed, whatever their distribution among owners. We have represented this effect by assuming the tax is levied on cars and thus applied an own-price elasticity to calculate the reduction in car numbers (see Appendix C). It is very likely that this treatment maximises the possible effect on car stocks, for it not only assumes that a car tax would be levied, but calculates as if all car use by owners is in the average city. Two levels of car stocks are shown for 1985 after use-pricing corresponding to the different increases in per trip costs necessary given the two different cross-elasticities.

TABLE 15: TOTAL VEHICLE KILOMETRES OF TRAVEL IN 1975 AND 1985 AFTER EACH LAND USE POLICY BEFORE AND AFTER EFFECTIVE USE PRICING

15A BEFORE 1985: ALTERNATIVE LAND USE OPTIONS

	1975	Existing Density	Concentrated	Dispersed	Green Belt Inner	Green Belt Outer	Total
Private Car	90,074	680,470	515,045	1,023,728	449,751	218,521	668,272
Taxi/Microbus	50,733	121,348	116,242	125,729	80,234	27,249	107,483
Bus	[illegible],232	235,720	245,016	217,128	165,004	65,004	230,408
Total Km's	249,039	1,037,538	876,303	1,366,585	694,989	311,174	1,006,163

15B AFTER

		Existing Density	Concentrated	Dispersed	Green Belt Inner	Green Belt Outer	Total
Private Car		510,351	386,283	767,799	337,314	163,896	501,210
Taxi/Microbus	1.	282,255	241,411	357,847	186,583	76,877	263,460
	2.	121,348	116,242	125,729	80,234	27,249	107,438
Bus	1.	235,720	245,016	217,128	165,004	65,404	230,408
	2.	259,292	265,268	247,672	181,604	74,700	256,304
Total	1.	1,028,326	872,710	1,342,774	688,901	306,177	995,078
	2.	890,991	767,793	1,141,200	599,152	265,845	864,997

SOURCE: NLP 1977

NOTES: [1]with car passengers transferred to taxi use after the 25% reduction in car trips
[2]with car passengers transferred to bus use after the 25% reduction in car trips

TABLE 16: STOCK OF VEHICLES 1975, 1985 UNDER ALTERNATIVE LAND USE POLICIES

	1975	1985: ALTERNATIVE LAND USE OPTIONS				1985: AFTER EFFECTIVE USE PRICING			
		Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt
Private Cars	2,394	20,826	17,111	27,866	22,853	19,967	16,064	27,286	22,080
						20,548	16,770	27,807	22,604
Taxis	337	871	906	803	852	2,027	1,882	2,286	2,102
						871	906	803	852
Buses	326	710	738	654	694	710	738	654	694
						781	799	746	772

SOURCE:- Nathaniel Lichfield and Partners, 1977.

1. With car passengers transferred to taxis after the 25% reduction in car trips - the high cross price elasticity option.
2. With car passengers transferred to buses after the 25% reduction in car trips - the low cross price elasticity option.

3.39 Stocks of taxis and buses after use-pricing are forecast on the basis that the entire reduction in person car trips is transferred to either taxis or buses.

3.40 The model indicates that the stock of taxis must at least double if all transferred trips are to be accommodated following effective use-pricing, whereas the stock of buses increases by between 8% and 14%. On the other hand, the probability of achieving a transfer is much higher in the case of taxis.

3.41 Additional Road Construction. Table 17 shows the amount of extra road provision that would have to be made under each policy option to maintain average speeds at their 1975 level and the percentage of urban area taken up. We have assumed an average travel speed of 25km per hour for cars and taxis and 12km per hour for buses, with buses weighted by a factor of three in the calculations to account for their higher occupation of road space (see Appendix C).

3.42 Most new roads would need to be constructed in the dispersed city case, with and without use-pricing and least in the concentrated city case.

3.43 Time Spent in Travel. Table 18 summarises the estimates of daily travel time. Non-mechanised travel time constitutes a high but declining proportion of total travel time, 63% in 1975 and between 47% and 56% in 1985. The highest totals occur in the concentrated option case due to the effect of the number of non-mechanised trips generated.

3.44 Consistency of Model Projections. To check that the model projections are reasonable, we have compared the main travel demand and supply characteristics with those of other urban areas for which the data exists.

TABLE 17: ROAD PROVISION IN THE AVERAGE KOREAN CITY

	Existed Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Road Length required:- (Km's)	1418	1284	1692	1379	[1] 1410 [2] 1325	1281 1220	1670 1538	1386 1295
Road Area (Km^2)	17.9	16.2	21.3	17.3	[1] 17.8 [2] 16.7	16.1 15.4	21.0 19.4	17.2 16.3
Urban Area (Km^2)	207	147	339	247	207	147	339	247
Roads as % urban area	8.6	11.0	6.3	7.0	[1] 8.6 [2] 8.1	11.0 10.5	6.2 5.7	7.0 6.6

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: 1 With car passengers transferred to taxis after the 25% reduction in car trips - the high cross price elasticity option.

2 With car passengers transferred to buses after the 25% reudction in car trips - the low cross price elasticity option.

TABLE 18: ESTIMATED HOURS OF TRAVEL PER DAY 1975 AND 1985

	1975	1985: ALTERNATIVE LAND USE OPTIONS				1985: ALTERNATIVE LAND USE OPTIONS AND EFFECTIVE PRICING OF CAR USE			
		Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt
Non Mechanised	169,969	242,939	283,604	202,865	231,238	242,939	283,604	202,865	231,238
Private Car	8,553	51,490	40,054	74,278	49,912	38,617	30,040	55,708	37,435
Taxi	7,868	12,322	12,018	12,468	11,156	[1]28,662	24,959	35,485	27,384
						[2]12,322	12,018	12,468	11,156
Bus	84,253	134,350	128,699	139,202	118,998	[1]134,350	128,699	139,202	118,998
						[2]161,168	149,560	177,888	144,993
Total Mechanised	100,674	198,162	180,771	225,948	180,066	[1]201,629	183,698	230,395	183,817
						[2]217,107	191,618	246,064	193,584
Total	270,643	441,101	464,375	428,813	411,304	444,568	467,302	433,260	415,055
						455,046	475,222	448,929	424,822

SOURCE: Nathaniel Lichfield and Partners, 1977.

NOTES: [1]With trips transferred to taxis from cars following use pricing.
[2]With trips transferred to buses from cars following use pricing.

These comparisons are presented in Tables 19, 20 and 21 respectively. The results are encouraging and confirm that the orders of magnitude forecast by the model are generally plausible.

3.45 Costing of Policy Alternatives. As indicated earlier, the different options represent different combinations of likely costs and benefits associated with the several land use policies. We are able to consider the transport items only here. If mechanised trips are made, they must be assumed at least to be matched, in the eyes of consumers, by the personal costs (outlays of cash and time) to make them. But whether they make trips or not depends, among other things, on the type of urban area they reside in. For example, a dispersed form of land use may well, as we have seen, lead to more trips. But it will also probably imply cheaper housing. We are not concerned with the trade-offs here; we are concerned with predicting the transport costs associated with the alternatives.

3.46 Costs have been divided into the following separate categories because of their incidence: costs of daily travel time, capital costs (which include road construction costs and costs of additions to vehicle stocks), annual replacement costs for vehicle stocks, and daily vehicle operating costs. The results of the costing exercise are summarised at the end of Section 3 (Table 30), and the way in which they were estimated are described below.

3.47 Cost of Daily Travel Time. Table 22 summarises the estimates of daily travel time costs for each of the policy options. Very considerable differences are disclosed. Without use-pricing the highest costs are incurred in the case of the concentrated option, reflecting mainly the relative speeds of travel. With effective pricing of use, highest costs are

TABLE 19: AVERAGE CITY/INTERNATIONAL COMPARISON OF PERSON TRIP RATES

	TOTAL PERSON TRIPS PER PERSON	TOTAL NON-MECHANISED TRIPS PER PERSON	TOTAL PUBLIC MECHANISED TRIPS PER PERSON	TOTAL PRIVATE MECHANISED TRIPS PER PERSON	TOTAL MECHANISED TRIPS PER PERSON
Average Korean city 1975	1.28	0.47	0.7434	0.0731	0.82
"Average Korean city 1985 (before pricing)	1.51	0.46	0.7525	0.2985	1.05
"Average" Korean city 1985 (after pricing)	1.51	0.46	0.8271	0.2239	1.05
Seoul 1970	1.29	0.35	0.8640	0.0300	0.89
Pusan 1973	1.28	0.49	0.7265	0.6900	0.79
Bogota 1969	2.30	0.44	1.5660	0.1859	1.90
Karachi 1970	1.85	1.21	0.5255		0.90
San Jose 1973	1.18	0.04	0.8736	0.2621	1.14
Nagoya 1970	2.75	1.13	1.0900	0.5300	1.62
Tokyo 1970	2.48	1.06	1.0500	0.3700	1.42
Keihanshin 1970	2.39	1.11	1.0300	0.2500	1.28
North Kyushu	2.68	1.04	1.0900	0.5500	1.64
Sapporo 1970	2.68	1.13	1.1000	0.4500	1.55
Okayana 1970	2.55	0.86	1.2600	0.4300	1.69
Sendai 1970	2.50	0.93	1.1200	0.4500	1.57
Kuala Lumpur 1973	1.76		1.7596	1.0521	-
Caracus 1966	-	-	-	0.7144	-
Hong Kong 1966	0.92	-	0.7483	-	-

SOURCES: Nathaniel Lichfield and Partners 1977
Annual report of roads 1975. Japanese Road Association.

TABLE 20: "AVERAGE" CITY/INTERNATIONAL COMPARISON OF SELECTED TRAVEL DEMAND CHARACTERISTICS

	CAR OCCUPANCY	AVERAGE CAR TRIP LENGTH (km)	KILOMETRES PER CAR PER DAY	KILOMETRES PER TAXI PER DAY
"Average" Korean City 1975	2.73	4.28	37.6	150.5
"Average" Korean City 1985 under alternative land use options before pricing:				
Existing density	1.89	4.64	32.7	139.3
Concentrated	1.94	4.28	30.1	128.3
Dispersed	1.81	5.22	36.7	156.6
Green Belt	1.86	4.15	29.2	126.2
Tel Aviv 1965	1.60	4.09	-	
Kuala Lumpur 1973	1.63	5.36	36.3	
Singapore 1968	1.66	7.03	35.4	
Bogota 1969	1.74	6.76	30.8	
Athens 1962	2.16	5.57	-	
Bankok 1972	1.69	-	25.9	
Karachi 1971	-	-	-	254.0
Copenhagen	-	-	-	150.0
London	-	-	-	180.0
Madrid	-	-	-	150.0
Paris	-	-	-	154.0

SOURCES:
1. Nathaniel Lichfield and Partners 1977
2. "Travel Characteristics in Cities of Developing and Developed Countries" World Bank STaff Working Paper No.230. Y. Zahavi, March 1976.
3. Alternative taxicab systems, A London Case Study, Transport Studies Group, Polytechnic of Central London, April 1976.

TABLE 21: "AVERAGE" CITY/INTERNATIONAL COMPARISONS OF SELECTED TRANSPORT SUPPLY CHARACTERISTICS

	CARS PER 1000 PERSONS	BUSES PER 1000 PERSONS	TAXIS PER 1000 PERSONS	ROADSPACE AS % OF URBAN AREA
"Average" Korean City 1975	3.50	0.4766	0.49	3.7
"Average" Korean City 1985 under alternative land use options before pricing:				
Existing Density	21.3	0.7262	0.89	8.6
Concentrated	17.5	0.7548	0.93	11.0
Dispersed	28.5	0.6689	0.82	6.3
Green Belt	23.4	0.7098	0.87	7.0
Seoul 1970	4.8	0.8697	1.83	6.3
Busan 1973	1.7	0.5165	1.51	3.4
Calcutta 1964	16.0	0.2607	1.18	-
Hong Kong 1966	22.0	0.6258	1.22	-
Karachi 1970	15.1	0.5311	1.52	-
Kuala Lumpur 1973	52.0	0.7840	1.76	-
Singapore 1972	73.0	1.5350	2.33	-
Tel Aviv 1970	-	-	-	12.0
Madrid 1970	-	-	-	17.0

SOURCES: Nathaniel Lichfield and Partners 1977; R.J. Smeed, "Traffic Studies and Urban Congestion", *Journal of Transport Economics and Policy*, January 1968.

TABLE .22: COST OF DAILY TRAVEL TIME (thousands Won)

	1985: ALTERNATIVE LAND USE OPTIONS.				1985: ALTERNATIVE LAND USE OPTIONS AND EFFECTIVE PRICING OF USE				
	Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt	
Daily cost of non-mechanised travel time	129,972	151,728	108,533	123,712	129,972	151,728	108,533	123,712	
Daily cost of mechanised travel time	106,017	96,713	120,882	96,336	107,872	98,279	123,261	98,342	Assumes all reduction in car trips transferred to taxis.
					113,478	102,516	131,644	103,568	Assumes all reduction in car trips transferred to buses.
TOTAL	235,989	248,441	229,415	220,048	237,844	250,007	231,794	222,054	Assumes all reduction in car trips transferred to taxis.
					243,450	254,244	240,177	227,280	Assumes all reductions in car trips transferred to busec

Source: Nathaniel Lichfield and Partners, 1977.

incurred with the dispersed option with all frustrated car trips assumed transferred onto buses, and lowest costs are also reached with the dispersed option when assuming that the reduction in car trips is transferred to taxis. Thus the effects of dispersion again chiefly depend on the difficult qualities of service provided in public transport. Given favourable circumstances, but only then, dispersion can yield lowest time costs.

3.48 The costs of travel times have been calculated on the basis of numbers of hours of travel per day by mode and an estimate of the future cost per hour of travel time. The value of travel time has been estimated by taking the conventional 25% of the hourly wage rate, where wage rate is estimated as 272 won per hour for 1975 and 535 won per hour in 1985 (1975 prices). 1/

3.49 Capital Costs. Tables 23 and 24 summarise estimated costs of additions to vehicle stocks and road construction costs.

(a) Road Construction Costs

3.50 These are calculated on the basis of the extra kilometres of road which would have to be provided in 1985 under each land use option to maintain 1975 average speeds for bus, taxi and private car, and a constant construction cost per kilometre of road. 2/ Extra kilometres of road are calculated using a relationship derived by Zahavi (1976). 3/

1/ Figures supplied by World Bank.

2/ Based on the figure of 120,750,000 Won per km provided by KIST.

3/ Average Speed = $\frac{\text{(a) Total road length}}{\text{(Total vehicle km's of travel)}}$

where the value of the constant, a , which changes directly with average speed, is found given the overall average speed for 1975 and the total road length in the average city in 1975.
The average of road length in Daegu, Gwangju, Daejon and Jeonju in 1975 of 1.47 km's. Source: Yearbooks.
Thus: $15.5 = \frac{(a)\ \ 437.5}{445.906}$ $\quad a = 15,798$

TABLE 23: CAPITAL COSTS OF ADDITIONS TO STOCKS OF VEHICLES (MILLION WON)

	1985: Alternative Lane Use Options				1985: Alternative Land Use Options After Effective Car Use Pricing			
	Existing Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Cars	43,315	34,585	59,859	48,079	[1] 41,297	32,125	58,496	46,262
					[2] 42,662	33,754	59,721	47,494
Taxi	1,255	1,337	1,095	1,210	[1] 3,972	3,631	4,580	4,148
					[2] 1,255	1,337	1,095	1,210
Buses	4,032	4,326	3,444	3,864	[1] 4,032	4,326	3,444	3,864
					[2] 4,778	4,967	4,410	4,638
Total	48,602	40,248	64,398	53,153	[1] 49,301	40,082	66,520	54,274
					[2] 48,695	40,088	65,226	53,387

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

TABLE 24: ROAD CONSTRUCTION COSTS

	1985 ALTERNATIVE LAND USE OPTIONS				1985 ALTERNATIVE LAND USE OPTIONS AFTER EFFECTIVE USE PRICING			
	Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt
Road Construction Costs (millions Won)	118,410	102,228	151,500	113,700	[1]117,444 [2]107,179	[1]101,865 [2]94,449	[1]148,843 [2]132,902	[1]112,372 [2]103,556

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1]With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing.
[2]With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing.

3.51 An average speed for 1975 of 15.9 km per hour is calculated on the assumption that buses travel at 12 km per hour and cars and taxis at 25 km per hour. An overall average is then calculated on the basis of the number of vehicle kilometres of travel by each vehicle in 1975, with bus kilometres of travel weighted by a factor of three to account for their extra size. The additional road kilometres required have already been summarised in Table 17.

(b) Capital Costs of Additions to Stocks of Vehicles 1975-1985

3.52 These costs are estimated on the basis of the estimated stocks of vehicles (Table 16) and current prices for an average car, taxi and bus. Taxes have been included in these costings since no data were available to indicate their full effect in current prices. However, since they represent a transfer of resources and not a true resource cost they should be explicitly recognised.

3.53 Table 23 summarises these costs. The concentrated option proves to be the least costly without pricing of car use. With pricing of car use the extent of costs depends wholly upon whether taxis or buses accommodate all transferred car trips and the extent to which car use responds to an increase in per trip costs.

3.54 Annual Replacement Costs for Stocks of Vehicles. These are calculated on the assumption of an average five year life for all vehicles. See Table 25.

3.55 Daily Vehicle Operating Costs. Table 26 summarises estimated daily operating costs, where these are defined as fuel and maintenance costs for private cars and fuel, maintenance and wage costs for taxis and buses.

TABLE 25: ANNUAL REPLACEMENTS COST FOR VEHICLE STOCKS 1975-1985 (MILLION WON)

		1985: Alternative Land Use Options				1985: Alternative Land Use Options After Effective Car Use Pricing			
	1975	Existing Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Cars	1125	9,788	8,042	13,097	10,740	[1] 9,384	7,550	12,824	10,377
						[2] 9,657	7,881	13,069	10,623
Taxis	158	409	426	377	400	[1] 953	885	1,074	988
						[2] 409	426	377	400
Buses	689	1,491	1,550	1,373	1,457	[1] 1,491	1,550	1,373	1,457
						[2] 1,640	1,678	1,567	1,621
Total	1967	11,688	10,018	14,847	12,597	[1] 11,828	9,985	15,271	12,822
						[2] 11,706	9,985	15,013	12,644

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

TABLE 26: ESTIMATED OPERATING COSTS PER DAY, CAR, TAXI, BUS (OOO WON)

	1975	1985: Alternative Land Use Options				1985: Alternative Land Use Options After After Effective Car Use Pricing			
		Existing Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Cars	2,702	20,414	15,451	30,711	20,048	[1] 17,658	13,365	26,566	17,342
						[2] 23,170	17,537	34,858	22,755
Taxis	3,145	7,524	7,207	7,795	6,664	[1] 17,500	14,967	22,187	16,335
						[2] 7,524	7,207	7,795	6,664
Buses	14,720	32,058	33,322	29,529	31,335	[1] 32,058	33,322	29,529	31,335
						[2] 35,264	36,076	33,683	34,857
Total	20,567	59,996	55,980	68,035	58,047	[1] 67,216	61,654	78,282	65,012
						[2] 65,958	60,820	76,336	64,276

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

After use-pricing car costs for users are increased by the extent of the additional tax imposed to reduced trip-making. However, the extent of this tax element is calculated and shown in Table 27. Without use-pricing costs are highest under the dispersed option and lowest under the concentrated option, whilst with use-pricing costs are highest under the dispersed option with the entire reduction in car trips transferred to taxis and lowest in the existing density case with the reduction in car trips transferred to buses.

3.56 Summary of the Costing Exercise. Table 27 summarises the results of the costings. Vehicle replacement costs have been expressed on a simple daily basis so that they can be included with the other daily costs incurred, time costs and vehicle operating costs. Capital costs (road construction and costs of additions to vehicle stocks) are shown as they are calculated, rather than on a discounted basis, for simplicity. The aggregate of the two groups of costs clearly show the trade-offs between policy options which the model indicates. By far the most costly policy, both on a daily and capital cost basis is the policy of dispersal without a change in the relative prices of public and private transport; whilst a concentrated or existing density policy in which car use is taxed effectively and frustrated car trips are transferred onto buses will be the least costly overall.

TABLE 27: SUMMARY OF COSTS 1985

DAILY COSTS	1985: Alternative Land Use Options				1985: Alternative Land Use Options After Effective Car Use Pricing			
	EXISTING DENSITY	CONCEN-TRATED	DISPERSED	GREEN BELT	EXISTING DENSITY	CONCEN-TRATED	DISPERSED	GREEN BELT
Daily cost of travel time ('000 won)	235,989	248,441	229,415	220,048	[1] 237,844 [2] 243,450	250,007 254,244	231,794 240,177	222,054 227,280
Daily vehicle operating costs ('000 won) [3]	59,996	55,980	68,035	58,047	[1] 57,216 [2] 65,980	61,654 60,280	78,282 76,336	65,012 64,276
Daily vehicle depreciation costs ('000 won)	32,022	27,447	40,677	34,512	[1] 32,405 [2] 32,071	27,356 27,356	41,838 41,132	35,129 34,641
Total daily costs ('000 won)	328,007	331,868	338,127	312,607	[1] 337,465 [2] 341,479	339,017 342,420	351,914 357,645	322,195 326,197
CAPITAL COSTS								
Costs of additions to vehicle stocks (millions won)	48,602	40,248	64,398	53,153	[1] 49,301 [2] 48,695	40,082 40,088	66,520 65,226	54,274 53,387
Road Construction Costs (millions Won)	118,410	102,228	151,500	113,700	[1] 117,444 [2] 107,179	101,865 94,449	148,843 132,902	112,373 103,556
Total capital costs (millions won)	167,012	142,476	215,898	166,853	[1] 166,745 [2] 155,874	141,947 134,587	215,363 198,128	166,646 156,943

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

[3] Of which additional tax element after effective car use pricing is as follows:

	Existing Density	Concentrated	Dispersed	Green Belt
Additional Tax element in user operating costs ('000 won)	2,348 7,859	1,777 5,949	3,532 11,824	2,306 7,719

4. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions from the Analysis of Options

4.1 Having laid out and described the analysis of travel demand and land use and pricing strategic policy alternatives, we now draw the essential conclusions which come from it.

Transport Implications of Land Use Alternatives

4.2 First whatever the land use or car tax policy adopted, vehicle miles will be far higher in 1985 in the average city. Even for the policy of concentrated land use, combined with a large scale transfer of car trips to public transport, which represents the combination of policies tested that minimises the vehicle mileage increase between 1975 and 1985, the increase is 208%. With no changes in use taxes, increases could range from 252% to 449% according to the land use policy adopted.

4.3 The choice of land use policy has significant implications. By 1985, the difference in terms of vehicle miles could be as much as 78% higher under the dispersed, as opposed to the concentrated, option. A green belt policy, by contrast, affects the issue little compared to the option of maintaining existing density; the major effects in transport terms, lie between the concentrated and dispersed choices. An effective use-pricing policy can cause some differences between the concentrated and dispersed options at 1985 in terms of vehicle miles (Table 15), as well as greatly affecting their expected vehicle mile increases between 1975 and 1985. Depending on whether the substitutes for car trips are buses or taxis, increases from 1975 may range from 208% for the concentrated/bus case, to 439% for the dispersed/taxi case.

4.4 Differences in vehicle miles are reflected in the transport costs that are implied. There is, however, as Table 27 shows, a difference between the options with respect to the types of costs involved. Whereas in terms of daily costs the Green Belt option shows the lowest total; for capital costs the lowest is the concentrated option. The dispersed case is highest on both counts, by a considerable margin (52%) in the case of capital outlays. The destination between the two types of cost is potentially important in economic planning terms. The opportunities foregone in each case may, at a given stage in Korean development, be quite different. Expenditure on construction costs may, for example, pre-empt other building projects; or, on the other hand, there may be good reason to emphasise the potential savings in operating costs. Certainly, at a practical level, the costs concerned are likely to be borne directly by very different groups, and construction costs, for example, will enter the road authorities' budgets directly. The contrasts thrown up by the models may therefore be significant. But in transport planning terms, one needs to put the two kinds of costs into relation with each other.

4.5 As a rough guide to bring the recurring daily costs in line with the one-for-all capital costs, we may consider the daily costs of travel over five years plus capital costs (Table 28). Because daily costs, which vary relatively little, outweigh capital costs in importance when summed in this way, the differences between the options have a narrower range than for capital costs above. The least cost option becomes the Green Belt, by a small margin over the concentrated option.

TABLE 28: DAILY COSTS OF TRAVEL OVER FIVE YEARS PLUS CAPITAL COSTS (millions Won)

	1985: ALTERNATIVE LAND USE OPTIONS				1985: ALTERNATIVE LAND USE OPTIONS WITH EFFECTIVE CAR USE PRICING			
	Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt
Daily costs of Travel over five years	598,613	605,659	617,082	570,508	[1]615,874 [2]623,199	618,706 624,916	642,243 652,702	588,006 595,310
Capital Costs	167,012	142,476	215,898	166,853	[1]166,745 [2]155,874	141,947 134,587	215,363 198,128	166,646 156,943
Total	765,625	748,135	832,980	737,361	[1]782,619 [2]779,073	760,653 759,504	857,606 850,830	754,652 752,253

SOURCE: Nathaniel Lichfield and Partners, 1977.

NOTES: [1]With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing.
[2]With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing.

4.6 The dispersed option shows about an 11% - 13% excess over the concentrated and Green Belt options, which is chiefly a reflection of trip making over longer distances. The absolute sums involved in these contrasts are large (for example, the costs of the Green Belt and Dispersed Options in terms of daily costs over 5 years plus capital costs represent 9% and 10% of Korea's yearly National income respectively at 1975). When use-pricing is imposed, the differences in total costs are larger, a reflection of the greater importance of time and vehicle costs. There is a difference of 14% between the dispersed taxi and Green Belt bus options. As Table 27 notes, however, with use-pricing not all of these costs reflect new resource outlays, as there is considerable additional tax revenue, particularly in the Green Belt case.

4.7 It should be stressed again that the dispersed, concentrated and other land use options represent very different opportunities to make trips, and that the transport costs and taxes associated with the options are a concomitant of substantial differences in housing and other conditions and costs.

Pricing of Modes and Land Use

4.8 The primary purpose of introducing pricing into our model was to indicate the relative effectiveness of the tax on car onwership and use-pricing approaches. The calculations show (Table 13 and discussion) that given effective substitutes for private cars (the higher cross-elasticity conditions particularly) much less severe taxes are needed to substantially lessen the likely effect of the increase of incomes, than are taxes on ownership alone. We presume that what is sought is the least punitive tax consistent with the policy ends sought. In every country, the adverse impacts of rising car ownership bear more greatly in urban areas than others, so the pricing instrument should be applied in urban areas either as a tax on use, or otherwise changing the relative prices and quality of private and public transport.

4.9 We have also, however, traced the impacts of a tax on car use to the total costs implied by the two accounts of modal competition. The same target reduction in car trips was assumed for each land use. The measured effects of the tax policies in terms of costs - seen in the contrasts between the left and right-hand sides of Table 28 for each given land option - are not as great as for the measured differences in vehicle mileage, of Table 15. These small differences are to be expected, since trips made in cars "reappear" - albeit at slower speeds - on public transport; relatively low priced cars are substituted for by higher priced, if fewer, buses etc.

4.10 Reducing car trips, as pointed out earlier, is a sensible policy when congestion is a problem. Our assumed state of the networks at 1985 is not characterised by severe congestion on average - cars and taxis still move at 25 k.m.h. The capital costs of roads reflect this assumption - we kept the implied quality of infrastructure service the same across the options, in order to make comparisons like-with-like. Total costs turn out to be about the lowest in the concentrated case. This is partly because mechanised trips are less in that case, and to some extent because we have been unable to distinguish between the costs of road construction in more and less dense areas. But the question at issue here is a different one; it concerns the management of a given investment - the appropriate policy to ensure its optimal use. Undoubtedly, the more dense the area, the greater is this problem of management, and we would expect this to be especially so in the concentrated case, in which greatest variance in traffic conditions can be foreseen. This throws even more weight on the conditions of substitution between the modes. The relative quality of the public transport substitutes has to be such as to create the rather high cross elasticities we have assumed, and which are proxied by taxis and improved bus services in our model.

4.11 As a means for changing relative prices, there are cogent reasons for preferring taxes on private car trips rather than reducing the price of public transport substitutes. The choice involves, on the one hand, a tax revenue, and on the other, some means of subsidising public transport - assuming that, as will be broadly true, one initiates the policy in a situation in which public transport charges fares which cover costs of operation. The first point is that, since total prices faced by trip makers in congested areas is higher in the taxation case than it would be in the other case, the change in prices required for a given decongesting effect is lower, an effect we have been unable to measure in our comparisons. More significant is the fact that a tax on car trips can take many forms - e.g. sophisticated metering schemes or, as in Singapore, a central area licence fee - which are compatible with equivalent treatment to other contributors to congestion, e.g., commercial vehicles. The policy can be flexibly applied and is relatively easily reversible. Moreover, experience in developed countries shows, on the other hand, how resistent to change a policy of public transport subsidy is when once embarked on.

4.12 Most important, however, is the creation of conditions in which the substitutes for private car trips in urban areas can most readily emerge. The tax on cars provides superior profit opportunities which will encourage innovation in public transport provision, and in particular those varieties of the public transport form which will suit the types of urban area land use strategies indicate. The urban forms we have described imply different market structures for public, including para-transit, transport. Subsidy, on the other hand, encourages the protection of fixed production modes.

4.13 Again, virtually all bus systems in developed countries have encountered increasing difficulty in coping with rising real costs of service provision, particularly at peak hours. To mitigate these difficulties, alternative and auxiliary services are essential. And the conventional buses, too, must increase their standards of comfort to match the rising expectations of customers. The financing of this kind of improvement is more likely to be forthcoming if, on the one hand, costs can be held down, and on the other, the taxation on major elements of competition raises the head-room for fares.

4.14 Taxis and other para-transit services are potentially more likely to be successful in competition with cars than are buses. In our model, taxis stand proxy for this varied set of services. We can note the immense increase in numbers implied between 1975 and 1985 between 5 and 7 times the 1975 numbers (Table 18). Especially if the price differential to discourage cars is in the form of an extra car use-tax, there should be no difficulty in fixing a price for taxis and other para-transit forms which will encourage large scale entry into the industry. The locational impact of the taxi is very important here, because the economy of para-transit operation depends on high levels of demand of trips. In central areas, for example, high taxi density encourages custom because of potential availability. A focussed car tax is more helpful here than a diffused one.

B. Recommendations for Creating the Necessary Supply Conditions

4.15 Given the conclusions on the analysis of land use and car ownership and use-pricing analysis, we now consider the requirements that must be met to create the necessary future supply conditions if the forecast modal uses are to be achieved.

(i) Public transport

4.16 The most important point here is the requirement for large scale investment in both the bus and taxi fleets (which we consider as a public transport mode). With respect to taxis, large scale investment depends upon the prospective returns to be made by operators. We have dealt with one necessary condition for this - the creation of the appropriate pricing framework. However, the Government will have the practical and continuous task of fixing specific fares. Given that there is such government control of fare levels, one possibility of maintaining sufficient inducements would be to monitor costs and relate permitted changes in fare levels to changes in costs. Ideally operators' opportunity costs would be monitored - an important part of which would be the wages which drivers could get in alternative occupations. Another alternative, which is used in London and appears to operate reasonably well, is the use of a fare index, related to taxi costs which is determined independently of the submissions of operators themselves.

4.17 Appropriate prices alone are not sufficient to ensure the desired developments. Supply must be free to adjust. The second condition necessary for the attraction of investment to the taxi industry is the relaxation of controls on the number of operators and vehicle licences. Given the basic freedom to enter in the quantitative sense, it is possible, without serious inhibition of competitive mechanisms, to make entry contingent upon meeting quality stipulations - which will raise the costs for operators, but still allow quantity adjustments. This is done in London for example, through a rigorous examination of the driver's driving skill, knowledge of the city, and so on, as a requirement for the granting of a licence. Spot checks are also carried out on taxis on a random basis, and failure to meet the required mechanical standards results in the suspension of a taxi from service. The quality control is so rigorous as to produce standards of safety and reliability which are probably even higher than for London buses, yet the industry is still a highly competitive one.

4.18 The issues affecting future investment in the stock of buses are similar to those concerning taxis. The requirement for additional buses is such that under no option is a decline in bus patronage predicted. This leads to the conclusion that provided the right entry conditions to the industry can be established, there would be no problem in attracting the necessary investment over the forecast period. Here it is critical that, as current operating costs vary significantly between different cities, the fare policy should also be so differentiated, and the current national uniform fare-setting mechanism should be revised accordingly. The objective would, in the case of each city, be to provide for a reasonable margin between costs and revenues.

4.19 As with taxis, there is a need for the removal of the restrictions on numbers of vehicles, and equally importantly, far more stringent controls on the conditions of entry in terms of safety, activities contributing to congestion such as setting down and picking up, with a view to improving the overall quality of the service provided.

4.20 Given the implementation of these recommendations, the conditions of entry that would result, and the increasing demand for public transport we have forecast, we can foresee no basic problem with respect to route withdrawal. Indeed, the competition for routes should increase over the forecast period. If, however, the system still produces an unsatisfactory route structure, this could be modified by allowing operators to bid for routes specified by the municipality. Here it is essential that the appropriate conditions are established so that competition for supplying such routes is in fact increased between operators offering different forms of service. Para-transit operators might, for example, bid for routes where conventional public transport (currently the only available secondary city mode of public transport) would be unsuitable.

4.21 Even assuming that all of the above conditions can be met, it is still unlikely that the quality of substitution necessary to bring about the required switch of usage from private to public transport will be achieved through conventional public transport alone. To achieve this, it will be necessary to consider the role that could be played by intermediate (para-transit) forms of public transport, for specific land use alternatives. In this respect, the greatest opportunities for the successful application of para-transit in bringing about the required substitution effects would appear to be the concentrated option, and the greatest difficulties are likely to be associated with the dispersed land use option.

4.22 Finally, with respect to public transport we return to the issue of the organisation of the industry, and particularly the case for municipalisation, which itself is basically related to the argument about economies of scale. It is our contention, supported by most empirical evidence on the subject, that there are no significant economies of scale in bus operations. Moreover, the creation of the larger organisational units that would follow from municipalisation would be more likely to hinder than help in creating the necessary supply conditions. We therefore see no reason to municipalise the existing bus industry.

(ii) Infrastructure

4.23 The most interesting point to emerge from our analysis here concerns the significant variance in the requirement for road investment across the pricing and land use alternatives. Under each alternative there would be a need to monitor conditions under the price policy adopted. We have agreed that the most appropriate form of car use tax would be some form of congestion pricing. The yields from this would be an important indicator on the demand side of the need for investment. Similarly, the use of roads under other pricing policies should also be monitored. Prospective yields will vary according to the land use option adopted. We have also noted that, in practice, costs of road construction will vary according to density. This second determinant of the needs for investment requires specific investigation and continuous review.

4.24 There will also be the need to monitor the infrastructure requirements of non-mechanised trip-makers, which will also vary considerably across the options.

(iii) Land Use

4.25 The importance of different secondary city land use patterns to the achievement of future transportation objectives in these cities has been brought out clearly in this study in terms of the different characteristics, supply requirements and costs associated with the various land use options. This in turn helps to define the importance of land use as an instrument of transportation policy. For purposes of shaping land use in this way it is fortunate that Korea has a well developed physical planning system which would be capable of implementing the necessary land use changes through the application of the existing planning instruments - maintaining green belts, building satellite towns, controlling industrial location and use zoning and so on.

4.26 Insofar as there is a weak link in the process, it relates not so much to the means by which policies are implemented as to the way in which they are generated and tested as part of the city master planning process. It does not appear that alternative land use strategies are currently generated and evaluated for their relative effectiveness as instruments of transportaiton policy on any consistent basis if indeed at all. We would strongly advocate, therefore, a much closer interaction between land use and transportation planning within the city master planning process with the above objectives clearly in mind. In this respect much still remains to be done.

4.27 The other significant point with respect to land use concerns the similarities and differences in the required transport investments themselves across the land use options, particularly with respect to the creation of the right conditions of substitution. Here we also see the need for specific policies for specific locations.

4.28 Thus in the central area a combination of congestion pricing, perhaps by means of central area licencing, and the introduction of a highly flexible para-transit (e.g. taxi/micro bus) system would be appropriate.

4.29 In the suburbs we visualise a major role for the shared taxi, given the more diffuse journey patterns, together with the recognition of poorly served areas and community groups through specific public transport subsidies.

(iv) Maintaining Appropriate Market Conditions

4.30 At several stages in the foregoing arguments we have pointed to the need to establish freer market conditions for the various forms and combinations of transport, and the creation of new ways of rationing road space by price. If these policies are adopted, it will not be sufficient to establish the appropriate framework; the markets must continue to be free to adapt to changing circumstances. Though in general the absence of economies of scale in road transport provision will promote competitive behaviour, there will be an active role for the city authorities in keeping markets free. Partly this is a matter of ensuring that controls established to maintain standards of quality do not become, through too rigid administration, unwanted barriers to entry. More than this, however, there will be a need for active diffusion of information about opportunities to expand transport services, and also a need to investigate that satisfactory provision of transport is not frustrated by uncompetitive commercial practices in the supply of inputs to urban transport.

4.31 With monitoring and action where necessary along these lines, it will also be possible to ensure that if transport is provided as a social service, e.g. to the elderly or handicapped, effective bidding for contracts to supply such service is maintained.

APPENDIX A

KOREA TRANSPORT AND URBAN DEVELOPMENT STUDY

Terms of Reference

Objective of the Study

1. This project is intended to review the existing transportation situation in Korean cities, particularly secondary cities (also referred to as "non-metropolitan" cities) with a view to providing appropriate policies for future transportation planning activities.

2. Its objective is to clarify the context and content of decision-making in urban transportation planning and its execution in Korea, as the initial step in the preparation of feasibility studies. To achieve its objective, the study will include the following:

(a) a description of the recommended policy directions to be pursued in response to personal travel problems of the larger Korean secondary cities;

(b) recommendations as to the way in which projects and instruments of policy should be generated, evaluated and monitored within the context of the general policy guidelines set out in (a) above;

(c) recommendations as to any institutional or management changes that may be necessary if the above recommendations are to be successfully implemented.

Areas of Work

3. The study is intended to clarify the structure of urban transportation policy-making in Korean cities. It will aim at establishing

a hierarchy of priorities in the issues to be addressed, information gaps to be filled, organizational issues and management priorities.

4. An important element of the study will consist of an examination of a possible significant increase in the demand for motorized forms of transport in urban areas. Attention should be paid to the time horizon over which this problem is likely to develop. The study will need to articulate and rank alternative transport and development policies for dealing with the problem.

5. Preliminary investigations of Korean sources have indicated the existence of serious limitations in the current information base on urban transportation in Korean secondary cities.

6. For that reason, Busan will be used for the analysis of the existing transport problems of secondary cities, and will provide the basis for such travel demand forecasts as are possible. This information base will be supplemented by the experience of Seoul and non-Korean cities in order to identify an appropriate range of transport policy guidelines for secondary cities.

7. The existing transportation demand characteristics of non-metropolitan cities will, as far as possible, be quantified through the investigation of Busan in terms of peak and off peak person trips by motorized/non-motorized mode, trip purpose and length of trip. Future changes in these demand characteristics will be related to changes in urban structure and rates of growth, socio-economic and transport supply characteristics. The effect of supply characteristics will be expressed in terms of a physical inventory (e.g. miles and type of roads, rail track, no. of

buses, rail cars, trains etc) and policy instruments (e.g. fare and licensing regulations). The allocation of transport investment across modes will also be analysed.

8. An attempt will be made to determine the extent to which existing transportation policies:

(i) povide efficiently for the demand for total person travel;

(ii) equitably provide for the mobility needs of community groups;

(iii) take due account of the physical, land use, economic, social and environmental consequences on other sectors of the community.

Consideration of Future Policy Options

9. In investigating future policy options, the study will have to do the following:

(i) evaluate the current urban transport technical forecasting procedures;

(ii) evaluate the current urban transport policies;

(iii) identify the range of urban policy directions open to secondary cities to include consideration of:

(a) changes in the use of existing policy instruments and regulations;

(b) changes in the utilization of existing infrastructure through measures such as reserved rights of way for public transport, bus priorities and other traffic management measures;

(c) changes in the allocation of investment within the transportation sector. This might imply shifting the allocation of investment from major urban road projects to the upgrading of the public transport system through, for example, the introduction of more flexibile intermediate forms of public transport (paratransit) and the provision of improved facilities for pedestrians and cyclists. Explicit consideration should be given to the needs of commercial traffic;

(d) land use zoning and locational changes to reduce the excessive concentration of major traffic generation in the CBD, such as markets, hotels, intercity bus terminals, and hence reduce congestion;

(e) changes in the organization and management of public transport.

Evaluation of Alternative Policy Options

10. In discussing policy options the project will make explicit the criteria that should be used for their evaluation in terms of factors such as:

(i) Transportation criteria such as the extent to which the efficiency of the transportation system would be improved, if at all, in terms of providing efficiently for the growth in urban travel demand. Another criterion could be the extent to which the recommended policy options could influence the aggregate demand for travel and choice of mode in a direction consistent with overall urban policy objectives.

(ii) Physical, land use, economic, social and environmental consequences.

(iii) Institutional, legal and financial feasibility.

Format of Recommendations

11. Recommendations will be presented for Korean secondary cities in terms of:

(i) A synopsis of the existing and anticipated transportation sector problems by city type;

(ii) recommended policy solutions and their implications;

(iii) recommended minimum information requirements;

(iv) recommended technical forecasting procedures and monitoring processes.

Staffing

12. An essential element of the review is the joint collaboration of Korean and foreign specialists so as to strengthen Korean urban transport planning capabilities. The experts carrying out the study are:

1. Mr. Kyu-Bok Whang, leader of the transportation economics group, KIST.
2. Mr. Christopher Turner, Partner, Lichfield and Partners, London.
3. Professor Michael Beesley, Associated Consultant, Lichfield and Partners, and London Graduate School of Business Studies.

Scheduling

1. The project will be initiated by a visit to Korea by Mr. Turner and Professor Beesley on or around March 28, 1977 for a period of approximately 12 days to define the work program, the general structure of the report and the division of labor with Mr. Kyu-Bok Whang.
2. During the last week of April 1977, Mr. Whang will go to London to review and discuss the progress of the study with Messrs. Beesley and Turner. Mr. Whang will spend 5 working days with Lichfield and Partners to perform this task.
3. Mr. Turner will make a second visit to Korea to work on the finalization of the draft report with Mr. Whang for a period of about 12 days.

Reporting

1. The work program outline resulting from the first visit of Messrs. Beesley and Turner will be submitted

to the Bureau of planning of EPB on or before ____________________ and a copy forwarded to the World Bank by consultants on the same date.

2. A progress report describing the work accomplished and the work remaining to be accomplished by the end of Mr. Whang's visit to London should be submitted to both EPB and the World Bank by June 15.

3. The draft report should be submitted for review by EPB and World Bank by August 15, 1977.

4. The final report incorporating the comments received from EPB and whatever consultative group it chooses to use for that purpose, should be submitted within two months of receipt of these comments.

13. Dissemination of Results developed during the preparation of the study will be considered confidential. In the event that the authors wish to submit selected elements of their findings to professional publications, they will be required to obtain prior clearance from both EPB and the World Bank of their manuscript. In case clearance is granted, the document will state explicitly that it represents only the views of the authors and not the views of either EPB or the World Bank.

APPENDIX B

INTERNATIONAL DATA

APPENDIX B

1.0 STRUCTURE OF PERSONAL TRAVEL DEMAND

1.1 Motorization (cars/1000 population) versus per capita Income

	CARS PER OOO. pop'n	$\frac{Y}{P}$ 1970 US $
San Jose	48.0	430
Adidjan	76.0	500
Bangkok	50.0	525
Kuala Lumpur	52.0	660
Bogota	22.0	760
Singapore	73.0	1100
Mexico City	78.0	1225
Caracas	91.0	1600
London	222.0	2550
Paris	248.0	3530
Washington DC.	316.0	5390
Seoul	4.8	440
Busan	1.7	350
Karachi	15.1	360

SOURCES [1] Zahavi "Travel characteristics in cities of Developing and developed countries" IBRD staff working paper No.230 Nathaniel Lichfield and Partners, 1977.

1.2 Total person trips per person versus Motorization (cars per 000)

	PERSON TRIPS/PERSON	CARS/000
Nagoya	2.75	248
Tokyo	2.48	139
Keihanshin	2.39	176
Northern Kynshu	2.68	191
Sapporo	2.68	145
Okayama	2.55	229
Sendai	2.50	180
San Jose	1.18	35.38
Lagos	0.82	29.40
Singapore	1.49	69.36
Kingston	1.21	83.97
Kuala Lumpur	1.76	122.04
Nicosia	2.63	168.15

SOURCES: *Ibid.* (*T.* 1.1.)

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1.3 Mechanized trips/person versus Annual Income per person

	MECHANISED TRIPS PER PERSON	INCOME/PERSON 1970 US $
Seoul	1.03	440
Busan	0.79	350
Bogota	1.90	760
Karachi	0.90	360
San Jose	1.14	430
Nagoya	1.62	3400
Tokyo	1.42	3800
Keihanshin	1.28	3600
North Kynshu	1.64	3100
Sapporo	1.55	3000
Okayama	1.69	3000
Sendai	1.57	2400

SOURCES: [1] Nathaniel Lichfield & Partners 1977

[2] Annual report of roads 1975
Japanese Road Association.

APPENDIX B

1.4 Non mechanized trips per person versus Annual Income per person

	NON MECHANISED TRIPS/PERSON	ANNUAL INCOME PER PERSON (1970 US $)
Seoul	0.35	440
Busan	0.49	350
Karachi	1.21	360
Bogota	0.44	760
San Jose	0.04	430
Nagoya	1.13	3400
Tokyo	1.06	3800
Keihanshin	1.11	3600
North Kynshu	1.04	3100
Sapporo	1.13	3000
Okayama	0.86	3000
Sendai	0.93	2400

SOURCES: [1] Nathaniel Lichfield and Partners 1977

[2] Annual Report of Roads 1975·
Japanese Road Association.

APPENDIX B

1.5 Public Transport Share of Mechanised Travel Market versus Motorization (cars per 000 pop'n)

	CARS PER 000	% PUBLIC TRIPS OF MECHANISED TRIPS
San Jose	35.38	0.77
Nicosia	168.15	0.17
Manila	39.05	0.68
Singapore	(1968) 53.08	0.61
	(1972) 69.36	0.52
Kuala Lumpur	122.04	0.33
Karachi	15.08	0.58
Busan	1.54	0.92
Hong Kong	21.98	0.82
Kingston	83.97	0.48
Athens	21.00	0.76
Bogota	24.00	0.83
Bangkok	61.00	0.76
Tel Aviv	72.00	0.61
Caracas	88.00	0.547
London	222.00	0.296
Baltimore	272.00	0.187
Seoul	4.80	0.920
Nagoya	248.00	0.265
Tokyo	139.00	0.593
Keihanshin	176.00	0.510
North Kyushu	191.00	0.452
Sapporo	145.00	0.459
Okayama	229.00	0.247
Sendai	180.00	0.373

SOURCES: [1]Nathaniel Lichfield and Partners, 1977
[2]Annual Report of Roads 1975, Japanese Road Association.

APPENDIX C

MODEL OF THE AVERAGE KOREAN CITY IN 1975 AND 1985

SUMMARY OF MODEL PROCEDURE

1. We have modelled the average Korean city in 1975 and 1985 to illustrate the effects upon trip making of adopting different land use policies, and policies of imposing supplementary taxes upon car use or onwership in circumstances where rapid income and population growth are forecast.

2. The parameters of the city which we concentrate upon in the modelling procedure are its population, area, population density, average income, level of car ownership per head and the distribution of daily person trips by mode.

3. As the basis for our average Korean city in 1975 we have used 1975 data for the four cities of Daegu, Daejon, Gwangju and Jeonju and taken the mean of their populations, area, and car ownership per person for our average city. Income per capita we have assumed is equal to the national average.

4. The 1975 distribution of daily person trips by mode in this "average" city is estimated using the above data and relationships between income, car ownership and average population density and the distribution of trips derived by the 1977 NLP secondary city study. 1/ Total trips are

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1/ NLP, Phase 1 City Study "Urban Transport Sector Working Paper", Information Availability and Travel Characteristics in Developing Cities, 3rd June 1977.

divided between mechanised trips and non-mechanised trips (walk and cycle trips), and mechanised trips between those made on public and private transport. Mechanised trips are estimated as a (positive) function of the level of income, non-mechanised trips as a (positive) function of the level of average population density. 1973 sample data for Busan were used to modify these relationships so that their estimates of trips by mode resembled a typical Korean distribution as closely as possible. Diagram A summarises this procedure.

5. The private-public split of mechanised trips in 1975 was estimated on the basis of the Busan distribution for 1973.

6. In forecasting the population of the average city in 1975 we have adopted the mean of a population forecast for the four secondary Korean cities and a forecast of average national income as the forecast income level.

7. To simulate the effects of adopting alternative land use policies between 1975 and 1985 we have postulated four areas for the 1985 average city - thus giving four different average population densities with the total forecast population the same in each case. Average income in 1985 is also the same under each land use option.

8. The four land use policies are:

(a) A policy of maintaining the 1975 average population density. This policy allows urban area to expand given the forecast increase in population.

(b) A policy of concentration. This policy maintains the 1975 area of the average city thus increasing average density given forecast population growth.

(c) A policy of dispersal. This achieves a decline in average population density 1975-1985 by allowing a considerable increase in urban area.

(d) A Green Belt Policy. This maintains the population and area of the 1975 city and distributes the forecast increase in population equally between the new satellite cities, each having an equal and lower average density than the centre.

9. We assumed for simplicity that our modelled city in each land use case (or its parts in the case of the Green Belt city) is circular.

10. Forecasting the distribution of total trips by mode under the alternative land use options is a two stage procedure.

11. First the distribution of trips by mode in the case of the existing density option is forecast. This involves simply substituting the income forecast into the equations for estimating mechanised trips. Non-mechanised trips per person remained at the 1975 level since population density is the same under this option with total walk trips increasing due to population growth. The private-public split of mechanised trips was estimated on the basis of an assumed level of car trip-making per day, given estimated car occupancy and the forecast level of car stocks. Car stocks were forecast on the basis of an estimated elasticity for car ownership with respect to income changes derived from international data.

12. In order to forecast the distribution of trips under the other land use options it was necessary to estimate an elasticity for the effect of changes in average population density upon mechanised trips per capita

and upon the level of car ownership. The number of mechanised trips per person and the level of car ownership were related inversely to changes in average population density. These elasticities were taken from other studies or derived from international data.

13. They were then used to modify the forecast mechanised trips and the private-public split of trips under the 1985 existing density option to arrive at forecasts for the other land use options.

14. From the estimates of the numbers and modal distribution of daily person trips in 1975 and 1985 we then estimated the number of public vehicle trips (private car trips having already been derived and public trips forming the residual of estimated mechanised trips). From these the number of vehicle kilometres of travel per day in 1975 and in 1985 under each land use option were calculated. For these estimates we forecast vehicle occupancy and average trip lengths under each land use option. The levels of taxi and bus occupancy in 1975 were estimated from Korean data. For 1985 their values were reduced to allow for some improvement in the public transport service. Average car and taxi trip lengths (assumed the same) were calculated as a (positive) function of the radius of the "average" city under each land use option on the basis of a relationship derived by Zahavi, whilst bus person trip lengths and daily kilometres of travel for each bus were again estimated from Korean data.

15. In calculating vehicle kilometres of travel (either person or vehicle kilometres) under all land use policies except the Green Belt policy, numbers of trips were simply multiplied by the average trip distance calculated as above. In the case of the Green Belt policy option, however, and to

DIAGRAM A: 1975 AVERAGE KOREAN CITY

1975 Data for Daegu, Daejon, Gwangju, Jeonju:
- Population
- Area
- Cars

→

Description of Average City 1975
- Population / Area — Av.Pop.Density
- Cars per Person
- Income per Person

Distribution of Daily Trips by Mode, Busan 1973

Cross Country Relationships from NLP City Study

↓

Relationships between Population, Car Onwership, Income and Daily Person Trips by Mode 1975:

1. Non-mechanised Trips per Person 1975 = f(Av.Popn.Density '75)
2. Mechanised Trips per Person 1975 = f(income per head '75)
3. Total Trips per Person 1975 = 1 + 2
4. Public/Private Split of Total Mechanised Trips 1975 = f(Busan Distribution 1973)

↓

Distribution of per capita and Total Daily Person Trips by Mode 1975 reflect trips made between parts of the Green Belt city, a simple gravity model was used to determine the destination of trips generated from each part of the city, whilst average trip distances between parts of the city were calculated using the Zahavi equation and the assumed distance between the centre of each separate part.

16. In estimating vehicle stocks with the car use pricing policy the effect of increasing costs of use upon car stocks has been traced through using a price elasticity for car ownership.

17. The final part of the model is the costing of the policy alternatives. A greatly simplified costing procedure has been adopted in keeping with the rest of the model.

18. Costs are divided into three separate categories because of their incidence - capital costs (which include road construction costs and the costs of additions to vehicle stocks), daily vehicle operating costs, daily costs of travel time and annual replacement costs for vehicle stocks.

19. The procedure for forecasting person trips and vehicle kilometres of travel under each land use option is summarised in Diagram B.

20. In estimating the effects of imposing supplementary taxes on private car use or ownership we have concentrated upon the use pricing policy which affects a reduction of 25% in car trips and the transfer of persons carried onto public transport. Having defined the means of implementing the pricing policy as imposing increased costs on car use, we then traced through the effects of this transfer upon vehicle kilometres of travel in each land use option case. We have assumed that all frustrated

car trips are transferred onto either buses or taxis and have calculated the increase in vehicle kilometres of travel in each case. These alternatives have been taken to represent low and high quality alternatives to private transport. Which alternative is provided determines the extent to which car use costs have to be increased in order to achieve the desired transfer of trips. With the high quality alternative (taxi) we have assumed that a high cross elasticity of demand pertains for car use in response to changes in the price differential between private and public transport, whilst with the low quality alternative (bus) a low price elasticity will result. Elasticities of 2.0 and 0.7 were chosen to calculate the necessary increases in costs for car use.

21. From these estimates of person and vehicle trips under each policy in 1985 we estimated the stocks of vehicles required in order to meet all trip demands, the total daily travel time and the amount of road construction that would have to be made in each policy case in order to maintain 1975 average speeds of travel.

Description of the Average Korean City 1975

22. The average Korean city in 1975 is described in terms of its population, area, population density, average income, level of car ownership per head and the distribution of daily person trips by mode. Trips are divided between non-mechanised trips (which theoretically should include both walk trips and cycle trips but which for the purposes of the model we define as walk trips only) and mechanised trips, themselves divided between those made on public transport, "public trips", and private car trips, "private trips."

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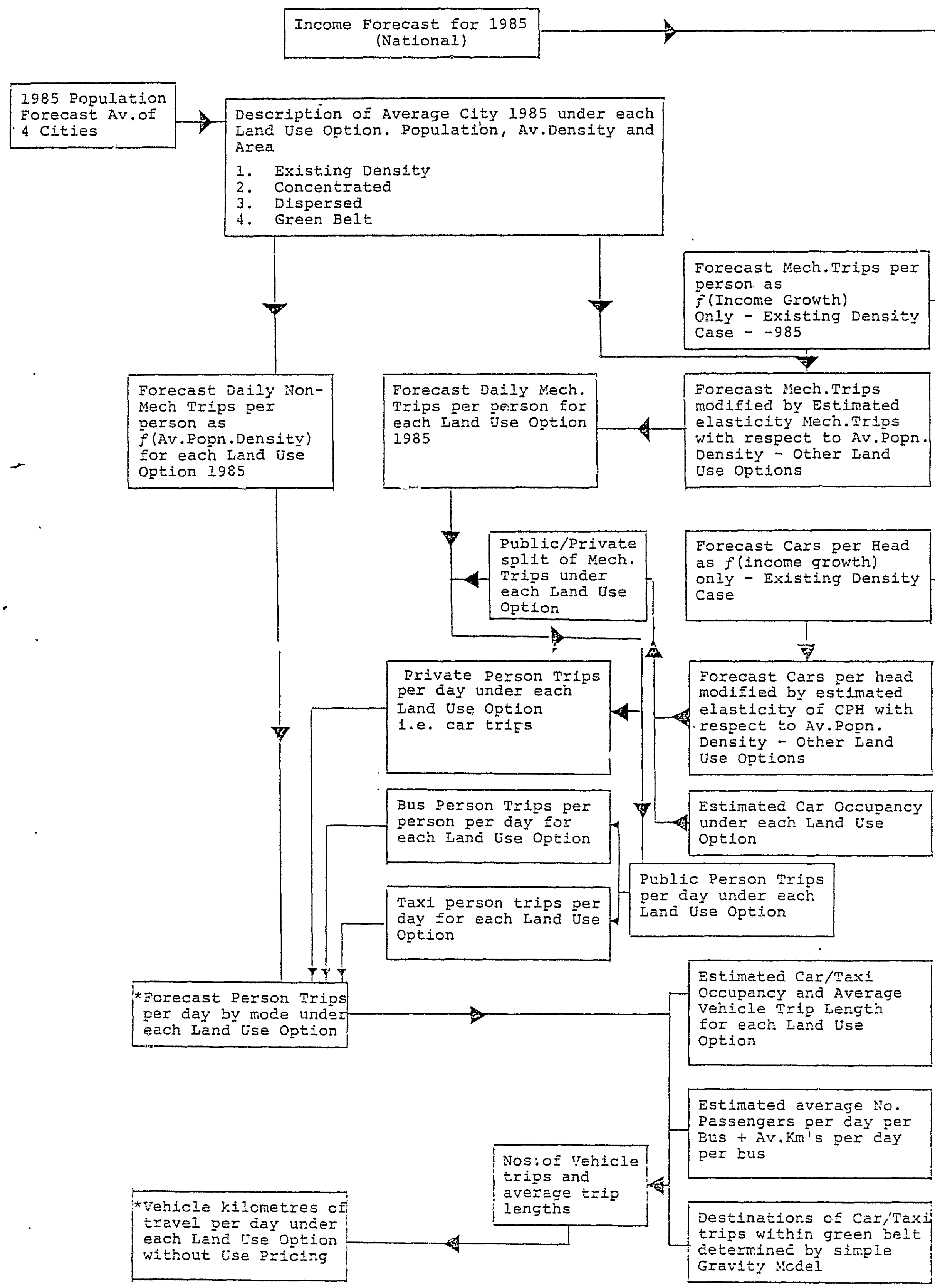
DIAGRAM B: 1985 AVERAGE KOREAN CITY



23. Poulation, area, density and level of car ownership per head is taken as the mean of those data for the cities of Daegu, Daejon, Gwangju, and Jeonju in 1975 (Table 1).

24. Income per capita is assumed equal to the national average in 1975.

25. Daily person trips by mode are estimated from the above and equations derived by the World Bank City Study 1977. Since the equations were calculated from cross country data their estimates of trips by mode are compared with 1973 survey for Busan, the most recent data available for a Korean distribution of trip-making and correction factors introduced on the basis of the Busan data in order that the distribution of trips more closely resembles a typical Korean distribution.

26. Equations used to estimate daily trips in the average city 1975 area as follows: - (Correction factors are the second bracketed terms).

Non mechanised trips per person (NMTP) $(0.000047 \frac{P}{KM^2} + 0.3)$ (0.893).......(1)

Total mechanised trips per person (TMTP) $= (0.76 + 0.00078 \frac{Y}{P})$ (0.76)...(2)

Where $\frac{Y}{P}$ = Korean average income per capita (1970 Won) expressed in 1973 US$ since all city study incomes were expressed in 1973 US$.

$\frac{P}{KM_2}$ = Average population density

$\frac{C}{P}$ = Car ownership per capita

TABLE 1: CALCULATING THE POPULATION, AREA, DENSITY AND LEVEL OF CAR OWNERSHIP PER HEAD IN THE AVERAGE KOREAN CITY 1975

	POPULATION 1975	AREA (km^2) 1975	DENSITY (PERSONS/km^2) 1975	CARS 1975	CARS PER HEAD 1975
Daegu	1,311,078	178.32	7,352	4,573	0.0035
Daejon	506,703	88.22	5,744	2,527	0.0049
Gwangju	607,058	214.78	2,826	1,673	0.0028
Jeonju	311,432	105.75	2,945	823	0.0026
Average City 1975	684,068	147.00	4,717	2,399	0.0035

SOURCE: Statistical Yearbooks

27. For the average city in 1975 mechanised trips are divided between private and public trips on the same ratio as in Busan in 1973, with 91% of mechanised trips made privately and 9% on public transport. Table 2 shows the data for Busan, and the basis for the correction factors.

28. The estimated distribution of trips by mode in the average Korean city 1975 is shown in Table 3.

THE AVERAGE CITY IN 1985

Population Forecast

29. We use Renaud's population forecast for our four cities to calculate the average city's 1985 population (Table 4).

Income Per Capita Forecast

30. A forecast for national income per capita, projected to grow at an annual compound rate 7% 1975-1985 is adopted for the average city. Thus average income is increased from $403 to $793.

Forecasting Population Density and Area Under Alternative Land Use Policies

31. We have described the outcome of adopting each of four theoretical land use policies in the average city. Forecast population is the same across the options, which differ in area and thus population density only.

32. Table 5 summarises the four alternative policy outcomes in terms of density and area, and compares these with the average city in 1975.

33. The alternative 1985 average cities were derived as follows:

Existing Density City.

34. Density remains constant 1975-1985, thus given population growth the area of the city is allowed to expand.

TABLE 2: DISTRIBUTION OF DAILY PERSON TRIPS BY MODE IN BUSAN 1973, ESTIMATES FOR THAT DISTRIBUTION ON THE BASIS OF CITY STUDY EQUATIONS AND THE IMPLIED CORRECTION FACTORS FOR THE EQUATIONS

TOTAL PERSON TRIPS PER DAY BY MODE	BUSAN ACTUAL 1973	%	BUSAN ESTIMATED 1973	%	IMPLIED CORRECTION FACTORS FOR EQUATIONS
Non Mechanised Trips (NMT)	996,400	39	1,115,997	35	0.893
Private Mechanised Trips	139,700	5	187,979	6	
Public Mechanised Trips (PMT)	1,450,100	56	1,900,678	59	
Total Mechanised Trips (TMT)	1,589,800	61	2,088,657	65	0.760
Total Person Trips	2,586,200	100	3,204,654	100	

SOURCES: [1] Busan Study 1974
[2] Nathaniel Lichfield and Partners, 1977.

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TABLE 3: THE AVERAGE KOREAN CITY 1975:
DAILY PERSON TRIPS BY MODE

	AVERAGE CITY 1975	
TOTAL PERSON TRIPS PER DAY BY MODE:		%
Non Mechanised Trips [1]	318,692	36.0
Private Mechanised Trips [2]	50,269	5.7
Public Mechanised Trips [3]	508,271	58.0
Total Mechanised Trips [4]	558,540	63.7
Total Person Trips [5]	877,232	100.0
DATA:		
NMTP		
P	684,068	
$\frac{Y}{P}$ ('75 US$)	403	
$\frac{C}{P}$	0.0035	

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1]Non-mechanised trips per person = $\{0.000047 \frac{P}{KM^2}\ 0.3\}\{0.893\}$

[2]Private Mechanised Trips = 9% Total Mechanised Trips as in Busan 1973.

[3]Public Mechanised Trips = Total Mechanised Trips - Private Mechanised Trips.

[4]Total Mechanised Trips per person = $\{0.76 + 0.00078 \frac{Y}{P}\}\{0.76\}$

[5]Total Trips = Sum [1] and [5] .

TABLE 4 - 1985 POPULATION OF THE AVERAGE CITY

	FORECAST POPULATION 1985
Daegu	2,066,000
Daejon	653,000
Gwangju	825,000
Jeonju	367,000
Average	977,750

SOURCE: Renaud

TABLE 5: AVERAGE CITY 1975 AND 1985 UNDER LAND USE POLICIES - DENSITIES, AREAS, POPULATIONS

	1975	1975 ALTERNATIVE POLICY OPTIONS					
					GREEN BELT		
		EXISTING DENSITY	CONCENTRATION	DISPERSION	INNER CITY	TOTAL OF OUTER SATELLITES	TOTAL
		(1)	(2)	(3)	←(4)→		
Density persons/km^2	4,717	4,717	6,575	2,886	4,717	2,937	3,959
Area km^2	147	207	147	339	147	100	247
Population	684,068	977,750	977,750	977,750	684,068	293,682	977,750

SOURCE: Nathaniel Lichfield and Partners.

Concentrated City.

35. The 1975 area is maintained thus forcing up average density in the face of population growth.

Dispersed City.

36. A fall in average density is desired under this policy. We have arbitrarily adopted the 1975 average for Gwangju and Jeonju as the desired level. Thus city area rises considerably in the face of population growth.

Green Belt City.

37. Under the Green Belt policy all population growth is diverted equally to two new satellite cities and the centre remains as the 1975 city in population size and average density.

Forecasting Daily Trips by Mode 1985

38. Table 6 summarises daily person trips by mode in the average city in 1975 and 1985 under each of the four land use options.

39. In making the forecasts, average income and the city's population is the same across the options.

40. The forecasts for car ownership per head and the distribution of trip by mode across the options are described below.

Forecasting Car Ownership per Head.

41. The level of car ownership per head varies directly in relation to real income changes and inversely in relation to changes in average population density. Thus each forecast of the level of car ownership includes an income and a density effect - except in the case of the existing density option in which the level of car ownership is influenced by the growth of average incomes only.

TABLE 6: SUMMARY: DAILY TRIPS BY MODE IN THE AVERAGE KOREAN CITY, 1975 AND 1985 UNDER THE ALTERNATIVE LAND OPTIONS

DAILY PERSON TRIPS BY MODE	1975	1985 AVERAGE CITY: ALTERNATIVE LAND USE OPTIONS					
	AVERAGE CITY	EXISTING DENSITY	CONCENTRATED	DISPERSED	GREEN BELT		
					INNER CITY	OUTER SATELLITES	TOTAL
	%	(1) %	(2) %	(3) %	← %	(4) — % →	%
Non Mechanised Trips	318,692 $^{36.0}$	455,511 $^{30.8}$	531,758 $^{34.5}$	380,372 $^{26.7}$	318,692 $^{30.8}$	114,879 $^{26.8}$	433,571 $^{29.6}$
Mechanised Trips — Private	50,011 $^{5.7}$	277,352 $^{18.7}$	234,202 $^{15.2}$	355,845 $^{25.0}$	194,050 $^{18.7}$	105,930 $^{24.7}$	299,980 $^{20.5}$
Mechanised Trips — Public	508,529 $^{58.0}$	747,027 $^{50.4}$	776,792 $^{50.3}$	688,392 $^{48.3}$	555,853 $^{50.5}$	207,722 $^{48.5}$	730,575 $^{49.9}$
Total Mechanised Trips	558,540 $^{63.7}$	1,024,379 $^{69.2}$	1,010,994 $^{65.5}$	1,044,237 $^{73.3}$	716,903 $^{69.2}$	313,652 $^{73.2}$	1,030,555 $^{70.4}$
Total Person Trips	877,232 ^{100}	1,479,890 ^{100}	1,542,752 ^{100}	1,424,609 ^{100}	1,035,595 ^{100}	428,531 ^{100}	1,464,126 ^{100}

SOURCE: Nathaniel Lichfield and Partners, 1977.

Forecasting Cars per Head as a Function of Income Growth Only - the Existing Density Option.

42. International experience indicates that the elasticity 1/ of the level of car ownership with respect to growth in incomes per capita declines as incomes grow past a certain income level.

43. UN data 2/ indicate that countries in the income range \$201 - \$375 per annum 1960-1970 had an average elasticity of 2.8, whilst those in the range \$376 - \$1000 had an average elasticity of 2.3.

44. We have assumed a similar proportionate fall in the Korean elasticity for the period 1975-1985 compared with previously, on the basis that Korea was at the lower end of the lesser income group of countries 1960-1970 3/ (and had an elasticity of 2.7), but that by 1985 with income forecast to grow to \$793 Korea will fall within the higher groups range of experience. Thus we estimate that Korea's elasticity for 1975-85 will fall from 2.7 to 2.2. 4/

45. Adopting this forecast elasticity for the average city, and applying it to the projected increase in income and the 1975 level of car ownership, we estimate the level of car ownership per head in the average city in 1985 in a situation in which average population density remains constant, to be 0.0213.

1/ All references to elasticity are to ARC ELASTICITY, defined as

$$\text{Arc. Elasticity of } Q \text{ with respect to changes in } Y = \frac{\Delta Q}{\Delta Y} \frac{(Y_1 + Y_2)}{(Q_1 + Q_2)}$$

2/ UN World Tables 1977.

3/ Ibid.

4/ $2.7 \times \frac{2.3}{2.8} = 2.2$

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Forecasting Cars per Head for the Concentrated Dispersed and Green Belt Options

46. Fairhurst 1/ estimates that the elasticity of car ownership with respect to positive changes in average population density net of income changes in London is approximately -0.6. This figure was used to modify the level of car ownership forecast under the existing density option for each of the alternative forecast land use options.

47. The level of car ownership in the average city in 1975 and 1985 under the alternative options is summarised in Table 7.

Forecasting Daily Person Trips by Mode

48. Non mechanised trips per person. Non mechanised trips per person in 1985 under each policy option are found by substituting into the previously used equation 2/ the forecast average population density for each option.

49. The number of non-mechanised trips per day in 1975 and under each of the 1985 land use options are shown in Table 8.

50. Total mechanised person trips per person. Mechanised person trips per person are forecast in the existing density case by substituting into the previously used equation the 1985 forecast level of income per capita.

51. Data from the City Study indicates that the number of mechanised trips is also inversely related to average population density with an elasticity of -0.04, and this figure was applied to the forecast under

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1/ M.H. Fairhurst - "The Influence of Public Transport on Car Ownership in London". Journal of Transport Economics and Policy. Sept. '75.

2/

$$\text{Non mechanised trips per person} = \left(0.000047 \frac{P}{KM^2} + 0.3\right) (0.893)$$

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TABLE 7 - CAR OWNERSHIP PER HEAD IN THE AVERAGE CITY 1975 AND IN 1985 UNDER ALTERNATIVE LAND USE OPTIONS

	1975	1985: ALTERNATIVE POLICY OPTIONS				
		(1) EXISTING DENSITY	(2) CONCENTRATION	(3) DISPERSION	(4) GREEN BELT	
					(a) INNER CITY	(b) OUTER SATELLITES
Cars per head	0.0035	0.0213	0.0175	0.0285	0.0213	0.0282

SOURCE: Nathaniel Lichfield and Partners, 1977.

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TABLE 8 - DAILY NON MECHANISED TRIPS PER PERSON 1975 AND 1985 UNDER ALTERNATIVE LAND USE OPTIONS

	1975	(1) EXISTING DENSITY	(2) CONCENTRATED	(3) DISPERSED	(4) GREEN BELT		
					INNER CITY	OUTER SATELLITES	AVERAGE
No.of non-mechanised trips per person	0.47	0.47	0.54	0.39	0.47	0.39	0.44

SOURCE: Nathaniel Lichfield and Partners, 1977.

existing density conditions to account for the effect of differing densities under the alternative land use options.

52. Total mechanised trips per person 1975 and 1985 are summarised in Table 9.

53. Private mechanised trips. The estimate of private trip making for 1975 divided by estimated average car occupancy (described below), and the number of cars implied a trip rate per car of 8.8 trips per day. For 1985 we have assumed a fall of 20% in trips per day per car, making 7.04 trips per car, for each of the land use options. Private person trips for each option were then derived from total vehicle trips by dividing by estimates of car occupancy for each option.

54. Car occupancy is estimated on the basis of the following relationship: - 1/

$$\text{Occupancy} = 0.864 - 0.267 \ \text{Ln (Cars per Head)}$$

$$r^2 = 0.43, \quad n = 8$$

55. Public mechanised trips. These are calculated as the residual of total mechanised person trips minus private mechanised person trips.

Estimating Total Vehicle km's of Travel in the Average City 1975, 85

Private Car km's Travelled Daily

56. Total daily car km's are calculated on the basis of the assumed daily trip rates per car, total car stocks (cars per head x population)

1/ Derived from international data recorded in Zahavi p. 70 "Travel Characteristics in Cities of Developing and Developed Countries". World Bank Staff Working Paper No. 230 March 1976.

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TABLE 9: TOTAL MECHANISED PERSON TRIPS PER PERSON 1975 AND 1985 UNDER ALTERNATIVE LAND USE OPTIONS

	1975	(1) EXISTING DENSITY	(2) CONCENTRATED	(3) DIS-PERSED	(4) GREEN BELT		
					INNER CITY	OUTER SATELLITES	AVERAGE
Total Mechanised Person Trips per person	0.8165	1.0477	1.0340	1.0680	1.0480	1.0680	1.0540

SOURCE: Nathaniel Lichfield and Partners, 1977.

and the average trip length (Table 10) average trip length for each option is estimated on the basis of the following relationship: - 1/

Average car trip length = $1.74\ r^{0.469}$ (Where r = City radius)

57. In modelling the average city we have assumed that both in 1975 and 1985 the city is circular. In this way we are able to calculate the radius, and therefore average trip length implied by a given area.

58. Calculating car km's travelled is straightforward for all cases except the Green Belt city option, where it has been necessary to estimate the number of trips occuring between parts of the Green Belt city and the varying average lengths of these trips. A simple gravity model is used to distribute these trips. This is described in greater detail below.

59. Estimating car kms' travelled in the Green Belt City. Diagram 1 shows the dimensions of our Green Belt city in 1985. The inner part of the city has the same dimensions as the average city 1975, the outer satellites each have a radius of 4 km's and are situated 8 kms on either side of the centre.

60. Average trip lengths are derived on the same basis as above, relevant "radii" for trips within and between the parts of the city and the average trip lengths derived from them are set out in Table 11.

1/ Zahavi. "Travel Characteristics in Cities of Developing and Developed Countries". World Bank Staff Working Paper No. 230, March 1976.

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TABLE 10 CALCULATING PRIVATE CAR KM'S TRAVELLED IN THE AVERAGE CITY 1975 AND 1985.

	1975	1985: Alternative land use options					
					GREEN BELT		
		EXISTING DENSITY	CONCENTRATED	DIS-PERSED	INNER CITY	OUTER	TOTAL
Stock of cars	2394	20826	17111	27866	14571	8282	22853
Vehicle Trips per car	8.8	7.04	7.04	7.04	7.04	7.04	7.04
Total car trips	21067	146615	120462	196177	102580	58306	160886
Average trip length km's	4.2756	4.6412	4.2756	5.2184	4.3844	3.7479	4.1537
Car km's travelled	90,074	680,470	515,045	1023728	449751	218521	668272

SOURCE : Nathaniel Lichfield and Partners, 1977

NOTES : [1] Average car trip length = $1.74\ r^{0.469}$

where r = city radius

61. The number of car trips generated within each part of the city are distributed in terms of their destinations on the basis of a simple gravity model in the following manner: -

$$\text{Proportion of trips from any part of city to any other part} = \frac{\frac{A_j}{T_{ij}}}{\Sigma \left(\frac{A_j}{T_{ij}}\right)}$$

Where A_j = Population of part of city receiving trips
T_{ij} = Distance between two parts

- For trips within any part of the city an impedance factor of $\frac{2}{3}$ has been used.

62. Table 12 shows the proportion and number of car trips per day by origin and destination within the Green Belt City, whilst Table 13 shows the car km's of travel calculated.

Taxi Vehicle Kms' Travelled Daily

63. Data for Busan 1973 indicate that approximately 7% of all public person mechanised trips are made by taxi and 93% by bus. We estimate numbers of taxi person trips per day in 1975 and 1985 in the average city under the alternative land use options on the basis that this percentage is maintained.

64. Total taxi kms' are calculated in the following way:-

Taxi km's of travel (taxi person trips per day taxi occupancy) x (average taxi trip length).

DIAGRAM 1: DIMENSIONS OF THE GREEN BELT CITY 1985

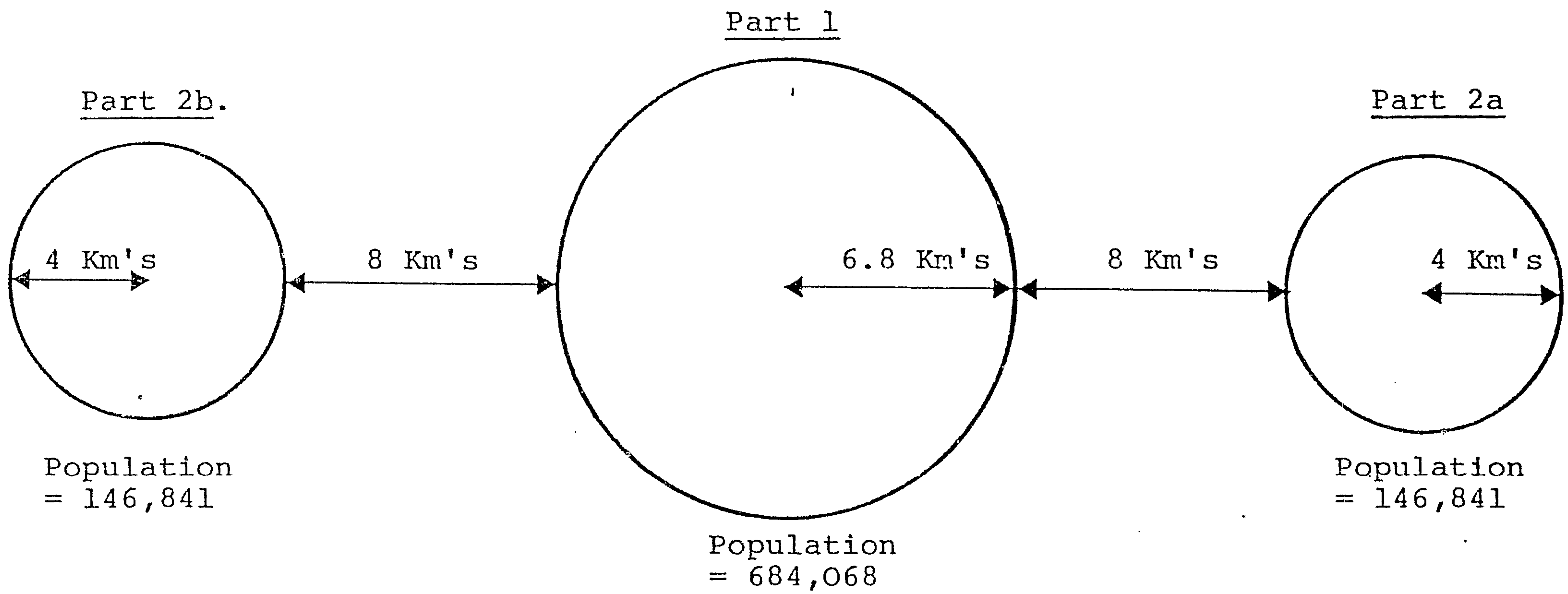

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TABLE 11: RADII AND AVERAGE TRIP LENGTHS IN GREEN BELT CITY 1985

To:

From:	1	2a	2b
1	r = 6.8 Trip L = 4.28	r = 18.8 Trip L = 6.89	r = 18.8 Trip L = 6.89
2a	r = 18.8 Trip L = 6.89	r = 4 Trip L = 3.33	r = 37.6 Trip L = 9.53
2b	r = 18.8 Trip L = 6.89	r = 37.6 Trip L = 9.53	r = 4 Trip L = 3.33

SOURCE: Nathaniel Lichfield & Partners 1977

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TABLE 12: PROPORTIONAL DISTRIBUTION OF CAR TRIPS IN GREEN BELT CITY 1985

To:

From:		1	2a	2b	TOTAL CAR TRIPS
1	%	96	2	2	100
	No.Trips	98477	2052	2052	102580
2a	%	10	89	1	100
	No.Trips	2915	25946	292	29153
2b	%	10	1	89	100
	No.Trips	2915	292	25946	29153
					160886

SOURCE: Nathaniel Lichfield & Partners 1977

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TABLE 13: CAR KM's TRAVELLED IN THE GREEN BELT CITY 1985

From: \ To:	1	2a	2b	ε
1	421481	14135	14135	449751
2a	20086	86400	2775	109261
2b	20086	2775	86400	109261
				668273

SOURCE: Nathaniel Lichfield & Partners 1977

We have taken a taxi occupancy of 3 (excluding driver) for 1975 and 2 for all land use options in 1985 and assumed that average taxi trip length is the same as average car trip length. For the Green Belt option taxi trips and taxi person trips have been distributed in the same way as car trips, (paras. 59-61) with the simple gravity model. Estimates of taxi travel for 1975 and all options are shown in Table 14.

Bus Vehicle kms' Travelled Daily

65. Bus kms' travelled under each option 1985 are calculated by the following method: -

$$\text{Total bus km's per day 1985} = \left(\text{Bus person trips per day}\right) \times \left(\text{Average km's per bus per day}\right) \div \left(\text{Average number of passengers carried per bus}\right)$$

Bus person trips in 1975 and 1985 are calculated on the assumption that 93% of public person trips are made by bus.

66. Average kms' travelled per day per bus and the average number of passengers carried in 1976 are calculated from data for the cities of Daegu, Daejon, Jeonju and Gwangju (see Table 15). These data are adopted for the average city in 1975. For the 1985 forecasts we have assumed average distance travelled per bus per day remains at the 1975 level, but that the number of passengers carried per bus falls by 20% to represent an expected improvement in travelling conditions. Table 16 summarises the calculations for estimating total bus km's travelled in 1975 and in 1985 under each of the options.

Summary of Vehicle Km's Travelled in Average City 1975 - 1985

TABLE 14: TAXI VEHICLE KM's TRAVELLED 1975 AND 1985 UNDER ALTERNATIVE LAND USE OPTIONS

	1975	1985: ALTERNATIVE LAND USE OPTIONS					
		(1) EXISTING DENSITY	(2) CONCENTRATED	(3) DISPERSED	(4) GREEN BELT		
					INNER	OUTERS	TOTAL
No.taxi person trips per day	35597	52292	54375	48187	36600	14541	51140
Taxi Occupancy	3	2	2	2	2	2	2
Taxi trips per day	11866	26146	27188	24094	18300	7271	25571
Average length taxi trip	4.2756	4.6412	4.2756	5.2184	4.3844	3.7479	Average 4.2033
Taxi Km's travelled	50,733	121,348	116,242	125,729	80,234	27,249	107,483

SOURCE: Nathaniel Lichfield and Partners, 1977.

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TABLE 15: 1976 BUS DATA FOR THE AVERAGE CITY

	AVERAGE MONTHLY KM's PER BUS	AVERAGE MONTHLY PASSENGERS PER BUS	AVERAGE NUMBER OF BUSES
Daegu	10,696	34,122	702
Daejon	9,370	33,910	217
Jeonju	8,924	24,397	182
Gwangju	8,394	45,414	201
Average City[1]	9,346	34,461	326

SOURCE: KIST 1977.

NOTE: Converted to daily figure on assumption that each bus operates for 6.5 days per week. Thus, daily Km's travelled = 332 Km's, and average passengers per day = 1,223 (in 1976). In the model the latter figure is assumed to fall by 20% to 978 by 1985.

TABLE 16: CALCULATIONS FOR ESTIMATING BUS KM'S TRAVELLED IN THE AVERAGE KOREAN CITY

	1975	Existing Density	1985 Concen-trated	Dispersed	GREEN BELT Inner	Outers	Total
Estimated no. bus person trips per day[1].	472,932	694,735	722,417	640,205	486,253	193,181	679,435
Passengers per day per bus[2]	1223	978	978	978	978	978	978
Bus stock[3]	326	710	738	654	497	197	694
Bus Km's per day per bus[4]	332	332	332	332	332	332	332
Bus Km's per day[5]	108,232	235,720	245,016	217,128	165,004	65,404	230,408

SOURCE: Nathaniel Lichfield and Partners, 1977.

NOTES:
1 93% public person trips
2 Estimated from bus data for Seoul. For 1975 The model overestimated the recorded number of daily bus passenger trips in the average city by 10%. Data in Table 16 indicates an average for the four cities of 43,2088 bus person trips per day. However, for consistency with other calculations we have used the actual recorded bus stock in 1975 as the level in our average city for that year.
3 For 1985 : Row 1 x Row 2
4 332 Km's per bus per day
5 Row 3 x Row 4

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TABLE 17: DAILY VEHICLE KM's OF TRAVEL IN THE AVERAGE CITY 1975 AND 1985 UNDER ALTERNATIVE LAND USE OPTIONS

	1975	1985: ALTERNATIVE LAND USE OPTIONS					
		(1) Existing Density	(2) Concen-trated	Dis-persed	(4) Green Belt		
					INNER	OUTERS	TOTAL
Private Car	90,074	680,470	515,045	1,023,728	449,751	218,521	668.272
Taxi	50,733	121,348	116,242	125,729	80,234	27,249	107,483
Bus	108,232	235,720	245,016	217,128	165,004	65,404	230,408
Total Km's	249,039	1,037,538	876,303	1,366,585	694,989	311,174	1,006,163

Source: Nathaniel Lichfield and Partners, 1977

TESTING POLICIES

Ownership Pricing

67. To represent a policy of ownership pricing we have asked "By what amount would car ownership alone have to fall to reduce the number of car trips by 25%, and what increase in price would induce that fall in ownership?" We have arbitrarily, but other studies indicate realistically, adopted a 25% reduction in car trips as the objective of our pricing policy.1/ Given our assumption of a constant car trip rate then car stocks must fall by 25% to achieve this.

68. It was not possible to use Korean time series data on car ownership and price to estimate an elasticity with which to calculate the size of the necessary price increase because of the structure of the Korean car market. Since a high proportion of cars were purchased by official and business institutions, changes in ownership levels were found to be insensitive to changes in price. We therefore relied upon other work to estimate the future Korean demand price elasticity.

69. Hess 2/ summarises empirical studies of the responsiveness of the levels of car ownership to change in the yearly total cost of owning and running a car in the USA. He calculates a current elasticity of -1.63, whilst other studies of the period from 1921 to 1964 find elasticities ranging from -0.6 to -2.2, with an average elasticity of -1.4.

70. As an example we have adopted three elasticities, -1.5, -1.0 and -0.5 to correspond with the different land use options in 1985. The high

1/ A Study of Supplementary Licencing, Greater London Council, 1974, IBRD "Study of Traffic Restraints in Singapore". 1975.

2/ Alan C. Hess. "A Comparison of Automobile Demand Equations" Econometrica, April 1977.

elasticity is used to calculate the change in ownership in the concentrated density option, the lowest in the dispersed option and for the outer section of the green belt, and the middle elasticity in the existing density option and for the inner section of the green belt city. Elasticity has thus been varied directly with average population density to correspond with differences in the level of public transport provision which one would expect to occur with differences in average density.1/ From these elasticities we have calculated the percentage increase in price necessary to reduce car ownership by 25% under each land use option. The percentage increase in taxes overall which these imply are also estimated.

71. Table 18 shows that taxes constitute 36% of the user cost (the relevant price for ownership decisions) of an average private car, assuming a 5 year life and an average annual travel distance of 10,000 Km's. The necessary percentage increases in price (user cost) and the implications for tax increases are summarised in Table 19.

Use Pricing

72. As a corrolary to our criteria for onwership pricing and in order to represent the aim of pricing use of cars we have asked - "what price differential would there have to be to induce a reduction of 25% in the level of car trips made per day and the transfer of those persons previously travelling by car onto public transport?"

1/ Let P_1 = real price 1985 prior to price increase = 1

$P_2 = P_1 + t$, where t = price increase

Q_1 = level of car ownership 1985 under each land use policy option

Q_2 = 0.0035 (1975 car ownership per head)

Then from equation for ARC elasticity (page footnote)

$$t = \frac{-2\,(\Delta Q)}{\Delta Q - (n\ Q_1 + Q_2)}$$

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TABLE 18: TOTAL USER COST OF AVERAGE PRIVATE CAR (1975 PRICES)

		WON	% TOTAL	TAXES AS % TOTAL
Fixed Costs[1]	Factory Price of which	2,350,000	45	
	(a) Commodity Tax	470,000	9	9.0
	(b) Defense Tax	47,000	9	0.1
		2,350,000	45	
	Registration	47,000	1	1.0
		2,397,000	46	
Annual Fixed[1] Costs (5yr life)	Motor vehicle tax (199,880 pa)	999,000	19	19.0
	Defense surtax (59,940 pa)	299,700	6	6.0
	License (14,400 pa)	72,000	1	1.0
		1,370,000	26	
Operating Costs[2]	50 000 KM's @ 30 WON per KM	1,500,000	28	
TOTAL		5,267,000	100	36

SOURCE: [1] Korean Institute of Science and Technology
[2] In the absence of data for Korea this is estimated on the basis of a 1975 average operating cost for a 1500 c.c. car in the UK supplied by the Automobile Association

N.B. This figure will need to be changed to reflect Korean data.

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TABLE 19 : THE INCREASE IN CAR PRICES AND TAXES NECESSARY TO REDUCE CAR OWNERSHIP BY 25% UNDER EACH LAND USE OPTION

	1985 Average City: Alternative Land Use Options				
	Existing Density	Concentrated	Dispersed	Green Belt Inner	Green Belt Outer
Reduction in car stocks	25%	25%	25%	25%	25%
Assumed own price η^1	-1.0	-1.5	-0.5	-1.0	-0.5
% increase in price required	33%	21%	80%	33%	80%
% increase in taxes overall to achieve required price increases	91%	58%	222%	91%	222%

Source: Nathaniel Lichfield and Partners, 1977

Notes: [1] Varies directly with the expected extent of provision of alternative transport to the private car

73. A price differential could be achieved by either increasing private car costs or reducing the costs to passengers of public transport.

74. A recent study of car licencing in London shows that private car use responds to positive changes in car trip costs with an elasticity of -2.0. 1/ This elastic response is determined by the quality of public transport in London which facilitates the transfer of trips onto public transport. However, because of the superior nature of private transport when car trips costs are increased a satisfactory alternative is not found for all frustrated car trips and total trip making declines.

75. Other studies indicate that in situations where a high quality alternative form of transport is not available the elasticity is much lower. Also, where differentials have been induced by a reduction in public transport costs, rather than increased car costs, trips have been generated. 2/ In the model we have calculated for unchanged total trip-making for simplicity, but have allowed for possible quality differences in the two types of future public transport (two versions of this quality are represented by a cross elasticity). We have assumed that this represents a situation in which all transferred trips are accommodated by increased taxi provision (i.e. a high quality alternative to private transport) and the second a situation where the transferred trips are accommodated by the increased provision of bus services (representing the lower quality alternative).

1/ "A Study of Supplementary Licensing" Greater London Council 1974.

2/ "An Evaluation of Free Transit Service" Charles River Associates Inc., August 1968.

76. For convenience we have expressed the induced price differential in terms of an increase in taxes on car use which increases per trip car costs. We calculate that in the situation where sufficient provision is made on public transport to accommodate the ready transfer of car passengers to public transport (represented by a prevailing cross price elasticity of -2.0) an increase in car trip costs of 15.4% will be necessary to reduce car trips by 25%. Where a lower quality alternative is provided, however, (represented by a prevailing cross price elasticity of -0.7) car trip costs need to be increased by 51.3% to achieve the same reduction in car trips in all land use options.

77. Table 20 shows the increase in public transport provision (either bus or taxi) required to accommodate those trips priced away from private cars. Table 21 summarises total vehicle kilometres of travel in 1985 under each land use option given effective car use pricing and the transfer of all frustrated car trips to either buses or taxis. In transferring persons from private to public transport we have assumed that average person trip lengths for those trips transferred remain the same.

Comparison of Price Increases Required to Achieve a 25% Reduction in Car Trips with Either Pricing of Ownership or Pricing of Car Use

78. Table 22 summarises the range of cross price and own price elasticities we have adopted for our model and the relevant price, or trip cost increases required to achieve the 25% reduction in car trips which we have specified as our criteria for pricing policies.

TABLE 20: THE INCREASE IN PUBLIC TRANSPORT PROVISION (EITHER BUS OR TAXI) REQUIRED TO COMPENSATE FOR REDUCTION IN CAR PERSON TRIPS FOLLOWING EFFECTIVE USAGE PRICING

		1985: Alternative Land Use Options					
		(1) Existing Density	(2) Concen-trated	(3) Dispersed	(4) Green Belt Inner City	(4) Green Belt Outer Satellites	Total
Reduction in car vehicle trips per day 1985 following use pricing		36,654	30,116	49,044	25,645	14,577	40,222
Reduction in car person trips[1]		69,338	58,552	88,961	48,513	26,483	74,996
Extra taxi provision	Extra taxi trips per day[2]	34,669	29,276	44,481	24,257	13,242	37,498
	Increase in taxi fleet[3]	1,156	976	1,483	809	442	1,250
	Extra taxi Km's per day[4]	160,907	125,169	232,118	106,349	49,628	155,977
Extra bus provision	Increase in bus fleet[5]	71	61	92	50	28	78
	Increase in bus Km's[6]	69,438	59,658	89,976	48,900	27,384	76,284

Source: Nathaniel Lichfield and Partners, 1977

Notes: [1] Reduction in car vehicle trips x occupancy
[2] Reduction in car person trips ÷ 2 (taxi occupancy)
[3] Extra taxi vehicle trips ÷ Av. trips per taxi per day (calculated for Seoul 1976 from yearbook as 30 per day)
[4] Extra taxi vehicle trips x Av. length taxi trip
[5] Reduction in car person trips ÷ Av. passengers carried per day per bus (978)
[6] Increase in bus fleet x Av. daily Km's per day per bus (332 KM's)

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TABLE 21: TOTAL VEHICLE KILOMETRES IN 1985 AFTER EFFECTIVE CAR USE PRICING

	Average City 1985 After Effective Car Use Pricing: Alternative Land Use Options					
	Existing Density	Concentrated	Dispersed	Green Belt		
				inner	outer	total
Private Car	510,351	386,283	767,799	337,314	163,896	501,210
Taxi/Microbus 1	282,255	241,411	357,847	186,583	76,877	263,460
Taxi/Microbus 2	121,348	116,242	125,729	80,234	27,249	107,483
Bus 1	235,720	245,016	217,128	165,004	65,404	230,408
Bus 2	259,292	265,268	247,672	181,604	74,700	256,304
TOTAL 1	1,028,326	872,710	1,342,774	688,901	306,177	995,078
TOTAL 2	890,991	767,793	1,141,200	599,152	265,845	864,997

SOURCE: Nathaniel Lichfield and Partners, 1977.

NOTES: [1]With car passengers transferred to taxis after the 25% reduction in car trips.
[2]With car passengers transferred to buses after the 25% reduction in car trips.

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TABLE 22: COMPARISON OF RELEVANT ELASTICITIES AND PRICE INCREASES FOR REDUCING CAR TRIPS THROUGH CAR OWNERSHIP OR USE PRICING

η	(a) Use Pricing:- % increase in trip costs necessary to reduce car trips 25%	(b) Ownership Pricing:- % increase in price of car necessary to reduce car trips 25%	(c) % increase in car price implied by increase in trip costs under (a)
-2.0	15.4		4.3
-1.5		21.0	
-1.0		33.0	
-0.7	51.3		14.4
-0.5		80.0	

SOURCE: Nathaniel Lichfield and Partners, 1977.

79. With use pricing and the provision of alternative public transport car trip costs must increase by 15.4% or 51.3% depending upon the quality of the alternative for private car users. Given that car trip costs are 28% of the total price of a private car 1/ these imply increases in car price of 4.3% and 14.4% respectively. These are lower than the increases in price necessary to achieve the same reduction in car trips via reductions in car ownership, which range from 21% to 80%.

FORECAST STOCKS OF VEHICLES

80. Table 23 summarises the estimates of the stocks of vehicles in the average city in 1975 and in 1985 under each of the land use options and after effective taxing of car use. Stocks in 1975 are the average of recorded stocks in the four cities of Daegu, Daejon, Gwangju and Jeonju.

81. Car stocks in 1985 under the land use options are calculated simply by multiplying forecast cars per head by population.

82. Car stocks after effective use pricing are different from the above because the increase in per trip costs have increased the total costs of owning and running a car. Given operating costs are 28% of the total cost of owning a car for five years (see Table 18) then the 15.4% and 51.3% increases in trip costs imply increases in total costs of 4.3% and 14.4% respectively.

83. Own price elasticities, used to calculate the effect of these cost increases upon car ownership and stocks of cars have been varied across the

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1/ The total 5 year cost of owning and running a car. See Table 18.

options to reflect differences both in the likely standards of public transport in each of the options (with higher population density options being more likely to have better public transport alternatives and therefore higher own price elasticities for car ownership with respect to changes in car prices) and the high and low cross price elasticities assumed to prevail in each option case. Table 24 shows the own price elasticities used in these calculations and the estimated changes in the levels of car ownership resulting from the increased car costs.

84. Taxi and bus stocks in 1985 after car use pricing are calculated assuming that the entire reduction in car person trips is transferred to either buses or taxis.

Forecast Additional Road Construction

85. The increase in kilometres of road in the average city 1975-1985 is calculated on the basis of the amount of road which would be required to maintain the 1975 estimated average speed of cars, taxis and buses.

86. Extra kilometres of road are calculated using the following relationship derived by Zahavi:- 1/

$$\text{Average speed} = (a) \ \frac{(\text{Total road length})}{(\text{Total vehicles Km's of travel})}$$

An overall average speed for 1975 of 15.9 Kph is calculated on the assumption that cars and taxis travel at 25 Kph and buses at 12 Kph, and on the basis of the number of vehicle kilometres of travel by each vehicle in 1975. Bus kilometres are weighted by a factor of three to account for their extra size. The value of the constant, a (estimated as 15,798), which changes

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1/ Zahavi, "Travel Characteristics in Cities of Developing and Developed Countries." World Bank Staff Working Paper No. 230, March 1976.

TABLE 23 : STOCK OF VEHICLES 1975, 1985 UNDER ALTERNATIVE LAND USE POLICIES

	1975	1985: ALTERNATIVE LAND USE OPTIONS				1985: AFTER EFFECTIVE USE PRICING			
		Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt
Private Cars	2,394	20,826	17,111	27,866	22,853	19,967	16,064	27,286	22,080
						20,548	16,770	27,807	22,604
Taxis	337	871	906	803	852	2,027	1,882	2,286	2,102
						871	906	803	852
Buses	326	710	738	654	694	710	738	654	694
						781	799	746	772

SOURCE:- Nathaniel Lichfield and Partners, 1977.

1. With car passengers transferred to taxis after the 25% reduction in car trips - the high cross price elasticity option.
2. With car passengers transferred to buses after the 25% reduction in car trips - the low cross price elasticity option.

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TABLE 24: THE EFFECTS ON CAR OWNERSHIP OF INCREASED TRIP COSTS

		1985 Land Use Option				
		Existing Density	Concentrated	Dispersed	Green Belt Inner	Green Belt Outer
Car Stocks prior to Use Pricing		20,826	17,111	27,866	14,571	8,282
Prevailing own Price Elasticity:- (a) with high cross price elasticity (-2.0) and 4.3% increase in car price		-1.0	-1.5	-0.5	-1.0	-0.5
(b) with low cross price elasticity (-0.7) and 14.4% increase in car price		-0.1	-0.15	-0.05	-0.1	-0.05
Change in Car Stocks	(a)	-859	-1047	-580	-601	-172
	(b)	-278	-341	-59	-194	-55

SOURCE: Nathaniel Lichfield and Partners, 1977 directly with average speed, is found given the overall average speed for 1975, the total road length in the average city 1975, 1/ and vehicle Km's of travel (with bus Km's weighted by a factor of three).

87. We have also estimated the area occupied by roads as a proportion of total urban area under each of the policy options. These results are summarised in Table 25. Whilst total road length is by far the greatest under the dispersed land use option, with or without car use pricing, the road area as a proportion of total urban area is the smallest.

Time Spent in Travel

88. Table 26 summarises estimates of daily travel time in the average city in 1975 and 1985. Non-mechanised travel time is calculated on the assumptions of an average trip length of 1.6 km's and speed of 3 kilometres per hour. Time spent in car and taxi travel is calculated with equal trip lengths for car and taxi travel in each option and an average speed of 25 kilometres per hour. However, the time taken for each taxi person trip is also increased by three minutes for waiting time. Time spent in bus travel assumes an average trip length of half the car trip length for each option, except for those persons transferring to buses after the pricing of car use whose trip lengths remain as before. An average speed of 12 kilometres per hour is assumed for bus travel.

1/ The average of road kilometres in Daegu, Gwangju, Daejon and Jeonju in 1975 of 147 km's. Source: Yearbooks

Thus: $$15.1 = \frac{(a)\ (437.5)}{445{,}906} \qquad a = 15{,}798$$

TABLE 25: ROAD PROVISION IN THE AVERAGE KOREAN CITY

	Existed Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Road Length required:- (Km's)	1418	1284	1692	1379	[1] 1410 [2] 1325	1281 1220	1670 1538	1386 1295
Road Area (Km^2)	17.9	16.2	21.3	17.3	[1] 17.8 [2] 16.7	16.1 15.4	21.0 19.4	17.2 16.3
Urban Area (Km^2)	207	147	339	247	207	147	339	247
Roads as % urban area	8.6	11.0	6.3	7.0	[1] 8.6 [2] 8.1	11.0 10.5	6.2 5.7	7.0 6.6

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With car passengers transferred to taxis after the 25% reduction in car trips - the high cross price elasticity option.

[2] With car passengers transferred to buses after the 25% reduction in car trips - the low cross price elasticity option.

TABLE 26: ESTIMATED HOURS OF TRAVEL PER DAY 1975 AND 1985

	1975	1985: ALTERNATIVE LAND USE OPTIONS				1985: ALTERNATIVE LAND USE OPTIONS AND EFFECTIVE PRICING OF CAR USE			
		Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt
Non Mechanised	169,969	242,939	283,604	202,865	231,238	242,939	283,604	202,865	231,238
Private Car	8,553	51,490	40,054	74,278	49,912	38,617	30,040	55,708	37,435
Taxi	7,866	12,322	12,018	12,468	11,156	[1] 28,662	24,959	35,485	27,384
						[2] 12,322	12,018	12,468	11,156
Bus	84,253	134,350	128,699	139,202	118,998	[1] 134,350	128,699	139,202	118,998
						[2] 161,168	149,560	177,888	144,993
Total Mechanised	100,674	198,162	180,771	225,948	180,066	[1] 201,629	183,698	230,395	183,817
						[2] 217,107	191,618	246,064	193,584
Total	270,643	441,101	464,375	428,813	411,304	444,568	467,302	433,260	415,055
						455,046	475,222	448,929	424,822

SOURCE: Nathaniel Lichfield and Partners, 1977.

NOTES: [1] With trips transferred to taxis from cars following use pricing.
[2] With trips transferred to buses from cars following use pricing.

TABLE 27 COST OF DAILY TRAVEL TIME (thousands Won)

	1985: ALTERNATIVE LAND USE OPTIONS.				1985: ALTERNATIVE LAND USE OPTIONS AND EFFECTIVE PRICING OF USE				
	Existing Density	Concentrated	Dispersed	Green Belt	Existing Density	Concentrated	Dispersed	Green Belt	
Daily cost of non-mechanised travel time	129,972	151,728	108,533	123,712	129,972	151,728	108,533	123,712	
Daily cost of mechanised travel time	106,017	96,713	120,882	96,336	107,872	98,279	123,261	98,342	Assumes all reduction in car trips tra ferred to tax
					113,478	102,516	131,644	103,568	Assumes all reduction in car trips tra ferred to bus
TOTAL	235,989	248,441	229,415	220,048	237,844	250,007	231,794	222,054	Assumes all reduction in car trips tra ferred to tax
					243,450	254,244	240,177	227,280	Assumes all reductions in car trips tra ferred to bus

Source: Nathaniel Lichfield and Partners, 1977.

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COSTINGS OF POLICY ALTERNATIVES

89. Costs have been divided into three separate categories because of their incidence: once and for all capital costs, (which include road construction costs and the costs of additions to vehicle stocks), daily vehicle operating costs, daily costs of travel time, and annual replacement costs for vehicle stocks. The results of the costing exercise are summarised in para. 95.

Costs of Daily Travel Time

90. Table 27 summarises the estimates of daily travel time costs for each of the policy options. With and without use-pricing the highest costs are incurred in the case of the concentrated option, reflecting mainly the relative speeds of mechanised and non-mechanised travel. Time costs for non-mechanised trips are highest in the concentrated case and lowest in the dispersed case whilst time costs for mechanised travel behave in the opposite way.

91. The costs of travel time have been calculated on the basis of numbers of hours of travel per day by mode (Table 26) and an estimate of the future value of travel time. The value of travel time has been estimated by taking the conventional 25% of the hourly wage rate, where the wage rate is taken as 272 Won per hour in 1975 and 535 Won per hour in 1985. 1/

Capital Costs

92. These costs (road construction costs and costs of additions to vehicle stocks) are summarised in Table 28.

1/ Figures supplied by World Bank.

TABLE 28: CAPITAL COSTS (millions won)

	1985: ALTERNATIVE LAND USE OPTIONS				1985: ALTERNATIVE LAND USE OPTIONS AND EFFECTIVE USE PRICING			
	Existing Density	Concen-trated.	Dispersed	Green Belt	Existing Density	Concen-trated.	Dispersed	Green Belt.
Road construction costs to maintain 1975 Av. speed.	118,410	102,228	151,500	113,700	[1] 117,444	101,865	148,843	112,372
					[2] 107,179	94,499	132,902	103,556
Costs of additions to vehicle stocks	48,602	40,248	64,398	53,153	[1] 49,301	40,082	66,520	54,274
					[2] 48,695	40,088	65,226	53.387

SOURCE: Nathaniel Lichfield and Partners, 1977.

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective use pricing.
[2] With person trips transferred to buses following reuction of car trips by 25% after effective use pricing.

Road Construction Costs

93. Road construction costs are estimated on the basis of extra road kilometres forecast for each policy option (Table 25) and a constant road construction cost of 120,765,000 Won per Km. 1/

Costs of Additions to Stocks of Vehicles 1975-1985

94. These costs are estimated on the basis of the estimated stocks of vehicles (Table 23) and current prices for an average car, taxi and bus taken as 2,350,000 Won for taxis and private cars and 10,500,000 for buses. 1/ Table 29 summarises these costs. The concentrated option proves to be the least costly both with and without pricing of car use, and with car use pricing less costly with the taxi style alternative.

Annual Replacement Costs for Stocks of Vehicle

95. These are calculated on the assumption of an average five year life for all vehicles. See Table 30.

Daily Vehicle Operating Costs

96. Table 31 summarises estimated daily operating costs, where these are defined as fuel and maintenance costs for private cars and fuel, maintenance and wage costs for taxis and buses. We have estimated these as 30 Won per kilometres for the average car, (without use pricing), 62 Won per kilometre for taxis and 136 Won per kilometre for buses. With use pricing the average cost for car use increases to 34.6 Won and 45.4 Won per kilometre depending upon the quality of public transport alternative offered

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1/ Figures supplied by KIST.

TABLE 29: CAPITAL COSTS OF ADDITIONS TO STOCKS OF VEHICLES (MILLION WON)

	1985: Alternative Lane Use Options				1985: Alternative Land Use Options After Effective Car Use Pricing			
	Existing Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Cars	43,315	34,585	59,859	48,079	[1] 41,297 [2] 42,662	32,125 33,754	58,496 59,721	46,262 47,494
Taxi	1,255	1,337	1,095	1,210	[1] 3,972 [2] 1,255	3,631 1,337	4,580 1,095	4,148 1,210
Buses	4,032	4,326	3,444	3,864	[1] 4,032 [2] 4,778	4,326 4,967	3,444 4,410	3,864 4,638
Total	48,602	40,248	64,398	53,153	[1] 49,301 [2] 48,695	40,082 40,088	66,520 65,226	54,274 53,387

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

TABLE 30: ANNUAL REPLACEMENTS COST FOR VEHICLE STOCKS 1975-1985 (MILLION WON)

	1975	1985: Alternative Land Use Options				1985: Alternative Land Use Options After Effective Car Use Pricing			
		Existing Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Cars	1125	9,788	8,042	13,097	10,740	[1] 9,384	7,550	12,824	10,377
						[2] 9,657	7,881	13,069	10,623
Taxis	158	409	426	377	400	[1] 953	885	1,074	988
						[2] 409	426	377	400
Buses	689	1,491	1,550	1,373	1,457	[1] 1,491	1,550	1,373	1,457
						[2] 1,640	1,678	1,567	1,621
Total	1967	11,688	10,018	14,847	12,597	[1] 11,828	9,985	15,271	12,822
						[2] 11,706	9,985	15,013	12,644

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

TABLE 31: ESTIMATED OPERATING COSTS PER DAY, CAR, TAXI, BUS (OOO WON)

	1975	1985: Alternative Land Use Options				1985: Alternative Land Use Options After After Effective Car Use Pricing			
		Existing Density	Concen-trated	Dispersed	Green Belt	Existing Density	Concen-trated	Dispersed	Green Belt
Cars	2,702	20,414	15,451	30,711	20,048	[1] 17,658	13,365	26,566	17,342
						[2] 23,170	17,537	34,858	22,755
Taxis	3,145	7,524	7,207	7,795	6,664	[1] 17,500	14,967	22,187	16,335
						[2] 7,524	7,207	7,795	6,664
Buses	14,720	32,058	33,322	29,529	31,335	[1] 32,058	33,322	29,529	31,335
						[2] 35,264	36,076	33,683	34,857
Total	20,567	59,996	55,980	68,035	58,047	[1] 67,216	61,654	78,282	65,012
						[2] 65,958	60,820	76,336	64,276

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1] With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2] With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

to motorists. The higher running cost is imposed where the lower quality alternative, represented by buses in our model, is offered and vice-versa. The increase in car trip costs are of course only an additional cost for car users, the whole increase transferring to Government in tax revenue. With and without use-pricing costs are highest under the dispersed option and lowest under the concentrated option. With car-pricing operating costs are however lower with the bus style alternative.

Summary of the Costing Exercise

97. Table 32 summarises the results of the costings. Vehicle replacement costs have been expressed on a simple daily basis so that they can be included with the other daily costs incurred, time costs and vehicle operating costs. The additional tax element included in vehicle operating costs following car use pricing is also shown. Capital costs (road construction and costs of additions to vehicle stocks) are shown as they are calculated, rather than on a discounted basis, for simplicity. The two groups of costs clearly show the trade-offs between policy options which the model indicates.

98. By far the most costly policy, both with and without car use pricing and on a daily or capital cost basis is the policy of dispersal. On a daily basis this is the most costly policy overall if adopted in conjunction with car use pricing and a bus style public transport alternative. On a capital cost basis this land use policy is most expensive overall if adopted without a policy of pricing car use. The least expensive combination of policies on a daily basis both with and without car use pricing is the Green Belt policy, although least expensive overall is the Green Belt policy without a policy of pricing car use.

TABLE 32: SUMMARY OF COSTS 1985

DAILY COSTS	1985: Alternative Land Use Options				1985: Alternative Land Use Options After Effective Car Use Pricing			
	EXISTING DENSITY	CONCEN-TRATED	DISPERSED	GREEN BELT	EXISTING DENSITY	CONCEN-TRATED	DISPERSED	GREEN BELT
Daily cost of travel time ('000 won)	235,989	248,441	229,415	220,048	[1] 237,844	250,007	231,794	222,054
					[2] 243,450	254,244	240,177	227,280
Daily vehicle operating costs ('000 won)[3]	59,996	55,980	68,035	58,047	[1] 57,216	61,654	78,282	65,012
					[2] 65,980	60,280	76,336	64,276
Daily vehicle depreciation costs ('000 won)	32,022	27,447	40,677	34,512	[1] 32,405	27,356	41,838	35,129
					[2] 32,071	27,356	41,132	34,641
Total daily costs ('000 won)	328,007	331,868	338,127	312,607	[1] 337,465	339,017	351,914	322,195
					[2] 341,479	342,420	357,645	326,197
CAPITAL COSTS								
Costs of additions to vehicle stocks (millions won)	48,602	40,248	64,398	53,153	[1] 49,301	40,082	66,520	54,274
					[2] 48,695	40,088	65,226	53,387
Road Construction Costs (millions Won)	118,410	102,228	151,500	113,700	[1] 117,444	101,865	148,843	112,373
					[2] 107,179	94,449	132,902	103,556
Total capital costs (millions won)	167,012	142,476	215,898	166,853	[1] 166,745	141,947	215,363	166,646
					[2] 155,874	134,587	198,128	156,943

SOURCE: Nathaniel Lichfield and Partners, 1977

NOTES: [1]With person trips transferred to taxis following reduction of car trips by 25% after effective car use pricing

[2]With person trips transferred to buses following reduction of car trips by 25% after effective car use pricing

[3]Of which additional tax element after effective car use pricing is as follows:

	Existing Density	Concentrated	Dispersed	Green Belt
Additional Tax element in user operating costs ('000 won)	2,348	1,777	3,532	2,306
	7,859	5,949	11,824	7,719

99. On a capital cost basis a policy of concentration proves least expensive both with and without car use pricing, the combination of concentrated population and car use pricing in conjunction with a bus style alternative being the least expensive overall.