Transport-Related Air Pollution Strategies:
What Lessons For Developing Countries?

Zmarak Shalizi
José C. Carbajo

September 1994
Discussion Paper
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This report was prepared by Zmarak Shalizi (Division Chief) and José C. Carbajo (Economist) in the Transport Division of the Environmentally Sustainable Development Vice Presidency. A first version was presented at the International Conference "Towards Clean Transport: Fuel Efficient and Clean Motor Vehicles" organized in conjunction with the OECD and International Energy Agency (IEA) in Mexico City, 28-30th March, 1994.

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ABSTRACT

Motorization—the growth in ownership and use of motorized vehicles—both facilitates economic development and causes environmental degradation. Governments worldwide are attempting to devise transport policies that balance the increase in mobility and accessibility, which motorization brings about, with the costs it imposes on the environment in the form of pollution, congestion and traffic accidents. These costs become economically and socially excessive when motorization reaches certain levels.

This paper reviews the current air quality strategy that is being pursued in developed and developing country cities where the air pollution problem has reached unbearable dimensions. The strategy is essentially curative—stabilize the amount of emissions first and then reduce the level of air pollution gradually. For mobile sources it focuses on improved fuel and automotive technologies for new vehicles, plus inspection and maintenance programs for the entire fleet on a routine basis.

Developing countries need to modify this strategy. They should adopt cost-effective solutions to problems which vary by locality. Interventions must be selective, enforceable and affordable. Given the low fleet turnover rate in these countries and the old technology used in domestic production of motorized vehicles special attention should be given to the most polluting and most heavily used components of the fleet.
A strategy relying on the ability to influence the development of new automotive and fuel technologies is not available to most countries nor is a technological fix sufficient. Most developing countries are not large enough players (as consumers or producers) in the global fuel and vehicle markets to be able to influence the development of new technologies. This is a concern, to the extent that the new technologies might incorporate operating and maintenance requirements that are too sophisticated and sensitive to be usefully adopted in countries with poor infrastructure and enforcement capabilities. Countries that must select from the options available in the global market must at least generate selection criteria based on local needs.

More importantly, air quality strategies which count on advances in automotive technology alone, such as in-vehicle emission control devices or fuel-efficient engines, are bound to be limited in their impact on motor-vehicle air pollution because they do not address the rise in car ownership caused by economic growth nor do they consider the increased vehicle use, as in the case of the United States, that is induced by improved automotive technology itself, such as the reduced cost of travelling associated with more fuel-efficient vehicles. Demand management measures are necessary to complement supply side interventions. Demand management measures, however, whether regulatory or pricing, have not been utilized much to date and are still being experimented with in only a few cases.

Finally, the paper notes that experience worldwide suggests that government intervention on transport-related air pollution tends to start only when pollutant concentrations reach intolerable levels for the urban population of the megacities. This need not continue. There is a need,
therefore, to develop a longer term *preventive* strategy, which would involve implementing a package of policies and measures capable of managing the process of motorization to avoid its negative environmental impacts. Medium-sized cities—where air pollution is not currently an issue but where, based on likely motorization trends, it could become a major problem in the next one or two decades—are prime candidates for initiating preventive strategies now.
I. INTRODUCTION

1. Developing countries are likely to enter the 21st century experiencing an unprecedented growth in road transport. There are many reasons for the increase in motorization—the growth in ownership and use of motorized vehicles. The two most prominent are the growth in income per capita and the growth in population, particularly urbanization—consisting of the natural rate of population growth in urban areas plus continued rural to urban migration. By the year 2000, an estimated 600 million people will be added to the cities and towns of the developing world, which represents two-thirds of the expected total increase in population worldwide.¹

2. In the period 1988-2000, the annual demand for motor vehicles in developing countries is estimated to grow by 220 percent (from 5 million vehicles p.a. to 16 million vehicles p.a.) as opposed to 10 percent in the more saturated markets of OECD countries.² Similarly, during the 1990s the average annual growth rate in vehicle use in developing countries is expected to be 4.95 percent (growing from 1.9 trillion vehicle-miles in 1990 to an estimated 2.8 trillion in 2000), or more than double the 2.36 percent annual growth rate expected in OECD countries (from 4.9 trillion vehicle-miles in 1990 to 6.1 trillion in 2000).³ These high rates of growth of vehicles and vehicle


use in developing countries may not be sustainable or desirable in the long run. However, they are
not surprising, nor necessarily undesirable in the short run, as the overall levels of personal mobility
and motorization in these countries is still very low compared to developed countries. The number
of people per passenger car is 303 in Sub-Saharan Africa and 1000 in Asia and the Pacific region
compared to 2 in North America, and 3 in Japan, Australia and the European Union (see Table 1).

Table 1: Motorization levels worldwide

<table>
<thead>
<tr>
<th>World Region</th>
<th>Population per passenger car (1989)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. and Canada</td>
<td>2</td>
</tr>
<tr>
<td>EU, Australia, Japan and New Zealand</td>
<td>3</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>9</td>
</tr>
<tr>
<td>Central and South America</td>
<td>45</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>85</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>303</td>
</tr>
<tr>
<td>Asia and the Pacific^a</td>
<td>1000</td>
</tr>
</tbody>
</table>


^a Excluding Australia, Japan and New Zealand

3. As is well known, motorization simultaneously facilitates economic development and causes
environmental degradation. As a result, governments worldwide are attempting to devise transport
policies that balance the benefits of increased mobility and accessibility, which motorization brings
about, with the costs it imposes on the urban environment in the form of pollution, congestion and
traffic accidents. These costs can be ignored or tolerated at early stages of development when they
are low but at high levels of motorization these costs can become economically and socially excessive. Some cities in developing countries, such as Bangkok, Seoul, Mexico City, and Buenos Aires are already more congested than any city in Western Europe, even though car ownership levels are only one-third those of Western Europe. In addition to congestion and high fatality rates, \textit{the growing dependence on motor vehicles powered by internal combustion engines has highlighted the problem of automotive air pollution and the excessive reliance on non-renewable fossil fuels.}

4. Significant intervention to control pollution from mobile sources started in developed economies in 1965 when legislation designed to actively combat air pollution from motor vehicles was enacted in the United States (\textit{US Motor Vehicle Pollution Control Act}). Subsequently, following the first energy crisis in 1973, developed economies started to actively encourage energy efficiency in motor vehicles. By contrast, measures to reduce automotive air pollution and to encourage energy efficiency in developing economies have started only recently, although the degradation in air quality is as severe as, if not more severe in some cases, than in the industrialized economies.

5. \textit{The current air quality strategy in developed countries attempts to first stabilize emissions (from both mobile and stationary sources) and then reduce them gradually.} This strategy has emerged during the past three decades and is anchored primarily in regulatory standards and, to a lesser extent, in market-based incentives. The core of the strategy applied to mobile sources is two-fold: (a) setting emissions standards for fuel quality and engine technology, and (b) monitoring compliance with those standards through inspection and maintenance programs. Given the 10-15 percent annual turnover of the fleet, this strategy can have a significant impact within 7-10 years.
6. **This strategy, however, needs to be modified in developing countries** where the nature of the problem and array of options is different from those in wealthier and more developed countries. The needed alterations to the current strategy are (a) *a greater focus on cost-effectiveness* rather than state-of-the-art technologies; (b) *an increased reliance on demand management measures* rather than exclusive attention to supply side interventions; and (c) *adopting a more comprehensive and preventive package of longer term measures* rather than the current partial and curative approach to the problem. This paper briefly discusses the limitations of the present strategy and suggests ways to address them, with particular emphasis on less developed countries.

**II. THE IMPORTANCE OF BEING COST EFFECTIVE**

7. Global and regional pollution problems related to motor vehicle use include global warming and stratospheric ozone depletion, ‘acid rain’ and tropospheric ozone formation. At present these problems are primarily caused by the motorized transport fleets in more developed countries. For example, emission of greenhouse gases such as carbon dioxide ($CO_2$) and chlorofluorocarbons (CFC) from motor vehicles in less developed countries contributes less than 3 percent to the global greenhouse effect or a quarter of the contribution from motor vehicles in OECD countries and Eastern Europe. Of course, this share will grow as the developing country share of global use of motorized vehicles increases. However, it is not the pre-eminent problem now.

8. By contrast, local impacts on health and welfare are the most serious aspect of motor vehicle pollution facing less developed countries. Lead and suspended particulate matter have been
highlighted in the 1992 World Development Report. However, it is important to note that automotive air pollution problems are not the same in all developing countries. They depend, in part, on the mix of pollutants released, weather patterns and exposure of the affected population. East Asian cities such as Bangkok and Manila, for example, suffer from high levels of particulate matter and oxides of sulfur, typical of large numbers of uncontrolled diesel-fuelled vehicles and two-stroke motorcycle engines. (In fact, the importance of two- and three-wheel motorized vehicles in South and East Asia is quite distinct from the pattern in OECD countries.) Central and South American cities, such as Mexico City and Santiago, experience frequent acute ozone problems, exacerbated by thermal inversion weather patterns which prevent dispersion.

9. A cost-effective air quality strategy in developing countries will have to go beyond the choice of interventions based exclusively on the emission reduction potential under ideal conditions per dollar of investment required. The quality of fuels, engine efficiency, vehicle maintenance, traffic operations and emissions control are all much worse in the developing countries, so that the energy use and pollution output are much greater per unit of travel. Hence, a cost-effective strategy needs to ensure that:

(a) the nature and magnitude of the problem is well defined, e.g., in China and South Asia, mixed traffic with pedestrians and animal powered vehicles

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sharing the right-of-way with motorized traffic contributes to high idling times
and suboptimal speeds for motorized traffic with concomitant increases in
vehicle emissions;

(b) \textit{the emissions reduction objective is clearly defined}, e.g., by area rather than
mobile source if necessary—such as in cases where a significant share of
transport-related air pollutant emissions come from area-specific refueling
systems, not just vehicle tailpipe exhaust; and

(c) \textit{the choice of interventions is enforceable and affordable both financially
and in terms of opportunity cost}—current Inspection and Maintenance (I&M)
programs generally target entire fleets, using sophisticated and complex
equipment, and on a routine basis. Evidence is increasingly showing that a
small proportion of vehicles is responsible for a major part of the emissions
and that even simple inspection procedures, randomly and selectively applied,
can reap a substantial part of the gains achieved by more costly programs.
For example, a 1991 study of automotive emissions in Mexico City concluded
that eliminating the gross polluter vehicles (26 and 14 percent of the fleet for
carbon monoxide (CO) and hydrocarbon (HC) emissions, respectively), and
tuning the vehicles to achieve an air-to-fuel ratio closer to the optimum, would reduce CO and HC emissions by nearly a factor of two.\(^6\)

10. Attention to the criteria above will often result in a set of selective interventions tailored to the specific characteristics, needs and capabilities of the area, region or country where the problem must be solved. To the extent that a general modification can be proposed to the current air pollution strategy, it is the need to focus on those vehicles in the existing fleet which are simultaneously the most polluting and the most heavily used. The reason for this proposal is straightforward. In developing countries, vehicle fleets have a low rate of renewal. The fleet turnover can be on the order of 15-20 years rather than the 7-10 years in developed economies. In addition, where there is domestic production of motorized vehicles, often the engine technology used is older, with substantially more emissions and lower fuel-efficiency (as low as a half of the best current models). For these high-polluting vehicles, interventions should include in order of increasing cost (a) maintaining vehicles tuned-up (either through incentives or general public education programs), (b) retrofitting of engines so existing vehicles can achieve lower emission factors and/or use reformulated or alternative fuels, and (c) encouraging more rapid replacement if retrofitting is more costly than acquisition of newer vehicles complying with current standards.

III. The Technological Fix Is Not Sufficient

11. The current air quality strategy in developed economies is based primarily on a search for a technological fix. It is possible that a no emission or very low emission motor vehicle (combining the superior energy density of chemical fuels, such as hydrogen, with the emission free advantages of an electric motor—provided the electricity is generated by renewable energy sources) will one day make automotive air pollution and dependence on fossil fuel for transport a historical footnote. However, that day is well in the future. In the meantime the polluting fleet is large and growing and the focus is appropriately on a reduction in emission factors (pollutants per unit of transport activity) through enhanced fuel quality and improved vehicle engines. However, there are limitations to a strategy focused primarily on affecting automotive technology:

(a) it exhibits diminishing returns in the absence of a breakthrough—technological improvements cost increasingly more to achieve a given additional reduction in emissions per vehicle-kilometer,

(b) it is not universally applicable—the option to influence the development of new technology is not open to every country, and

(c) it is partial and incomplete—technological improvements, such as increased fuel efficiency, can themselves induce an increase in vehicle-kilometers travelled by lowering the cost of travelling, which may be sizable enough to offset the reduction in emissions per vehicle-kilometer.
12. Some elaboration of these points is in order. Improvements in emissions reduction have not been steady. Between 1979 and 1983, improvements in the fuel economy of new cars in developed economies were very pronounced—almost 30 percent. However, since 1983 the trend in fuel efficiency improvements has slowed down in part because further incremental improvements in fuel efficiency at low cost are more difficult to attain given the levels already achieved,\(^7\) and in part because of changes in market demand for “preferred” technologies resulting from the fall in real oil prices, and the shift towards bigger and more powerful cars even in Europe and Japan.

13. The ability to influence the development of technological options largely depends on the position the country or region has in the markets for fuel and motor vehicles. Influencing automotive technology or fuel composition is feasible for countries with large internal auto markets plus the capability to produce motor vehicles and refine/blend fuels. This has been the case in developed countries where the current air quality strategy was incubated. It is also potentially available to some large developing countries such as Brazil, Mexico, India, China and a few others. Large consumers of motor vehicles and fuels, such as California, can also have a greater impact on the development of vehicle technology and fuel composition than large producers with small internal markets such as Korea, Venezuela or Abu Dhabi. However, countries and regions that are not major players (as producers or consumers) in the global motor vehicle or fuel markets cannot hope to intervene and influence the design of cleaner vehicles or cleaner fuels. This is of concern to the extent that the new technologies developed incorporate operating or maintenance requirements that are too sophisticated or sensitive to be used in areas with poor infrastructure or enforcement capabilities.

14. Most countries and regions in the world do not have the ability to affect the development of new fuel and vehicle technology. These countries or regions can only adopt domestic/local standards that allow them to select from the array of options generated in the global market. This is a limitation, for the reasons noted above. However, for countries in this category there is still substantial latitude to (a) set appropriate emissions targets for locally problematic pollutants, and (b) develop criteria for selecting appropriate fuels and engine-types/pollution abating equipment from the relatively wide array already available.

15. Whether or not a country or region has the ability to influence the development of new fuel and automotive technologies, air quality strategies which count on technological advances alone, such as in-vehicle emission control devices or fuel-efficient engines, are bound to be limited in their impact on motor-vehicle air pollution because they do not address the rise in vehicle ownership caused by economic growth nor the increase in vehicle use that is induced by improved fuel efficiency itself. The growth in the motor vehicle fleet, plus the increased average number of miles driven by more fuel efficient vehicles can partially or fully offset the improvements obtained from the increase in energy efficiency and the reduction in emissions output of individual vehicles. As the Environmental Protection Agency in the US has noted, cars and trucks (in the US) still account for almost half the emissions of the ozone precursors, volatile organic compounds (VOCs) and nitrogen oxides (NOx), and up to 90 percent of CO emissions in urban areas. The principal reason
is the rapid growth in the number of vehicles and the total miles driven, which has offset a large portion of the emission reductions gained from motor-vehicle controls since the 1960s.\textsuperscript{8}

16. Demand management is the missing ingredient in the current air pollution strategy. It is desirable, therefore, to complement the supply-side interventions with demand management measures if the ultimate objective is to secure improved levels of air quality. Altering incentives is essential if social costs are to be internalized in private behavior. Measures directed at encouraging the development of alternatives to polluting, motorized transportation, reducing the need for travel or creating disincentives to excessive automobile use, are policy options that need to be considered and pricing has a critical role to play. Quantitative restrictions are occasionally appropriate. However, improved pricing is the preferred market-based approach as nobody disputes that it can perform the “win-win” role of both generating revenue for the implementation of much needed investments to improve air quality, and inducing a more environmentally friendly choice of fuels, vehicles and the extent of vehicle use.

17. \textit{Pricing measures to signal the social costs of pollution and congestion are not yet widely accepted.} In some developing countries domestic fuel prices are barely at the level of border prices. This has been justified on equity grounds where public transport fares are controlled even though a significant portion of vehicle trips is a result of the private use of the automobile which is limited to upper income groups in most of these countries. In some cases, the use of fuel benefits from

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preferential treatment in tax codes (through tax expenditures in the form of exemptions and deductions) with the objective of lowering the cost of transportation for small operators, or encouraging industrialization, including location of economic activity in rural or remote areas. Not taxing intermediate inputs, such as fuel, used by businesses, such as transport operators, is appropriate if there are no externalities associated with the use of the intermediate inputs. However, rarely are domestic fuel prices in developing countries high enough to reflect the wider environmental costs of vehicle usage. In other cases, prices of leaded fuel are lower than that of unleaded fuel thereby stimulating misfueling and undoing the benefits of introducing catalytic converters. Parking charges and other market-based forms of restricting car use are also not very common, in part because reliable public transport options are not available.

18. Where pricing measures have been used to limit the growth of the vehicle fleet, they have been in the form of luxury import tariffs rather than domestic excises. These have often been motivated by the desire to protect the domestic car industry rather than restrict car ownership per se. The reduction or removal of these import tariffs in the context of trade liberalization programs has not been accompanied by the imposition of domestic luxury excises and has resulted in a dramatic spurt in motorization as latent demand became effective, for example in Korea in the late 1980s and China more recently.  

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19. The process of identifying appropriate forms of demand management is not simple, even for non-price measures, and there is a need for more experimentation to tailor measures to country and culture-specific conditions, as not all measures work equally well. For example, traffic bans in the form of odd/even car license number restriction have been tried in Athens, Mexico City, and Santiago with mixed success. In Athens, the number of households with two cars increased and motorists who were not allowed to enter the city center drove around the city to get near their destination thereby increasing the length of their trips and increasing emissions.\textsuperscript{10} The exclusion zone was doubled in mid-1991, and since January 1993 only cars showing a special permit that qualify them as “clean” are allowed to enter the city center. In Mexico City there is evidence that motorists resorted to second-hand vehicles to avoid the restriction imposed by the “Hoy No Circula” (Day without a car) program, and that the economic bonanza enjoyed by the country in the early 1990s induced an increase in motor vehicle registrations and use thereby reducing the benefits of the program. Similarly, the daily restriction on traffic in Santiago is becoming less effective as a result of the rapid increase in vehicle ownership and use, as well as the exception granted to automobiles equipped with catalytic converters.\textsuperscript{11}


IV. A GOOD PREVENTION IS BETTER THAN A GOOD CURE

20. The current trends of urbanization and motorization in developing countries are in many ways reproducing the pattern already followed by developed economies. However, despite a deceleration in growth rates relative to those experienced at the beginning and middle of this century, the dependency on motorized vehicles is still growing in developed countries. With the continuing growth in urban populations, residences are increasingly locating on cheaper land in the urban periphery. This in turn is inducing a substantial decentralization of employment and an increase in the number and length of vehicular trips. In addition, the increase in the number of cars per household and the transport of a larger proportion of goods by road continue to raise the overall level of motorization. Given this evolution in the industrialized economies, the principal developmental strategy questions that arise for developing countries are the following: Does the development pattern of industrialized countries associated with the heavy dependency on the automobile have to be reproduced? Are there policy mistakes and/or environmental costs in this pattern that can, and should, be avoided? What are the policy implications?

21. Experience worldwide suggests that government intervention in the area of transport-related air pollution tends to start very late, when pollutant concentrations reach intolerable levels for the urban population of the megacities. The current two-step sequence—of initially stabilizing emissions then gradually reducing them—is essentially a crisis response strategy—that is, when the problem is already acute and is perceived by the public as a health hazard. By then, land-use patterns and the modal dominance of the automobile are difficult to undo, even in the medium term, hence the
need to endure “sub-optimal” air quality for long periods of time. In short, interventions are more partial and curative rather than comprehensive and preventive.

22. Difficulties have been encountered in implementing effective measures to reduce the reliance on polluting, motorized vehicles in existing megacities. There is no reason why lessons should not be drawn now from this and applied to the next generation of secondary cities which are growing rapidly. A cost-effective long-term strategy would involve identifying and implementing policies and measures designed to manage the process of motorization and its associated environmental impacts. Such a strategy would have to include, amongst its many components, paying substantially greater attention to preventive actions such as better strategic land-use planning and greater reliance on a more effective multimodal transport system.

23. Unfortunately, no successful prototype city or strategy exists in developing countries which can be emulated. Even potentially successful examples in OECD countries, as well as Eastern Europe, are becoming rarer as city size and motorization continue to increase. There is a need, therefore, to develop a broad consensus and commitment to experiment with promising options, such as anticipatory incorporation of the potential for Mass Rapid Transit (MRT) into the urban structure. There is a curious “Catch 22” situation that has afflicted many MRT proposals in developing countries. When cities are small the corridor flows are not sufficient to justify an MRT system: by the time the cities have grown to the size at which traffic volumes seem adequate, the urban structure has already developed to the point at which the superimposition of an MRT network is physically very difficult and inordinately costly to build as well as operate. Experience suggests
the possibility of a phased approach in which, at an early stage in the city’s development, an adequate right-of-way network would be protected for urban transport corridors identified well in advance of city growth, to be upgraded sequentially to the carrying capacity of the corridor (initially for dedicated busways, eventually light or medium rail, and ultimately full metros) as economically and financially justified to meet an increasing public transport demand. Such a long-run land-use strategy does require a capacity to plan and willingness to commit to an urban structure which is rare. However, the consequences of not doing it are increasingly clear. Long-term strategies could start to be applied in some developing countries with medium-sized cities that have a high potential for growth. There may be other promising approaches to be tried. What is not in doubt is the need to anticipate and address the inevitable growth in transport demand before irreversible, or difficult to reverse, commitments have been made in lifestyles and urban form. Since 1950, the rate of growth of smaller towns and cities in developing countries has been higher than the exceptional 4 percent annual growth rate experienced on average by the urban sector. About 66 cities worldwide will have more than 4 million inhabitants by the year 2000 (and 135 cities in 2025) and the majority will be in developing countries. Policy makers should start focusing on these cities now before they enter the population and income ranges within which the level of motorization and its negative environmental impacts become critical.

V. CONCLUSIONS

24. At early stages of development the benefits of motorization are substantial. As income and population conurbations grow the costs of motorization rises more rapidly. Many cities in developing countries are experiencing the high costs of motorization much earlier than their
counterparts in developed countries. The state-of-the-art technological solutions to deal with manifested environmental problems are expensive and difficult to afford given the limited financial and economic resources available in developing countries. Policy makers in these countries need to be selective and emphasize cost-effective solutions. In particular, they need to complement supply side interventions with demand management measures. These can be regulatory interventions. But given the need to finance the development and improvement of transportation alternatives, pricing mechanisms should be explored more actively. Lessons need to be learned from cases where the problem has become unmanageable for lack of adequate attention and commitment to preventive measures. There is a whole generation of new cities that will be entering the income and demographic range where motorization can substantially reduce the quality of life. Potentially effective preventive measures should be identified and introduced in these cities now.