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Environmental Impacts of Trade Liberalisation and Policies for Sustainable Management of Natural Resources

A Case Study on India's Automobile Sector

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NOTE

The views and interpretation reflected in this document are those of the author(s) and do not necessarily reflect an expression of opinion on the part of the United Nations Environment Programme.

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The United Nations Environment Programme

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With today's rapid pace of unprecedented environmental changes, UNEP works to build tools that help policy-makers better understand and respond to emerging environmental challenges. Towards this end, UNEP provides policy-makers with useful tools to monitor the environment, such as integrated environmental and sustainability indicators, and models for effective tools to manage it, such as economic instruments. UNEP's work concentrates on helping countries strengthen environmental management in diverse areas including freshwater and land resource management, the conservation and sustainable use of biodiversity, marine and coastal ecosystem management, and cleaner industrial production and eco-efficiency, among many others.

UNEP, which is headquartered in Nairobi, marked its first 25 years of service in 1997. During this time, in partnership with a global array of collaborating organisations, UNEP has achieved major advances in the development of international environmental policy and law, environmental monitoring and assessment, and our understanding of the science of global change. This work has, and continues to support, successful development and implementation of the world's major environmental conventions. In parallel, UNEP administers several multilateral environmental agreements including the Vienna Convention's Montreal Protocol on Substances that Deplete the Ozone Layer, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (SBC), the Convention on Biological Diversity and most recently, the Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention, PIC). In recent years, UNEP has also been an important catalyst, and major supporter, of continuing international negotiations on an international agreement to deal with the problem of persistent organic pollutants (POPs).

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The mission of the Division of Technology, Industry and Economics (DTIE) is to encourage decision-makers in government, industry, and business to develop and adopt policies, strategies and practices that are cleaner and safer, use natural resources more efficiently and reduce pollution risks to both human beings and the environment. The approach of DTIE is to raise awareness by fostering international consensus on policies, codes of practice, and economic instruments through capacity-building and information exchange and by means of demonstration projects.

The Economics and Trade Unit

The Economics and Trade Unit (ETU) is one of the units of the Division of Technology, Industry and Economics (DTIE). The work programme of the Unit consists of three main components, economics, trade and financial services. Its mission is to enhance the capacities of countries, particularly developing countries and countries with economies in transition, to integrate environmental considerations in development planning and macroeconomic policies, including trade policies. UNEP's mission in this field is also to address the linkages between environment and financial performance and the potential role of the financial services sector in promoting sustainable development. The trade component of the Programme focuses on improving countries' understanding of the linkages between trade and environment and enhancing their capacities in developing mutually supportive trade and environment policies, and providing technical input to the trade and environment debate through a transparent and a broad-based consultative process.

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PREFACE

With the recent acceleration of global trade, countries throughout the world have benefited from more investment, industrial development, employment and income growth. Recognising that the benefits of trade can strongly contribute to the improvement of basic living standards, many of the world's developing countries and countries with economies in transition, have sought to actively participate in the global trading regime. For most of these countries, efficient and effective participation in the global economy has required substantial economic restructuring at home. Thus, in recent years, national governments have implemented structural adjustment programmes to stabilise and reorient their economies in order to face the challenges of development. This included in the first instance the restructuring of economies to increase foreign exchange earnings through enhanced trade and trade liberalisation as embodied in the set of agreements of the World Trade Organisation (WTO).

National experiences with structural adjustment programmes have been mixed. Nevertheless, trade liberalisation elements of restructuring programmes have facilitated the rapid growth of targeted export markets, and succeeded in attracting much needed foreign investment to fuel continued economic growth. Recently, however, many undesirable effects of rapid increases in trade have emerged. Affected countries find that inadequately managed economic activities, supporting, or supported by, growing trade, often result in serious environmental degradation. Air, water and soil pollution, and unrestrained natural resource exploitation, grow to levels that jeopardise the viability of the economic activities they support. Trade thereby becomes unsustainable.

The United Nations Environment Programme (UNEP) believes that the potential for negative impacts of trade on the environment can be minimised, if not avoided entirely, by integrating environmental considerations – that complement rather than inhibit trade – into development planning. Over the past two years, UNEP has worked closely with six countries – Bangladesh, Chile, India, Philippines, Romania and Uganda – on comprehensive projects to identify the impacts of trade liberalisation on national environmental resources and the use of economic instruments to sustainably manage these impacts.

These projects have encompassed new action-oriented research on unique trade-related environmental problems and their social and economic implications in diverse sectors and varied country settings. Importantly, projects have involved multi-stakeholder participation in numerous consultations to accurately identify the dynamics of environmental degradation, and to develop innovative and widely acceptable national response strategies. Each study concludes by recommending a set of practical measures – comprising ready-to-apply command and control measures and economic instruments designed to meet national conditions – that promise to effectively halt trade-related environmental degradation, and in turn, ensure that the country's trade remains robust yet sustainable over the long-term. But the projects do not end with published studies, the final component of each country project involves a pilot implementation of proposed measures undertaken by national authorities in collaboration with each project's national team and UNEP.

This report on the automotive industry in India, is one in a series of UNEP publications presenting country studies implemented under a first phase of "Capacity Building for Integrating Environmental Considerations into Development Planning and Decision-making" projects funded by the Ministry of Foreign Affairs of the Government of the Netherlands. Other projects in the first round examine the shrimp farming industry in Bangladesh, the Chilean mining sector, the Romanian water sector, the Philippines' forestry sector, and the Ugandan fisheries sector.

As we approach the WTO's Third Ministerial Meeting in Seattle, which may mark the launch of the next round of trade negotiations, this report provides a valuable source of information and knowledge on India's experience with the environmental impacts of trade liberalisation and the development of measures to address these impacts and promote sustainable trade and environmental policies.

The complex trade-environment dynamics and innovative strategies to manage emerging environmental problems of the Indian automotive industry are presented and discussed in detail in this report. The insights that this, and other reports in the series provide, make the series an extremely valuable resource for policy-makers and sectoral practitioners aiming to effectively address the emerging environmental impacts of trade in their own countries.

ACKNOWLEDGEMENTS

The preparation of this country report on India's automotive industry has been made possible by the cooperation and commitment of many individuals and organisations.

The Indian national team – the author of this report – is to be commended for taking the lead in project execution. Led by Ranganathan Venkatesan, Mihir Pandey and Shankari Banerjee of the National Council of Applied Economic Research in New Delhi, the team – with members coming from an array of research institutions, non-governmental organisations and national agencies – worked tirelessly to organise national workshops, gather field data, analyse economic and environmental trends, develop policy recommendations, and report on their activities and research results. Additionally, a National Steering Committee was established to ensure the project remained relevant and on-track, and local citizens' groups helped identify emerging environmental problems, elucidate their causes, and elaborate policy responses.

The work of a varied set of national team members, supplemented with inputs from a wide group of national constituents that participated in consultations, was essential in ensuring that diverse cultural and social perspectives were integrated into the project. Indeed, all of these national actors are to be thanked for their genuine interest and commitment in the project, and for the valuable contributions they made to the project's success. In addition, national authorities are to be thanked for their steadfast support of the project's objectives.

The Economics and Trade Unit (ETU), Division of Technology, Industry and Economics (DTIE) of the United Nations Environment Programme (UNEP), was responsible for the overall coordination and management of all six country projects. Through a joint UNEP-UNCTAD (United Nations Conference on Trade and Development) collaboration, René Vossenaar and Veena Jha provided technical guidance and assistance to the national teams on various aspects of their research. International expert meetings further provided a forum for project implementation review by national teams and representatives of relevant international and United Nations organisations. Additionally, critical reviews of draft reports were provided by Theodore Panayotou of the Harvard Institute of International Development and Konrad von Moltke of the Institute of Environmental Studies of Vrije University.

Once the national team had completed their final report, Eugenia Nuñez, Desiree Leon and Rahila Mughal of UNEP worked closely with an external editor, Robert Hamwey, to process the report for publication.

Finally, it must be recognised that like so many international environmental research projects, funding from interested sponsor governments is the key to their existence. UNEP is indebted to the Ministry of Foreign Affairs of the Government of the Netherlands who generously provided the financing that made this project possible.

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LIST OF ABBREVIATIONS

ACU	Asian Clearing Union
AIAM	Association of Indian Automobile Manufacturers
BIS	Bureau of Indian Standards
CAC	Command-and-control
CNG	Compressed natural gas
CO	Carbon monoxide
CPCB	Central Pollution Control Board
CRRI	Central Road Research Institute
CSE	Centre for Science and Environment
EU	European Union
EV	Electric Vehicles
FDI	Foreign Direct Investment
FII	Foreign institutional investment
GAIL	Gas Authority of India Limited
Gm	Gram
HC	Hydrocarbons
IGIDR	Indira Gandhi Institute of Development Research, Mumbai
Km	Kilometre
MBI	Market based incentive
MODVAT	Modified value-added tax
MOEF	Ministry of Environment and Forests, Government of India
MRTP	Monopolies and Restrictive Practices Act
MTNL	Mahanagar Telephone Nigam Limited
NAFTA	North American Free Trade Association
NOx	Nitrogen oxides
NRI	Non-resident Indian
PUC	Pollution under control
QRs	Quantitative Restrictions
RBI	Reserve Bank of India
SIA	Secretariat for Industrial Assistance
SO2	Sulphur dioxide
SPCB	State pollution control boards
UNEP	United Nations Environment Programme
WHO	World Health Organisation
WTO	World Trade Organisation

PART I

The Impact of Trade and Investment Policies on the Environment with Reference to the Automobile Sector in India

1. ECONOMIC REFORMS, DEVELOPMENT NEEDS AND THE ENVIRONMENT

The goal of most developing economies is “growth with social justice”, that is, accelerated economic growth as well as an equitable distribution of the benefits of growth. The path towards this objective, however, especially the role of the state in this regard has been debated for a long-time. Increasing reliance on the market is the norm today, and a wide range of market-friendly reforms are being undertaken in developing countries to address economic problems. If market failure justified government intervention earlier, the market is now making a comeback because of widespread “government failure”. Market failure includes the inability of markets to allocate resources optimally over time due to their myopic nature. In many countries, however, the regulatory state has resulted in economic losses due to faulty investment decisions and in diversion of resources to rent-seeking activities because of the very regulations themselves. But the critical issue is not the presence or absence of state intervention, but the extent and quality of such interventions.

Economic reforms encompass a broad area of adjustment between private, public, internal and external sectors of an economy to set the stage for “getting the prices right”. Through proper balancing between sectors, the economy's productive efficiency is supposed to improve. Simultaneously, reforms reduce the volume of “rent seeking” arising out of control and coercion within the system (Bhagwati et al. 1975).

Economic reforms initiated across the globe are widespread both at the macro and micro level. They have affected international trade, government budgets, private investment (domestic as well as foreign), wages, income distribution, etc. The role of economic reform in enhancing growth and productivity also assumes importance in view of the economic situation in the developing countries; many of them burdened with debt and with overall macroeconomic crises. In most of these countries the inward-oriented policies of the past came under critical scrutiny and the anti-export and anti-privatisation policies of the past were discredited.

The agenda of economic reforms in many developing countries during the 1980s and 1990s was aided by Structural Adjustment Loans (SALs) from the World Bank. There was a great deal of uniformity in the Structural Adjustment Programmes (SAPs) which set the course of economic events in many developing countries – they are based on what is popularly known as the Washington Consensus which emphasises a greater use of market mechanisms and private incentives to enhance the outward orientation of the economy (Williamson 1990). These programmes tend to reduce government intervention in the industrial sector and create a more export oriented trading economy. This “translates into less reliance in command-and-control environmental regulations[1], and other government measures which may unduly burden the development aims of both industry and government” (Rosencrantz et al. 1999, p.6). The mechanisms for attaining the goals set out in the reforms programme include liberalising exchange rates, interest rates, reducing government budget deficits, promoting the role of market, fostering globalisation, enhancing the role of the private sector, and strengthening government and market institutions. These policies are coupled with pricing and other sectoral reforms in industry, agriculture and energy. Although these policies are often not directed explicitly towards influencing the quality of the natural environment, they may, nonetheless, have significant impacts. For instance, as discussed below, greater revenue

[1] Command-and-control (CAC) is a shorthand description of environmental policies that are regulatory in nature in contrast to those that are market-based, e.g., pollution taxes or tradable permits. Under CAC, individual sources of emissions are regulated through a set of dos and don'ts, e.g., by requiring compliance with (typically uniform) emissions standards and/ or the mandatory use of pollution control equipment, etc..

flows from increased trading activities can provide developing countries an opportunity to invest more in environmental protection.

These countries are now actively reversing the inward looking legacy of central planning to that of open international economic relations through a series of trade and investment liberalisation measures in order to catch up with the developed world. The rationale behind such measures is that any activity which interferes with the free flow of capital, goods and services will produce sub-optimal results. Import substitution and accompanying protective measures such as tariffs, controls and restrictions raise the cost of domestic production. Such policies discriminate against those export items that can be traded in the global market on the basis of a country's comparative advantage. Therefore a country should specialise in the production and exports of only those items where it enjoys a comparative advantage and earnings from such exports should be able to pay for required imports.

There is considerable variation across countries in the pace and extent of trade liberalisation. However, most of them have completely removed restrictions on current account transactions and several countries have taken steps to liberalise financial flows. Other policies like removal of trade restrictions, quotas, quantitative restrictions etc., (tariff and non-tariff barriers) are all directed to maximise the advantage of international trade. Trade liberalisation can thus help to create a more efficient and productive economy.

The basic arguments for trade liberalisation and market-oriented policies include:

- exposing domestic producers to competition (both internal and external) leads to greater capacity utilisation and forces them to reduce costs to meet the rigours of a competitive market,
- enhancement in efficiency, along with openness, helps enlarge the size of the external market to compensate for any domestic demand limitations. In this process, increased trade diversification becomes a major part of liberalisation and export promotion,
- reducing static inefficiencies arising from misallocation and misuse of resources in the economy,
- leading to greater industrial efficiency through improvement in Total Factor Productivity (TFP) growth by providing greater access to imported intermediate goods, capital goods and technology.

Given the potential benefits of trade liberalisation, it is important to examine whether such policies are in conflict with the environment as they expand production and accelerate growth. Although trade stimulates social progress it is also argued that trade liberalisation in many instances has resulted in developing countries specialising in polluting industries (the so-called pollution haven hypothesis). This is discussed at length below.

1.1 Sustainable development and the environment

Development aims to increase public welfare and provide a healthy environment. However, in the past, developmental objectives were often perceived to be in conflict with environmental objectives. This perception of development is now changing as society attempts is to integrate environmental conservation into economic development to generate sustainable development. In other words, the negative impacts of economic activity on natural and environmental resources are accounted for and managed so that they are minimised. To achieve sustainable development, these impacts must be correctly assigned to, and incorporated in, economic activity as costs.

Environmental problems are often caused by policy distortions and market failure. The former are a result of government actions (e.g., subsidies, tariffs, quantitative restrictions, etc.) that distort the functioning of markets by creating an imbalance between private and socially optimal levels of resource use by producers and consumers. Policy distortion can lead to market failure.

Market failure can also occur in the absence of these distortions due to one or more of the following reasons:

(i) the presence of environmental externalities – environmental damage costs that remain external to a producer's (or consumer's) economics. When externalities are present, the production and consumption activities of some economic agents impose costs on other agents which are not compensated by the market. The market fails in the presence of externalities because the externality generator does not pay for the environmental damage resulting from its economic activity, and so it does little to protect or conserve environmental resources. Externalities thus lower social welfare.

(ii) improper valuation of ecosystems – some or all of the economic values of ecosystems are not accounted for, i.e., direct and indirect use values, existence values and option values.

(iii) the absence of (or ill-defined) property rights.

Policy distortions and market failures may reinforce each other to severely degrade the environment. For example, the problem of air pollution (an environmental externality) is worsened by energy subsidies that encourage wasteful use of fossil fuels. Similarly, the failure to account for the value of biodiversity in forests (improper economic valuation) is compounded by policies such as low stumpage fees.

Since the costs of environmental degradation (or conversely the benefits of environmental protection) are not reflected in the price of the goods and services, intervention is necessary to induce the externality generator to either reduce output to the socially optimal level, or, when possible, to switch to production methods which reduce externalities. This can be achieved either directly through command-and-control measures, that impose damage limits, or through market-based instruments (MBIs), that impose damage costs.

Also, in an effort to minimise the extent of market failure, a great deal of work has been done recently on green accounting or the inclusion of natural resources as an important element of individual agents' and the nation's income accounting. Accounting for the depletion and degradation of natural and environmental resources is important in providing a basis for environmental policy formulation.

Economists have tried to revise the conventional measure of GNP to account for costs of pollution, depletion of natural resources etc. Within this context, attempts are made to attain an optimal balance between economic growth and environmental protection which entails a set of intergenerational criteria for decision-making. Economic planners have realised the importance of the "need to produce along with the "need to protect" and have stressed the need to reconcile demand" with ecological imperatives.

This new approach is embodied in the currently popular term sustainable development originally proposed in the report "World Conservation Strategy: Living Resource Conservation for Sustainable Development", prepared jointly by the World Conservation Union, United Nations Environmental Programme and World Wide Fund for Nature in 1980. Sustainable development is both a development concept and a development paradigm. It is multidimensional since it is defined by the three interacting dimensions of ecology, economics and ethics. In short, sustainable development means "meeting the needs of present generation without compromising the needs of future generations". To operationalise the concept of sustainable development we begin by measuring Green GNP as:

Green GNP = Conventional GNP + Value of Environmental Services/ Resources - Cost of Environmental Damage

therefore, the Green Net National Product is:

Green NNP = Green GNP - dK - dN

where, dK = depreciation of man made capital, and dN = depreciation of environmental assets.

For economic development to be judged as sustainable, the economy should save more than the sum of physical and natural asset depreciation (Pearce and Atkinson 1992). Thus, the sustainability rule is $S > (dK + dN)$, where S = saving of the economy.

The traditional cost-benefit analysis rule for the potential acceptance of any project can also be modified as:

$$\Sigma_t [(B_t - C_t - E_t)/(1 + r)^t] > 0$$

where,

r	=	the discount rate
B_t	=	non-environmental benefits at time t
C_t	=	non-environmental cost at time t
E_t	=	environmental cost (positive for environmental benefit)

The sustainable development path is shown in Figure 1.1. Path S is sustainable and path E is efficient but non-sustainable. Path N is both non-sustainable and non-survival, because the average level of well being falls below the minimum level (poverty line). But from the vantage point O in the figure, it is not possible to ascertain which development path a country is pursuing. Finally, sustainability of development revolves around the issue of irreversibility. The more irreversible the damage done by the current generation, the fewer degrees of freedom future generations will have to raise their own well being. Sustainable development is therefore also guided by the need to avoid any significant irreversible damage.

The difference between economic development and sustainable development is that traditional development theory did not take adverse environmental effects into account. Sustainable development can still have adverse environmental effects but it takes them into account and seeks to limit them. Therefore, development with sound environmental and ecological balance improves health and quality of life that eventually maintains the process of sustainable development.

1.2 Environmental effects of economic reforms

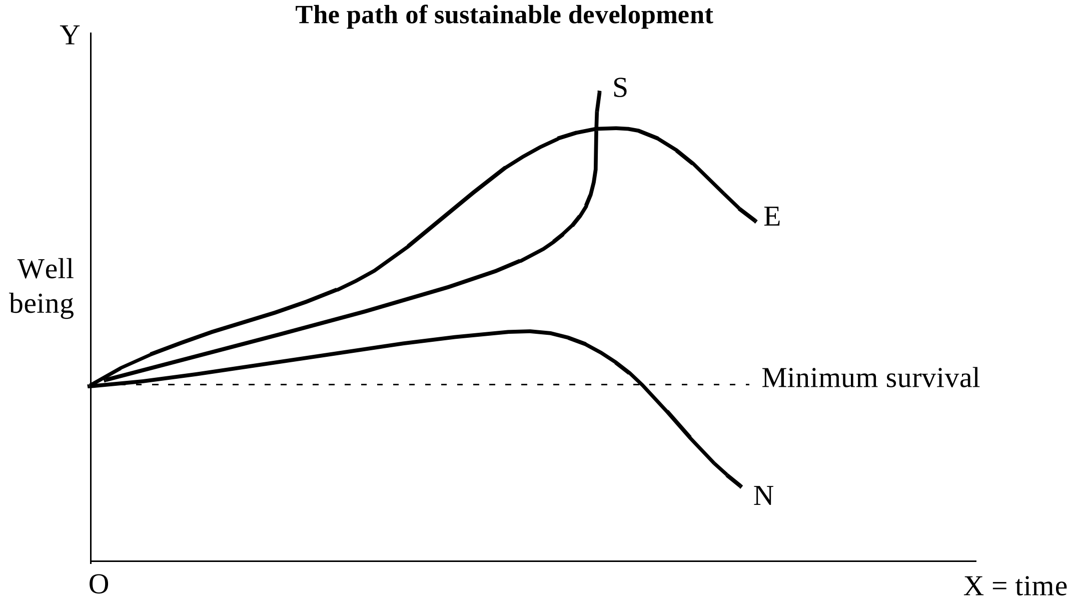
The link between economic reforms and the environment can be complex and is usually country-culture specific. Shifts in relative prices due to changes in the pattern of taxes, trade duties, real wages, exchange rates, etc., have impacts, both positive and negative, on the environment. SAPs in particular can have wide ranging implications for resource use and the environment. For example, there are usually strong positive linkages between energy conservation and reforms in energy pricing.

Numerous studies on the possible links between economic policies and the environment have been conducted for different countries. These studies have examined the impact of economic policies on pollution and environmental quality indicators, and have evaluated various economic performance criteria, such as growth in gross domestic product, employment, current account balance, fiscal deficit, inflation, and interest rates resulting from stricter environmental controls. Some studies have even attempted to incorporate the estimated benefits of reduced environmental damage so that these can be traded against direct economic losses resulting from the environmental policies. Typically, such studies in developed countries are based on countrywide single or multi-sectoral growth models (Bergman and Olsen 1992).

In India, stabilisation and structural adjustment programmes are not even a decade old, and so the impact of these programmes on the environment has not been comprehensively studied to date. However, since the late 1970s, stabilisation and structural adjustment programmes have been adopted by developing countries to maintain a viable balance of payments consistent with the inflows of foreign exchange to allow policies of economic modernisation and growth to continue.

FIGURE 1.1

The path of sustainable development

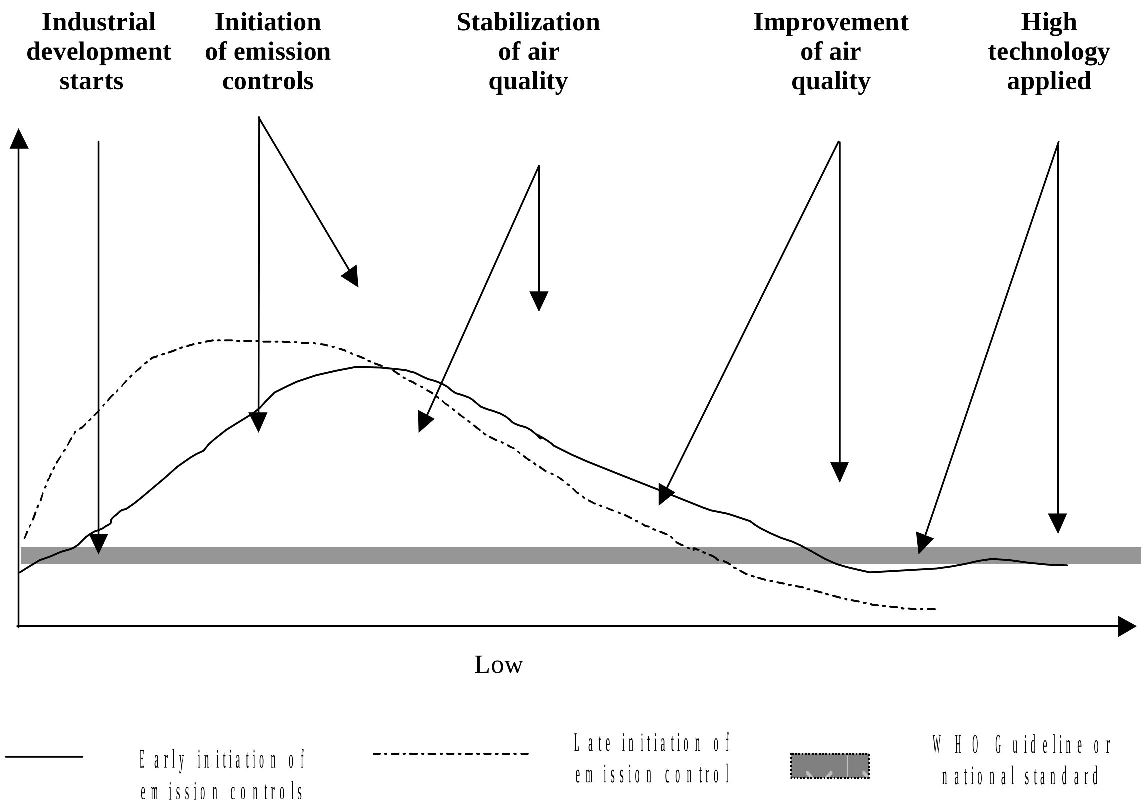


These countries have started the process of liberalisation at a later stage than many of the western countries. Hence the pollution associated with rises in economic activities (production, consumption, trade) accompanying liberalisation have reached a stage that was present, for example, in London in the 1950s before "clean air" legislation was introduced. This relationship between the level of development and environmental quality is illustrated in Figure 1.2.

When examining trade policies, per se, the key questions are: Do these policies reduce or increase economic distortions? Do they in some way mitigate the problem of market failure mentioned above? This discussion also implies that generally, trade is not the main cause of environmental problems. To the extent that trade liberalisation leads to a set of policies that reduce economic distortions and promote economic efficiency, such reforms are generally good for the environment.

However, in the presence of unaddressed market failures and/or policy distortions, increased trade may aggravate environmental problems. For example, trade liberalisation may encourage deforestation or over-fishing. When negative impacts exist, the solution is not to delay stabilisation programmes, but rather to devise specific measures, such as sensible forestry and fishing laws, to counteract the negative effects. In other words, the solution in this case is not to reverse trade reforms, but rather to introduce complementary measures that will address the market failure or policy distortion that is causing the environmental damage (Munasinghe and Cruz 1994). For example, in a study of Morocco, trade liberalisation was shown to result in a major expansion of the economy, but at the expense of unsustainable increases in water consumption (Goldin and Host 1994). The complementary reform of increasing the highly subsidised price of water closer to economic levels, preserved the economic gains of trade reform while curbing water use to more sustainable levels.

In general, trade policy alone would be a rather ineffective instrument with which to address specific environmental problems. A policy programme that seeks to promote both trade liberalisation and environmental protection is more attractive. These latter policies could, for example, include product rules, emission standards, etc. With product rules, the emphasis is on a commodity's impact on the environment and resource stocks. Recognising the importance of consumer sovereignty and rights of each nation to protect its own population, the General Agreements on Trade and Tariff (GATT) establishes an equivalent-standard rule which enables countries to protect their environments and population. This code allows a nation to set any standard it likes, provided the standards for locally made and imported goods are equivalent. Automotive emission



standards, for example, are enforced irrespective of the country of vehicle manufacture. This is very important as harmonised standards do not allow for differences in environmental conditions, denying related comparative advantages (Barrett 1993). The need for exhaust emission controls, for instance, is likely to be greater in regions with higher population densities. Socio-economic differences are also important. A wealthy nation may be less willing to accept polluted air in its cities than a poor one. Additionally, national tastes and preferences for environmental quality vary. The equivalent-standard approach, however, does leave room for innovation. For example, one automobile manufacturer may use a catalytic converter to achieve a given standard while another may rely on a special type of engine.

1.3 Environmental effects of trade: a conceptual framework

Trade leads to an expansion in the scale of economic activity as efficiency gains are realised. In addition to this scale effect, changes may also occur in the *composition* of output, the *production techniques* used, and in the location of economic activity. To trace the effect of trade-induced economic expansion on the environment, it is necessary to analyse the structure of this growth in terms of four components:

(i) *Growth* in output, or the *scale* effect as efficiency gains from free trade are realised. Trade can have positive scale effects as higher incomes lead to greater demand for environmental quality (assuming that it is a normal good) and more funds are available for environmental protection. Of course, this may only occur after a threshold level of income is achieved (the *environmental Kuznets curve* argument). At the same time, however, growth may also lead to faster depletion of natural resources and increased pollution.

(ii) Change in the *composition* of output as countries specialise according to their comparative advantage. Again, in some cases this may lead countries to specialise in "cleaner" products, whereas in other instances quite the reverse may occur. As an example of the former, in Mexico it was conjectured that increased specialisation due to NAFTA-related trade liberalisation, would result in a shift to labour-intensive and agricultural activities that were cleaner and less energy-intensive (Grossman and Krueger 1991).

(iii) Change in *production techniques* – change in inputs and/or technology used – or *intensity* effect. Trade may lead to the diffusion of cleaner production technologies which reduce pollution intensity. Similarly, trade-induced change in relative prices may make it possible to use alternative (cheaper) inputs which also happen to be cleaner.

(iv) Change in the *location* of economic activity. Within a country production may become more dispersed or more concentrated as factors of production are more efficiently allocated in response to market signals. In countries with limited infrastructure concentrated around port cities, which often also double as national capitals, export promotion could lead to further concentration of economic activity in these area.

Thus we see that each one of these four factors may move in different directions, vis-à-vis their impact on the environment, and therefore it is difficult to generalise about their aggregate effect. For example, in the case of Indonesia, the last two factors worked in favour of reduced pollution, but these gains were overcome by the scale effect (Wheeler and Martin 1993).

Whether a move towards trade liberalisation leads to more or less pollution is, from a policy point of view, not the appropriate question. *The relevant issue is whether trade liberalisation is compatible with effective environmental protection.* Ideally trade related problems should be addressed with trade policies, while any environmental issues that arise need to be addressed by targeted environmental measures, rather than by seeking to restrict trade induced growth.

1.4 Environmental effects of trade liberalisation

In most cases environment is not a major consideration when trade reform is considered (as is the case with other structural adjustment policies). It is also, however, widely accepted that trade reform inevitably has impacts on the environment. Some of these effects may be quite direct and can be easily anticipated (e.g., the effect of trade liberalisation in timber exporting countries), while others are more indirect (such as the effect of an exchange rate adjustment on demand for consumer-oriented exports). In terms of the analytical framework developed earlier, one can however argue that, to the extent trade reforms eliminate policy distortions and improve the efficiency of resource use, they are generally good for the environment. In developing countries where import substitution programmes were in place, these distortions have historically been in the form of discrimination against their primary and labour-intensive export manufacturing sectors and agriculture (in which they have a comparative advantage), and favouring their import-competing industrial sectors. Industrial countries, on the other hand, have tried to protect industries that are losing comparative advantage but provide significant employment, e.g., agriculture, coal mining, textiles, and automobiles (Anderson 1993).

Removal of distortions through trade reform leads to higher incomes in both rich and poor countries, as well as a relocation of production and consumption. *Higher incomes* in poor countries lead to environmental benefits in at least three ways: (i) an increased desire for better environmental policies (since demand for environmental quality is income elastic, at least after a threshold level of income); (ii) a lower rate of growth of population that leads to less stress on natural resources, and (iii) higher opportunity costs for time increase the relative price of wood and charcoal as sources of household fuel. Since four-fifths of the timber harvested in developing countries is used as household fuel, this last effect can lower deforestation and desertification (Anderson 1993).

In addition to income effects, trade reforms also result in *global shifts in production and consumption* as subsidies on production and export are eliminated, and trade barriers (tariffs as well as quantitative restrictions) are dismantled. These shifts have been analysed in the case of coal and food, two of the world's most distorted commodity markets (Anderson and Blackhurst 1992). Both goods tend to be priced below international levels in developing countries and above them in rich nations. For coal, environmental effects arise mainly in the course of consumption, whereas in the case of *food* the impact on the environment is during production.

It has been estimated that import protection and direct producer *subsidies* for *coal* in developed economies (which account for a third of world coal consumption) has kept prices higher than border prices (in 1986 by about 100 per cent in the United Kingdom, 240 per cent in the former West Germany, and 290 per cent in Japan (*Jolly* et *al.* 1990)). Elimination of these distortions would shift production from these countries to the rest of the world. A tax on the consumption of coal in developed countries could maintain consumer prices at pre-reform levels. At the same time, higher world prices would reduce consumption and pollution in the rest of the world. These environmental gains would be reinforced if developing countries (which account for about half of world coal consumption), were to reform their markets simultaneously.[2] The combined effect of these changes would be reduced pollution, improved efficiency of resource use, and increased government tax revenue (by maintaining pre-reform price levels for consumers in developed countries).

Similarly, the *reduction of agricultural trade protection* in rich countries would lead to a relocation of production to poorer countries, as well as an increase in their incomes (Anderson and Blackhurst 1992, Anderson and Tyers 1993). At the same time, concerns over the negative environmental impacts of increased use of fertilisers and pesticides in developing countries (a consequence of these shifts), are largely unfounded: the absolute amount of the use of these inputs is still quite low, and therefore any increase would be from a very low base level. Further, the worldwide use these chemicals would fall since their use per unit of output is much higher in developed countries. Finally, any negative environmental effects in developing countries due to excessive use of inputs (such as water logging due to subsidised water or electricity), arise due to policy distortions, and not trade liberalisation *per se*. The last point is worth emphasising since it lies at the heart of the controversy regarding trade liberalisation and environment in general and GATT in particular.

With regard to the direct effects of liberalisation on timber trade and *deforestation*, Barbier et *al.* (1991) found that timber trade was not the major reason for deforestation – domestic distortions (subsidies, non-economic prices, etc.) had played a larger role. As a corollary, when trade reforms were combined with appropriate domestic environmental and agricultural policy measures, it resulted in welfare gains and an improvement in environmental quality (Harold and Runge 1993).

With respect to *industry* the major implication that emerges from available empirical evidence is that trade liberalisation does not necessarily give rise to the migration of polluting industries to the developing world (i.e., the pollution haven hypothesis does not find empirical support). On the contrary, several positive aspects are likely to arise as more efficient resource allocation benefits the environment in several sectors. However, the expansion of economic activity induced by trade liberalisation (the scale effect) increases existing pollution and may create new environmental problems if environmental costs are not internalised.

[2] According to the International Energy Agency, during 1988-90 the domestic price of steam coal as a proportion of Western European import price, was 15 per cent in the former Czechoslovakia, 20 per cent in Poland, 32 per cent in Hungary, and 27 per cent in India.

India's policies, including those related to trade, have begun to address environmental issues. An effective method of directing production techniques towards more environmentally friendly methods without relying on strict instruments like trade bans has been introduced, e.g., mandating cars have catalytic converters, etc. Finally, time is an important factor in any assessment of the environmental effects of trade liberalisation. The environmentally beneficial effects of foreign direct investment (FDI), technology transfer and changes in trade patterns occur over a long period of time.

1.5 Environmental implications of the Uruguay Round and beyond

The GATT's Uruguay Round, concluded in December 1993 after seven years of arduous negotiations, resulted in the most comprehensive trade agreements ever negotiated under the GATT. More than 120 countries participated in the negotiations aimed at reducing barriers to trade, including tariffs and non-tariff barriers such as quotas, export subsidies and anti-import regulations, in order to increase living standards, employment and output. members agreed, inter alia, to cut tariffs on average by almost 40 per cent, to significantly reduce existing farm subsidies, to eliminate textile and apparel quotas (i.e., through the MFA) over a period of 10 years. They also agreed to adopt new rules for trade in services and trade-related intellectual property and investment, to strengthen international dispute settlement procedures, and to establish a new World Trade Organisation (WTO) to succeed the GATT.

The Uruguay Round explicitly acknowledges the need for sustainable development and for institutionalising the protection and preservation of the environment. The preamble to the WTO agreement allows for "the optimal use of the world's resources in accordance with the objective of sustainable development, seeking both to protect and preserve the environment and enhance the means for doing so in a manner consistent with needs and concerns at different levels of economic development." The operational implications of this statement are to be determined primarily by WTO's Committee on Trade and Environment. In principle, however, the signatories agree that there should not (and need not) be any conflict between an open and equitable multilateral trading system and environmental protection.

Predicting the *environmental effects of the Uruguay Round* is difficult because they are indirect – beyond general pronouncements, environmental issues were not explicitly addressed in the negotiations[3]. These issues will, nevertheless, be a top priority for the WTO whose legitimacy may well depend on the successful resolution of a growing number of environment-related trade disputes. According to Charles R. Carlisle, Deputy Director-General of GATT, the links between trade and environmental policies could be the "number one trade issue of the 1990s." He further states that "trade and environment could be central to GATT's next Round, which could become, who knows, the "Green Round"? (Wilkinson, 1994, p. 395).

The experience of NAFTA in coordinating trade and environmental concerns could be of considerable relevance for GATT's unfinished environmental agenda. For instance, under Article 104 of NAFTA, trade provisions of specific international agreements such as CITES, the Montreal Protocol or the Basel Convention take precedence over NAFTA. Similar features could be incorporated into the GATT by suitable modifications to Article XX which specifies the circumstances under which deviations from GATT obligations for environmental purposes are justified. As environmental problems related to the global commons emerge, this issue of precedence will also become more important.

[3] This is not meant as a criticism. In fact the position taken here is that the management of environmental issues, per se, is distinct from trade policies and should not generally be addressed by the latter.

1.6 Effects of environmental policies on trade

In this section we reverse the focus and examine the impact of environmental policies on trade. Two key sets of related issues can be identified here. The first question is whether regulations to protect the environment in one country place it at an unfair disadvantage vis-à-vis another that does not have similar regulations? Two potential outcomes of this situation have been the centre of recent research. The first is referred to as “environmental dumping”, i.e., countries with lax environmental policies have lower costs of production, and therefore, an unfair trade advantage that permits them to sell relevant goods at low prices relative to competitors in other countries where regulation is in place.[4] The second is known as the “pollution haven” hypothesis which posits that polluting firms relocate to countries with low levels of environmental regulation.

On dumping, the present consensus is that except in the case of a few industries, the costs of pollution control are only a small fraction of total production costs. Thus, more stringent environmental regulations do not necessarily lead to reduced trade competitiveness. As the same time, those countries that adapt early to improved environmental regulations will have a competitive advantage in the future, as environmental controls progressively tighten worldwide. Similarly, empirical evidence examined so far does not support the pollution haven hypothesis (Tobey 1990, Birdsall and Wheeler 1992). On the contrary, there is some indication that open economies, even if they have low levels of environmental regulation, attract major industrial multinationals, which tend to use cleaner technologies regardless of local environmental standards.

The second (perhaps more important) set of issues relates to how a country reacts to environmental dumping or pollution havens? The key policy question here is whether restrictions on trade are the optimal way to “level” the environmental playing field. The short answer to the question is, no – trade policy measures are typically not the first-best instruments for achieving environmental objectives. Their use in lieu of more efficient instruments unnecessarily reduces the level and growth of global economic welfare, and may even add to, rather than reduce, global environmental degradation. For example, a proposed ban on the import of tropical hardwood logs by European countries led Indonesia to unilaterally ban log exports. However, felling has continued, thus reducing domestic log prices, and generating huge (virtual) subsidies for Indonesian furniture and other timber-based industries for which there were no import bans and exports thus grew. Also, as a consequence of low timber prices, less of each tree is now used, adding to inefficiencies.

[4] In a different context the same argument can be made about “social dumping”: lax labor laws, child labor, unsafe working conditions, etc., provide some countries with an (allegedly) unfair cost advantage.

2. INDIA'S STRUCTURAL ADJUSTMENT PROGRAMME AND THE AUTOMOBILE SECTOR

2.1 Salient features of the structural adjustment programme

India embarked on a policy of liberalisation and structural adjustment in July 1991. The common objective of all the measures undertaken is to improve the efficiency of the economy. The regulatory mechanism hitherto in place involved multitudes of controls, which in effect fragmented capacity and reduced competition across all sectors. The new economic policy aimed at creating a more competitive environment, thereby improving productivity and efficiency in the economy. However, the need, for economic reforms was felt for quite some time. In fact, the reforms date back to the regime of the late Indira Gandhi in early 1980s, which were further carried out by her successors. Nevertheless, their magnitude and intent was negligible. The changes brought about were not systematic and were never integrated into an overall framework. The immediate reason for the 1991 reforms however, was the impending financial crisis and risk of default on various loan repayments. For the period 1985-90 as compared to 1980-85, the central Government fiscal deficit as per cent of GDP, had risen from 6.3 per cent to 8.3 per cent, revenue deficit was up from 1.1 per cent to 2.6 per cent, and budget deficit was up from 1.2 per cent to 2.1 per cent. Fiscal imbalance and the budgetary deficit spilled over into money supply growth and excess demand fuelled inflationary pressure. Also, the macro-economic imbalance had spilled over to a balance of payments problem (BoP). The primary goals of the Structural Adjustment Programme (SAP) initiated were to reduce the central Government fiscal deficit, to bring the current account deficit into manageable proportions and to raise GDP growth to around 6 per cent by the mid 1990s.

The stabilisation policies of the Indian Government during early 1990's included demand management policies, such as fiscal policy measures that control the domestic budget balance and improve the balance of payments and inflation; industrial policy and factor market reforms; financial sector reforms and liberalisation of capital flows. The thrust was towards export-led growth. The main macroeconomic policy measures aimed to generate:

- A liberalised trade regime with tariff rates comparable with industrialised countries and with very little discretionary import licensing.
- An exchange rate system, free of allocative restrictions on trade.
- A financial system working in a competitive environment.
- An efficient and dynamic industrial sector. This required the abolition of the Monopolies and Restrictive Trade Practices (MRTP) Act.
- Public Sector Policy reforms to establish an autonomous, competitive and streamlined public enterprise sector geared to the provision of essential infrastructure, goods and services, and the development of key natural resources.
- A larger space for the private sector to operate.

The new economic policy adopted the principle of the market economy as its main operative principle. The most radical changes implemented in the reform process have been made in the area of industrial policy. It marked a major departure from the regime of controls and licenses that previously characterised trade and industry. Systematically, the barriers and regulations for entry, expansion etc. have largely been abolished. Licensing is only needed for a small list of industries, primarily for environmental and pollution control. Control through the Monopoly and Restricted

Trade Practice (MRTP) Act was also eliminated. One area, where licensing control still remains in place relates to the list of industries reserved for the small-scale sector, which the Government pledges to continue for social reasons. The policy also simplified earlier policies and procedures for Foreign Direct Investment (FDI) projects in virtually all sectors except those of strategic concern like defence, railways and nuclear energy. The policy has succeeded to a large extent in attracting foreign investment into India and encouraging foreign investment and technology transfer agreements. The policy changes have also resulted in the simplification of the procedures required at various stages of project development including registration, financing, clearances, setting up of the plants etc.

The list of industries reserved for the public sector has been drastically pruned and many critical areas have been opened to private investment (e.g., electricity has been opened up for private investment including foreign investment). Policy towards foreign investment has also been liberalised to a large extent. Permission now is automatically granted for foreign equity investment up to 51 per cent for a large list of 34 industries. Various restrictions under FERA have also become redundant now (Annex 1 contains details of the new industrial policy). By doing away with all these restrictions, the new industrial policy has introduced an element of competitiveness in domestic industry. Movement towards enhanced competitiveness has led to decreasing costs and improved quality and productivity.

Reforms in the export sector have also been quite comprehensive and broadly covers five areas – reduction in tariff rates and tariff slabs, phasing out of quantitative restrictions (QRs), easing of exchange control regulations, a more open policy regarding foreign direct investment (FDI) and rationalisation of export subsidies. Trade was ultimately freed, subject to a negative list for imports, in 1994-95 and by making the rupee fully convertible on the current account. To create a globally competitive environment, the Government of India has taken various steps to reduce the degree of regulation and licensing control on foreign trade. A brief account of these policies is given in Annex 2.

Apart from macroeconomic reforms of 1991, several microeconomic or "sectoral" reforms were launched with a medium term perspective. These reforms were initiated with a view to improve the efficiency, productivity and international competitiveness of India's manufacturing sector. Reforms were also initiated towards streamlining the structure of indirect taxes and excise duties on domestically produced goods and customs duties on imports. These reforms have accelerated India's exports and also facilitated imports of essential inputs such as capital goods.

2.2 Impact of stabilisation measures

The structural adjustment policies initiated in the Indian economy did yield some anticipated results and India has been successful in achieving stabilisation. Since the crisis of 1991, the foreign exchange reserves have stabilised. The rupee has been made convertible on the current account. The trade account, though still negative, has improved, although the success can be attributed to a large extent to import compression due to the decline in trade with Eastern Europe and the former Soviet Union. Nevertheless, the contribution of export growth has long-term favourable implications, and the competitiveness of Indian industry has improved.

In the area of industry, significant deregulation of prices and distribution has taken place. However, the measures still remain on the softer side, neither trying to remove the many implicit subsidies, nor trying to contain the wage bill of the government. Thus, containing of the fiscal deficit has been difficult. Surprisingly, however, the inflation rate has remained low. Even in the field of taxation, the rates of indirect taxes are still relatively high, particularly on the imports.

An examination of the performance of the Indian economy for the period 1991-92 to 1996-97 shows that after initial showdown in 1991-92, there was a strong revival of economic growth. GDP growth recovered to 5 per cent in 1992-93 and 1993-94 and was over 7 per cent in 1995-96.

TABLE 2.1

Impact on key economic indicators, 1990-91 to 1997-98

Indicators	**90-91**	**91-92**	**92-93**	**93-94**	**94-95**	**95-96**	**96-97**	**97-98**	**98-99**
Growth of GDP	5.3	1.2	5.1	6.2	7.8	7.2	7.5 Q	5.0 A	5.8 A
Growth in agricultural production (per cent)	3.8	-2.0	4.1	3.6	75.0	-2.7	9.3	-3.7	3.9 P
Growth in Industrial Production (per cent)	8.2	-0.6	2.3	6.0	9.4	12.1	7.1	4.2	3.5 @
Gross Domestic Savings #	24.3	22.9	22.0	217	24.2	24.1	24.4 P	23.1 Q	NA
Gross Domestic Investments #	27.7	23.4	23.9	22.4	25.4	25.8	25.7 P	24.8 Q	NA
Current a/c deficit #	-3.2	-0.4	-1.8	-0.4	-1.1	-1.8	-1.0	-1.5	
Fiscal Deficit #	7.7	5.4	5.2	6.9	5.6	4.9	4.7	5.5	5.1
Budget deficit #	2.1	1.1	1.8	1.4	0.1	0.9	0.5	0.0	
Imports (US $ billion)	24.1	19.4	21.9	23.3	28.6	36.7	39.1	40.8	31.6 @
Exports (US $ billion)	18.4	18.3	18.9	22.7	26.8	31.8	33.5	34.0	24.3 @
Exports #	6.2	6.7	7.1	8.1	8.1	8.9	8.6	8.3	NA
Imports #	9.4	7.7	9.4	9.6	10.9	12.0	12.5	12.2	NA
FDI #	0.03	0.10	0.20	1.60	1.60	1.40	1.50	NA	
Exchange Rate (Rs /US $)	17.9	24.5	30.6	31.4	31.4	33.5	35.5	37.2	41.99
Population (Million)	846.3	863.2 B	880.4 B	898.0 B	915.9 B	934.2 B	949.9 B	965.6 B	

SOURCES: Economic Survey (various issues), Government of India. (ii) CMIE (1994b)

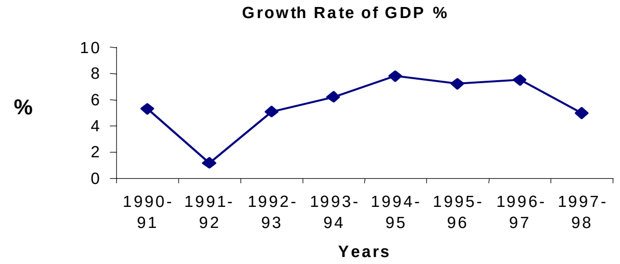
NOTES: **P** – Provisional, **Q** – Quick estimate, **A** – Advance estimates. **B**- Based on estimates by Technical Group on Population. **C** – Average VIIIth Plan (1992-97). **NA** – Not Available. # – As a percentage of GDP. @ – April - December 1998.

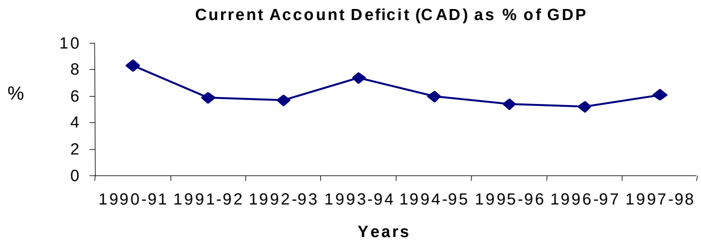
Agricultural growth had supported 1992-93 growth even though industry had remained sluggish. Industry recovered moderately in 1993-94 and 1994-95 and fully n 1995-96. Economic growth in 1996-97 was 7.5 per cent leading to an average of 6.5 per cent for the Eighth Plan period (see Figure 2.1). However the savings rate did not keep up with that pace and average.

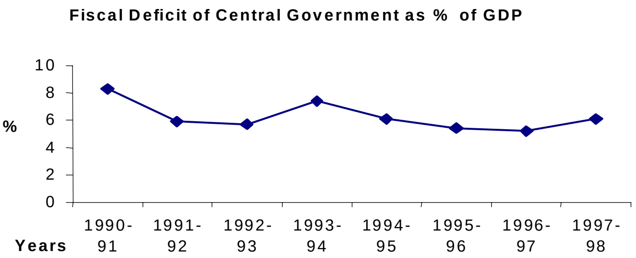
The overall growth in the economy slowed down in the last year. The drop in GDP growth in 1997-98 is attributable to a sharp fall in the growth rate in agriculture and deceleration in the industrial sector. The decline in export growth rate is mainly due to the decline in the flow of world trade in 1996 and 1997. There was also a noticeable decline in the export prices of some major manufactured goods. It was also, partly due to an appreciation of the US dollar against other major currencies in the international markets. However, on the whole, the competitiveness of Indian industry increased. The impact of such policy reforms in the overall economy can be seen from Table 2.1.

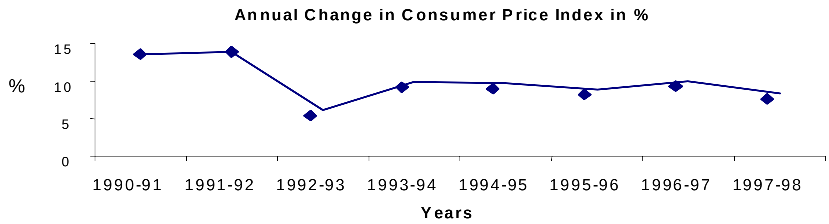
2.3 The automobile industry

In India, the automobile sector has grown tremendously over the last fifteen years. The automobile industry had a combined turnover of Rs 450,000 million ($10 billion) in 1997-98, with sales of around four hundred thousand passenger cars, three million two wheelers and two hundred thousand commercial vehicles (CVs), which made it the 12th largest industry in the country (AIAM 1998 annual report). The total capacity of on road vehicles having four or more wheels such as LCVs, MCVs and heavy commercial vehicles, jeeps and passenger cars numbered around 1,296,000. The increased supply in terms of number of vehicles as well as the entry of multinationals like Daewoo, Hyundai, Honda, Peugeot, General Motors, Ford, Mercedes-Benz, and Fiat into the Indian car market has created an unique situation hitherto unknown to the Indian market.









The Indian automobile sector has gone through three distinct phases: the early regime of licensing until 1983; partial liberalisation of rules in 1983-84, which led to the entry of Maruti and the proliferation of two wheelers and LCVs; followed by the phase in the 1990s when economic reforms were introduced in the economy as a whole. The early regime was governed by regulations where imports, collaborations, and equity ventures were severely restricted by the government. Capacity expansion was also restricted (under the Monopolies and Restrictive Trade Policies Act) and the Government issued the required licenses. Technology transfer from foreign companies was subject to Government approvals. All these factors had an impact on the supply as well as the prices of the vehicles. Thus the period was characterised by limited ownership of vehicles over a longer period of time. There was also pent-up demand. During the second phase, entry of the first multinational company into the automobile sector i.e., Suzuki Motor Company of Japan (in collaboration with Maruti) redefined the automobile sector and led to its tremendous growth. The Government on the one hand encouraged the company by giving it fiscal concessions (lowering import and excise duty), and on the other hand forced the company to adopt a phased manufacturing programme whereby the company had to increase the indigenous portion in the production process gradually. The impact of Maruti resulted in the rise in the sales of car from 112,550 (including jeeps) in 1980 to 345,157 in 1990 registering a three-fold increase within a decade. The advent of Maruti Udyog Limited in the Indian scenario had dramatic effects both in terms of quality and price. They pioneered the concept of an affordable family car, and cashed in on pent-up demand. Thus the actual boom in the car market started when Maruti entered the scenario in 1984 with its small and fuel-efficient family car models.

The recent measures of liberalisation have led to a further increase in the domestic as well as foreign investment in the automobile sector. Until the liberalisation policies of the 1990s, Maruti had a free run in the Indian automobile market with very little competition. But the scenario changed with the introduction of the structural adjustment programme, and further entry of new players increased competition in the automobile sector. The international vehicle manufacturers are increasingly setting up joint ventures in the country, with each player targeting to manufacture from 20,000 to 150,000 cars per annum. In fact for the first time the automobile sector had really become competitive. At the same time, an overall growth in the income levels (the GDP grew quite robustly since 1993) resulted in an increase in demand for personalised modes of transport.

The structural adjustment process initiated by the Government of India has had a significant impact on the Indian automotive industry. This sector has undergone several policy changes with respect to industrial licensing, foreign investment and technology, fiscal and monetary policies, exports, imports, etc. There are now very few Government regulations or direct controls as compared to other developing countries in Asia. The automobile sector is now segregated into three categories in the passenger car section alone; small, medium and luxury cars, with intense competition between the three sub-categories. Moreover, from just five-six models not even a decade back, today around five new models are being introduced every year. The primary beneficiary have been consumers, who are now reaping the benefits of enhanced choice, better technology and decreased real prices. Today, even environmental concerns are increasingly becoming an important parameter in their decision making process.

2.4 Salient features of new policies in the automobile industry

Industrial Policy

- Announcement of National Industrial Policy: Production licensing was done away with for all types of automotive vehicles except motor cars in July 1991.
- Production licensing for cars was abolished in April 1993.
- For all delicensed industries, no approval is required from the central Government and only a memorandum of information is required to be filed with the Secretariat of Industrial Approvals (SIA) for statistical purposes.
- Announcement of National Highway Policy: This will have a positive impact on the automobile industry.
- Automatic approval for projects involving import of capital goods :
  - (i) in cases where foreign exchange availability is ensured through foreign equity; or
  - (ii) if the CIF (Cost, Insurance, Freight) value of imported capital goods is less than 25 per cent of the total value of the plant and equipment subject to a maximum of Rs 20 million.

Foreign Investment

- Automatic approval for up to 51 per cent foreign equity stake has now been allowed in segments like –
  - – Commercial vehicle, public transport vehicles including automotive commercial three wheelers, Jeep type vehicles, industrial locomotives.
  - – Automotive two wheelers and three wheelers
  - – Automotive components / spares and ancillaries

- For approval of projects in the car segment, a further condition of dividend balancing has been imposed (i.e., outflow on account of dividend payments has to be balanced by the foreign exchange earnings through export over a period of time). Dividend balancing is spread over 7 years from the commencement of production. Balancing is not required beyond this period.

Foreign Technology Agreements

- Automatic permission for technology purchases up to a lump sum payment of Rs 10 million, 5 per cent royalty on domestic sales and 8 per cent for exports, subject to total payments of 8 per cent of sales over a 10 year period from the date of agreement or 7 years from commencement of production. The royalty rates are net of taxes.

Engaging Foreign Technicians

- No permission is now needed for hiring of foreign technicians or foreign testing of indigenously developed technologies. Payment may be made from blanket permits for free foreign exchange according to RBI guidelines.

Exim Policy

- Imports of Motor Vehicles falls in the restricted category i.e., vehicles can be imported against a specific license or in accordance with a public notice by the Director General of Foreign Trade (DGFT).

- Capital goods, components, parts and consumables for the manufacture of vehicles can be freely imported.

Fiscal & Monetary Policies

- The Rupee has been made convertible on current account. This simplifies imports and exports.
- Excise duties for motor vehicles range from 10 per cent to 40 per cent
- Customs duties on motor vehicles range from 50 per cent to 110 per cent.
- Customs duties on components and parts range from 37.5 per cent to 87.5 per cent

Economic reforms have had a positive effect on both demand and supply of automobiles. The impact of the SAP is outlined in Table 2.2, below.

Many foreign companies have invested in this sector, including most major companies world-wide. There has been a phenomenal growth rate in the passenger car and LCV segment. Sales of both the segments grew at the rate of over 20 per cent annually. Overall, the automotive boom that started in the mid 80s got a further boost.

The table below gives the compound average rate of growth (CARG) for different types of vehicles, at the national level. The figures are for three periods – 1977-83, 1984-91 and 1992-97. The demarcation is essentially pre-partial liberalisation, partial liberalisation and full liberalisation.

As can be seen from the table, the growth rates in the post-SAP period, i.e., 1992-97, outstripped the growth rates in all the categories. This marked increase in the post liberalisation period reflects an overall improvement in the condition of the economy, which in turn fuelled the increase in the demand. The most significant growth rate occurred in the car and jeep segments of the market. These along with the two wheeler segment represent personalised modes of transport. Growth in these categories increases the number of vehicles on the road, leading both to traffic congestion and increases in the pollution load.

TABLE 2.2

Effect of the SAP on the Indian automobile sector

Policy	Supply side impact
Removal of Entry Barriers	• Increase in number of players. Entry of world class auto-giants • Elasticity in supply of vehicles. Second largest producer of two-wheelers, fifth largest manufacturer of commercial vehicles now manufacturing close to half a million passenger cars each year. • Intensification of competition and attainment of greater economies of scale with volume growth. Downward pressure on prices leading to further augmentation of demand.
Liberal FDI	• Growth of component industry. • Faster diffusion of technology leading to new models, new engines and environmentally sound vehicles • Long-run gain in productivity due to sophisticated technology. • Removal of restriction on original equipment manufacturers' (OEM) capacity (via FDI in car-manufacturing joint ventures) will bring supply up to current demand. • Export competitiveness in terms of costs and quality. Growth in exports of vehicles and components.
Trade liberalisation	• Growth in imports of vehicles components (also vehicles in CKD/SKD conditions during the initial years).
Policy	**Demand side impact**
	Overall growth in the economy in the wake of liberalisation.
Fiscal and monetary policies	• Effect of faster rising income on vehicle sales. • Shift in consumer choice. • Gradual switch from two-wheelers to four wheelers. • Faster replacement of demand. • Shift from seller's market to buyer's market.

TABLE 2.3

Compound average rate of growth of vehicle sales (national figures in per cent)

Vehicle Type	1972-83	1984-91	1992-97
Cars	1.48	13.3	21.23
Jeeps	2.73	8.39	16.39
LCVs	13.89	8.14	24.0
HCVs	6.68	4.59	14.14
Two Wheelers	9.51	14.67	16.82
Three Wheelers	11.41	11.87	13.60
All Vehicles	**9.88**	**11.97**	**17.68**

SOURCE: Sales data is from the Various Issues of ACMA.
NOTE: CARGs have been calculated using semi-log model.

However, compared to other segments, the market for cars is still very small because of the high level of taxation leading to high prices of cars. Cars and jeeps have relatively less indigenous components than other segments. Under the current reform policy, imports of consumer goods are not fully liberalised. Automobiles fall under this category where the customs duty on imports of motor vehicles and their parts are restricted or prohibitive. Hence, constraints in the supply side persist. With the world market for automobile having stabilised over the last few years, after growing steadily for more than three decades, the liberalisation measures adopted by the Indian Government gave attracted European and Japanese/Korean manufacturers to explore the large Indian market. As a result of their entry into the Indian car market, an over capacity was created. Except Maruti, none of the new players are manufacturing more than 25,000 cars per annum. Maruti dominates this segment, accounting for more than 80 per cent of the market share for cars during 1997-98. (see Table A3.1 in Annex 3).

The two wheeler segment was delicensed in the mid-1980s, when a large number of new players came into the industry and entry barriers for both capital and technology were lowered. The relatively low tax structure encouraged demand and it grew from under 4 lakhs in 1980 to over 1.8 million by 1990 – a growth of over 4 times (AIAM Dataman, 1997). The sector has fiscal regulations such as excise taxes (low at 15 per cent for sub 75 cc engines and 25 per cent for engine size greater than 75cc), sales taxes, etc. The last decade has seen a very rapid growth in the ownership of two wheelers, mainly because of an increasingly deteriorating and unreliable public transport system. In fact, in most towns and developing cities, public transport system is almost non-existent. Demand for two wheelers is around over 3 million vehicles a year, as compared to 0.4 million passenger cars.

The Indian two wheeler market was mainly a scooter market until the mid 80s, but currently mopeds and motorcycles account for around two-thirds of the total two wheelers. The majority of growth in this sector is from the rural areas. Local players (e.g., Bajaj Auto) dominate the overall market of two as well as the three wheelers, whereas Japanese joint venture manufacturers have a majority share in the motorcycle market. The market share of the major companies for scooters, mopeds and motor cycles are given in Table A3.2 in Annex 3. The market share of the three wheeler segment follows in Table A3.3 in Annex 3, and here Bajaj Auto Limited is the overwhelming leader.

At present, in the commercial vehicle segment there is very little government control, unlike in the two wheelers segment. Only fiscal controls, which are being exercised by the Government as a policy instrument, are present in this segment. Telco dominates the entire market for LCVs and HCVs. The market share of this category is in Table A3.4 in Annex 3.

The inflow of foreign direct investment to the transport industry as a whole during 1991-98 was around Rs 106,030 million accounting for 6.25 per cent of the share of total FDI in India. Out of this, the passenger car segment accounts for the maximum share. A list of recent foreign collaboration in the Indian automobile sector, along with their equity participation and installed capacity is given in Annex 4.

There has been a substantial increase in the growth rates of exports as well as imports of automotive vehicles, and of components, during the post liberalisation phase. In the passenger car segment almost all new vehicle manufacturers initially imported cars in Completely Knocked Down (CKD) and Semi Knocked Down (SKD) conditions, but have increased the indigenisation of components slowly. By Government orders the indigenisation level has to reach 85 per cent by the year 2000. So, initially there have been phenomenal rates of growth because of the imports in the form of CKD/SKD kits.

Exports as a percentage of total sales of vehicles increased in quantitative terms for almost every segment (except medium and heavy commercial vehicles) over the last few years. One of the reasons for this is that all imports generally have an export obligation, and the automobile manufacturers, especially those with joint ventures have to adhere to these requirements. Moreover, free trade under WTO can open export opportunities for Indian products especially in the two wheeler segment. However, in order to fully exploit this export potential, Indian players need to improve their product design and quality standards to international levels. They must further cut down costs and improve competitiveness. The vehicles should also adhere to the emission standards prevalent in export markets.

TABLE 2.4

Growth rates of exports & imports of vehicles & its components (per cent)

Period	Exports		Imports	
	Vehicles	Components	Vehicles	Components
1981-82 to 1990-91	7.3	15.6	- 1.3	14.0
1992-93 to 1996-97	33.4	19.6	50.2	36.6

Figures for Compound Average Rate of Growth have been computed using a semi-log function
Source: ACMA Various issues for the database.

TABLE 2.5

Exports as a percentage of total sales of vehicles

Category	1990-91	1997-98
Cars	2.1	7.1
Jeeps / Multi Utility Vehicles	7.4	2.4
LCVs	2.7	12.8
MCVs & HCVs	5.0	4.9
Scooters	0.4	2.4
Motor Cycles	0.4	4.0
Mopeds	3.4	7.7
3-Wheelers	6.5	8.0

SOURCE: ACMA, various issues.

As can be seen from the table, in almost all categories, except Jeeps, exports as a percentage of total sales has gone up and in some categories quite dramatically. Vehicles manufactured in absolute terms have also risen. This is a positive sign for the Indian automobile sector. It also suggests that Indian vehicles are reaching global standards, both in terms of quality, and emission standards. Moreover, this technological effect in turn enhances the scale effect of the sector, and translates into higher sales.

India's development programmes involving rapid rates of growth of industry and agriculture have created enormous pressure on its environmental resources. In the design of economic policy in India, issues related to trade and environment have not been sufficiently addressed. There is a widespread belief in India that trade liberalisation measures which are an important component of the reform process, can lead to further environmental degradation. As long as environmental damage remains an externality (not internalised) it can be expected to continue.

3. THE NATIONAL CAPITAL TERRITORY OF DELHI: A CASE STUDY

A general perspective on the automobile sector in India was presented in the previous chapter. This chapter focuses on the environmental impacts of the SAP introduced in India in 1991 with reference to the automobile sector through a case study. It is our contention that the SAP contributed to the rapid growth of the automobile sector by bringing in irrevocable changes. These changes had opposing effects on vehicular emissions. On one hand, an increase in vehicle population increased emissions (the scale effect discussed earlier), but on the other hand new technologies and replacement of old vehicles drastically reduced emissions per vehicle in all categories (technology effect). Fuel quality is also an important factor in vehicular emissions and this has also started improving. Another important factor is traffic management since congestion leads to reduced vehicle speed, extra fuel consumption and increased emissions. Congestion has increased significantly in most Indian cities.

3.1 Vehicular emissions and air quality in Delhi

To examine the effect of the SAP on vehicular emissions we have chosen the National Capital Territory of Delhi as a case study. We had several reasons for this, one being that the impact of the SAP has not filtered down to rural areas. Also, a sizeable proportion of vehicle sales take place in Delhi – it has more registered motor vehicles than India's other three large metropolitan cities (Calcutta, Mumbai and Chennai) combined. Our main reason, however, is that for most air pollutants the location of emissions is important since pollution is a spatial phenomenon[5]. Therefore, the analysis of vehicular emissions has to be with reference to a specific spatial setting. In other words, since the marginal impact on air quality of vehicle emissions varies spatially, it is necessary to specify the spatial context of these impacts, that is, it is necessary to demarcate a geographic area for the study – in our case it is the NCT of Delhi.

Delhi is the capital of India, situated on the bank of the river Yamuna in North India[6]. It has an area of 1,483 square kilometres and a population of around 9.42 million people with a density of 6,352 persons per square kilometre according to the 1991 census. It is situated between the latitudes of 28°24'17" and 28°53'00" N and the longitudes of 76°50'24" and 77o20'37" E. It is 216 metres above sea level.

Since 1912, when it became the capital of India, Delhi has emerged as a multi-dimensional and multi-functional urban centre. Its growth has essentially been haphazard and uncontrolled, leading to serious infrastructure and environmental problems. The city's population grew by about 53 per cent between 1971 to 1981 and by another 52 per cent between 1981 to 1991 to reach 9.42 million. The compound annual growth rate has hovered around 4.3 per cent since 1951 which is twice the country's average population growth rate. Delhi's share of India's population has increased from less than one-half per cent in 1951 to 1.11 per cent in 1991. At the current rate of growth the projected population figure for Delhi by the year 2001 is 14.19 million (Table 3.1).

[5] This applies only to *non-uniformly mixed* pollutants such as particulates, SOx, CO, etc., which are found in vehicular emissions. For *uniformly mixed* pollutants such as carbon dioxide or CFCs which are implicated in climate change and ozone depletion, respectively, the location of emissions does not matter – a tonne of CO2 emitted anywhere on the planet would have the same impact on global temperature.

[6] While Delhi has an elected assembly and a chief minister it is not a state but rather a union territory administered by the central government. Key functions such as law and order are vested in the representative of the central government, the Lieutenant Governor.

TABLE 3.1

Delhi population

Census Year	Population (millions)	Compound annual growth rate for the preceding decade	Percentage of all India
1951	1.74	–	0.48
1961	2.66	4.31	0.61
1971	4.07	4.34	0.74
1981	6.22	4.34	0.91
1991	9.42	4.24	1.11
2001 (Projected)	14.19	4.23	1.47

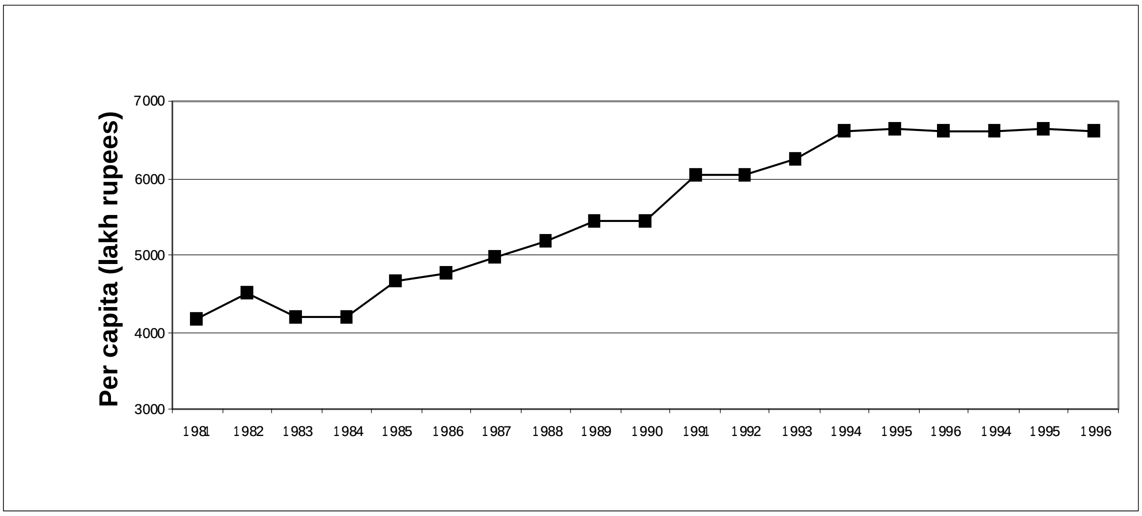
SOURCE: District Census hand books, Directorate of Census operations, Delhi

Even a lower annual rate of 2.5 per cent for the 1991-2001 decade would result in an overall population of over 12 million. Migration influx has worsened the situation.

Delhi is also, however, a relatively affluent city. Its per capita income at about double the national average, and is the highest among Indian states and union territories. This partly explains the large and rapidly growing number of motor vehicles in Delhi. The number of registered motor vehicles rose from 0.2 million in 1971 to 1.8 million in 1991 – a nine fold increase (Table 3.2). It is interesting to note over the same period, population increased by slightly more than two times. In particular, since partial liberalisation of the automobile sector in 1983-84, there has been tremendous growth in the demand and sales of motor vehicles. Over the last decade, i.e., between March 1988 and March 1998, the number of registered motor vehicles soared from 1,284,196 to 3,033,045 – an increase of 1,748,849 vehicles (136 per cent).

FIGURE 3.1

Per capita net state domestic product, Delhi (1980-81 prices)



The growth in motor vehicle population, however, has not been even across all categories – personalised modes of transport have dominated in this growth. This category, consisting of two wheelers and cars/jeeps accounts for more than 90 per cent of Dehli's motor vehicles (Table 3.5) and has been increasing throughout the 1990s. The huge growth in the two wheeler category has been due to relaxation of Government industrial policies and import levies since the early eighties. On the other hand, the share of buses – the primary mode of public transport in Delhi – is an insig-

FIGURE 3.2

Net state domestic product, Delhi (1980-81 prices)

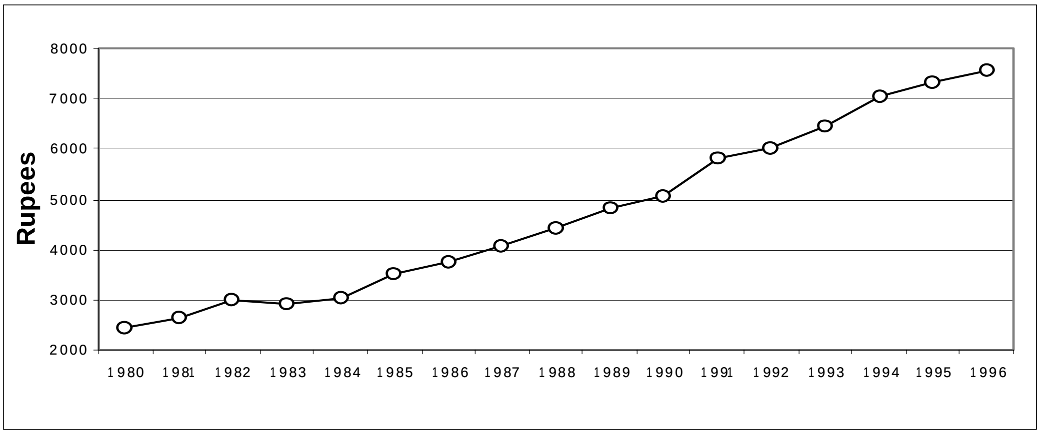


TABLE 3.2

Registered motor vehicles, Delhi

Year	Total no. of vehicles	Compound annual growth rate since the previous period (per cent)
1970-71	2,04,078	–
1980-81	5,57,000	10.56
1990-91	18,04,490	12.47
1994-95	24,32,320	10.46
1997-98	30,33,045	11.67

SOURCE: AIAM

nificant share of one per cent of the total vehicles in Delhi. Yet, buses currently meet about 53 per cent of total passenger travel demand. Even the percentage share of the intermediate mode of public transport (three wheelers and taxis), accounted for 4.6 per cent of all motor vehicles in 1984-85 but this figure had decreased to 3.1 per cent by 1997-98. Sales of intermediate public transport vehicles today account for 2 per cent of total motor vehicles sold. So, the shift towards personalised mode of transport has been marked. This has made traffic management more difficult since availability of road space has not increased commensurately. This has led to congestion, in turn reducing vehicle speed and causing extra fuel consumption and pollution.

TABLE 3.3

Registered motor vehicles, Delhi ('000)

Year	Car/Jeep	2-Wheelers	3-Wheelers	Taxis	Buses	Goods Vehicles
1986	179.7	665.1	31.9	8.7	14.0	61.7
1989	292.9	1008.9	54.7	9.2	16.6	83.2
1993	477.8	1403.1	70.5	11.4	23.2	111.3
1995	575.8	1617.7	75.0	12.5	26.2	125.0
1996	633.8	1741.3	79.0	13.8	27.9	133.9
1997	705.9	1876.1	80.3	15.0	29.6	140.9
1998	765.5	1991.7	80.7	16.7	32.3	146.7

TABLE 3.4

Increase in motor vehicles registered, Delhi ('000)

Year	Car/Jeep	2-Wheelers	3-Wheelers	Taxis	Buses	Goods Vehicles
1985 to 1986	21.8	86.0	18.5	0.2	0.5	9.3
1988 to 1989	43.8	119.5	7.4	0.3	1.0	9.4
1992 to 1993	37.6	85.9	3.3	0.7	3.0	3.6
1994 to 1995	53.5	125.5	2.9	0.7	1.0	8.7
1995 to 1996	58.0	123.5	4.0	1.2	2.0	8.8
1996 to 1997	72.1	134.8	1.2	1.3	1.7	7.0
1997 to 1998	59.5	115.7	0.5	1.6	2.8	5.7

TABLE 3.5

Composition of vehicles (as percentage of total vehicles), Delhi

Categories	1984-85	1990-91	1994-95	1997-98
Two Wheelers	74.0	67.7	66.5	65.7
Cars/Jeeps	13.8	21.6	23.7	25.3
Three Wheelers	3.6	3.5	3.1	2.7
Taxis	1.0	0.5	0.5	0.4
Buses	1.6	1.1	1.1	1.0
Commercial Vehicles	6.0	5.6	5.1	4.9
Total	**100**	**100**	**100**	**100**

SOURCE: AIAM

TABLE 3.6

Registered petrol and diesel vehicles, Delhi

Year	Petrol	Diesel
31.03.1971	163,776	16,658
31.03.1981	491,368	44,643
31.03.1991	1,692,281	120,686
31.03.1994	2,098,413	149,590
31.12.1996	2,590,830	202,776

SOURCE: Data for 31.03.1971 to 31.03.1994 from H. S. Bhatia, Vehicular Pollution Load Assessment and Alternate Strategies, paper presentation at the National Conference on Delhi Transportation System in the 21st Century. Data for 31.12.1996 from Delhi Statistical Handbook 1997, Directorate of Economics and Statistics, Government of Delhi.

It is not surprising, therefore, that Delhi faces an acute air pollution problem associated with the use of energy in the transport sector. It is among the 12 cities mentioned in the 1992 WHO/ UNEP report on "Urban Air Pollution in Megacities of the World" as having a serious particulate pollution. Furthermore, it is estimated that approximately 67 per cent of air pollution was caused by motor vehicles in 1996. The Central Pollution Control Board (CPCB) estimates that roughly

TABLE 3.7

Daily air pollution load, Delhi (metric tonnes)

1991	1450
1992	1700
1993	2010
1994	2400
1995	2890
1996	3000

SOURCE: MOEF, 1996

TABLE 3.8

Sources of air pollution, Delhi (per cent)

Year	Industrial & Power	Vehicular	Domestic
1970-71	56	23	21
1980-81	40	42	18
1990-91	29	64 (928 mt)	7
1996	25	67 (2010 mt)	8
2000-01 (projected)	20	72	8

mt = metric tonnes
SOURCE: MOEF, 1996

TABLE 3.9

Trends in vehicular emissions, Delhi

Year	Daily emissions (metric tonnes)	Proportion of total load (percent)
1991	928	64
1996	2010	67

SOURCE: MOEF, 1996

TABLE 3.10

Air pollution from road transport, selected cities

Region	Year	Total Pollutants ('000 tonnes)	Per cent attributable to road transport
Mexico City	1987	5027	80
Sao Paulo	1987	2110	86
Manila	1987	500	71
Kuala Lumpur	1987	435	79
Osaka	1982	141	59
Phoenix	1986	1240	28
Delhi	1996	3000	67

SOURCE: Tietenberg ,1996 and MOEF, 1996

2,000 metric tonnes of air pollutants were emitted everyday in by motor vehicles in Delhi in 1996[7]. This is an increase of over 100 per cent from the 1991 levels. The pollution load from motor vehicles shows an increasing trend both in terms of absolute amounts as well as a proportion of total air pollution. The pollutants which are conventionally measured to estimate pollution, are Carbon Monoxide (CO), hydrocarbons (HC), Oxides of Nitrogen (NO_X), Sulphur Dioxide (SO_2), Lead (Pb) and Particulates (differentiated between total and respirable particulate matter). Conventionally, the first four pollutants are added to arrive at the total pollution load.

While the majority of the increase in motor vehicles is accounted by petrol driven two-wheelers and cars, there has also been a more than proportionate increase in the consumption of diesel fuel as well (Tables 3.11 and 3.12).

TABLE 3.11

Fuel consumption, Delhi ('000 tonnes)

Year	Petrol	HS Diesel
1980-81	133	377
1989-90	330	718
1992-93	363	810
1994-95	408	929
1995-96	436	1153
1996-97 *	476	1242
1997-98**	585	1199

SOURCE: Delhi Statistical Handbook, various years
* Ministry of Petroleum and Natural Gas
** Oil Co-ordination Committee

TABLE 3.12

Diesel to petrol consumption ratio

India	> 6
Delhi	2
Other Countries	< 1

CPCB has been monitoring air quality in major cities since 1984 under the National Ambient Air Quality Monitoring Network[8]. An ambient concentration level is a measure of the average density of pollutants usually specified in terms of pollutant mass per unit volume of air. They are expressed in units of micrograms per cubic metre (mg/m^3) or in terms of relative volume of pollutants per unit volume of air (parts per million – ppm). CPCB has also specified National Ambient Air Quality Standards (NAAQS) for CO, NO_X, SO^2, lead and particulates. These standards are differentiated by three types of location – industrial, residential, and sensitive areas (Table 3.13).

The NAAQS, however, are for overall air quality and are to be met after aggregating emissions from transport, power, industry and domestic sources. As stated earlier, vehicular emissions are by far the biggest contributor to air pollution in Delhi. Moreover, the share of vehicular pollution to total pollution has grown tremendously since the early 1970s (from 23 per cent in 1970-71 to 67 per cent in 1996 – Table 3.8).

[7] Estimates of the pollution load varies across studies. For example, the study by Ganesan (1998) puts the vehicular pollution load at 1,046 MT.

[8] There are six monitoring stations in Delhi under this programme located at Ashok Vihar, Shahzada Bagh, Siri Fort, Janakpuri, Nizamuddin, and Shahdara, representing a mix of residential and industrial areas.

TABLE 3.13

National ambient air quality standards (mg/m^3)

Pollutant	Averaging time	Type of area	WHO Recommended Limits	Pollutant	
		Sensitive	Residential	Industrial	Averaging time
CO	1 hour	2000	4000	10000	30000
	8 hours	1000	2000	5000	10000
NO_x	24 hours*	30	80	120	150
	Annual **	15	60	80	-
SO_2	24 hours	30	80	120	100-150
	Annual	15	60	80	40-60
Lead	24 hours	0.75	1.00	1.5	-
	Annual	0.50	0.75	1.0	-
SPM	24 hours	100	200	500	150-230
	Annual	70	140	360	60-90
RPM	24 hours	150	100	75	
	Annual	120	60	50	

SPM Suspended Particulate Matter; RPM – Respirable Particulate Matter (less than 10 microns in diameter), also known as PM10.

* 24 hourly/8 hourly values should be met 98 per cent of the time in a year. 2 per cent of the time they may be exceeded but not on two consecutive days. Applied to all pollutants.

**Arithmetic mean of a minimum of 104 measurements in a year, taken twice a week 24 hourly at uniform intervals. Applies to all pollutants

Table 3.14 presents a broad overview of the state of ambient air quality for Indian cities. The data suggests that as far as air quality is concerned, the major problems are carbon monoxide and particulates. While hydrocarbons are not monitored, they may be a problem area as well. Other pollutants are still within limits: in fact the concentration of lead and sulphur dioxide have gone down over the last few years. Table 3.15 presents more detailed data on air quality for Delhi which indicates high values of suspended particulate matter (SPM) at all monitoring stations.

TABLE 3.14

Ambient air quality status, India

Pollutant	Period	WHO ($\mu g/m^3$)	Indian ($\mu g/m^3$)	Status
SPM	Annual average	60-90	360	All sites exceed WHO standards; many
	24 hour average	150-230	500	Indian standards as well
RPM	Annual average	-	120	WHO standards exceeded at many sites
	24 hour average	70	150	-do-
NO_x	Annual average	-	80	All within standards
	24 hour average	150	120	All within standards
SO_2	Annual average	50	80	All within standards
	24 hour average	125	120	All within standards
CO	8 hour average	10000	5000	Exceeded at many sites
Lead	Annual average		1.0	Mostly within standards

TABLE 3.15

Ambient air quality data for Delhi (mg/m^3)

Year	Sulphur Dioxide		Nitrogen Dioxide		Suspended Particulate Matter	
	Annual Mean	Per cent Variation (base 1989)	Annual Mean	Per cent Variation (base 1989)	Annual Mean	Per cent Variation (base 1989)
1989	8.7		18.5		373	
1990	10.2	(+) 17.0	22.5	(+) 22	338	(-) 10.0
1991	13.3	(+) 53.0	27.2	(+) 47	317	(-) 15.0
1992	18.4	(+) 111	30.4	(+) 64	377	(+) 1.0
1993	18.5	(+) 113	33.2	(+) 79	372	(-) 0.3
1994	19.5	(+) 124	33.0	(+) 78	377	(+) 1.0
1995	19.0	(+) 118	34.1	(+) 84	407	(+) 9.0
1996	19.0	(+) 109	33.7	(+) 82	387	(+) 4.0
1989 (Jan-Aug)	10.1		20.2		377	
1997 (Jan-Aug)	16.2	(+) 60	33.0	(+) 63	370	(-) 2.0

SOURCE: White Paper on Pollution in Delhi with an Action Plan, GOI, MOEF

TABLE 3.16

Vehicular emissions, 1994 (tonnes/day)

City	Particulates	SO_2	NOx	HC	CO	Total
Delhi	10.30	8.96	126.46	249.57	651.01	1046.30
Mumbai	5.59	4.03	70.82	108.21	469.9	659.57
Calcutta	3.25	3.65	54.69	43.88	188.24	293.71

SOURCE: CPCB (1995)

TABLE 3.17

Annual vehicular emissions – TERI estimates ('000 tonnes).

Year	Categories of Pollutants						
	CO	HC	NOX	SO2	Total	Pb	Particulates
1991	138.67	54.76	33.22	3.85	230.5	78.48	7.05
1996	177.74	71.45	43.93	5.18	298.3	101.93	9.44
2001(projected)	201.72	83.15	53.58	7.05	345.5	110.99	11.58

SOURCE: Environmental Impacts of Energy Use in Large Indian Metropolises: Delhi, Calcutta, Bangalore and Mumbai, *TERI, Draft Final Report*, 1997.

As mentioned earlier, estimates of pollution load vary widely across studies. Tables 3.16, 3.17 and 3.18 provide estimates of vehicular emissions for Delhi by CPCB, TERI and this study, respectively[9]. The CPCB data suggests that among all the metropolitan cities in India, Delhi has the highest vehicular emissions which is consistent with its large motor vehicle population. TERI estimates are generally less than half of our estimates. Our estimates also show the contribution to

[9] The emission figures reported by CPCB and us are in tonnes/day whereas those by TERI are in thousand tonnes/year. Table 3.22 converts our estimates to annual values (in thousand tonnes) by multiplying the figures by 365 and dividing by 1000.

TABLE 3.18

Vehicular emissions, Delhi (tonnes per day)

								Per cent of total emissions					
Year	**CO**	**LEAD**	**HC**	**SO_2**	**NO_x**	**TSP**	**Total**	**2WH**	**3WH**	**CAR**	**TAXI**	**CV**	**BUS**
1988	566	0.43	174	26	367	50	1184	13.7	9.3	18.2	2	46.7	9.8
1991	803	0.62	244	35	498	67	1648	13.6	8.8	20.9	1.7	46.3	8.5
1994	956	0.78	285	41	584	78	1945	13.6	8.6	21.9	1.6	44.8	9.3
1997	1115	0.23	334	26	702	93	2270	14.8	8.1	21.7	1.54	45.2	9.3
1998	1144	0.24	345	14	730	98	2332	14.3	7.9	21.8	1.4	44.9	9.5

SOURCE: Our calculations. 2WH = two wheelers, 3WH = three wheelers, CV = commercial vehicles

total vehicular emissions by different categories of vehicles. In our calculations, annual emission loads from vehicles are computed by multiplying the number of motor vehicles in each category by the vehicle utilisation factor and the emission factors:

$$\text{Annual emissions (p)} = \Sigma i \text{ Ni Ui Eip}$$

where, N = number of vehicles; U = vehicle utilisation (km/day); E = emission factor (gm/km); i = vehicle type (e.g., cars, two wheelers, three wheelers, commercial vehicles, etc.); p = pollutant type (e.g., CO, HC, NOx, etc.) in grams. We divide the emissions, p, by 1,000,000 to convert grams into tonnes per day. The number of vehicles (N) is based on registration data. For the vehicle utilisation factor, we use a constant set of figures, calculated specifically for Delhi (Table 3.19). Emission factors for different vehicles are given in Table 3.20. In the table, emission factors for vehicles before 1991 are based on emission data for on-road vehicles provided by the Indian Institute of Petroleum (IIP). Emission factors for vehicles after 1991 are based on Automotive Research Association of India (ARAI) and Indian Oil Corporation (R&D division) data, whereas emission factors for vehicles after 1996 and 1999/2000 are based on the 1996 Conformity of Production Standard and the 1999/2000 Conformity of Production Standard. Emission factors for lead are based on the fact that 70 per cent of the lead in fuel is emitted through exhaust.

TABLE 3.19

Vehicle utilisation factors

Types of Vehicle	**Effective distance travelled daily per vehicle (km.)**
Cars and Jeeps	27
Two Wheelers	13.5
Three Wheelers	120
Commercial Vehicles	186

SOURCE: Das Aditi et al. The automotive air pollution perspective and potential abatement measures, The Indian Journal of Transport Management, 1997.

We should emphasise the approximate nature of various estimates of vehicle emissions presented here (CPCB, TERI, and this study). Imprecision results from using emission factors and vehicle utilisation rates that are approximate, for instance, emissions (gm/km) would vary considerably by vehicle speed, fuel quality, ambient temperature and a host of other factors, which the estimates do not explicitly consider.

Having said this, the emission factors in Table 3.20 above point to an interesting fact: until1991, emission norms remained unchanged. This reflects the low priority that the problem of

TABLE 3.20

Emission factors by vehicle type (gm/km)

Type of Vehicle	Year	CO	HC	NO_X	SO_2	Particulates	Pb
Cars and Jeeps	Up to 1991	25	5.00	2.00	0.053	-	0.030
	1991-1994	19.8	2.73	2.00	0.053	-	0.030
	1994-1995	19.8	2.73	2.00	0.053	-	0.008
	1995-1999	6.45	1.14	1.14	0.053	-	0.003
	1999-2000	3.16	0.56	0.56	0.053	-	0.003
	2000-2005	2.2	0.25	0.25	0.053	-	0.003
Two	Up to 1991	8.30	5.18	0.1	0.023	-	0.008
	1991-1994	6.49	4.5	0.1	0.023	-	0.008
Wheelers	1994-1996	6.49	4.5	0.1	0.023	-	0.002
	1996-2000	5.00	4.32	0.1	0.023	-	0.002
	2000-2005	2.4	2.4	0.1	0.023	-	0.0002
Three	Up to 1991	12.0	7.0	0.26	0.029	-	0.019
	1991-1994	12.0	7.0	0.26	0.029	-	0.019
Wheelers	1994-1995	12.0	7.0	0.26	0.029	-	0.005
	1996-2000	8.1	6.48	0.26	0.029	-	0.005
	2000-2005	4.8	2.4	0.26	0.029	-	0.0004
Commercial Vehicles	Up to 1991	12.7	2.1	21.0	1.5	3	-
	1991-1996	12.7	2.1	21.0	1.5	3	-
	1996-2000	9.96	1.44	16.8	0.75	2.4	-
	2000-2005	5.35	0.66	9.34	0.37	2.4	-

SOURCE: IIP, ARAI

vehicular pollution had in India. Emission norms were first implemented in 1991 and correspondingly we see a decrease in the emission factors. With the introduction of low lead petrol from 1994, and unleaded petrol from 1995, emission factors for lead came down. Overall, emission intensity will decrease further since Euro I emission norms have come into effect in Delhi this year (a year ahead of schedule following Supreme Court orders) and Euro II emission norms are to be implemented from the year 2000. Our calculations take these norms into account. At present, however, the Euro norms are only being implemented in Delhi. It should also be noted that significant reduction in emission factors have taken place in the post-SAP period (1991 onward). A correlation between the two cannot be ruled out as with liberalisation newer and cleaner technologies have come into the Indian market.

With respect to the contribution of various pollutants by vehicle type (Table 3.21), while significant carbon monoxide is emitted by all vehicle categories, the highest emitters are scooters, motorcycles and three wheelers, all powered by two-stroke engines. Diesel vehicles and passenger cars, however, are also significant emitters. Vehicles with two-stroke engines contribute to more than half of unburned hydrocarbons. For oxides of nitrogen, diesel vehicles contribute an overwhelming proportion.

Fitting catalytic converters to cars have reduced emissions of CO and if they can be fitted into two wheelers as well, CO emissions can be curtailed further. Even for HC, the emission rates are higher for gasoline than diesel vehicles due to the lower combustion efficiency of gasoline engines. About 25 to 40 per cent of the fuel supplied to small two-stroke gasoline engines in two and three wheelers is wasted without being burned due to "short circuiting" of the fresh fuel-air mixture to the engine exhaust. This inherent weakness in the existing design of two-stroke engines is a large contributor to unburned HC mentioned above. In fact, two and three wheelers contribute over

TABLE 3.21

Emission load by vehicle type, all India, 1992-93 ('000 tonnes)

Category	CO	HC	NO_x	Total
Passenger cars, jeeps, etc.	441.5	60.6	41.1	543.2
Mopeds	188.2	134.6	1.6	324.4
Scooters/ M.Cycle/ 3-wheelers	608.4	426.2	5.7	1040.3
Diesel vehicles	496.7	172.8	799.0	1468.5
Total	1734.8	794.1	847.4	3376.3

SOURCE: Indian Institute of Petroleum (1994)

TABLE 3.22

Annual vehicular pollution (in '000 tonnes)

Year	CO	HC	NO_X	SO_2	Total load
1991	293.14	88.89	181.86	12.73	576. 62
1996	393.63	116.87	245.27	17.13	772.90

SOURCE: Our calculations.

70 per cent of HC emissions. On the contrary, the emission rate for NO_x is higher in diesel fuelled heavy vehicles because of lower combustion temperatures as compared to gasoline fuelled vehicles. This is why commercial vehicles contribute the bulk of NO_x emissions. Emission rates for SO_2 are also higher for diesel vehicles, with commercial vehicles contributing more than 50 per cent of total SO_2 emissions. Lead is emitted only by gasoline vehicles whereas the majority of suspended particulates are emitted by diesel vehicles. Particulates are carcinogenic and the smaller their size, the more harmful they are.

3.2 SAP and sales of motor vehicles in Delhi

This study mainly uses sales data instead of registered vehicles. The primary reason for this is that sales can also be viewed as derived demand. Annual sales for different types of motor vehicles are shown in Table 3.23. Since the partial liberalisation of the automobile sector in 1983-84, there has been tremendous growth in sales of motor vehicles. As mentioned earlier, however, the growth has not been even across all categories of motor vehicles with personalised modes of transport (two wheelers and cars/jeeps) dominating sales growth. In fact, this category now accounts for more than 90 per cent of all motor vehicles in Delhi (Table 3.5).

Consumers have been the real beneficiaries of liberalisation and globalisation as the competitiveness of Indian industry has improved, particularly in the automobile sector. With the entry of new players, and accompanying FDI and increased competition, there has been tremendous improvement in the quality of motor vehicles. Their prices in real terms have also fallen. In effect, the automobile industry has evolved from a sellers' market into a buyers' market with greater consumer choice in terms of different models and superior quality.

Both demand and supply factors have contributed to a shift towards personalised modes of transport which has been the dominating factor in the growth of the automobile industry. With respect to demand, an increase in the ability to pay for vehicles for an average resident of Delhi cannot be denied: during the period 1984-85 to 1996-97 per capita real income in Delhi increased from Rs 4,201 to Rs 6,612, that is, by 57 percent. The change in the pattern of vehicle ownership

Table 3.23

Annual sales of vehicles

Year	Cars and Jeeps	Two Wheelers	Three Wheelers	Commercial Vehicles	Total
1977	4476	21672	850	2219	29217
1978	4112	16056	1068	2565	23801
1979	3844	97659	1109	2578	105190
1980	4419	24232	1255	2998	32904
1981	5682	29248	1447	3627	40004
1982	6049	52874	2166	5383	66472
1983	5563	60756	4099	4867	75285
1984	10333	65161	3315	4524	83333
1985	25706	85987	5268	4393	121354
1986	28281	98368	5656	5170	137475
1987	42470	91237	6196	6273	146176
1988	41008	98153	6434	8177	153772
1989	45736	87510	6805	7297	147348
1990	46735	110474	6859	8802	172870
1991	38945	91975	6128	8838	145886
1992	34807	80485	5283	5033	125608
1993	41323	76440	1980	5372	125115
1994	43493	106826	4209	6131	160659
1995	58569	130390	4848	12672	206479
1996	66290	145197	2773	13452	227712
1997	68685	140289	1678	13306	223957

SOURCE: *Facts and Figures*, ACMA.

has been marked during the 1990s with a slow but steady shift from two wheelers to cars. Also, shifts in the nature of employment (growth of private sector/multinational companies with attractive salary packages) and rapid urbanisation has created a new class of consumers. Customer expectations are changing with improved living standards and awareness. On the supply side, many car manufacturers are encouraging the graduation from two wheelers to cars and attractive loans are being offered. Such schemes are also available for second hand cars. This, however, leads to longer use of older cars more polluting cars and thus aggravates vehicle emissions problems. Vehicle kilometres travelled (VKT) in Delhi are high. In addition to income-induced travel demand, this is also due to the absence of effective public transport as well as the large size and extended nature of the city.

To estimate incremental sales for different types of motor vehicles as a result of the SAP, we use vehicle sales for two periods – post-SAP (1992-97) and pre-SAP (1977-91) and apply a linear time trend[10] to each vehicle type to project sales from 1998-2005. In other words, the first projection assumes vehicle sales from 1998-2005 follow the 1992-97 trend, whereas the second assumes the 1977-91 pre-liberalisation trend will continue. The difference between the two projections enables us to get an approximate estimate of incremental sales due to the SAP.

As can be seen from the graphs (Figure 3.3) except for the three wheeler category, projections with post-SAP data lie substantially above the projections with pre-SAP data and are much steeper. Three wheelers, which are privately owned vehicles used exclusively as a public mode of transport, are interdependent of the other three vehicle categories. Thus, it is possible that an increase

[10] That is, for each vehicle type sales in year t, $S_t = a + bt$.

TABLE 3.24

Trends in income, Delhi (1980-81 prices)

Year	Net SDP (Rupees. Crores)	Per Capita NSDP (Rupees)
1980-81	2454.68	4030
1981-82	2654.63	4163
1982-83	2990.01	4495
1983-84	2918.78	4206
1984-85	3040.41	4201
1985-86	3520.45	4665
1986-87	3748.29	4765
1987-88	4078.90	4975
1988-89	4428.64	5185
1989-90	4838.29	5438
1990-91	5046.41	5447
1991-92	5813.66	6046
1992-93	6016.94	6042
1993-94	6432.80	6238
1994-95	7058.54	6609
1995-96	7332.89	6629
1996-97	7573.64	6612

SOURCE: Directorate of Economics and Statistics, Govt. of NCT of Delhi.

FIGURE 3.3

Forecast sales by vehicle type in Delhi

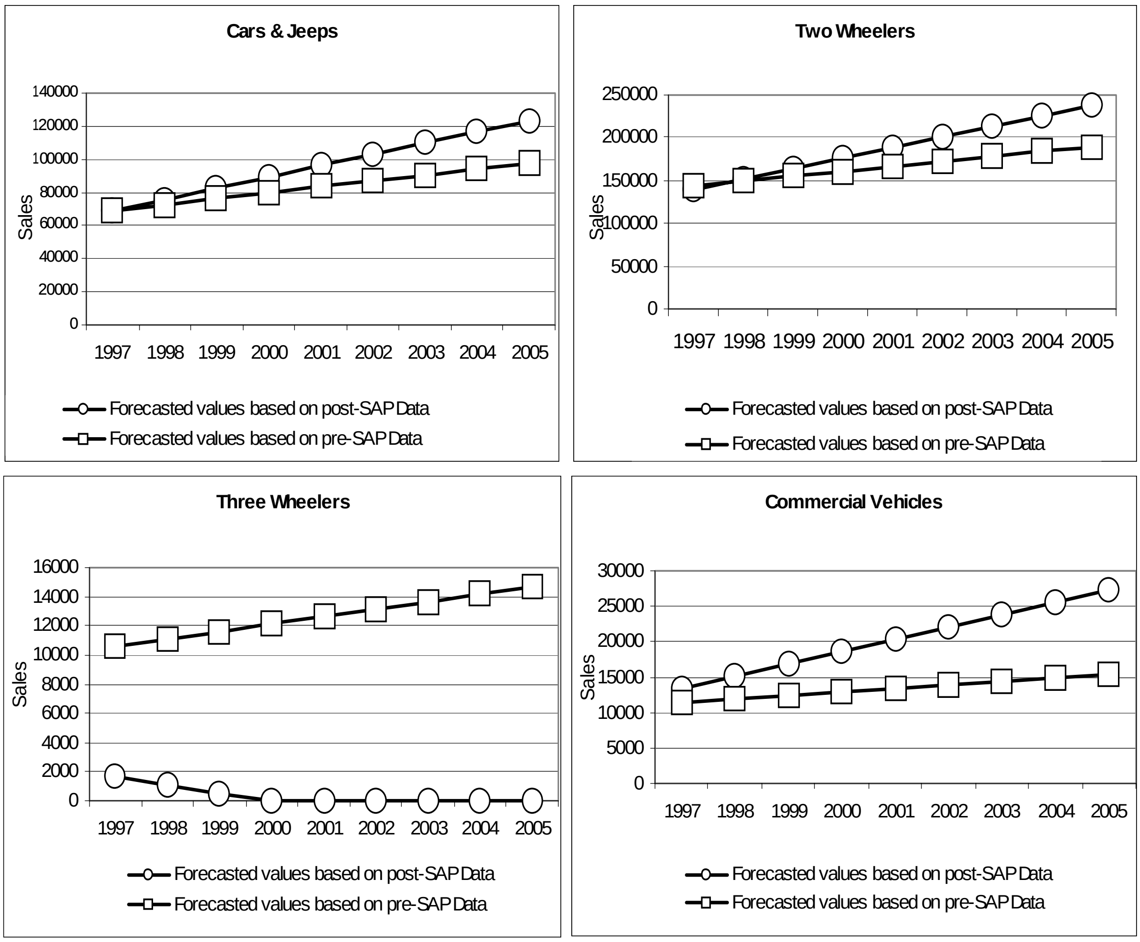


TABLE 3.25

Projected vehicle sales, Delhi (linear time trend)

Year	Cars and Jeeps	Two Wheelers	Three Wheelers	Commercial Vehicles	Total Sales	Total Vehicles
2001	96105	188994	0	20268	305368	3052876
2002	102961	201170	0	22009	326140	3274864
2003	109816	213347	0	23750	346913	3507236
2004	116671	225523	0	25491	367685	3772955
2005	123526	237699	0	27231	388457	4032449
2011	164657	310757	0	37676	513090	5996905

SOURCE: Our calculations.

in sales of cars and two wheelers act as a substitution for three wheelers. The projected zero sales (which reflects derived demand) could be a result of this post-SAP substitution. For other vehicle categories the difference between the two sets of projections is significant, indicating that liberalisation did strengthen the demand for motor vehicles in India.

Table 3.25 shows projected sales of vehicles in Delhi for 2001-2011 assuming the trend in the post-SAP (1992-97) period. Thus, the number of vehicles in Delhi in 2004 and 2011 will be 3.8 million and 6 million, respectively. According to the 'white paper' on pollution in Delhi prepared by the Ministry of Environment and Forests, Government of India, the corresponding figures are 4.6 million and 6 million. Thus, there is a substantial difference for the 2004 figure, but the figures for 2011 are the same.

As an alternative approach to simple time trend projections we also use an econometric model for projecting vehicle sales for Delhi. The reason is that a linear time trend ignores the impact of other variables on future vehicle sales. We estimate separate equations for each vehicle type (car/jeep, two wheelers, three wheelers and commercial vehicles) since the determinants of sales for each category (and their marginal impact on sales) may differ. After trying various explanatory variables for cars and two wheelers, we use density of population and per capita income, whereas for three wheelers and commercial vehicles, we use population and state domestic product (SDP) as explanatory variables. These variables are likely to have a positive effect on sales. The choice of these variables is based on their high statistical significance from of various estimated relationships (standard errors of the coefficients, adjusted R2, etc.).

Further, we apply the Box-Cox transformation to decide between a linear or log linear specification for each equation. Thus, for cars, three wheelers and commercial vehicles the log linear model gives a better fit, whereas for two wheelers we use a linear specification. Finally, instead of deciding a priori on the year for structural break, we use the Chow test and Cusum square test to check for the structural stability of the models. Here we test for two years that are relevant vis-à-vis the SAP, namely, 1984 and 1991. On the basis of these tests we find 1984 as the structural break for cars and 1991 for three wheelers and commercial vehicles. These are then incorporated in the respective equations through appropriate dummy variables. For two wheelers neither test shows any structural break thus no dummy variable is used. Finally, the explanatory variables in these equations (SDP, population, etc.) are extrapolated by a time trend to project vehicle sales for the period 1997-2011. The results for selected years are given in Table 3.26. Comparing Tables 3.25 and 3.26, we note that sales for all vehicle types (except three wheelers) are significantly lower in the latter table. Despite the rather simple specification of the sales equation in this econometric exercise, we believe it may be more appropriate to use this as a basis for projecting sales than the time trend method. n Part II of the study we use the econometric projection to estimate pollution

TABLE 3.26

Projected vehicle sales (econometric forecast)

Year	Cars	2 Wheelers	3 Wheelers	Commercial Vehicles
2001	77808	148480	8468	12495
2002	82125	153310	9290	13197
2003	86595	158130	10167	13920
2004	91217	162960	11103	14660
2005	95894	167780	12099	15421
2011	126880	196730	19471	20390

SOURCE: Our calculations

load. In the following section, however, we revert to the time trend projection since the objective there is to look at the counterfactual (no SAP) and compare it with the actual situation (post-SAP).

3.3 SAP and vehicular emissions in Delhi

One of the aims of this study is to examine the effect of the SAP on the automobile sector and in turn on vehicular emissions. In this section we compute incremental vehicle emissions due to the SAP by first computing the incremental sales due to the SAP (based on the time trend projection) and then multiplying these by emission factors and vehicle utilisation rates to arrive at emissions (Table 3.27). From the table, two things are evident. First, there is an increasing trend for all pollutant types from 2000 to 2005[11]. Since the average kilometres travelled remain the same and emission factors decline over time, the increase in emissions is due to higher sales of vehicles due to the SAP. Secondly, the figures for HC are negative. This is because projected sales of three wheelers are zero by the year 2000 with post-SAP data, while the corresponding figures with pre-SAP data are quite high. So the difference in sales is negative and this contributes to the overall negative emissions for HC (other pollutants are not affected to the extent of becoming negative). This also implies that three wheelers make a relatively large contribution to HC emissions.

We next look at incremental emissions excluding three wheelers (Table 3.28). This table provides a better picture of the possible effects of the SAP on vehicular emissions in Delhi. As expected emissions for all pollutants increase.

A crucial element in these calculations is the choice of emission factors. India, however, has not been able to develop reliable emission factors to date. Calculation of emission factors requires an extensive data base – there are a multitude of factors like type of fuel, engine design, vehicle speed, vehicle age, vehicle maintenance, etc., that need to be accounted for. The emission factors presently in use are those developed by IIP or ARAI. Both of them, however, use a very small sample size, and they are not designed statistically. Hence they are just broad indicators. For example, the CO emission factor for three wheelers according to ARAI is 13.9 grams per kilometre, but it can vary from 5.1 grams per kilometre to 39.4 grams per kilometre[12].

Next, total annual emissions are calculated for the period 2001 to 2005 using projected vehicle populations (Table 3.25), emission factors (Table 3. 20 – so Euro I and Euro II norms are taken into account) and vehicle utilisation factors (Table 3.19). For calculating the total vehicle population for any given year, an assumption regarding the attrition factor is made (Table 3.29)[13]. Thus,

[11] As stated above, the figures are a product of the number of vehicles times average kilometres traveled times the emission factors. The number of vehicles here pertains to the difference between sales in the pre- and post-SAP periods.

[12] For details see Agarwal et al. (eds.) State of India's Environment: The Citizens' Fifth Report, Centre for Science and Environment, New Delhi, the chapter on Atmosphere.

[13] For its calculations, Tata Energy Research Institute (TERI), has also used very similar attrition factors ("Environmental Impacts of Energy Use in Large Indian Metropolises: Delhi, Calcutta, Bangalore and Mumbai", TERI, Draft Final Report, 1997). The only difference is in the figure for commercial vehicles which TERI assumes as 10 years.

TABLE 3.27

Incremental annual vehicular emissions due to the SAP (in tonnes)

Year	CO	HC	NO_x	SO_2	Total Pollution Load
2000	12646	-7737	34913	1329	41151
2001	17219	-7165	42649	1662	54366
2002	22704	-6299	50679	1995	69080
2003	28188	-5433	58710	2329	83794
2004	33672	-4567	66740	2662	98508
2005	39157	-3701	74770	2996	113222

SOURCE: Our calculations.

TABLE 3.28

Incremental vehicular emissions due to the SAP – excluding three wheelers (in tonnes)

Year	CO	HC	NO_x	SO_2	Total Pollution Load
2000	25363	4981	36291	1482	68117
2001	30475	6090	44085	1822	82472
2002	36497	7494	52174	2162	98327
2003	42519	8898	60262	2502	114182
2004	48541	10302	68351	2842	130037
2005	54564	11706	76439	3182	145891

SOURCE: Our calculations.

TABLE 3.29

Attrition factor by vehicle type

Vehicle Type	Attrition Factor
Cars and Jeeps	25 years
Two Wheelers	15 years
Three Wheelers	20 years
Commercial Vehicles	15 years

TABLE 3.30

Total annual emissions ('000 tonnes)

Year	CO	HC	NO_X	SO_2	Total Load
2001	338.9	104.5	210.8	12.3	666.5
2002	341.1	104.2	217.6	12.9	675.8
2003	341.1	104.3	217.2	12.9	675.5
2004	340.0	103.9	216.6	12.8	673.3
2005	341.6	104.4	218.0	13.0	677.0

SOURCE: Our calculations.

in effect we assume the number of vehicles beyond this vintage that are still in use on Delhi roads is negligible. Table 3.30, which shows projected total annual emissions, indicates a stabilisation of the pollution load with time. The primary reason for this is that with the passage of time, old vehicles become obsolete and also because there is a huge difference in the emission factors between pre-1991 and post-2000 vehicles. On the negative side, however, without any improvement in road infrastructure and alternative modes of transport, an unabated increase in personalised modes of transport will slow down traffic and add to pollution. Moreover, it will be some time before fuel quality improves to the levels of industrialised countries.

PART II

Designing Market Based Instruments for Vehicular Pollution Abatement

4. MARKET BASED INSTRUMENTS AND VEHICULAR POLLUTION

In Chapter 3 of Part I of this study, we focused on motor vehicle emissions and air pollution in Delhi and their relationship with the SAP. It was pointed out that the analysis of vehicular emissions had to be conducted with reference to a specific spatial setting which in this study is the National Capital Territory (NCT) of Delhi. Furthermore, in that chapter we highlighted the role of motor vehicle emissions in the acute air pollution problems in the city[14]. In this part of the study, we focus on the role of market based instruments (MBIs) in abating vehicular pollution. In particular, this chapter looks at MBIs in the overall context of policies for pollution abatement and provides a brief overview on MBIs (sections 4.1 and 4.2, respectively). It then develops an analytical framework for examining motor vehicles emissions (section 4.3) and examines policies for reducing vehicular emissions with particular emphasis on MBIs (section 4.4). In this chapter we also examine issues of implementation as well as international experience in controlling vehicular emissions (sections 4.5 and 4.6, respectively). Again, the emphasis is on the role of MBIs in this regard. Chapter 5 focuses on Delhi as a case study and examines various policy options for reducing vehicular emissions including MBIs.In particular, it considers the cost-effectiveness of various options as well as the health benefits of an improvement in air quality in Delhi. Finally, Chapter 6 presents an action plan for reducing vehicular pollution in Delhi.

4.1 Policies for pollution abatement: the role of market based instruments

We begin with an overview of alternative approaches to address pollution, of which vehicular emissions are a subset. As stated above, the emphasis here is on economic instruments (EIs) or market-based instruments (MBIs)[15]. Briefly, MBIs are schemes that make use of the market and price mechanism to encourage firms/individuals to adopt environmentally-friendly practices. They comprise a wide range of instruments from traditional ones such as pollution taxes and tradable permits to input taxes, product charges and differential tax rates (see section 4.2 below). The common element among all MBIs is that they work through the market and alter the behaviour of economic agents (such as firms and households) by changing the nature of incentives/disincentives these agents face.

Economists have advocated the use of MBIs to address environmental problems for over three decades. This advocacy is primarily on grounds of efficiency[16]. In other words, MBIs are a more cost-effective means of achieving a given environmental quality than alternative approaches such as direct regulation of polluters[17].

MBIs, however, comprise only one of a set of policy instruments available for pollution abatement. Table 4.1 below provides a taxonomy of these instruments and places MBIs in the context of other policies. In India, there has been an overwhelming past reliance on command-

[14] In this context, detailed information on various aspects of motor vehicles in Delhi (their population, growth and composition, etc.), as well as on vehicular emissions and air quality was provided and is not repeated in this part of the study.

[15] A number of terms have been used to descri", "economic approaches", "market-oriented approaches", "market-based incentives", "incentive mechanisms", and "incentive-based mechanisms". For our purpose we treat them as equivalent.

[16] According to economists a policy is efficient if it achieves its objective at least-cost compared to alternative policies.

[17] It is only recently, however, that MBIs have been endorsed both by the international community and by the Indian government. See for instance, Principle 16 of the Rio Declaration on Environment and Development, Chapter 8 of Agenda 21, and the *Policy Statement for Abatement of Pollution* by the Government of India, 1992.

TABLE 4.1

Taxonomy of policy instruments to reduce pollution

Policies	Direct instruments	Indirect instruments
Market-based instruments	Effluent charges; tradable permits; deposit refund systems	Input/output taxes and subsidies; differential tax rates
Command-and-control measures (CAC)	Emission regulations (Source-specific, non-transferrable quotas)	Regulation of equipment, processes, inputs, and outputs
Government production or expenditure	Regulatory agency expenditures for purification, cleanup, waste disposal, and enforcement	Development of "clean" technologies

SOURCE: Eskeland and Jimenez (1992)

and-control (CAC) measures listed in the second row of the table, followed by direct government expenditures on pollution abatement (such as the Ganga Action Plan).

In theoretical terms, MBIs are the most cost-effective means of achieving a given target of pollution abatement, for example, a reduction in particulate emissions by x tons per annum. Annex 7 provides details on simulation studies which demonstrate the efficiency of MBIs over command-and-control policies. Intuitively, MBIs result in lower total pollution abatement costs (as compared to CAC) because they allow a shift in abatement from high cost to low cost abaters. By contrast, CAC measures apply uniformly to all polluters such that the same environmental quality has to be achieved by polluters irrespective of their abatement cost structures. Since the ultimate goal of these targets is to attain a certain level of environmental quality in a given region, MBIs are usually implemented on a spatial basis. In addition, implementation becomes more complicated for pollutants where the location of discharge matters (see Annex 7 footnote). In such cases, appropriate weight has to be provided for the differential impact of sources of emissions on environmental quality.

There is another aspect to the cost-efficiency of MBIs over CAC measures. Unlike some CAC measures, MBIs do not dictate how pollution is to be controlled and are not biased towards end-of-pipe treatments (like, for example, mandatory catalytic converters in automobiles). Thus, under MBIs, economic entities such as vehicle owners have an incentive to choose among alternative methods for pollution abatement on the basis of least-cost. In trying to achieve the cheapest means of pollution abatement, firms also have an incentive to innovate and develop new control technology and expertise in the long run. Thus, R&D is encouraged for better abatement technology. On the other hand, under an uniform emission standard (CAC) there is no incentive to abate beyond the required level. Furthermore, mandatory environmental standards are generally based on the best available technology (BAT) for pollution abatement at the time of legislation. Therefore, with improvement in technological knowledge over time the norms become outdated.

In addition to cost-efficiency, MBIs have additional advantages over the CAC approach: when the technology required to meet the standards is not widely available outside the incumbent firms, CAC measures can act as a barrier to entry to new firms. Finally, the use of MBIs like taxes, user fees, and auctioning of permits, provides a source of revenue that could potentially be used in promoting environmental projects.

4.2 A brief overview of market based instruments

MBIs can be classified in two groups: price-based instruments and quantity-based instruments. While all of these instruments can be used to address a wide range of environmental problems, they are described below primarily in terms of their application to pollution abatement. Within the first group, one can further differentiate between direct and indirect price-based instruments. The former induce generators of pollution to internalise the external costs of pollution by charging for the use environmental resources, e.g., air and water. Indirect price-based instruments, on the other hand, increase (decrease) the prices of outputs and inputs that are complementary (substitutes) to the polluting activity. For example, a tax on petrol (or a subsidy to mass transit) is an indirect price-based instrument to address vehicular air pollution[18]. A brief description of major types of price-based instruments is given below. In this list, the first two instruments would be considered direct instruments, whereas the rest are indirect instruments.

Price-based instruments:

(i) *Emission/effluent charges,* also referred to as emission/effluent taxes, fees, pollution charges, pollution taxes, or Pigouvian taxes (after the economist A.C. Pigou who first proposed them in 1920), are charges/fees/taxes levied on polluters based on the quantity and/or quality of pollutants discharged into the environment.

(ii) *Deposit refund systems* comprise refundable deposits added to the purchase price of a polluting product (e.g., lead acid batteries, glass beverage bottles, tires, etc.). A variant of this would be performance bonds where firms post monetary bonds which would be forfeited if they polluted in excess of acceptable levels, or if the area were not returned to its original state (as in the case of surface mining).

(iii) *Input taxes/product charges* are fees added to the price of inputs or outputs of products that are potentially polluting in either the manufacturing and/or consumption phase (such as fertiliser and pesticides), or for which a special disposal system has been established (for example, a product charge on lubricating oil to pay for the recycling of waste oil)[19]. Examples of an input tax would be a tax on the carbon or sulphur content of coal. All of these taxes/charges are "second best" (compared to emission/effluent charges) since they are not directly levied on the harmful activity but on proxies to it.

(iv) *Differential tax rates* promote consumption of environmentally friendly products (e.g., tax differentiation between leaded and unleaded gasoline, or between appliances using ozone depleting CFCs and those that do not). The differential arises due to a tax on the polluting product and/or a subsidy on the non-polluting one.

(v) User and administrative charges are direct payments for the costs of collective/public treatment of pollution (e.g., collection and treatment of solid waste). Administrative charges include fees paid to authorities for services or the implementation and enforcement of environmental regulations (e.g., consent fees).

(vi) Subsidies comprise grants, low interest loans, and tax concessions to encourage pollution abatement – hybrid scheme – combined charge-subsidy system where polluters pay for emissions above some mandatory baseline, but receive a subsidy for emission reductions below the baseline.

(vii) Enforcement incentives include non-compliance fees and assignment of liability for environmental damage. All of these are typically linked with direct regulation. Thus,

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[18] From this example it will be clear that the effectiveness of indirect instruments crucially depends on the strength of the linkage between the transactions (to which the tax is applied) and the pollution that the policy seeks to control.

[19] Note the use of the phrase *potentially* polluting: often only improper use of a product, e.g., incorrect/excessive application of fertiliser, causes pollution. Also note that a product charge on fertiliser is presumptive in nature and cannot distinguish between careful and careless farmers. This is the reason why we call it a "second best" tax.

non-compliance fees or fines are charged in proportion to the extent of violation of the pollution standard. Similarly, liability assignment provides incentives for pollution abatement by making polluters liable for the damage they cause.

Quantity-based instruments:

These instruments create transferable rights for the use of environmental resources such as air and water which are assigned, sold or auctioned to polluters. The major instrument in this category is the marketable permit[20]. Under this approach, a target level of environmental quality is translated into the total amount of allowable emissions/effluent that can be discharged. The regulatory agency then allots, sells or auctions the right to discharge units of pollution in the form of permits which can be bought and sold (i.e., traded), subject to an overall ceiling of allowable discharges which has been fixed a priori. Since this ceiling is usually less than the current aggregate level of discharges, there is a scarcity value to the permits and this sets the initial price for them. This price increases over time as economic activity increases and more firms bid for the permits[21].

There is another set of quantity-based instruments which are used in conjunction with direct regulation to take advantage of some of the flexibility of MBIs without going all the way to a full-fledged system of MBIs. Also known as partial trading schemes, some of them which have been used (mainly in the United States) are netting, bubbles, offsets, banking, and lead trading. They are briefly explained here[22]:

Under *netting* a firm is allowed to create a new source of emissions in an industrial plant by reducing emissions from another source in that plant. Thus the same level of net emissions is maintained. This is also called *internal trading* since it only involves one firm.

In a *bubble*, a firm is allowed to add up the emission limits from individual sources of a pollutant in a plant. It can then adjust the amounts abated from different sources as long as the aggregate limit is not exceeded[23]. The objective behind a bubble is to allow a firm to meet its emission reduction goal as flexibly and cheaply as possible while ensuring that air quality is not degraded. It is similar to netting except that netting applies only to new sources within a plant.

An emissions *offset* policy allows new entrants to a non-attainment area (an area that is not in compliance with environmental standards) to procure sufficient reductions from existing firms (over and above their previous legal requirements) so as to offset the increase in pollution which would otherwise occur when the new source starts production.

An emissions reduction *banking* is a system for allowing sources to reduce their emissions by more than the required amount and to bank excess reductions for future use.

Finally, under the *lead* trading programme in the United States, petroleum refineries switching from the manufacture of leaded to unleaded petrol were allowed to trade in "lead credits", that is, refineries that had exceeded their lead reduction target could sell lead credits to those who had fallen short of targets[24].

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[20] Also known as tradable permits, tradable pollution permits, transferable permits, emissions permits, emissions trading, or pollution licenses.

[21] It is important to note two additional aspects of tradable permits. Firstly, tradable permits are not a "license to pollute," as is sometimes argued: while purchase of permits does allow a firm to discharge more, this is matched by an equal reduction by another firm which has sold the permit, and thus forfeited its right to discharge by that amount. Secondly, if permits are designed so that they expire annually (or every few years) and have to be repurchased, the regulatory agency can even tighten ambient air/water quality standards over time by *reducing* the amount of permits it sells each time.

[22] For details see Hahn (1989).

[23] The term originates from the placing of an imaginary bubble over a plant such that all emissions are monitored only at a single point.

[24] For details see Hahn and Hester (1989a).

4.2.1 The choice between different MBIs

Within MBIs, taxes and tradable pollution permits have received by far the most attention. Below we list some arguments for and against either instrument.

Arguments for tradable permits:

(i) One of the most important reasons advanced in favour of permits is that they allow the regulatory authority to control the quantity of emissions (determined by the desired ambient quality), whereas under a tax system the level of emissions is determined by polluters[25].

(ii) Under a system of taxes, the regulatory authority needs to periodically adjust the tax rate to allow for inflation (if the rates are set in nominal terms), and for growth in the level of industrial activity. In the case of permits, however, their price automatically adjusts to such changes – with growth in industrial activity the demand for pollution permits would increase and so would their price, as long as additional permits are not issued.

(iii) When permits are initially distributed free of cost to firms ("grandfathered") instead of being auctioned, they have an advantage in terms of political acceptability over a pollution charge (Baumol and Oates 1988, pp. 178-179). By contrast, taxes impose a new financial liability on polluting firms.

Arguments for taxes:

(i) A grandfathered system of permits favours incumbent firms at the expense of new firms, whereas taxes treat all firms old and new alike. Thus, under a system of permits new sources would face a greater financial burden than otherwise identical existing sources. This bias against new sources could retard the introduction of new facilities with newer technologies embodying the latest innovations (Tietenberg 1991, p. 98). Further, even in the case of grandfathering (of permits), subsequent buying and selling of permits is required to achieve a cost effective outcome. The reason being that the initial distribution does not reflect the marginal abatement cost of different polluters, and is usually not optimal.

(ii) With respect to monitoring of emissions/effluents, costs are incurred under both taxes and permits (or for that matter, under a CAC regime as well). Tradable permits, however, have the added cost of tracking the trades (sales and purchases of permits) in the market. In other words, the de facto allocation of pollution rights in the economy has to be monitored.

(iii) Advantages of permits will not be realised if market imperfections prevent the permit market from functioning smoothly. For example, if the flow of information is imperfect, potential buyers and sellers of permits will not be able to engage in profitable trades. In the presence of this and other distortions in the permit market (e.g., large search costs, strategic behaviour on part of the players), an emission tax system may be preferred.

(iv) Taxes may be the more appropriate instrument when sources are individually small, but numerous. For instance, in the United States it has been noted that much of the permit trading involves large corporations, perhaps since it is only feasible for larger firms to absorb the high transaction costs without jeopardising the gains from trade (Tietenberg 1991, p. 105). Also, with large transaction costs, the final equilibrium allocation of permits, and hence the aggregate costs of control, also become sensitive to the initial permit allocation (Hahn and Stavins 1992, p. 466).

[25] This aspect matters a lot in the real world where there is uncertainty about abatement costs. In a world with full knowledge about abatement costs taxes and permits have equivalent impact. In the presence of uncertainty about abatement costs, a tax may not ensure the desired environmental quality since it may not be set at the appropriate level.

With respect to the practical aspect of enforcing and monitoring MBIs, a general rule is that permits work better when there are a few, large polluters, whereas taxes are more suited for a situation where there are a large number of relatively small sources. As is intuitively obvious, in the latter case monitoring of permit trades would be more difficult.

4.3 Vehicular emissions: an analytical framework

Vehicular emissions for a given period (say, daily or annual) may be viewed as the product of: (i) emissions per unit of fuel; (ii) fuel consumed per kilometre, and (iii) total vehicle kilometres travelled (VKT)[26]. The last factor, VKT, can be further viewed as a product of the number of vehicles times the number of kilometres each travels. Conversely, (i) and (ii) may be viewed as a composite variable, namely, emissions per kilometre[27]. In sum, vehicular emissions can be decomposed in a number of ways. The main reason for disaggregating emissions is that it facilitates analysis by identifying the underlying components and the actual point of impact of different measures for emission abatement. It also makes transparent the interlinkages and feedback mechanisms among these measures. As an illustration, in North America fuel consumed per kilometre (due to bigger cars) and VKT are high by world standards, but emissions per unit of fuel are quite low. The reverse is true in developing country cities such as Delhi.

Following Heil and Pargal (1998), Figure 4.1 illustrates the major determinants of emissions from passenger vehicles. The figure is a minor modification of the decomposition above in that (ii) now refers specifically to units of fuel per passenger kilometre and (iii) refers to passenger kilometres travelled (PKT). The same framework can be modified to include freight transport as well. Each factor is influenced by a set of determinants (shown by arrows), some of which are linked to one another (as indicated by dotted lines). The advantage of this framework is in the clear separation of the determinants of vehicular emissions. For example, we see that reducing emissions per unit of fuel by 50 percent, ceteris paribus, would halve total emissions, as would curbing PKT by the same proportion. While the former is a technical measure requiring no change in behaviour, the latter depends on substantial behavioural modification. In practice, it is quite likely that curbing vehicular emissions will entail a combination of policies that affect two or all three factors. Figure 4.2 rearranges the three components of vehicular emissions and their determinants and adds a list of policies that may help control them[28]. It is evident that while policies such as emission taxes and permits target total emissions directly in theory, in practice there are few policies that actually do so. Most of them are technical fixes such as emission/fuel standards or incentives to change passenger behaviour.

From Figure 4.2 we also note that the divisions between the three components of emissions overlap. Some determinants such as age of vehicle affect more than one component, and appear more than once, as do corresponding policies. These overlaps reflect the crosscutting nature of vehicle emissions and the difficulties in designing policies to reduce them. In particular, there exist complementarities across various policy levers – policies to reduce traffic congestion, for instance, increase average speed and thus reduce emissions[29]. These complementarities, however, may at times work in opposite directions. For instance, improving fuel efficiency may lower emissions but also increases PKT (due to reduced cost of travel). This in turn increases emissions and the two effects may, ceteris paribus, balance out on the whole.

[26] This decomposition follows Levinson and Shetty (1992).

[27] For instance, this would be equivalent to the emission factors used in chapter 3 earlier.

[28] This discussion is based on Heil and Pargal (op. cit.).

[29] For Indian motor vehicles it is estimated that driving at 10 km/hour can increase fuel consumption by 126 to 298 percent (depending on the type of vehicle) as compared to an optimum speed of about 40 km/hour (AIAM, 1996).

A similar point is made with respect fuel taxes which contrary to popular belief, may not lower emissions for two reasons (Sevigny 1998). First, fuel taxes may encourage the purchase of fuel efficient cars and the lower operating costs of the new vehicle may increase PKT/VKT. Also, as Sevigny points out, “While a gasoline tax encourages the purchase of fuel efficient cars, the correlation between emissions per mile and miles per gallon (MPG) is weak.” (op. cit., p. 12) The reason is that fuel efficiency depends in part on vehicle weight, engine size and performance, vehicle aerodynamics and gearing. These features generally do not affect emissions, which depend on the completeness of the fuel burn and the presence or absence of emissions control systems such as a catalytic converter.

4.4 Policies for reducing vehicular emissions: an overview

Tables 4.2 and 4.3 present a range of policies for reducing vehicle emissions in the context of the framework discussed in section 4.3 above[30]. Table 4.2 lays out the objectives of different policies and the mechanisms through which they work, as well as highlighting important incentive considerations that would determine their success. The mechanisms are broadly classified along two dimensions: whether they work through supply (SS – supply side) or through demand (DS – demand side), and whether they are market-based (“market”) or of the CAC variety (“control”)[31]. This table, thus, attempts to provide a basis for an integrated policy framework. Table 4.3 provides examples of policies that have succeeded as well as those that have not, as well as tips for implementation. The two tables clarify key issues related to selection and implementation of transport policies. It should be noted, however, that these tables do not present a cost-effectiveness ranking of policies, since this would vary with the particular context. Table 4.5 provides the same information as Table 4.3 in a simpler format. The advantage here is that it provides a basis for direct comparison between MBIs and CAC.

The high dependence of motor vehicle emissions on behavioural factors implies that it is difficult to predict the magnitude of abatement induced by different policies. Policy combinations and complementarities complicate matters further. Still, behavioural modifications are crucial for reductions in automobile emissions. For example, while stringent emission standards have significantly reduced emissions per unit of fuel in the United States, aggregate emissions in some US cities have started rising again (Shalizi and Carbajo 1994). This is because of the unregulated component, namely, PKT. In fact, new cars in the US may emit 95 percent less CO, HC, and NOx than did uncontrolled cars in the 1960s (Harrington and Krupnick 1997)[32]. Thus, abatement opportunities through technological improvement have been nearly exhausted. At the same time, however, travel demand management has received little attention. In fact, emission abatement through reducing PKT would be more cost-effective (Eskeland and Devarajan 1996).

4.5 Implementation issues

It is important to consider the policies discussed above in a holistic manner to ensure that they are implemented effectively[33]. Thus, a policy considered in isolation may be ineffectual because of the countervailing impact of other factors. For instance, mandating strict emission

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[30] This discussion is based on Heil and Pargal (op. cit.).

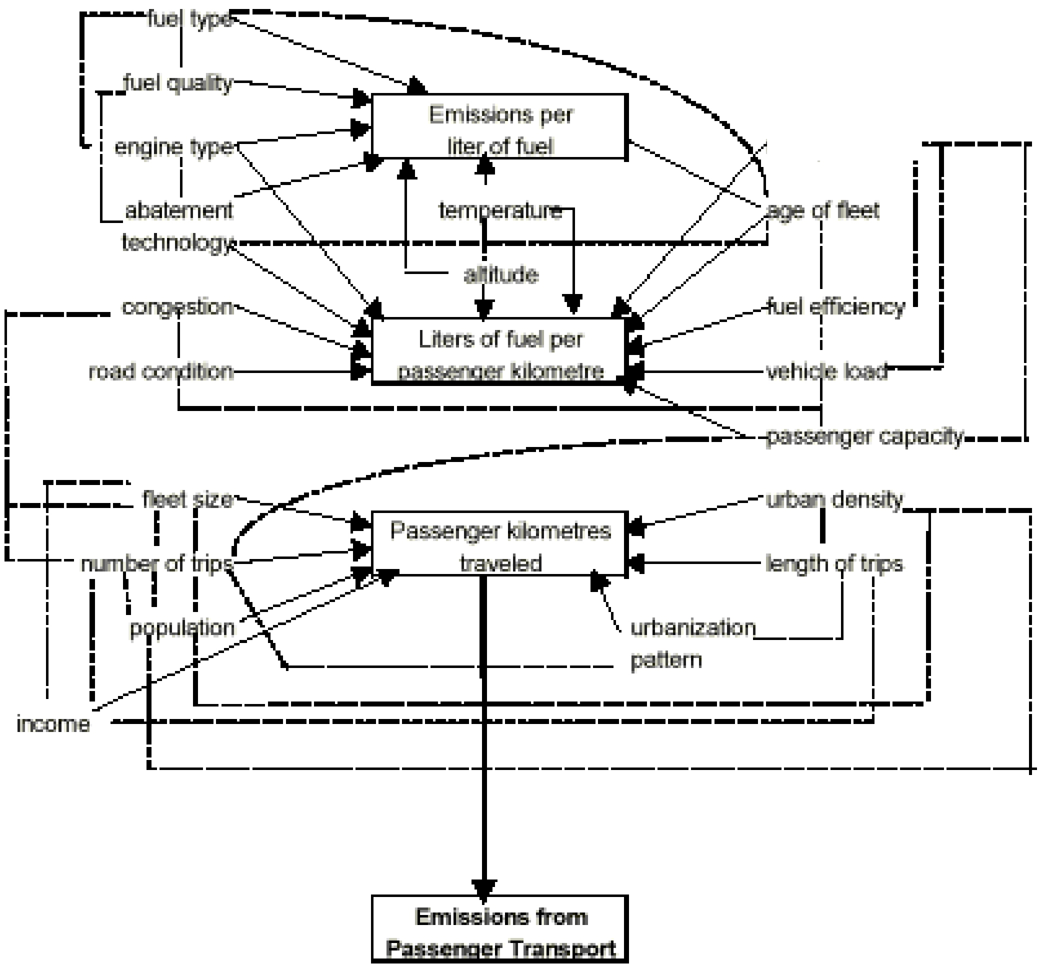
[31] Some instruments such as retrofitting programmes or new vehicle quotas can be classified either as “market” or as “control” depending on the manner in which they are implemented. For instance, if quotas are tradable they become market-based otherwise they are CAC.

[32] In the US, the approach towards vehicular pollution combines control of emissions at the point of manufacture with those from in-use vehicles. A certification and enforcement programme is used to administer new car emission standards – prototypes of car models are subjected to stringent tests and only those models with a certificate of conformity are allowed to be sold. The associated enforcement programme consists of assembly line testing, recall, anti-tampering procedures and warranty provisions to ensure that manufacturers meet the emission standards. Standards on fuel content and alternative fuels and vehicles have also been passed. For in-use vehicles the main emission control strategy is a regular inspection and maintenance programme. The US approach for new car emission standards has been adopted by Austria, Sweden, Switzerland, Norway and Finland, and later by the European Community as well. For a critique of the US approach see Harrington et al. (1998).

[33] This discussion is based on Heil and Pargal (op. cit.)

FIGURE 4.1

Urban passenger transport emissions: major determinants and linkages



Total emissions = emissions per liter x liters per passenger km x passenger kms traveled.

NOTE: Solid lines represent direct determinants of the components of transport emissions Dotted lines show linkages between determinants.

SOURCE: Heil and Pargal.

FIGURE 4.2

Policies targeting urban passenger transport emissions and their determinants

URBAN PASSENGER TRANSPORT = EMISSION PER LITRE OF FUEL X LITRES OF FUEL PER PASSENGER X PASSENGER KILOMETER TRAVELLED

Policies targeting total emissions	**Detemrinants**	**Policies targeting emissions per litre of fuel**	**Determinants**	**Policies targeting litres per passenger kilometre**	**Detemrinants**	**Policies trageting passenger kilometre travelled**
emissions taxes	fuel type	emission standards1	fuel efficiency	fuel economy standards	fleet size	new vehicle quotas
emissions permits	fuel quality	fuel quality standard		fuel taxes/pricing		cost of vehicles
	-lead level	*-limited lead content*				licensing/registration fees
	-sulphur level	*-limit sulphur content*				
paving	*-volatility*	*-volatility limits*	engine type	promote cleaner engines	number of trips	urban density/zoning
	-oxygenation	*-clearner octane booster*		such as 4-stroke		road pricing/user fees
						parking fees
						no-car zones
						no-car days
						fuel taxes
	engine type	promote cleaner engines	vehicle load	promote car pooling, HOV enforce		
		such as 4-stroke		against overloading		
	technology	mandated abatement	age of vehicle	early scrappage incentive	distance of trips	urban planning
	-catalytic converter	equipment or retrofitting		inspection & maintenance		locally based work/school
	-fuel injection			roadside inspection		
	-turbocharging		congestion	traffic engineering	urban density	zoning laws
				demand management		promote walking, biking
				road supply		
	age of vehicle	early scrappage incentives	transport mode/	provide public transport to	population	urban planing
		inspection & maintenance	passenger	lower fuel per passenger		
		roadside imspections	capacity	kilometre travelled	income	
	temperature	none	--bus, rail, metro			
	altitude	none	road condition	regular maintenance pave		
				major raods		

1 Some countries have technology forcing low emissions vehicle and zero emission requirements that mandate manufacturers build some proportion of their fleet to meet emission standarda which are attainable only through alternative fuels.

SOURCE: Heil and Pargal 1998

TABLE 4.2

Policies to mitigate transport emissions: objectives and mechanisms

Characteristics	Direct objectives	Policy instruments	Functional mechanism	Incentive/Efficiency consideration
Transport emission	Directly reduce vehicle emission	mandated emission standards	emission stds: SS control	Standard may stimulate new technology. Increased cost of new technology and slightly reduced fuel economy may compel some to keep using older , more polluting cars longer.
Fuel quality	Reduce lead content ; reduce sulphur content Use cleaner octane booster like oxygenation	mandated fuel standards; emissions tax; Emission permits	fuel stds: SS, control emission fee: DS, control	Lower tax rate for unleaded gasoline (so unleaded is cheaper than regular) creates incentive for consumer to shift to unleaded . Lead trading and banking at the refinery level can reduce cost of converting to unleaded fuel.
Engine type	Encourage conversion away from highly polluting engines	promote halt to building & importing 2-stroke engines; retrofit existing 2-strokes; convert spark engines to run on alternative fuels	omission stds: SS, control. outright ban: SS, control retrofitting prg. SS, control or market	Conversion of new vehicle production to make cleaner engines is useful, but for developing countries. Where fleet turn over is slow, the effect on lower emissions will be very small. Retrofitting existing vehicles has greater impact, but will not likely be adopted without significant subsidies (despite low or negative cost).
Technology	Control emission through technological measures	mandate catalytic converters in new cars; Mandate PCV valves to control crankcase emissions retrofitting program	catalytic convtr.: SS, control crankcase emiss: SS, control or market Retrofitting: SS, control or market	Mandated technological fixes require adequate lead time for manufacturers to adjust. Insufficient lead time can cause loss of market share to foreign competitors or (temporary) lack of supply for consumers. Advanced 3-way catalytic converters must be imported by most developing country car manufacturers, adding to production costs.
Size of fleet	Control ownership of private vehicles	ownership restrictions: new vehicle quotas; high ownership fees; import tariffs	quota: SS, control or market. ownership fee: DS, market tariffs; DS; control	Fees could have added impact if earmarked toward improving public transport systems. Import tariff may reduce efficiency of domestic manufacturers and create political constituencies.
Age of fleet	Lower average age of vehicles in fleet; Repair or scrap old, highly polluting vehicle	scrappage incentives: Higher registration fees for old cars I/M program for at least class of high polluters, roadside inspections	registration fee: DS, market. I/M: SS, control. roadside inspection: SS, control	Early scrappage incentives may enhance prospects for new car manufacturers and dealers/distributors. However, may dampen used car market and harm relatively lower income consumers who can only afford to buy older, used vehicles. I/M and roadside insp. Can reduce gross polluters, but may raise costs for those who cannot afford new cars
Public transport	Reduce congestion and emission per passenger kilometre	Provide well coordinated public transport systems that can diminish number of private commuters	buses: SS, market. trains: SS, market metro: SS, market	Public transport is key to attracting consumer s away from private motorised transport. Incentives needed to attract commuter's efficiency, reliability, convenience. Private provision /operation of public bus systems may be viable without subsidy (Seoul, Hong Kong).

SS = Supply Side, DS = Demand Side, control = mechanisms that depend on command-and-control (regulations), market = mechanisms that work through the market.

TABLE 4.2 (*continued*)

Characteristics	Direct Objectives	Policy Instruments	Functional Mechanism	Incentive/Efficiency Consideration
Congestion	Improve traffic flows; Increase average speeds(congested conditions can increase exhaust emissions of CO, HC and CO2 by three fold over free-flowing urban traffic)	*Direct* : new vehicle quota; high taxes on ownership; no car zones; no car days; area pricing; road pricing; insurance adjustments according to vehicle usage	quota: SS, control or market. Ownership fee: DS, market . no-car zones: DS, control no-cars days: DS, control area pricing :DS, control road pricing: DS,control insurance: DS,market	Disincentives for private vehicle ownership can pay long–run dividends by preventing widespread use and entrenchment/ dependency. But still staff quota/fees may harm domestic vehicle manufacturers, and becomes a political issue Quotas on only new cars may encourage purchases of older, more polluting ones. Electronic road pricing technology permits variable fee assessment on cars to reflect marginal social cost according to degree of congestion, pollution etc.
		Efficiency enhancement: computerised traffic lights; dedicated road lanes; staggered working hours; car pooling incentives; light rail or bus system;	lights; efficiency, control. dedicated lanes: SS, control staggered hrs.: DS, control carpools: DS, market rail/bus: SS, state (control) or private (market)	Improving flow of traffic reduces congestion, but this may encourage more private travel. Efficient mass transit is a critical component of complementary policies that both deter consumers from private motorised transport and attract them to public transport. Incentive and profitability for private sector provision and operation of public transport may hinge in part on the extent and severity of the disincentive for consumer ownership and use of private cars.
		Road supply: state-built roadways; joint public- private roads; private new toll road.	roads: SS, state joint roads: SS state/private private roads: SS, private	Increasing roads raises incentive to drive . But, if toll rates reflect construction/maintenance costs, then incentive structure yields more allocatively efficient consumer choices.
Number and length of trips	Control number and distance of private vehicle trips taken by passengers	Reduce need for private travel: Zoning laws- "living downtown" urban plans, high density corridors, higher urban density; provide efficient public transport.	zoning: DS or SS, control public transport: SS, market. driving fees: DS, control parking fees: DS, market fuel taxes : DS, market no-car zones: DS, control	Well designed zoning policies reduce consumer demand for private motorised travel. May also create sufficient incentives for private sector to provide public transport (since high density/ ridership along accessible routes may be profitable). Urban density amenable to pedestrians may stimulate small retail business due to walk-by traffic and window shopping. Pedestrian friendly urban areas call for safeguards: well-enforced crosswalks, sidewalks and night-time illumination.
		Reduce incentive to drive: High peak hour driving fee; High parking fees; High fuel taxes; No-car zones		High car usage /parking fees may spark resentment among consumers, especially in the absence of adequate public transport may dampen private car sales.

SS = Supply Side, DS = Demand Side, control = mechanisms that depend on command-and-control (regulations), market = mechanisms that work through the market.
Source: Heil and Pargal 1998

TABLE 4.3

Policies to mitigate transport emissions: implementation issues and examples

Characteristic	Policy Instructions	Implementation Issues	Examples
Transport emissions	directly reduce vehicle emissions through stds.	Emissions standards may be technology-forcing or technology-following.	Emission standards: highly successful in US
Fuel type	mandated fuel standards ; emissions tax; emissions permits	Mandated fuel standards have been highly successful in US, Japan Europe. Reformulation cost can be significant, but much lower than health benefit. Oxygenation reduces HC and CO emissions, but may raise NOx	Zero-lead stds: Thailand, Mexico, Brazil, Colombia, Japan. Volatility limits: US, Sweden, Finland. Oxygenation Stds: US, Brazil, S.Africa, S.Korea, Thailand, Sweden, Finland. Emission fees: none
Engine type	promote a halt to building and importing dirty 2-stroke engines; convert new 2-strokes; convert bus/truck/taxi engines to run on alternative fuels	Adequate lead-time is required for manufacturers to comply at low-cost . Cost to consumers is about 6 per cent for motorcycles (to add catalytic converters to 2-strokes in Taiwan) Some conversions may have low or negative costs (due to fuel cost saving, etc.) .Others may require strong incentive / support programs.	Elimination of 2-stroke motorcycles by setting emissions standards: US Taiwan: adopted US standards, but more recent technology allows some advanced 2-srokes to meet standards. Retrofitting trucks to run LPG: Bangkok Converting taxis to run on LPG: Tehran Converting buses to run on CNG: Santiago
Technology	mandate catalytic converters in new cars ; Mandate PCV valves to control crankcase emission; retrofitting program	Consumer tampering with catalytic converter may be problematic. I/M programme can mitigate this.	Catalytic converters: US Crankcase emissions: US Retrofitting catalytic converters: Germany, Sweden , Hungary
Size of fleet	ownership restrictions: new vehicle quotas; high ownership fees	Requires strong policies to succeed amid economic growth. More feasible if consumer demand is relatively low, cities are dense, public transport is efficient, and complementary policies (like high parking fees, road/area pricing, high fuel taxes) exist.	Quota: Singapore High ownership fees: Singapore Vietnam
Age of fleet	scrappage incentives: higher registration fees for old vehicles; I/M program for at least class of high polluters; roadside inspections	Scrappage programs have worked , e.g., subsidised trade-in programs; I/M programs are costly to set-up and administer. Inspecting subset of vehicles may be more feasible.	Scrappage incentives: Singapore, Mexico City (taxis) I/M: US, European Union, Japan, Roadside Inspection: Hong Kong, Mexico, Thailand

SOURCE: Heil and Pargal 1998

TABLE 4.3 (*continued*)

Characteristic	Policy Instructions	Implementation Issues	Examples
Congestion	*Direct*: new vehicle quotas; high taxes on ownership; no-car zones; no-car days; area pricing; road pricing; insurance adjustments	Direct policies succeed in some cities. Require political will and strength (because of consumer opposition) No-car days in Mexico had perverse effect of raising emissions. No-car zones have been well-received by consumers and business owners in some areas. Area and road pricing requires initial investment ,but fees generate revenue. Insurance: verification of usage rates is difficult.	Quota: Singapore High ownership fees: Singapore ,Vietnam No-car zones: Curitiba, Brazil Tokyo, Hong Kong No-car days: Athens, Mexico City ,Santiago Area pricing: Singapore, Amsterdam, unsuccessful in Kuala Lumpur. Road pricing: widespread Insurance adjustment: US
	Efficiency Enhancement: computerised traffic *lights*; dedicated road lanes; staggered work hours; car pooling incentives; light rail or bus system	Traffic engineering can work, but sometimes there is an immediate one-time benefit followed by gradual deterioration. Initial cost may be high (but usually outweighed by benefits) Commuters spacing has mixed record. Mass transit done well is effective, but may be costly (esp. subway system). Buses are relatively cheaper .	Synchronised traffic lights: widespread (London is advanced). Dedicated bus lanes; Bangkok, Jakarta, Manila , Sao Paulo, Tehran, Tokyo; HOV lanes for cars are widespread Staggered work hours: Singapore, Surabaya Car pooling incentives: US , Singapore Light rail/metro: Cairo, Calcutta, Hong Kong, Mexico City, Pisau, Rio de Janerio, Santiago, Sao Paulo, Seoul, Seoul, Singapore
	Road Supply: state built roadways; joint public–private roads; private new toll roads.	Increasing road supply has low prospects for success in long run (since it may encourage more driving), but can help in short run.	New public road construction: widespread New private toll road constructions
Number and Length of trips	reduce private travel need: zoning laws, “living downturn” urban plans; high density corridors; provide public transport. r*educe incentive to drive*: high fees to drive during peak hours; high parking fees; high fuel taxes; no-car zones	Zoning laws/action may be politically–laden. Zoning reorganisation may be too late in established cities. No car zones have been popular in some cities.	Living downtown zoning : Washington ,DC High density corridors: Curitiba , Arlington, Peak time driving fees; Singapore Parking fees: widespread No car zones: Curitiba , Brazil , Tokyo, Hong Kong
Public transport	Provide well-coordinated mass transit systems that can diminish number of private commuters.	Provision of public transport may be costly. Private suppliers may relieve burden from the state Lower fares do not necessarily attract more riders. Coordination of mass transit such as feed–in routes and park and ride schemes improve efficiency.	Buses : widespread Trains: widespread Metro: Cairo, Calcutta , Hong Kong Mexico City , Pusan, Rio de Janeiro, Santiago , Sao Paulo ,Seoul , Singapore Park and ride : widespread

TABLE 4.4

Summary comparison of selected transport projects

City	Project	Overall aim	Specific objectives	Demand side measures	Supply side measures	Impact upon air pollution	Critical factors	Comments
Hong Kong (1995-)	Vehicle Pollution Control Program	Reduce ambient concentration of PM and Lead.	Curtail emission of PM and lead per unit of fuel.		Reformulation of diesel fuel to reduce sulphur content New, tighter vehicle emission standards.	Lower emissions from using cleaner fuel.	Fuel and emission standards become stricter over time.	Future plans introducing vehicle inspection ,and converting light duty diesel vehicles to run on gasoline.
Seoul (1995 -)	Bus lane priority	Improve urban road transport.	Increase central city traffic speeds. Reduce congestion.		Improve bus service by establishing bus priority lanes.	Lower emissions since less congestion and high bus readership reduces fuel use per passenger km.	Earlier pro-car policies helped create congestion problem.	Bus lanes have reduced congestion, but enforcement must be sustained. Situation would be worse without intervention.
Bangkok (1979-85)	Bangkok Traffic Management Project	Improve road transport efficiency.	Increase traffic speeds. Reduce car use. Reduce congestion.	Cut number of downtown parking spaces	Establish bus lanes. Modernise traffic signals.	Initial declines in congestion & poor public transport led to more vehicles so overall impact on emissions unclear.	Lack of long range planning spawned acute congestion problem.	Maintenance of traffic signals and enforcement of bus lanes are critical. Situation would be worse without intervention.
Santiago (1989-95)	Urban street and Transport Project	Improve roads and curb air pollution.	Integrate transport modes.	Weekly ban on vehicles without catalytic converters, Ban empty taxis in CBD	Pave and repair dirt roads. Retire old buses. Computerise traffic lights. Develop and enforce emission & fuel standards. Introduce unleaded gas.	Paving road directly reduces total PM emissions. Despite encouraging greater car use, the level of car pollution declined post project.	Low-cost paving method permitted a quadrupling of expected new pavement.	Increasing supply of roads encourages more car use. Bikeway was scrapped.
Curitiba (1979-85)	Brazil Urban Transport Project	Improve access and efficiency of transport system.	Synchronise bus system, improve energy efficiency. Reduce commute time for residents of outlying areas.		Establish truck / branch bus line system. Pave feeder roads. Establish High-density corridors Along trucks.	Likely lower emissions due to road paving ,greater fuel efficiency on better roads and higher bus use.	Bus system's success became a model for other cities.	Bus system requires passengers to change buses. Fare system should be integrated.

TABLE 4.4 (*continued*)

City	Project	Overall aim	Specific objectives	Demand side measures	Supply side measures	Impact upon air pollution	Critical factors	Comments
Singapore (1975)	Area Licensing Scheme	Manage urban transport and constrain motorisation.	Reduce demand for cars. Restrain car usage. Reduce congestion. Change modal split.	Increase private cost of vehicle ownership through car taxes. Auction car licenses. Raise cost of usage via monthly user fees and high parking fees in the Restricted Zone (RZ). Restricted travel zones. Land use planning.	Provision of a high quality, integrated public transportation system. Increased road capacity and traffic engineering.	Concentration of NOx, CO PM declined within RZ suggesting impact of policy.	Sound public transport alternative. Authority of central govt Policy fine-tuned over time.	Traffic declined in RZ during operational hours but increased on routes outside and during hours preceding.
Mexico (1992)	Transport Air Quality Management Project	Improve urban air quality	Reduce vehicle emissions. Improve fuel quality. Restrain car usage.	Increase gasoline prices, make unleaded fuel competitive; make CNG cheapest. Hoy no circula , with exemption for clean vehicles	Fuel reformulation. Encourage clean fuels; CNG retrofitting. Taxi replacement.	Impact on emissions through cleaner fuels.	Program fine-tuned over time	Cheap local "people's car" and low cost of car ownership undermines program. Limits to technological solution like emissions standards.
Kuala Lumpur (1975)	Second Urban Transport Project	Improve efficiency of transport system in KL.	Restrain car usage. Improve public transport.	Area Licensing Scheme	New road construction. Phase-out seat tax on buses.	Indeterminate		Area licensing collapsed due to political / admin. problems, inadequate public transport.
Tehran (1995 -)	Transport Emission Reduction Project.	Reduce emissions per unit fuel (via emission standards). Reduce fuel use per passenger km.			New vehicle emission and fuel use standards.	Unknown since plan has not yet been implemented.	Technical solutions are easier to implement than those requiring behavioural changes.	Emissions from installed base unaffected. Limits to technological solutions.

SOURCE: Heil and Pargal 1998

TABLE 4.5

Taxonomy of policy instruments to control motor vehicle emissions

	Market based instruments		*Command-and-control regulations*	
	Direct	**Indirect**	**Direct**	**Indirect**
Vehicle	• Emissions fees	• Tradable permits • Differential vehicle taxation • Tax allowances for new vehicles	• Emission standards	• Compulsory inspection & maintenance of emissions control systems • Mandatory use of low polluting vehicles • Compulsory scrappage of old vehicles
Fuel		• Differential fuel taxation • High fuel taxes	• Fuel composition • Phasing out of high polluting fuels	• Fuel economy standards • Speed limits
Traffic		• Congestion charges • Parking charges • Subsidies for less polluting modes	• Physical restraint of traffic • Designated routes	• Restraints on vehicle use • Bus lanes and other priorities

SOURCE: Carbajo 1991

standards without providing unleaded gasoline would be impractical since the primary means of meeting such standards, catalytic converters, function only with unleaded fuel[34]. Similarly, any demand management policy (to reduce private motorised travel) would only work fully if viable public transport (or non-motorised alternatives) were available. As such, a "supply" of public/alternative transport is an indispensable part of the strategy[35]. In the context of CAC policies also such as inspection and maintenance (I&M), it is important to strengthen institutional capability as a complementary measure. In sum, therefore, it is important to design complementary policies in a manner that integrates public and private transport, and combines supply and demand management.

It should also be kept in mind that the success of a policy may result in perverse incentives. For example, paving dirt roads to reduce PM from re-suspension may increase demand for travel. Likewise, reducing traffic congestion tends to attract more drivers since private travel becomes easier. In Delhi, it has been noted that building more bridges and/or widening existing ones across the river Yamuna eventually increased the population locating on the other side with a concomitant increase in the volume of traffic and no reduction in congestion or emissions[36]. This again highlights the importance of demand management.

[34] This observation has particular resonance in the Indian context where stringent emission standards enforced by the Supreme Court for Delhi (Euro I and II standards) may not be met due to poor fuel quality.

[35] Having said this, however, it is also true that there is 'chicken and egg' problem here in that the viability of public transport depends on adequate demand for it. In other words, demand management (tolls, taxes, etc.) is often a prerequisite to wean commuters away from private modes of travel towards public transport and for the latter to break even. This issue again is highly relevant for Delhi where it is often debated whether demand management policies will work in the absence of a viable alternative to private motor vehicles.

[36] A similar apprehension is expressed about the MRTS (Mass Rapid Transit System) under construction in the city now. For instance, some Indian experts have argued that the cost-effectiveness of metro rail systems needs to be evaluated very carefully: "Current evidence suggests that metro rail systems, especially the construction of two or three lines at great cost, *do not help in reduction of private vehicle use, congestion or pollution*" (Mohan and Tiwari, 1999, p. 1595, emphasis added)

4.6 International experience in controlling vehicular emissions

Tables 4.4 and 4.6 present information on selected urban transport projects and the use of MBIs to abate vehicular pollution, respectively. The projects discussed in Table 4.4 are

- Hong Kong Vehicle Pollution Control Programme
- Seoul Bus Lane Priority Programme
- Bangkok Traffic Management Project
- Santiago Urban Streets and Transport Project
- Brazil Curitiba Urban Transport Project
- Singapore Area Licensing Scheme
- Mexico Transport Air Quality Management Project for Mexico City
- Second Kuala Lumpur Urban Transport Project
- Teheran Transport Emissions Reduction Project

Several projects in the sample focus on reduction in emissions per vehicle through technical fixes such as cleaner fuel, emission standards and technology, and inspection and maintenance programmes. It is also worth noting that unrelated government policies (such as incentives for private car ownership and use in Mexico City and Seoul) undermine air pollution and transport efficiency goals. This observation has particular relevance for the case study on Delhi (chapter 5) where similar incentives are provided, e.g., through subsidised loans for the purchase of cars and two wheelers.

As Table 4.6 shows, many countries use MBIs to control vehicular emissions[37]. Following the discussion in section 4.2 above, however, very few of these instruments are of the classic Pigouvian tax or tradable permit variety. Most of them would be classified as indirect price-based instruments, that is, those that alter prices of outputs or inputs which are complementary or substitutes to the polluting activity. In particular, the use of differential tax rates to encourage use of unleaded petrol or cleaner fuel in general, is widespread. A good example of a direct price-based instrument (in terms of the discussion in section 4.2), would be the deposit refund system for old cars in Greece and Norway and for automobile batteries in Rhode Island, United States. The toll system in Bergen, Norway and the Area Licensing Scheme (ALS) of Singapore are particularly good examples of user charges. In general, there are important lessons here for the case study on Delhi in the next chapter.

[37] While this list of the use of MBIs is extensive, it is not exhaustive. This table is extracted from a more comprehensive review of applications of MBIs in various countries in Appendix 8.

TABLE 4.6

International experience with MBIs for control of vehicular emissions

Australia	Increase in petrol taxes. Price differential between leaded and unleaded petrol in favour of latter.
Austria	Introduced environmental tax on car registration in 1992 based on price of new car and its average petrol consumption. Simultaneously, the VAT rate on new vehicles was reduced.
Belgium	Cars not satisfying emission standards have higher tax rates.
Britain	Various vehicle taxes including: sales tax on new cars (17.5 per cent), and an annual vehicle excise duty. Taxes on commercial vehicle sales, ownership and use are higher and more complex than taxes on private cars (vehicle excise duty is based on number of axles and weight). Tax differential between leaded and unleaded petrol has increased over time and now stands at 4.8 pence per litre. The proportion of unleaded petrol in total sales rose to 50 per cent in 1993 compared to a negligible share in 1986. Cost savings in buying unleaded petrol outweighed the fixed costs of converting cars to run on unleaded petrol for all except those doing few miles/year.
Chile (Santiago)	In 1990, the city allocated bus transit rights and auctioned routes based on fares and types of buses. A tradable permit system for industry was also introduced on fixed sources, with emissions exceeding 1,000 m^3/hr. Emission trade-off, however, is not allowed beyond a day, nor across seasons, and property rights are not well defined.
Canada (provinces)	British Columbia has a tax of C$5 per lead acid battery and some provinces have charges on tires. Leaded petrol has been phased out since December 1990.
Denmark	Since the mid-1980s, leaded and unleaded gasoline have had differential tax rates. In 1994, market share of unleaded petrol was nearly 100 per cent.
Finland	Environmental taxes on cars, based on whether or not they are equipped with a catalytic converter. Tax differentiation in favour of lead-free petrol was introduced in 1986. By 1992, the market share of unleaded petrol was 70 per cent. Since 1993, excise tax on diesel favours sulphur-free diesel.
Germany	Annual motor vehicle tax is structured so as to provide tax incentives to cars meeting EU emission standards. Rates are differentiated by age of the car. Since 1994, diesel engine cars face an additional tax compared to petrol cars. The duty differential between leaded and unleaded petrol is DM 0.10 per litre: market share of unleaded in total sales rose from 11 per cent in 1989 to 80 per cent by 1993.
Greece	A 1990 law provided exemption from the road surtax and the initial lump sum tax for five years for new cars fitted with a catalytic converter. Exemption was given only when the buyer had scrapped his old car. About 300,000 old cars were scrapped and pollution considerably reduced. In addition, there is a *mandatory deposit-refund* on car hulks older than 15 years. The system is combined with a tax differentiation, and the refund is payable only if a new car is bought that satisfies EC emission standards.
Hungary	In May 1992 a tax of 0.7 per cent of the price was introduced on motor vehicle fuels. The revenue is earmarked (through the Central Environmental Fund) mostly for environmental expenditure relating to vehicular traffic, and the remainder for nature conservation and to raise environmental awareness. The tax rate on lead-free petrol is lower than the leaded variety, and consumption tax for new cars with catalytic converters has a discount of Forint 50,000.

Ireland — The excise duty on leaded petrol is higher than that on the unleaded petrol.

Japan — Tax deductions are available for cars with low emissions, electric cars and cars running on alternative fuels.

Luxembourg — Excise and VAT rates higher on leaded petrol than on unleaded petrol by a margin of 2-3 per cent.

Mexico (Mexico City) — In 1990 the price difference between leaded and unleaded gasoline was reduced from 40 per cent to 11 per cent (leaded gasoline being cheaper than the unleaded). By June 1994, the excise tax on leaded petrol was higher than that on the unleaded (though the VAT rate was 10 per cent on both).

Netherlands — In 1988, environmental charges were introduced on fuels, and in 1990, a carbon (CO_2) component was added to the tax base. Sales tax on cars complying with future European standards reduced (and raised for dirtier models). In the 1980s, in the small car market (two-thirds of total market), the percentage of future European standard compliant cars increased from 37 per cent to 70 per cent. Unleaded petrol was made cheaper than leaded petrol – within two months unleaded petrol completely replaced normal petrol in service station forecourts. The carbon tax on motor fuels is too low for significant incentive effects but its revenue funds government environmental investments.

New Zealand — Fee is levied on lead added to gasoline at the rate of NZ$0.066 (US$0.039) per gram – in effect preferential tax treatment of unleaded over leaded petrol.

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Norway — Taxes are based on the sulphur, carbon and lead content of fossil fuels. The CO_2 tax was introduced in 1991 and its revenue represents an important element of the national budget, e.g. in 1994 it contributed 6 billion NKr to state revenues. Since 1986 basic petrol tax differentiates between leaded and unleaded petrol. In 1995, rate differential was introduced for leaded petrol based on the emissions of lead per litre. Introduced *mandatory deposit-refund system* for car hulks in 1978: new car buyers pay a deposit and a larger amount is refunded on return to an official recovery site. Almost 90-99 per cent of car hulks are returned, and the revenues are used for refunds and financial assistance for collection, transportation, and scrapping facilities.

In 1986, the city of Bergen, Norway, introduced a *toll system* for motorists entering the city between 6 am to 10 PM on weekdays, to reduce congestion and pollution. The rate is differentiated by the loading capacity of vehicles. The system can be improved by designing higher tolls for the peak hours only. The toll revenue collected (56 million NKr in 1986, 59 million NKr in 1988) is used to finance the construction of by-passes through the surrounding mountains in order to keep the long-distance traffic away from the city centre. After the by-passes are completed, the tolls will be removed.

Portugal	The tax differential in favour of unleaded petrol being phased out since unleaded petrol sales as a proportion of total sales are about the EU average.
Singapore	Imposed large "additional registration tax" (besides the flat registration fee) levied as a percentage of cost of the car to restrict ownership (and thereby traffic congestion): rates were 100 per cent in 1976 and 150 per cent since 1983. The tax is reduced if an old vehicle is scrapped when a new one is purchased (to discourage older, more polluting vehicles). In 1990, Singapore also introduced a *marketable permits system* for rights to own motor vehicles ("certificates of entitlement"). By mid-1992, the vehicle quota premium for standard cars rose to US$ 12,000. This and complementary policies (e.g., ALS) restricted the growth in car ownership and traffic. Singapore implemented the *Area Licensing Scheme (ALS)* to reduce traffic congestion in 1975. A vehicle entering the restricted zone (encompassing 620 hectares) requires a licence ticket on a daily/monthly basis for the peak hours. By 1989, the fee was highest for company cars, less for private cars/taxis, and least for motorcycles. The fine for non-compliance was about ten times the daily licence price. In 1988, the average violations/day was 100, while the number of licences/ day issued was 12,000. The restricted zone also has higher parking fees, and strict enforcement at 28 points of entry to the zone. Although car traffic rose after 1977, private car traffic was 64 per cent below the pre-ALS flows by 1982 in the peak hours, despite the growth in income and employment. Complemented with other policies, ALS helped reduce the smoke and acidity in the city air.
Sweden	Product taxes on all fossil fuels since 1991. In 1993, gasoline tax revenue was more than 40 per cent of environmental taxes (latter constituted 6 per cent of total tax revenue). With a tax differential of 0.51 SEK/litre between leaded and unleaded gasoline in 1993, the consumption of former was reduced to less than half of the total. In 1991, diesel was classified into 3 categories by pollution potential, and a special diesel fuel tax differentiated by type of diesel was levied. At the same time, there was a tax rebate for producers of the two types of cleaner diesel since 1991. By early 1993, about 75 per cent of total diesel sales constituted cleaner types of diesel (compared to 1 per cent in 1990), and 25 per cent were of the standard variety. Vehicle taxes (sales and annual taxes) are based on vehicle weight and environmental characteristics. Special tax on cars without catalytic converters, and subsidy on new cars with catalytic converters succeeded in introducing low pollution vehicles at a rate faster than normal. There is also a mandatory deposit-refund for car hulks.
Switzerland	With a tax differential of ECU 0.04/litre in favour of unleaded petrol over leaded, the market share of unleaded was 65 per cent in 1992.
South Korea	Introduced environmental quality improvement charges (EQIC), notably emission charges, in 1991. The charges were imposed on large facilities (e.g., leisure complexes, hotels, department stores), and vehicle (buses and trucks using diesel fuel) which discharge air and water pollutants.
Taiwan	Started promoting unleaded gasoline in 1984. In 1989, the price of unleaded gasoline was cheaper than the leaded by a margin of NT$1/litre. Complemented by other regulations on new cars and emissions, the market share of unleaded gasoline increased from 18.7 per cent in 1990 to 51.84 per cent in 1993. The average lead content in ambient air in Taipei decreased from 0.46 g/m in 1989 to 0.18 g/m in 1992.

Thailand	In 1991, began subsidisation of unleaded gasoline to make it slightly cheaper than leaded, in order to reduce atmospheric lead content (1990 USAID study estimated a loss of up to 700,000 IQ points collectively of Bangkok children by age 7, due to elevated blood lead levels). A surtax on leaded gasoline finances the subsidy on unleaded. In Bangkok, unleaded gasoline accounts for 40-50 per cent of the gasoline market.
United States	The federal government introduced a gasoline tax in 1932, while some states already had such a tax as early as 1919 (Oregon). The gasoline tax served as the most important source of revenue for states in 1930s and 1940s. Most of the revenue is earmarked for transportation programmes (road/highway construction and maintenance). Federal taxes on motor vehicle usage include a 12 per cent manufacturers excise tax on trucks and trailers, annual use tax on heavy vehicles like trucks, excise tax on tires weighing over 40 pounds, and a "gas guzzler" tax on automobiles with unsatisfactory fuel economy ratings. States have a range of auto taxes and fees. In 1989, revenues from state motor vehicle and license fees was $10.15 billion. In Rhode Island, US, automobile batteries have a *mandatory deposit* of $5, paid at the time of sale. The dealers hold the deposit (returned if a used battery is returned within seven days of purchase), and are required to return 80 per cent of the deposit funds they hold to the state. The system is considered to be a success.

5. REDUCING VEHICULAR POLLUTION: A CASE STUDY OF DELHI

In this chapter we focus on Delhi as a case study and examine various policy options for reducing vehicular emissions including MBIs. We begin by characterising the policy regime for vehicular pollution abatement in India in general and Delhi in particular, which is essentially CAC in nature (section 5.1). We then examine problems and prospects for implementing MBIs in the Indian context and suggest measures to overcome them (section 5.2). This includes legislative and other actions with respect to the design and enforcement of MBIs in the specific context of India. This is followed by lessons for Delhi from international experience with MBIs for vehicular pollution abatement (section 5.3). In light of this, potential interventions (market based and otherwise) are identified such as an environmental excise duty for new vehicles (section 5.4) The impact of these interventions on vehicular emissions in Delhi is also estimated. Next, we consider the cost-effectiveness of various policy options (section 5.5) as well as the health benefits of an improvement in air quality in Delhi (section 5.6).

5.1 Current policies for reducing vehicular emissions in Delhi

Vehicular pollution in Delhi is addressed mainly through command-and-control (CAC) strategies[38]. In general, the central government has enacted a number of laws for the control of air pollution (which includes motor vehicle emissions) that apply to all of India including Delhi. These are Section 278 of the Indian Penal Code 1860, Environment Protection Act (EPA) 1986, Air: Prevention and Control of Pollution Act 1981 (amended in 1987), Air: Prevention and Control of Pollution Rules 1982 and Motor Vehicles Act 1939 (amended in 1988 and 1994). The government has also notified air quality standards for major air pollutants, such as carbon monoxide, hydrocarbons, oxides of nitrogen, lead, particulate matter, and sulphur dioxide (see Table 3.13 in Part I of this report).

The Ministry of Environment and Forests (MOEF) of the Government of India is the nodal agency which looks into various aspects of vehicular pollution. With respect to motor vehicle emissions in particular, norms are notified under the Environment Protection Act (EPA) by MOEF which apply to the entire country. These are included in the Motor Vehicles Act (MVA) which is enforced by the Ministry of Surface Transport (MOST) since traffic management is primarily its concern. Mass emission standards (gm/km of pollutants emitted) for new vehicles were notified on February 5, 1990 (Table 5.1)[39]. These were revised (made more stringent) in 1996 and standards for the year 2000 were also announced. For the first time, separate obligations for vehicle owners, vehicle manufacturers and for enforcing agencies were stipulated. With respect to vehicle owners, the 1990 rules stipulate maximum volumetric concentration of gases in the exhaust for in-use vehicles[40] and it is the responsibility of owners to ensure their vehicles meet these limits. Similarly, manufacturers are responsible for ensuring that new vehicles meet the mass emission

[38] Policies for vehicular pollution abatement in Delhi are a hybrid of central and city government initiatives since Delhi is not a state but (largely) a centrally administered Union territory. The situation is further complicated by the intervention of the Indian Supreme Court after a series of public interest litigations (PILs) or class action suits were filed. In particular, the court has created an Environment Pollution (Prevention and Control) Authority (EPCA) that reports directly to it and suggests policies for pollution abatement in the city.

[39] Mass emission standards refer to gm/km of pollutants emitted by a vehicle during mass emission tests conducted under specified driving conditions.

[40] Idling carbon monoxide (CO) for 4 wheeled petrol driven vehicles should not exceed 3 percent by volume. For petrol driven 2 and 3 wheelers, the corresponding figure is 4.5 percent.

TABLE 5.1

Emission standards for new motor vehicles in India (as on April 1996), gm/km

Vehicle type	CO	HC	HC+NOx	NOx
2-wheelers	4.5	-	3.6	-
3-wheelers	6.75	-	5.4	-
Cars	8.68-12.4	-	3.0-4.36	-
Diesel vehicles (> 3.5 tonnes)*	11.2	2.4	-	14.4
Diesel vehicles (< 3.5 tonnes)*#	14.3	-	2.7	-

* figures for diesel vehicles are in gm/kWh (kilowatt hour)

figures pertain to 1991 standards

NOTE:

1. Standards are for warm start emissions, i.e., when engine has reached operating temperature and emissions are reduced. Same figures for cold start (when emissions are higher) would imply more stringent standards.

2. Driving cycle (which simulates average driving pattern such acceleration, cruising, deceleration, etc.) is not defined.

SOURCE: Centre for Science and Environment, 1996, Tables 3.1.1 and 3.1.2

standards prescribed, whereas officials of enforcing agencies (police or transport department) are empowered to check vehicle emissions. In addition, fairly stringent Euro I and II emission norms[41] for Delhi were notified by the Supreme Court on April 29, 1999. The notification makes it mandatory for car manufacturers to conform to Euro I and Euro II norms by May 1999 and April 2000, respectively, for new non-commercial motor vehicles sold in Delhi[42].

While the entry of multinational companies with new fuel-efficient technologies in the area of engine design, improved chassis structure, etc., has had a positive impact on emissions, compliance with Euro norms will require further changes in engine design. Specifically, to comply with these norms a multi point fuel injection (MPFI) system is needed and for this the engine design has to be modified, not merely retrofitted. Thus, of all vehicle components the engine is the one most affected by changes in emission norms. Compliance with these norms will entail an increase in production cost, some or all of which could be passed on to consumers.

Some of the policies initiated by the government to combat vehicular pollution in Delhi and in other parts of India are:

- Unleaded petrol and low sulphur diesel have been introduced. Unleaded petrol was introduced in the four major metropolitan cities (Delhi, Mumbai, Calcutta and Chennai) in April 1995[43]. Since September 1998, only unleaded petrol is sold in Delhi and is even used by cars without catalytic converters. Contrary to international experience cited earlier, the switch from leaded to unleaded petrol in Delhi was not made through differential pricing but by eliminating supply of leaded petrol completely. With respect to diesel, its sulphur content was 1 percent till 1997 when it was reduced to 0.25 percent (known as ELSD or extra low sulphur diesel) for the metro cities and for areas around the Taj Mahal (Taj trapezium). In September this year, supply of diesel with 0.05 percent sulphur content (ULSD or ultra low sulphur diesel) to Delhi was commenced[44]. Diesel with 1 per cent sulphur content has been completely phased out from the country. Again, as in the case of unleaded petrol, there was no attempt to use differential pricing for encouraging cleaner diesel (as in Sweden and Norway – Table 4.6).

[41] As in the case of other emission norms these are mass emission standards stated in terms of maximum allowable amounts of CO, HC and NOx in gm/km.

[42] At present these norms apply to motor cars only but the Supreme Court has recently suggested that they be extended to two and three wheelers as well (TOI 1999a).

[43] The rest of the country is expected to be covered by the year 2000.

[44] To this end, the state owned "Indian Oil Corporation Limited (IOCL) has invested Rs. 46.7 billion to make process changes at its refineries to upgrade the quality of its petrol and diesel to make the products more environment friendly." (TOI 1999b) US$1 = Rs. 43 approximately.

- Compressed natural gas (CNG) has been introduced as an alternative cheap and clean fuel in Delhi, Mumbai and Baroda. By installing a CNG kit, petrol vehicles can be converted to CNG. Inadequate supply of CNG and the high cost of the kit, however, have affected its acceptance among consumers. Under orders of the Supreme Court all 7,000-odd buses in Delhi are to be converted/replaced by CNG buses by March 31, 2000.
- As mentioned earlier emission norms for all categories of petrol and diesel vehicles have been introduced at the manufacturing stage. Mass emission standards for vehicle manufacturers came into force in April, 1991. These were tightened in 1996 and will again be in 2000.
- Pre-mixed fuel (petrol and lubricating oil) for use in two-stroke engines of two and three wheelers has been introduced at petrol stations in Delhi and elsewhere[45]. This is in response to the fact that drivers often use too much oil in the erroneous belief that this is good for the engine (with disastrous effect on emissions).
- Poor maintenance of vehicles adversely affects their emission efficiency. The role of maintenance in combating vehicular pollution was reflected in a government policy which for the first time in 1989 made a certificate of fitness mandatory for registration of all public and commercial vehicles and for personal vehicles older than 15 years. This does not, however, specifically target the vehicle's emission performance. In addition, as stated above the 1990 vehicle emission rules require all motor vehicles to comply with notified emission standards – it is now mandatory for every motor vehicle to obtain a certificate of pollution under control (PUC) every three months. (Only CO, however, is measured.)
- In Delhi, under Supreme Court orders, commercial vehicles older than fifteen years and taxis and autorickshaws (three wheelers with two stroke engines) older than ten years, are prohibited from operating. This, however, does not apply to the thousands of truck and other vehicles entering the city from other states.
- Steps to check fuel adulteration
- Monetary fines for violating emission standards. The fines are fixed charges rather than related to the extent of violation.

Except for fines for non-compliance with emission standards, economic instruments are absent among policies for controlling vehicular emissions in Delhi. At the same time the critical state of atmospheric pollution in Delhi described in chapter 3 is a clear indication that policies currently in use have failed to have the desired impact. The major thrust of the regulatory (and more recently judicial) efforts is towards enforcing mass emission standards for new vehicle and volumetric emission limits for in-use vehicles. *With reference to the analytical framework developed in section 4.3 above, there is no attempt at demand management to reduce vehicle kilometres travelled (VKT) or to create disincentives for the use and ownership of private vehicles*.

Even with respect to end of pipe emissions, most of the emphasis is on new vehicles. In-use vehicles have not been given much importance except for volumetric emission limits, that too only for CO. A vehicle's emissions, however, are directly proportional to its vintage. In other words, old vehicles pollute more and incentives for scrapping old vehicles are required. The age composition of Indian vehicles (Table 5.2) shows that new vehicles (up to 5 years old) constitute only about 37 percent of all registered vehicles with the remaining roughly two-thirds of total vehicle population being older. Among cars and jeeps, only 31 percent are five years or less in age. The table also shows that more than one-third of all vehicles are more than ten years old, that is, they belong to the period when there were no emission norms. Since the two wheeler segment was liberalised in the early eighties, the figure for two wheelers which are more than fifteen years old is much less compared to other categories. This has pulled down the average age profile for all vehicles since more than two-thirds of total vehicles consist of two wheelers. In all other vehicle

[45] As pointed out in chapter 3 (section 3.1) despite a discernible shift towards cars in Delhi, the major portion of personalised transport comprises two-wheelers, and of these a very high proportion run on two stroke engines. They are the worst offenders vis-à-vis SPM and HC emissions.

TABLE 5.2

Age composition of vehicle population, all India (per cent)

Age	All vehicles	2 and 3 wheelers	Cars and jeeps	Buses	Goods vehicles	Other
1 year (1997)	10.7	10.8	10.5	12.3	21.2	4.3
2-5 years	26.7	28.7	21.0	17.8	12.0	29.8
6-10 years	30.0	30.6	25.5	22.1	23.4	26.8
11-15 years	17.5	18.0	16.2	14.0	16.4	16.2
> 15 years	16.0	11.8	26.4	33.8	27.0	22.8
All ages	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: Vehicle registration figures from AIAM

categories (except two wheelers) about 40 percent of vehicles are more than ten years old while for buses this figure is nearly 50 percent. While the actual pollution caused by these old vehicles is difficult to calculate, it is obvious from this discussion that a more focused approach towards older in-use vehicles is needed.

Further, control of emissions from in-use-vehicles is not in the domain of vehicle manufacturers but in the hands of end users as the vehicles are subjected to a variety of usage, fuels, lubricants and maintenance practices. The automotive industry can at best play a supportive role by arranging for free camps to check emissions from in-use vehicles and tuning them up for compliance with CO limits, creating awareness among users for proper maintenance of their vehicles, etc.. In fact, proper maintenance alone can reduce emissions considerably. In sum, a two-pronged strategy for new and in-use vehicles, respectively, is called for.

Moreover, other policies such as those to encourage clean fuels like CNG appear to be half hearted and ineffective. It also appears unlikely that the Delhi government will be able to meet the Supreme Court deadline on CNG buses by next March[46]. Another major policy to address vehicular pollution in Delhi is to build a metro rail system, the first phase of which (55.3 kms.) is to be completed by March 2005 at a cost of 48.6 billion rupees (US$1 = 43 rupees approx.). Supporters of the project claim that it will reduce the pollution load in the city by 258 metric tonnes daily (TOI 1999c). As discussed in chapter 4, however, it is debatable whether this project will achieve the emission reduction envisaged (Mohan and Tiwari op. cit.).

5.2 Problems and prospects for using MBIs in India

In order to move from the theory of MBIs (sections 4.1 and 4.2) to actual practice, it is necessary to examine potential problems (and identify solutions) in using market based approaches for environmental protection in general in the Indian context. This is because MBIs for vehicular pollution abatement cannot be viewed in isolation from the overall context in which they are implemented. For instance, the manner in which unleaded petrol was introduced in Delhi without resorting to any economic incentives (contrary to international practice), or for that matter the entire gamut of CAC policies for vehicular pollution abatement, reveals something about the mindset in India. In this section we classify barriers to the implementation of MBIs into four broad groups and suggest possible solutions. As we see below, some barriers particularly institutional and organisational are not unique to MBIs and apply equally to a CAC regulatory regime as well.

[46] At present about 100 buses can be converted from diesel to CNG every month with a possible increase in capacity to 500 buses per month. Even at this higher rate Delhi government's transport minister Mr. Parvez Hashmi admits that it would take a year and a half to convert all the 7,000 buses to CNG – a year in excess of the Supreme Court deadline of March 2000 (Sharma 1999a). This is also assuming that CNG technology will be technically viable – the engine of the first CNG bus introduced in July this year overheated and the bus had to be withdrawn from service (Sharma 1999b).

5.2.1 Policy barriers

(i) The biggest policy barrier is inadequate understanding of MBIs among all stakeholders (policy makers, industry, NGOs, intelligentsia and people at large) at all levels. This results in a number of misconceptions about MBIs, not only among the general public and NGOs, but among industry and policymakers as well. While there are a number of legitimate concerns about MBIs such as the problem of thin markets, it is not true that MBIs are a “license to pollute” as is often argued. A better understanding of what MBIs can and cannot do and wider dissemination of information about their actual track record in other countries (particularly developing countries), is vital for their general acceptability.

(ii) More generally, market based approaches are part of an overall economic approach to environmental problems. Unfortunately, while regulatory agencies and industry have a number of competent technical staff such as environmental scientists and engineers, neither has environmental economists[47].

(iii) There is a large lobby among stakeholders in favour of status quo. Most of them favour fine tuning of the current policy regime rather than a major paradigm shift entailed by MBIs. For example, firms that have invested heavily in pollution abatement equipment do not stand to gain much out of differential abatement implicit in MBIs. Further, many firms are still in the rent-seeking mindset of the “license-permit raj”[48] – they are more comfortable with a CAC regime where they can lobby and manipulate regulators and regulations, than with a market based regime where they have to play in a competitive market. For example, in the case of vehicle emission standards, the strategy of Indian auto makers was to keep lobbying for extension of the deadline for compliance[49]. Similarly, the bureaucrat-dominated regulatory agencies in India are more comfortable with CAC and deeply suspicious of markets (see 5.2.4 below). In short, it is not apparent that there is a serious commitment to MBIs among various stakeholders.

(iv) In addition to a bias towards direct regulation, enforcement agencies such as MoEF, CPCB, SPCBs and state transport departments, lack policy analysis capability. This makes it difficult for them to take a holistic and long-term view of environmental issues whether they be transboundary environmental problems such as climate change or vehicular pollution. Most agencies are preoccupied with day-to-day administration, litigation and answering legislative queries. Due to these short-term pressures they are unable to focus on “big picture” issues, and even if they would like to they lack the ability to do so. With respect to vehicular emissions in particular, the government of Delhi has mostly been reactive (to court orders and PILs) rather than proactive in terms of formulating a long term plan.

(v) A major legal barrier is that enabling changes in current laws are required to allow differential abatement entailed by MBIs such as an emissions tax or permits. Since the CAC regime is enshrined in the current legislation, new legislation to supersede/modify existing laws (such as the Motor Vehicles Act) is required.

5.2.2 Institutional and organisational barriers

We concern ourselves here with issues of governance which are a major barrier to successful implementation of MBIs. As mentioned earlier, however, good governance is not required for MBIs alone but for any pollution abatement regime. One problem of governance not explicitly mentioned below but which is a backdrop to everything else is corruption. Bribing of regulators

[47] This is both a problem of supply and demand since this area of economics is in its infancy in India, and there are very few environmental economists in the country.

[48] The license permit rule – an often used shorthand description for dirigism in India which has now been partially undone.

[49] This eventually resulted in a backlash as citizens and courts lost patience with such dilatory tactics. In fact, the activist stance of the Supreme Court now and its perceived draconian decisions have to be viewed in this context.

at various stages of monitoring and enforcement can render MBIs ineffective. To repeat, however, this problem is not unique to MBIs.

(i) While there is an elaborate institutional framework in place for pollution abatement at the national and state level, it is not very effective and needs to be strengthened. Moreover, there is hardly any capability at the local/municipal level to address environmental problems such as vehicular pollution.

(ii) In particular, enforcement agencies at the state level such as transport departments are not autonomous. This limits their effectiveness. Moreover, they are often managed by non-specialists and bureaucrats who do not understand the complexities of pollution abatement. To an extent, this is also true at the central level where the Ministry of Environment and Forests (MoEF) is dominated by generalists[50].

(iii) Further, monitoring and enforcement are areas where institutional deficiencies are critical with respect to the use of MBIs in India. It is often argued that MBIs require more intensive monitoring and enforcement as compared to CAC.

(iv) There is lack of accountability and transparency with respect to regulatory agencies as well as industry. With respect to accountability, there is no provision to prosecute officials who are derelict in implementing the law. Further, punitive measures that do exist in the law (e.g., imprisonment) are rarely invoked. Another aspect of lack of accountability is that unlike private firms which face "hard" budgets, state-owned enterprises (SOEs) are less responsive to market forces[51]. With respect to vehicular pollution in Delhi, some of the worst offenders are the large, antiquated fleets of SOEs such as the Delhi Transport Corporation (DTC) and other state road transport companies. With respect to transparency, there is inadequate access to the decision-making process and to information on the nature and extent of pollution.

5.2.3 Financial barriers

(i) While total cost to society for meeting environmental standards can be less in theory under MBIs than CAC (as argued in chapter 4.1), under some MBIs the cost to individual polluters could be higher. For instance, under a system of tradable permits (which are not distributed free to polluters but have to be purchased), they pay for both the right to pollute (i.e., permits) as well as for any abatement that they undertake. Similarly, for MBIs such as a flat rate tax on vehicle emissions, vehicle owners pay tax on all uncontrolled emissions as well as incurring abatement costs for the amount of emissions that they do control[52],[53].

(ii) Unlike the current CAC system since MBIs entail financial transactions, there could be greater scope for malpractice, and the issue of credibility in managing these funds would become critical. Another problem in this context could be controversy regarding how revenue from instruments such as taxes or auction/sale of permits should be used.

5.2.4 Political and cultural barriers

We discuss here socio-cultural and other problems which are hard to define but are perhaps the most critical vis-à-vis implementation of MBIs in India.

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[50] Out of a total staff of about 1200, MoEF has only 70 odd scientific and technical personnel.

[51] Thus, unlike private firms, SOEs face "sof"" budgets. The phrase "soft" budgets was initially coined in the context of formerly centrally planned economies of central and eastern Europe to indicate the latitude SOEs have in ignoring market forces through incurring losses or by mark-up pricing (by virtue of their monopolistic power).

[52] A uniform tax, of course, is only one of several possible tax schemes. For instance, under a "standard plus" scheme tax is levied only on emissions in excess of a given standard and avoids this double burden. A "pollution prevention rebate" scheme goes even further – vehicle owners that reduce emissions *below* the standard are actually given a rebate.

[53] For the non-economist we should clarify that expenditures on taxes or purchase of permits are considered *transfers* within society not affecting the real resource cost of compliance. However, since they do reflect an out-of-pocket expense for individuals/firms they do increase the cost of compliance for these entities.

(i) Recent reforms notwithstanding, India has a long tradition of dirigism. For historical and other reasons which we do not go into, Indian policymakers and intelligentsia generally view markets with suspicion. This is also true in the context of environmental policies. Thus, given the mindset of the regulators and the regulated, it is not surprising that traditional CAC approaches have been relied on so far. This mindset is also a major obstacle to implementing MBIs. As mentioned earlier, most stakeholders are comfortable with status quo (in terms of the policy regime) despite clear evidence that the current regime has failed in abating pollution.

(ii) In addition to regulatory agencies, politicians too would lose a lot of discretion and influence under a market based regime and would therefore be reluctant to embrace it.

(iii) Government agencies at all levels in India do not have a tradition of openness and public participation. Since colonial times the government and its decision-making processes are generally viewed as being removed from the people. While this style of functioning would suffice for a heavy handed regulatory approach, it would be a problem for MBIs, particularly when they are being phased-in and when dialogue, discussion and debate would be required.

(iv) In a pluralistic society like India where various interest groups (industry, labour, farmers, etc.) jostle to extract concessions from the state, a sense of being entitled to handouts or a "free lunch" is deeply rooted in the Indian psyche. By corollary, people are reluctant to pay for services whether they be highway tolls, user fees for roads/parking, or emission taxes. Thus, there is resistance to "pay" for the use of clean air or road/parking space as would be the case under MBIs.

5.2.5 Is there a way out? possible solutions

The preceding discussion presents a formidable list of potential barriers to the implementation of MBIs in the Indian context. These problems, however, are not insurmountable. While specific suggestions are made below, by far the most important requirement is that there should be a desire and commitment towards MBIs on part of all stakeholders. We do not prioritise the recommendations below. Some of them are obviously easier to implement than others. Similarly, some of them may take longer to implement than others.

(i) There is need for a better understanding of MBIs on part of key players, namely, industry, regulators, citizens and NGOs. To this end, it is important for these parties to initiate thorough discussion and debate (but within a limited time frame) on MBIs.

(ii) It is necessary to strengthen the knowledge base for MBIs. Information on best practices vis-à-vis MBIs around the world should be compiled and analysed for possible lessons for India and for Delhi. This information should be regularly updated since applications of MBIs around the world are increasing rapidly.

(iii) Policy analysis units should be established at central and state level agencies staffed, inter alia, by economists which take a holistic and long-term view of economic approaches to environmental problems. These units could also undertake activities mentioned in (i) and (ii) above, such as initiating a debate on MBIs and compiling best practices.

(iv) More broadly, in order to bridge the gap between technical and economic aspects of environmental management, there is an urgent need for capacity building in environmental economics in the country. It is necessary to integrate economics and environment in universities and colleges at the stage when environmental professional are being trained. In addition, regulators and corporate managers in the environmental field should be exposed to economic approaches to environmental problems.

(v) The overall process of deregulation and globalisation of the economy should be maintained and even accelerated. A more market-oriented mindset would help in the acceptability of MBIs as well. Similarly, pressure to reduce the fiscal deficit by reducing expenditure should result in downsizing of government. In addition, privatisation of SOEs (which is slowly getting under way in India) will go a long way in increasing their accountability. In the overall context of deregulation, there should be a careful review of environmental functions the government could withdraw from – a knee-jerk response of solving problems by laws and regulations should be avoided.

(vi) There should be a comprehensive overhaul of the functioning of enforcement agencies and they should be made autonomous of state interference. It should also be ensured that these agencies are managed by environmental experts rather than generalists. While some agencies face resource constraints, it is generally agreed that lack of autonomy is a greater problem than paucity of resources. Further, it is not enough to prosecute vehicle owners or manufactures for violating the laws. Regulators should also be held liable for failing to enforce regulations. If regulators are also prosecuted they will be more vigilant and alert.

(ix) Existing environmental laws should be amended and/or new ones enacted to empower central/state governments to prescribe MBIs. Before this can happen, however, it will be necessary to convince the political establishment at the highest levels about MBIs.

(x) A key requirement for bringing about greater transparency and accountability (which are critical for effective functioning of MBIs) is right to information. It is necessary to build this requirement into environmental laws and to implement it seriously.

5.3 Policy implications of international experience for abating vehicular emissions in Delhi

- Focusing on reductions in emissions per kilometre, as in the United States, has only a limited impact on aggregate vehicular emissions since it does not affect VKT. On the contrary, in the US even as cars became cleaner, vehicle miles travelled by an average driver doubled between 1970 and 1988. In other words, while technical fixes have been used in many countries such as the US (section 4.6), they are not in themselves enough to curb vehicular emissions. Behavioural modifications are also crucial.

- With respect to curbing demand for travel by private motor vehicles while it is important to provide a viable "supply" of public transport as an alternative (section 4.5), the two measures need to go hand in hand. There are two reasons for curbing demand for private travel in the context of augmenting supply of public transport. First, this ensures adequate usage of the public transport alternative and second it also ensures that there is no net increase in private travel as a consequence of reduced congestion.

- If sequencing between supply augmentation and curbing demand is necessary, the latter should precede the former. Otherwise, for Delhi in particular it has been noted that increased availability of road space, wider and more bridges across the river Yamuna, etc., simply create incentives for more private travel. Similar outcomes are possible for the proposed MRTS which may nullify the projected reduction in vehicle emissions (see section 5.1 above).

- The experience of Mexico City and Seoul show that incentives for private car ownership and use undermine air pollution and transport efficiency goals. In Delhi (and in the rest of the country) subsidised loans by employers (government, public sector and private companies) for purchase of motor vehicles, also undermine efforts to curb vehicular emissions. Moreover, recent revisions in wages for government employees by the Fifth Pay Commission have also enhanced the ceiling for these loans (even as vehicle prices have declined in real terms). Additional perverse incentives in the form of (inflation-indexed) "vehicle allowance" not only encourage use of private motor vehicles but also insulate operating costs (mainly fuel) against inflation, thus making private travel demand virtually price inelastic. Such perverse incentives for vehicle ownership and use should be done away with and instead use of public transport by employees should be subsidised[54].

- There is a need for using economic incentives to scrap older vehicles as in the case of Greece (Table 4.6).
- Differential pricing of fuels such as petrol and diesel should be used to encourage cleaner varieties as in the case of Sweden, Norway and a host of other countries (Table 4.6).
- In the context of CAC policies also, such as inspection and maintenance, it is important to strengthen institutional capability as a complementary measure. In Delhi, for instance, the traffic police has a strength of only 2,000 for monitoring over 3 million registered vehicles in the city.

5.4 Policy options for abating vehicular emissions in Delhi: an analysis

Following the discussion above we propose two broad types of policies – for new vehicles and for in-use vehicles, respectively. The main policy recommended for reducing new vehicles emissions, the environmental excise duty (EED), is in lieu of the current emphasis on mandatory emission standards such as the Euro norms. As discussed below, EED is in the nature of a "second-best" tax. With respect to emissions from in-use vehicles a range of options are explored from CAC to market based interventions.

5.4.1 Environmental excise duty for new vehicles

With respect to new vehicles the central government could levy an environmental excise duty (EED) on manufacturers of motor vehicles in proportion to their level of tailpipe emissions[55]. In other words, manufacturers would be charged a duty on each vehicle that would be proportional to the emissions of specific pollutants[56]. Taxes based on this principle already exist in Germany, Japan, the Netherlands, and several other countries (Table 4.6). In Germany, for example, the annual motor vehicle tax is structured so as to provide tax incentives to cars meeting EU emissions standards. The rationale for EED and recommendations on specific rates, are spelt out below.

Before we describe the EED in detail, we characterise the first-best tax as a benchmark with which the EED can be compared. Like any other form of pollution, vehicular pollution is an externality. The standard economic prescription for externalities is to induce polluters to internalise (i.e., take into account) the costs imposed on others. This can be done in several ways of which emission taxes are one (section 4.2). Ideally, this tax should be levied on the actual emissions generated by each vehicle per tax period (i.e., per quarter or per fiscal year)[57]. Two aspects of vehicular emissions, however, make it difficult to implement this "first best" solution: the sources of vehicular emissions are mobile[58] and many. Thus, unlike emissions from stationary sources, a

[54] For instance, conveyance allowance could be given only to those employees who commute by public transport or "chartered bus" (private buses on contract to carry office commuters).

[55] In general, excise duties are indirect commodity-based taxes levied by the central government. They are an important source of revenue. Indirect taxes in India account for almost 70 per cent of total tax revenue. Two major indirect taxes are customs and excise duties which account for 31per cent and 37 per cent of total tax revenue, respectively. Part of this revenue is ultimately shared with the states.

[56] For instance, in the case of petrol vehicles where three pollutants are targeted, namely, hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx), EED could be calculated as follows: EED = D1(HC) + D2(CO) + D3(NOx). D1, D2, and D3 are rates for EED (in Rs.) per gram/kilometre of HC, CO, and NOx emitted, respectively. We discuss this further below where actual rates for EED are recommended. A variant of this scheme was first proposed some time back (Mills and White, 1978).

[57] In other words, a "first-best" pollution tax is levied on in-use vehicle emissions at the rate of Rs. *x* per gram of pollutant, say t. Thus, the total tax bill (T) for a vehicle owner in a tax period is = tax rate (t) x emission rate of pollutant in grams/kilometre (e) x vehicle kilometres travelled (VKT). e is the pollution intensity of the product (the vehicle), whereas VKT is the level of output. For any given tax rate t, a vehicle owner can reduce the tax burden by reducing e and/or VKT. In other words, $dT = [(\partial T/\partial e)\, de + (\partial T/\partial VKT)\, dVKT]$.

[58] It is for this reason that vehicular pollution is also often referred to as *mobile source pollution*.

TABLE 5.3

Current rates for excise duties on motor vehicles

Duties are levied ad valorem and are differentiated by different types of vehicles:

Motor vehicles

1.	Motor vehicles for the transport of goods	40 per cent
2.	Motor vehicles designed for carrying 7 persons or less including driver	40 per cent
3.	Motor vehicles designed for carrying 8 to 13 persons including driver	20 per cent
4.	Motor vehicles designed for carrying more than 13 persons including driver	15 per cent
5.	Special purpose motor vehicles (e.g., ambulances, fire tenders, breakdown vans)	15 per cent

NOTE: 3-wheelers are treated as a special class of motor vehicles listed above in 1-5. Whether they carry goods or passengers, a concessional rate of excise duty of 15 per cent is applied to them.

Two-wheelers

6.	2-wheelers with engine capacity greater than 75 cubic centimetres (cc)	25 per cent
7.	2-wheelers with engine capacity 75 cc or less	15 per cent

SOURCE: Jain (1996), Chapter 87

vehicle may travel hundreds of kilometres and emit in many different locations[59]. In addition, there are many of them: Delhi alone has over three million registered vehicles. While these features do not change the basic prescription of internalising the externality through Pigouvian taxes, they make it difficult to administer these taxes in practice. In addition, monitoring actual (in-use) vehicle emissions requires technologies like remote sensing, which have not been applied anywhere in the world so far.

In view of the problems mentioned above, EED is recommended as a "second best" practical measure to curb vehicular emissions. It would be easy to administer since it would be levied on manufacturers of motor vehicles who are relatively few in number. The government already has a machinery in place for the collection of excise duties motor vehicles (see Table 5.3 for rates). The only difference between a conventional excise duty and EED is that while the former is ad valorem, the latter is levied on the emissions rate for new vehicles, e (see footnote above). The rationale for EED is that producers should be liable for producing an environmentally "dirty" good. It is, of course, true that vehicular pollution does not arise during the production of the good but during its consumption (use). It is also true that how polluting a vehicle is also depends on how it is maintained, and how intensively it is used (total annual emissions = emissions rate per km. x kms used in a year). Nevertheless, there are certain characteristics of a vehicle, such as its engine technology (2 stroke versus 4 stroke, fuel injection versus carburettor) and emissions control technology (e.g., whether it has a catalytic converter or not), that are determined by the producer, and which critically influence its emissions rate, e. In other words, the technology embodied in a vehicle inherently limits how "clean" the vehicle can be.

In this context, EED attempts to achieve two objectives: (i) it attempts to recover from vehicle manufacturers the cost imposed by their product on the environment[60], and (ii) it encourages

[59] In fact, this would be a reason for not having a uniform tax rate t but constructing it as a weighted average of differentiated tax rates on the basis of marginal social damage in different areas where a vehicle travels.The weights would be proportional to the VKT in different areas. For instance, a truck plying in Delhi and rural areas would be charged a tax rate that would be a weighted average of two rates. This procedure would (undoubtedly) be extremely complicated!

[60] Some or all of this burden will be passed on to buyers through higher vehicle prices, who will then share the liability for environmental pollution. The burden sharing will, of course, depend on the price elasticity of demand (see discussion below). It should be noted that in the case of Euro norms as well part of the higher costs of compliance are passed on to consumers through higher car prices.

them to produce cleaner products by giving them an economic incentive to do so – the lower the level of emissions the less is the amount of duty paid. In addition, rather than the all-or-nothing nature of emission standards at present, EED allows vehicle manufacturers to reduce emissions incrementally. Thus, they can reduce their tax bill for each gram/kilometre (or fraction thereof) of emissions reduced. In this sense, EED is a fiscal incentive that should be welcomed by vehicle manufacturers. EED does not mandate technologies for abatement. Manufacturers are free to choose whether and how they reduce emissions: in principle, it would be legal to sell any vehicle, regardless of how dirty it is, provided EED is paid. The implications of this and the safeguards required are spelt out below.

5.4.1.1 Limitations of environmental excise duty

It is important to mention three potential limitations of EED, and highlight complementary policies that would be required to address some of the incentive effects of EED. Since EED is to be levied on new vehicles, it does not address pollution from in-use vehicles for which separate policies are suggested. Nevertheless, due to the inherent problems of taxing mobile source pollution mentioned earlier, EED remains an attractive option to address pollution from new vehicles, and in any event the two are not mutually exclusive. More important, however, in the post-liberalisation period new vehicle sales in the country have grown phenomenally[61]. In addition, demand projections for the year 2000 estimate the market new vehicles between 4-8 million per year (Shah 1996). What all this means is that the average age of the vehicle fleet in the country will decline. Thus, it is important to focus on the new vehicles emissions (in addition to devising strategies to address emissions from in-use vehicles).

Second, EED is a “blunt” policy instrument to reduce vehicular emissions, since it will also affect vehicles sold in areas where the marginal social damage (MSD) of pollution low – for instance, in semi-urban and rural areas. While it is possible, in principle, to set different rates of EED for low/high polluted areas, we do not recommend this since it would create enforcement problems[62]. The inefficiency of a uniform EED, however, is mitigated to an extent because of the high correlation between urbanisation and motorisation[63].

Finally, EED may increase the cost of new vehicles (as would Euro or other emission norms). This, of course, would depend on the costs incurred by manufacturers for vehicle modifications, and the extent to which these are passed on to buyers which in turn depends on the price elasticity of demand. While (surprisingly) there are no estimates of demand elasticity (aggregate or by vehicle type), anecdotal evidence leads us to believe that the 2 wheeler segment is more sensitive to price changes than 4 wheelers[64]. As a corollary to an increase in the price of new vehicles, the demand for used vehicles (and their prices) may increase[65]. Thus, on the margin potential buyers of new vehicles may now decide to postpone their purchase (and hold on to their old more polluting vehicle longer), or first-time buyers may choose to buy a second hand vehicle rather than a new one. We would need to offset this negative incentive effect.

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[61] Sales of new vehicles (exclusive of exports) increased by 25 per cent in 1994-95 and in 1995-96 (AIAM, 1996a, page 108).

[62] This is an important lesson from the experience with catalytic converters which were made mandatory for new cars registered in metropolitan cities since April 1995. Since such cars required unleaded petrol and till last year only selected pumps in Delhi sold unleaded petrol, this requirement was often evaded by car owners registering their vehicles in neighbouring states (Centre for Science and Environment 1996).

[63] In fact, the percentage of urban population is one of the most important determinants of motorisation, i.e., motor vehicles per 1000 population (see for instance, Faiz et al., 1990, Table 14).

[64] This is partly a consequence of the fact that the market for 2 wheelers was liberalised much before that for 4 wheelers, and consumers have much more choice. Moreover, some of the demand for new 4 wheelers is from institutional owners (government, corporations) and more affluent sections of society, all of whom are relatively impervious to price changes. As an aside, Shah (1996) does report elasticities of car population (and other vehicle types) with respect to GNP (op. cit. p. 5.14-5.15). What we require, however, are demand elasticities by income group. In any event, the GNP elasticity figures bear out our intuition: elasticity of car population to GNP is lower (1.8) than that for 2-wheelers (4.5).

[65] This is a standard result in all cases of *differentiated regulation* which create a bias against new sources of pollution (see Gruenspecht 1982).

5.4.1.2 Rates for environmental excise duty

Separate rates are recommended for 2 and 3 wheelers and for 4 wheelers, respectively. The basis for these rates is indicated in Annex 9. For each vehicle type, there are two duty slabs based on an emissions cut-off, namely, emissions standards for the year 2000. In other words, to avail the lower duty slab, vehicles would have to meet the year 2000 standards for CO, and for HC+NOx. Within each slab, EED would be based on aggregate emissions of CO, HC and NOx. Thus, there is an element of progressivity built into the rate structure.

We do not support the view that there should be EED exemption for vehicles that meet the 2000 emission norms. This view is motivated by the fact that vehicle manufacturers should be prodded to move faster towards 2000 norms (for instance through EED) and rewarded if they do so. Granting EED exemption, however, will not provide any incentive to reduce emissions *below* 2000 standards. It is also important to emphasise that the marginal contribution of all vehicular emissions to pollution is the same, whether it is a zero emissions vehicle going from zero to 1 gram/km or a "dirty" vehicle going from 19 to 20 grams/km – *ceteris paribus*, the extra gram from both vehicles impacts equally on air quality. Nevertheless, as we see below EED rates for vehicles meeting 2000 standards are only a tenth of those that do not.

(*a*) EED for 2 and 3 wheelers (petrol):

Slab 1 (emissions greater than 2.0 gm/km of CO *and* 1.5 gm/km of HC+NOx): **EED = Rs. 550/gm/km of (CO + HC + NOx)**[66]
Slab 2 (emissions up to 2.0 gm/km of CO *and* 1.5 gm/km of HC+NOx): **EED = Rs. 55/gm/km of (CO + HC + NOx)**

(*b*) EED for 4 wheelers (petrol):

Slab 1 (emissions greater than 2.72 gm/km of CO *and* 0.97 gm/km of HC+NOx): **EED = Rs. 650/gm/km of (CO + HC + NOx)**
Slab 2 (emissions up to 2.72 gm/km of CO *and* 0.97 gm/km of HC+NOx): **EED = Rs. 65/gm/km of (CO + HC + NOx)**

In addition, these rates should be increased every fiscal year in real terms[67]. *A gradual racheting up of EED is a crucial component of our recommendations* because a key objective of EED is to encourage manufacturers to *gradually* phase-in fundamental changes in technology which results in significantly cleaner vehicles. In our opinion, once manufacturers are confronted with EED they have three choices: (i) to pay the duty and carry on with business-as-usual; (ii) to reduce emissions to the extent possible through minor modifications and invest in R&D (in the short- and medium-run), and at the same time introduce new technologies such as 4-stroke engines for two wheelers, MPFI, etc. (in the long-run), and (iii) introduce new technologies immediately.

We feel that (ii) is the most desirable option where manufacturers start exploiting opportunities for marginal reduction in emissions right away, while looking for ways to significantly lower them in the long-run. In this context, it is important that the rates should neither be too low nor too high. Too low a rate would imply that manufacturers would "pay and pollute", whereas a

[66] Unlike the EED formula in a footnote above, we do not propose different rates for the three pollutants, namely, D1, D2, and D3. This allows manufacturers to trade off reductions across pollutants on a one-to-one basis.

[67] By using the appropriate component of the wholesale price index (WPI) as the deflator.

very high rate coupled with the lead time required to phase-in new technologies, would result in a hefty tax burden (that would be unavoidable in the short- to medium-term till cleaner vehicles were available) which would be unfair. Therefore, the rates have been deliberately set at levels lower than what would be required for manufacturers to make the technological change instantaneously[68]. As an aside, two points should be noted. First, under EED the only incentive for producing a zero emissions vehicle (ZEV) would be that the duty would be reduced to zero. While ZEVs are not available in India at present, in order encourage the manufacture of such vehicles, and to make them competitive, we recommend that the overall excise duty on ZEVs be reduced to half of that for other vehicles, or perhaps even completely eliminated[69].

Secondly, we have not recommended EED for diesel vehicles. In this context, it is well known that several vehicle manufacturers are producing diesel versions of their vehicles (such as cars) to take advantage of the subsidised diesel prices which are primarily meant for agriculture. *Rather than ban diesel cars to prevent misuse of the subsidy, we recommend that their price be increased in proportion to the capitalised value of the price differential between petrol and diesel over the lifetime of the vehicle.* While diesel models of cars are more expensive even now as compared to petrol models, the extra price paid is recovered in at most eight years[70]. A doubling of the price differential would double the break even period and deter this practice. This could be dubbed as a "diesel surcharge". (In Germany, for instance, since 1994 diesel engine cars face an additional tax as compared to petrol cars – Table 4.6.)

5.4.1.3 Issues related to implementation of environmental excise duty

(i) *EED to be collected up front as a presumptive tax*: In order to make implementation of EED easier, it could be collected up front as a surcharge from vehicle manufacturers based on the presumption that emissions (in gm/km) are at the level of the 1996 standards. The amount collected would be determined on the basis of total production times EED assessed per vehicle. If the manufacturer can show that emissions are lower (as would be the case for example for Euro I and II compliant vehicles), the duty could be accordingly refunded.

(ii) *Tax credit for buyers of cleaner vehicles*: As mentioned earlier, it is important to offset the negative incentive effect of an increase in the price of new vehicles as a result of EED. The magnitude of this increase depends on the extent to which costs are passed on by manufacturers to buyers. In this context, new vehicle buyers should be allowed to offset the *incremental* cost of a new vehicle (the increase in vehicle price which is due to EED-induced emission control costs), *from the income tax due* on their tax returns[71]. To this end, vehicle manufacturers would have to declare for each model the increase in retail price that was due to reduced emissions, and also declare the nature of vehicle modifications for this purpose. Some of the revenue from EED could be used for this tax-offset. The revenue, however, should not be returned to manufacturers under any guise, including R&D. Doing so would only reduce their overall costs, and therefore encourage the possibility of "pay and pollute".

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[68] Further, given the uncertainty about costs of emission reduction technologies, and lack of data on several variables, the rates should, in any event, be biased downwards – which is what we have done (see Annex 9).

[69] Recall from Table 5.3 that excise duties on motor vehicles are as high as 40 per cent. Thus, this would be a significant concession.

[70] For example, the on-road price in 1995 in Mumbai for the petrol model of a Premier Padmini car was Rs. 196,000 compared to Rs. 256,000 for the diesel model – a difference of 60,000 rupees (AIAM, 1996b). Given the current savings of about Rs. 12/litre for diesel over petrol, if a car runs about 6,000 kms. annually at the rate of 10 km/litre, the break even period is about 8 years. For more intensively used vehicles such as taxis, the break even period is perhaps half of this figure. Since the useful life of a vehicle in India is much longer than 8 years (Table 5.2), there is a good case for increasing the price of diesel cars so that the break even period increases. Ideally, the price of diesel cars should be so high that the break even period exceeds the life of the car (making the cost savings from cheaper diesel redundant).

[71] For those who are in the zero tax bracket and/or do not file returns (most likely prospective buyers of two-wheelers), this amount could be refunded as a lump sum by the income tax department upon submission of a claim. In this context, an unintended benefit of this proposal would be that anyone purchasing a vehicle with black income would not be able to claim the tax credit!

An important clarification with respect to the tax credit is that *it should be available only on the portion of incremental cost due to lower emissions*. To elaborate, the portion of EED-induced cost that is passed on to buyers comprises two components: (*a*) EED paid on uncontrolled emissions and (*b*) cost of vehicle modifications and/or emission control devices to reduce emissions. For each manufacturer the relative share of (*a*) and (*b*) will vary depending on the extent to which he decides to "pay and pollute" and/or reduce vehicle emissions. *Tax credit should not be offered on a vehicle that is more expensive simply because of the amount of EED paid*[72]. It should be viewed as an incentive for buyers to go in for cleaner new vehicles. In this sense the negative incentive is only partially offset.

(iii) *EED is not a "license to pollute"*: In view of the preceding discussion, it should be re-emphasised that EED does not simply allow a manufacturer to pay and pollute. If the rate of EED were high enough it would not make good business sense for a manufacturer to do so. This makes it all the more imperative that despite starting from a relatively low rate, EED should be increased continuously till it starts having the desired effect in terms of cleaner vehicles[73].

(iv) *Certification of emissions*: Under EED, accurate measurement of emissions is critical since real money is at stake. Therefore, monitoring activities should be conducted by a neutral agency in which the government, vehicle manufacturers and the general public have faith. Without endorsing it, we recommend that the current system for certification of emissions by ARAI should continue for the time being. This would enable EED to be levied immediately.

In addition, however, manufacturers would have to provide a warranty that any vehicle sold would continue to meet its declared level of emissions for 2 years after sale or 16,000 kms, whichever comes first[74]: significant deviation between declared and actual emissions would make the manufacturer liable for extra EED on all vehicles of that make and model. These measures would safeguard against manufacturers providing carefully engineered "cream puffs" for testing[75].

Implementation of EED would be a landmark event in using economic approaches to address vehicular pollution in India. It would provide flexibility to manufacturers in reducing vehicle emissions. In this context, it is useful to recall what Mills and White had to say when they recommended a similar scheme twenty years ago, "The manufacturers would no longer face all-or-nothing, zero-one deadlines for meeting standards. Instead, *they would have proper incentives to plan and pursue research on emissions control in an optimum fashion.... They would no longer have incentives to collude, to delay progress on emissions control, or to bluff or engage in brinkmanship contests with government authorities*. They would be rewarded for producing clean cars and for producing control devices that were durable and easily maintained. They would be able to trade off among pollutants and could choose low-cost strategies that were especially good at reducing some pollutants even if they could not reduce others. ... The problem is important. The means of properly dealing with them are at hand. It is a shame they are not being used." (Mills and White, op. cit., p. 393, 402, emphasis added).

5.4.2 Policy options for reducing emissions from in-use vehicles

We now turn to in-use vehicles which, given their age profile, are a significant source of emissions (Table 5.2). It was also noted above (section 5.1) that current policies for curbing in-

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[72] Consider as an extreme example, the case of a manufacturer who chooses to simply pay EED and not reduce emissions at all. Further, he passes on all or some of the duty to the buyer through a higher vehicle price. In this case there should be no tax credit.

[73] Another safeguard that is already in place to alleviate this concern is the fact that all new vehicles already meet the 1996 emission standards which are a definite improvement over the 1991 standards. Thus, one can argue that the 1996 standards provide a *de facto* "pollution ceiling" which cannot be breached (unless all the engine modifications, etc., carried out so far are undone!).

[74] Provided the vehicle and/or the emission control equipment was not misused or tampered with (for instance, using leaded petrol in a car with a catalytic converter).

[75] We agree that poor quality of fuel is a source of concern, particularly in the context of meeting emission norms (see Centre for Science and Environment, 1996, p. 53). While we do not address this issue here, it should be flagged as a matter that deserves serious attention. For certification of emissions the quality of fuel used could be as specified in the norms.

use vehicle emissions are inadequate. Following the taxonomy in Table 4.5, we classify policy options for in-use vehicles as direct and indirect. The former target vehicle emissions directly as in the case of emission taxes/standards, whereas the latter (e.g., vehicles taxes or I&M), affect complements and substitutes to vehicular emissions. As Table 4.5 also indicates, within each category one can further distinguish between market based and CAC policies[76]. In this context, it should be noted that the same goal, e.g., clean fuel can be attained either through MBIs (differential fuel taxation) or through CAC policies (mandatory fuel quality standards).

Below, we quantify the reduction in vehicular emissions in Delhi for five actions:

(i) inspection and maintenance (I&M) for in-use vehicles

(ii) random checks of on-road vehicles

(iii) use of CNG as an alternate fuel

(iv) reducing sulphur content in diesel

(v) use of low smoke lubricating oil for 2-stroke engines

It should be noted that the first two actions are explicitly CAC in nature, whereas the last three can be implemented either through CAC policies or through MBIs[77]. For instance, low sulphur diesel could be phased in through administrative fiat and/or enhanced supply (as has already been done in Delhi – section 5.1) or through differential taxation, the most elaborate example of this being Sweden – Table 4.6. In either case, however, the actual cost of the action is that of desulphurisation for oil refineries. The only difference is that under the market based approach, behavioural modifications complement the supply side by creating a demand for low sulphur diesel, whereas in CAC the emphasis is on supply alone. The same reason applies to CNG and low smoke 2-stroke engine oil.

The reason for focusing on these five actions is that they are all currently being implemented or are under active consideration in Delhi. Thus, it is possible to quantify the potential reduction in emissions they can achieve. We describe these actions in detail below:

(i) *Inspection and maintenance* actions focus on in-use vehicles. These comprise mostly older technology vehicles (with inherently poor emission performance as compared to new vehicles). Further, the use of a vehicle leads to deterioration of mechanical and electronic components and there are also maladjustments during repair and servicing. These factors, coupled with poor maintenance, lead to high level of emissions from in-use vehicles. For example, a poorly adjusted engine or a damaged catalytic converter can lead to higher emissions by as much as a factor of four, while CO emissions can increase by as much as 400 percent between services through normal drift. A suitable test procedure to examine the safety and emissions performance of vehicles periodically could lead to increased awareness and maintenance by vehicle owners.

I&M programmes can be of two types: centralised or decentralised. Centralised programmes have a few high volume inspection facilities run by the government or under close monitoring by the government. Decentralised programmes utilise private service centres as inspection stations to supplement the high volume inspection facilities. I&M programmes are usually implemented through an annual registration and insurance system. Centralised I&M programmes are found to be more effective in reducing emissions because of less chance of fraud.

Estimates of emission reduction through an I&M programme vary. AIAM (1998) reports two sets of estimates: a reduction of 25 percent for CO and HC and 10 percent for NOx (Michael Walsh), and a reduction of 20 percent for CO and HC and 1 percent for NOx (USEPA). In our calculations below we use the more conservative of the two estimates, i.e., USEPA.

[76] In Table 4.5, policies are first distinguished as MBI and CAC and then further classified as direct and indirect. Here we reverse this sequence without any loss of generality.

[77] Thus, a distinction is made here between an *action* (endpoint) and a *policy* (means of getting to that endpoint).

An I&M programme could be introduced in Delhi in conjunction with a system of annual vehicle registration which could include registration fees linked to the age and emission performance of the vehicle (as is the case in several countries)[78]. This would serve two purposes: (a) it would ensure all vehicles undergo mandatory I&M, and (b) older more polluting vehicle would be penalised leading to faster vehicle replacement by consumers. The costs of the programme are start-up costs (land and equipment), operating costs (labour and equipment maintenance)and vehicle repair costs. AIAM plans to start a centralised I&M facility which will cost about 80 million rupees of which it is willing to contribute 10 million rupees (AIAM 1998). Operating costs could be recovered by increasing the annual vehicle registration fees to include the cost of testing[79]. The current Pollution Under Control (PUC) certification could be replaced by this comprehensive I&M programme.

To facilitate monitoring colour coded stickers displaying prominently the month when inspection is due could be used. Vehicle insurance should also be linked to this programme. The programme can be started in conjunction with the process of registration and vehicle testing coinciding with the month when insurance is due.

(ii) The I&M programme would need to be complemented by a system of *random checks of on-road vehicles* to penalise those not complying with the programme. Such a system would able to apprehend the worst polluters (gross polluters). It is estimated that about a quarter of all vehicular emissions are from only 5 per cent of the vehicles. Similarly, 43 per cent of these emissions are from 15 per cent of the fleet, and 60 per cent of the emissions are from only 20 per cent of the fleet (Faiz et al. 1996). *Therefore, curbing gross polluters would reduce vehicular emissions by at least 15-20 per cent.* The costs of carrying out spot checks are essentially manpower costs and the cost of purchasing and maintaining mobile emission testing equipment.

(iii) *Use of CNG as an alternate fuel* for motor vehicles is being promoted in India and in Delhi in particular, and its distribution network is being expanded. Till recently, manufacture and sale of bifuel (petrol and CNG) cars or retrofitting of CNG kits in petrol driven vehicles, was limited. The main hurdle was the lack of an effective CNG distribution network. This network is confined to urban areas, and that too on a limited scale – the entire city of Delhi has only 9 CNG filling stations. Two recent developments, however, have changed the outlook for CNG, particularly in Delhi: (*a*) commencement of production of CNG powered heavy commercial vehicles (HCVs) by Ashok Leyland, and (*b*) an order by the Supreme Court of India on expanding the CNG distribution network to 80 filling stations in Delhi. The Supreme Court has also mandated that all buses in Delhi 8 years or older switch to CNG by 1.4.2000, and all city buses irrespective of age (DTC and private) switch to CNG by 31.3.2001.

Economic incentives to back these initiatives could include higher commission to providers of CNG to help expand the distribution network. Schemes for retrofitting passenger cars with CNG kits and replacement of diesel commercial vehicles with CNG vehicles will help take advantage of the wider distribution network. The schemes for retrofitting could include supply of subsidised CNG kits and/or CNG itself. The current price of CNG in Delhi, equivalent to 1 litre of petrol, is about 8 rupees as against 24 rupees/litre for petrol, while CNG conversion kits cost Rs. 30,000-35,000. At an average fuel efficiency of 16 kms./litre of petrol, the cost of the CNG conversion kit can be recovered in 30,000 kilometres[80]. With a lower average the recovery period would be shorter.

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[78] In Delhi at present there is a *one time* vehicle registration fee which is as low as about 1,200 rupees (<$30) for motor cars. Earlier, there was a system of annual vehicle registration which was changed to reduce administrative and other transaction costs (queuing, etc.). There is no reason, however, why it cannot be revived if the benefits outweigh the costs. Vehicle insurance, in any event, has to be renewed annually even now and the two could be combined.

[79] AIAM proposes a fee of Rs. 750 for HCVs, Rs. 475 for LCVs, Rs. 350 for taxis and Rs. 275 for three wheelers. The AIAM proposal is currently for commercial vehicles only.

[80] This would be the typical fuel efficiency of the most widely used motor car in Delhi, *Maruti 800* (a small 800 cc car manufactured by Maruti Udyog Limited – a joint venture between Suzuki Motors and the Indian government).

The use of CNG reduces CO and NOx emissions by 20 percent and particulate emissions by about 90 percent (Faiz et al. 1996). Assuming 18 percent of commercial vehicles are buses (the proportion of buses in 1998 vehicle registration data), and that all buses and three wheelers switch to CNG by March 2001 (as per Supreme Court orders), the reduction in emissions will be 12,000 tonnes of CO, 7,300 tonnes of NOx, and 5,110 tonnes of particulates per annum. The reduction will be higher if private vehicles switching to CNG are also considered. The cost of providing CNG will be the cost of setting up an additional 71 fuel stations, including land and capital costs, and the subsidy on CNG, if any. The cost of CNG conversion kits are recoverable by the user within 1 to 3 years, and hence not included in the costs.

(iv) The *sulphur content in diesel* sold in the country is to be reduced to 0.25 perc ent this year (from 0.5 per cent) for which the oil companies have invested about 60 billion rupees in desulphurisation plants. Further reduction in sulphur content requires an additional investment of 150-200 billion rupees in all the refineries in the country. Reducing the sulphur content from 0.25 per cent to 0.05 per cent is expected to reduce particulate emissions from diesel vehicles by 10-15 per cent (World Bank 1997, IIP 1994). About 3.5 per cent of the total diesel is sold in Delhi, and assuming the same proportion of investment in desulphurisation can be attributed to Delhi, about 5.25 to 7 billion rupees will be spent to reduce particulate emissions by 27,740 tonnes annually.

As an aside, there is also the problem of *fuel adulteration* that negates the benefit of cleaner fuel and catalytic converters. While oil companies guarantee Bureau of Industrial Standards (BIS) levels at the refinery, the distribution channel is not monitored closely, with the result that the customer often gets adulterated fuel. One of the main reasons for this is the vast difference in the price of fuels. The supply of kerosene oil at highly subsidised rates (about one fifth the price of petrol) leads to it being mixed with petrol or diesel. Price increases in kerosene are considered politically infeasible, and hence little can be expected on this front. The government needs to reconsider its entire energy pricing policy which is still largely based on administered prices, as well as expand the supply of other fuels like LPG for domestic use to prevent adulteration of petrol and diesel. The distribution network of petrol needs to be strengthened and the sale of coloured kerosene increased to prevent adulteration.

(v) The use of pre-mixed *low smoke lubricating oil for 2-stroke engines* will also reduce vehicular emissions substantially since these engines are mostly found in two and three wheelers which account for over two-thirds of motor vehicles in Delhi (Table 3.5). The sale of such oil has already commenced in Delhi, and no loose lubricating oil can be legally sold in Delhi for 2-stroke engines. The use of such oil reduces emissions of CO, HC, NOx and particulates by 50 percent (Faiz et al. 1996). This will, therefore, lead to a reduction of CO, HC, NOx, and particulate emissions by 27,702 tonnes, 20,319 tonnes, 478 tonnes, and 15,446 tonnes, respectively, per annum in Delhi. The cost of this action is primarily the cost of providing higher grade oil.

Tables 5.4 through 5.6 quantify the reduction in vehicular emissions through these five actions. Table 5.4 shows the projected daily vehicular pollution load for the year 2001. Here we utilise projected vehicle sales from the econometric model in Part I (section 3.2, Table 3.26). Total vehicle stock for each vehicle type in the year 2001 is the sum of actual and projected sales till that year[81]. For cars, for instance, we add actual and forecasted sales for each year for the period 1977-2001 (25 years) to arrive at the total stock. It should be noted, however, that this stock comprises vehicles of different vintages which have different emissions factors attached to them (Table 3.20). Thus, emissions of each pollutant by cars in 2001 in Table 5.4 are a weighted total of sales in each year (for the period 1977-2001) multiplied by the emission factor for that year and by the vehicle utilisation factor (Table 3.19).

To these figures we then apply an estimated percentage reduction in emissions due to each action described in (*i*) through (*v*) above. These percentages are shown in Table 5.5. It should be

[81] Assuming a life of 25, 15, 20, and 15 years, respectively, for cars, 2 wheelers, 3 wheelers and commercial vehicles.

TABLE 5.4

Projected daily vehicular pollution load in 2001(tonnes)

£Vehicle type	CO	HC	NOx	SO2	Total pollution by vehicle category
Cars	349.95	63.46	34.57	1.29	449.27
Two wheelers	132.4	98.35	2.31	0.53	233.59
Three wheelers	130.18	79.74	3.34	0.37	213.63
Commercial vehicles	276.4	43.47	461.21	28.96	810.04
Total	888.93	285.02	501.43	31.15	1706.53

TABLE 5.5

Percent emission reduction in 2001 by different actions

Policy	CO	HC	NOx
Inspection and maintenance	20	20	1
Spot checking	15	15	15
Alternative fuel (CNG)	20	*	20
Improved diesel	*	*	*
Low smoke lubricating oil for two stroke engines	50	50	50

SOURCE: as in text

TABLE 5.6

Daily vehicular emission reduction achieved in 2001(tonnes)

Policy	CO	HC	NOx	Total pollution reduced
Inspection and maintenance	177.8	57.0	5.0	239.8
Spot checking	133.3	42.8	75.2	251.3
Alternative fuel (CNG)	81.3		92.9	181.2
Improved diesel				
Low smoke lubricating oil for two stroke engines	66.2	49.2	1.2	116.5

NOTE: Emission reduction due to CNG is calculated for 3 wheelers and commercial vehicles only, and emission reduction due to low smoke lubricating oil for two stroke engines is calculated for 2 wheelers only.

emphasised that these figures are best estimates based on a survey of literature and expert opinion. Table 5.6 simply shows the actual reduction in emissions after applying these percentages. For example, given a total daily load of CO of 889 tonnes in 2001, a 20 percent reduction through an I&M programme results in an actual daily reduction in CO emissions by 178 tonnes. It should be noted that some actions apply to specific vehicle types only: low smoke lubricating oil applies only to two wheelers (all 3 wheelers are assumed to be converted to CNG by then as per Supreme Court orders) and CNG conversion is only assumed for 3 wheelers and commercial vehicles.

5.5 Cost effectiveness of various policy options for vehicular pollution abatement

Given the variety of potential policy measures for addressing vehicular emissions, some ranking and prioritisation among them is required. Since a reasonably accurate cost benefit assessment (CBA) is not feasible given the absence data on environmental benefits of abating vehicular emissions, control measures are analysed instead in terms of cost effectiveness. The difference between the two is that the latter simply ranks policies in ascending order in terms of cost per ton-netonneof pollutant reduced. A policy which has a lower cost per tonne as compared to another is deemed cost effective. Unfortunately, a paucity of information and the limited scope of this study does not permit us to construct such a ranking for policies for vehicular pollution abatement for Delhi, per se. Instead, we rely on studies done in other developing country cities that face similar problems and where similar options have been considered. In particular, we focus on a World Bank Transport Air Quality Project Management project for Mexico City where the cost effectiveness of interventions similar to the ones we have discussed for Delhi were estimated (World Bank 1992b). Broad categories of pollution control measures examined in the project were:

- I&M programmes
- emission standards for new vehicles
- retrofit of in-use vehicles with CNG, catalytic converters, cleaner engines, etc.
- replacement of existing high-use vehicles with cleaner new ones
- reformulation of petrol and diesel
- vapour recovery from petrol distribution and marketing
- shutting down of (polluting) petrol refinery in downtown Mexico City
- imposition of taxes on petrol to reduce demand and taxes on old vehicles to encourage turnover
- paving of unpaved roads

To estimate the effect of different emission control measures on pollutant emissions, first the *counter factual* (annual emissions that would have resulted in the absence of that action) is estimated. For each action, emissions reduction from the baseline (common to all policies being evaluated) is estimated and compared to the annual cost for each measure. This cost is annualised total cost (capital and operating costs, repair costs and the value of lost time incurred in implementing that action). Cost effectiveness is then calculated by dividing annual cost by *toxicity weighted* emissions reduction. Policies can then be ranked on the basis of cost effectiveness (US$/tonne emissions reduced).

A prerequisite for such an exercise is to *aggregate different pollutants* using toxicity weights (based on their relative noxiousness) to arrive at total emissions, expressed in *toxicity weighted tons/year*. The reason is that the impacts of emission control measures vary in terms of which pollutants are reduced, and by how much. Thus, aggregation across pollutants is necessary to estimate the cost per tonne emission reduced for each control measure. In other words, while costs of all measures are expressed in similar units (rupees) their effects (pollutant reduced) should also be in similar units to allow comparison across measures. One could try and side step this issue by simply comparing policies by pollutant, e.g., cost per tonne CO reduced, etc.. The problem with this approach is that any control measure generally reduces more than one pollutant and apportioning the cost of the measure across pollutants becomes difficult[82].

Table 5.7 shows the cost-effectiveness of selected control measures in Mexico similar to the ones considered above for Delhi. The figures are in ascending order with those in parentheses showing negative marginal cost. Thus, retrofit of minibuses with CNG actually entails a negative marginal cost since annual cost savings on fuel outweigh the capital cost of conversion[83]. The same is true for CNG retrofit for gasoline (petrol) trucks.

[82] This is essentially a problem of apportioning costs of *joint products*. The relative weights used in the Mexico project were: lead (85), NOx (4.7), PM10 (2.3), VOC (1.8), SOx (1.4), dust (0.9), and CO (0.04). These weights are relative – they do not add up to 100.

TABLE 5.7

Cost effectiveness of various control measures (US$/tonne)[84]

Minibus CNG retrofit	(248)
Gasoline truck CNG retrofit	(225)
Centralised I&M high-use vehicles	207
Decentralised (garage-based) I&M high-use vehicles	287
Centralised I&M passenger cars	858
Reduce sulphur content in diesel (from 1 per cent to 0.1 per cent)	961
Decentralised (garage-based) I&M passenger cars	1,025
Road paving (1000 kms.)	1,335
Reduce sulphur content in diesel (from 0.4 per cent to 0.1 per cent)	1,371

SOURCE: World Bank 1992(b) Annex IV

The table above throws up some interesting results. First, CNG retrofit of buses and trucks is extremely cost-effective. Second, given economies of scale, centralised I&M programmes are more cost effective than decentralised ones. Further, targeting high-use vehicles (which are presumably also higher emission vehicles) through I&M, is more cost effective than targeting passenger cars. Finally, the incremental cost of reducing the sulphur content of diesel increases quite steeply. All of these findings are highly relevant for control measures being implemented or under consideration in Delhi.

5.6 Health benefits of improving air quality in Delhi

Finally, we turn to an examination of the health benefits from improving air quality in Delhi, since *the primary rationale for reducing vehicular emissions is the health benefits from doing so*. Table 5.8 lists WHO and USEPA standards on safe exposure levels for different air pollutants. (NAAQS for India are shown in Table 3.13.) Tables 5.9 and 5.10 present the health impact of these pollutants categorised by source, that is, by vehicle type as well as by different characteristics of motorised fleets that are the primary determinants of these emissions. This helps in deciding which aspects of the problem need to be addressed, and is of particular relevance when designing projects/interventions for reducing vehicular emissions. For example, Table 5.9 indicates that petrol volatility is responsible for CO and HC emissions, whereas Table 5.10 shows the approximate magnitude of emissions generated by major vehicle types[85]. The tables do not, however, indicate which health impacts would be of greater concern, nor which would be most readily addressed. This is partly because the answers to these questions are location and circumstance specific. With respect to Delhi, the earlier discussion indicates that PM is the pollutant of primary concern (Tables 3.14 and 3.15) where vehicles are responsible for a substantial share.

As in the case of cost effectiveness, once again there is inadequate information for Delhi to estimate the marginal effect of vehicular emissions, per se, on the concentration of various pollut-

[83] The added capital cost of CNG conversion is spread over a period of 5 years (useful life of retrofit) in the Mexico study. In the case of Delhi too, if we take the price difference between diesel and CNG conservatively at Rs. 4/litre (actually, diesel prices have just been hiked and the difference is almost double this figure now), and the fuel efficiency of buses at 12 kms./litre, and an annual usage as 30,000 kms., the break-even period is 3 years (given an investment of Rs. 30,000 for CNG conversion). If this cost is spread over 5 years as in the Mexico study, then the annual cost in Delhi too would be negative (Rs. 4,000). This would then need to be divided by tons of emissions reduced to arrive at the cost per ton.

[84] This is not a complete ranking of all control measures considered in the Mexico City study but only representative figures that are similar to the measures considered for Delhi. For further details see World Bank (1992b), Table 29.

[85] These figures are mostly for developed countries. For developing countries, vehicle emissions correspond more closely with the uncontrolled emission figures given in the table in many cases.

ants mentioned above[86]. At best, we can examine existing estimates of dose-response relationship between ambient air quality and health endpoints, namely, mortality and morbidity. In other words, given the current state of data we can simply relate reductions in the concentration of, say PM10 (whatever its source may be), to a decline in mortality in Delhi (i.e., a dose response relationship). It is not possible, however, to ascertain the relationship (except in a heuristic manner) between ambient concentration of a given pollutant and the actual amount emitted by vehicles

TABLE 5.8

Standards and guidelines for transport related air pollution
Maximum acceptable outdoor exposures (all figures in mg/m^3)

Pollutant	WHO standards	USEPA standards
Carbon dioxide (CO2)	1800	1440
Carbon monoxide (CO)	100 (15 minute average)	
	60 (30 minute average)	40 (1 hour average)
	10 (1 hour average)	10 (8 hour average)
Lead (Pb)	0.5 (annual average)	1.5 (annual average)
Nitrogen dioxide (NO_2)	500 (10 minute average)	
	125 (24 hour average)	
	50 (annual average)	100 (annual average)
Ozone	120 (8 hour average)	235 (1 hour average) 156 (8 hour average)
Particulate matter (PM10)	–	150 (24 hour average)
Fine particulate matter (PM2.5)	–	65 (24 hour average) 15 (annual average)
Sulphur dioxide (SO2)	500 (10 minute average)	365 (24 hour average)
	125 (24 hour average)	80 (annual average)
	50 (annual average)	

NOTES:

1. Concentration limits for carbon dioxide are associated with indoor air.
2. CO2 effects are associated with global climate change, not direct health effects.
3. WHO guidelines do not include a PM10 standard. For PM10, available epidemiological data did not facilitate the establishment of a level below which no effects would be expected. Therefore no specific guideline value was established, but, instead, exposure-effect information was provided giving guidance to risk managers about the major health impact for short and long term exposure to various levels of this pollutant.

SOURCES:

World Health Organisation. 1998. *WHO Air Quality Guidelines for Europe*, 2nd ed.

California Environmental Protection Agency, Air Resources Board. 1998. "Review of existing standards and guidelines applicable to indoor air quality" (Draft memo).

[86] Given the *non-uniformly dispersed* nature of vehicular pollutants, not only would this require a complete emissions inventory (including traffic census, origin-destination surveys, etc.), but also atmospheric dispersion data.

TABLE 5.9

Impacts of transport related air pollution by contributing characteristic

Characteristic	Pollutant	Sources	Health impacts
Fuel quality / fuel volatility	CO HC Pb SOx PM VOC	CO: exhaust emiss. from fuel volatility HC: exhaust emiss. from fuel volatility Pb: lead in petrol SOx: from sulphur in petrol and diesel[87] PM: from sulphur in petrol and diesel VOC: evaporative emissions from petrol[88]	CO: reduced blood oxygen HC: ozone precursor (ozone: respiratory illness, asthma, eye irritation, activity restriction) Pb: hypertension, loss of IQ points, premature death SOx: respiratory illness, premature death PM: respiratory illness, asthma, chronic bronchitis, premature death VOC: some (like benzene) are carcinogenic; also photochemical smog precursor
Congestion	CO HC CO2 PM	CO: frequent acceleration, low speeds HC: frequent acceleration, low speeds[89] CO2: frequent acceleration, low speeds PM: low speeds	see above CO2: greenhouse gas
Age of fleet	CO HC CO2	CO: old, poorly maintained cars[90] HC: old, poorly maintained cars CO2: older vehicles, less fuel efficient	see above
Size of fleet	all	contributes to congestion number of cold starts	see above
Number of trips	all	contributes to congestion number of cold starts[91]	see above
Length of trips	all	kilometres travelled	see above
Road conditions	CO HC CO2 PM	may slow travel, over burden engines similar effect to congestion reduce fuel efficiency unpaved/poorly maintained roads cause PM from re-suspension	see above

SOURCE: Heil and Pargal 1998

[87] Reducing petrol volatility from 9 psi to 8 psi lowers total evaporative emissions by 34 percent with no appreciable effect on fuel economy. It also lowers HC emissions by 4 percent and CO by 9 percent (Faiz et al. 1996).

[88] Acceleration in modern cars propels engines into "enrichment mode" whereby CO emissions rise by a factor of 100 and those of HC increase by a factor of 10 (Harrington and Krupnick 1997). Emissions from heavy diesel vehicles are especially sensitive to speed and acceleration. In France, congested conditions increase automobile exhaust emissions of CO, HC, and CO2 by 3-fold over free flowing urban traffic (Faiz et al. 1996).

[89] Poorly maintained vehicles without catalysts can generate four or more times the HC and CO of a well maintained vehicle without a catalyst (Faiz et al. 1996).

[90] Under cold conditions engines require additional fuel to start, generating very high HC and CO emissions. Cold starts account for over 80 percent of total HC and CO emissions from modern, emission-controlled vehicles (Faiz et al. 1996).

TABLE 5.10

Impacts of transport related air pollution by vehicle type

Vehicle Type	Pollutant	Quantity (grams per kilometre)	Health impacts
Motorcycles and scooters	CO[1]	CO: in EU: controlled 4-stroke 20; unctrld 40; controlled 2-stroke 22; uncontrolled 24.6	CO: reduced blood oxygen
	HC	HC: in EU: uncontrolled 4-stroke 5.9; uncontrolled 2-stroke 19.0	HC: ozone precursor (ozone: respiratory illness, asthma, eye irritation, activity restriction)
	PM[2]	PM: in US: uncontrolled 2-stroke 0.206; uncontrolled 4-stroke 0.048	PM: respiratory illness, asthma, chronic bronchitis, premature death
	NOx	NOx: in EU: controlled 4-stroke 0.1; controlled 2-stroke 0.3	NOx: ozone precursor (ozone: respiratory illness, asthma, eye irritation, activity restriction)
	VOC[3]	VOC: in EU: 4-stroke 2.8; 2-stroke 14.9	VOC: some (like benzene) are carcinogenic; also photochemical smog precursor
	CH4	CH4: in EU:4-stroke 0.20; 2-stroke 0.15	CH4: greenhouse gas
	CO2	CO2: depends on fuel quality	CO2: greenhouse gas
Petrol driven passenger cars[4]	CO	CO: in US: 6.2; uncontrolled: 42.67	
	HC	HC: in (uncongested) urban France: 3.52	
	PM	PM: in EU: 0.00	see above
	NOx	NOx: in US: 0.52; uncontrolled: 2.7	
	VOC	VOC: in US: 0.67; uncontrolled: 5.62	
	CH4	CH4: in US: 0.04; uncontrolled: 0.19	
	CO2	CO2: in US: 200; uncontrolled:399	
Diesel buses and trucks[5]	CO	CO: in US :6.33; uncontrolled: 7.31	
	HC	HC: in US: 1.32; uncontrolled: 2.52	see above
	PM	PM: in EU: 1.6	
	SOx	SOx: in India: 1.5	SOx: respiratory illness, asthma, chronic bronchitis, premature death
	NOx	NOx: in US: 5.09; uncontrolled: 15.55	
	VOC	VOC:	see above
	CH4	CH4: in EU: 0.175	
	CO2	CO2: in US: 982; uncontrolled: 1249	

1. Emissions data for CO, HC, NOx, VOC, and CH4 from Faiz et al. (1996), Table 2.6 for uncontrolled and Table A2.1.3 for controlled.

2. Emissions for PM are average FTP emissions from U.S. uncontrolled motorcycles (Chan and Weaver 1994, Tables 5.1 and 5.2).

3. All VOC emissions data refer to non-methane volatile organic compounds.

4. Emissions figures for U.S. refer to advanced 3-way catalysts for "controlled" and no catalyst for "uncontrolled" (Faiz et al. 1996, Table 2.1). PM figure derived from Tables A2.1.1, A2.1.2.

5. U.S data refer to heavy duty trucks (Faiz et al. 1996, Table 2.4, Table A2.2.5). Data for EU covers heavy duty vehicles in urban conditions (Table A2.2.3). Emissions for India cover heavy duty trucks (Table A2.2.12).

SOURCE: Heil and Pargal 1998

TABLE 5.11

Annual health incidence and health costs due to ambient air pollution exceeding WHO guidelines in 36 Indian cities (1991-92 data)

	Physical impacts	Cost valuation ($ million)
Premature deaths	40,351	170 - 1,615
Hospital admissions and sickness requiring medical treatment	19,800,000	25 - 50
Minor sickness (including Restricted Activity Days and Respiratory Symptom Days)	1,201,300,000	322 - 437
Total		517 - 2,102

SOURCE: Brandon and Hommann 1995

Even with respect to dose response studies there exists only one estimate that uses actual data for Delhi (Cropper et al. 1998). Other studies on health effect of air pollution use dose response functions for other countries, typically the United Sates. Brandon and Hommann (1995), for instance, extrapolate dose response functions from developed countries to estimate mortality and morbidity due to ambient air quality exceeding WHO guidelines in 36 Indian cities, including Delhi. The pollutants considered are PM, SO2, NOx, and lead. Ozone and indoor air pollution are not considered due to lack of data. They estimate that over 40,000 premature deaths would be avoided if pollutant levels in these cities were reduced to the WHO annual average standard. According to them Delhi alone accounts for 7,500 or almost a fifth of premature deaths[91]. In addition, there are added morbidity effects of air pollution such as restricted activity days (RADs) and/ or respiratory symptom days (RSDs).

Brandon and Hommann also monetise estimates of premature deaths and sickness by using value-of-life and medical treatment cost figures from the United States (adjusted for Indian income levels). Thus, health costs of air pollution are estimated to be in the range of $0.5 to 2 billion (Table 5.11), with PM10 and SO2 accounting for over 95 percent of the total. The cost of health impacts for Delhi alone is $100-400 million. Using a similar approach, a more recent study arrives at much higher estimates: 885 to 4,250 billion rupees[92] (TERI 1998). The main reason for these extremely high values is the use of total exposure as an indicator of air pollution. In any event, as mentioned above both sets of estimates should be taken as broad indicators and not as precise numbers.

Cropper et al. focus on actual TSP concentrations and mortality in Delhi during the period 1991-94 and find that "a given reduction in TSP reduces non-trauma deaths in Delhi by a smaller percentage than predicted by U.S. studies," (op. cit. p. 2-3, emphasis added). In fact, they find that a 100 microgram (mg/m3) reduction in TSP concentration in Delhi leads to a 2.3 per cent reduction in deaths – about one-third of the effect found in the U.S. However, since the age distribution of these deaths is very different in Delhi, that is, much younger people die as compared to the U.S., an improvement in air quality would save more life years than in the U.S. on average. Interestingly enough, Cropper et al. estimate that a reduction in PM10 concentration of the magnitude envisaged by Brandon and Hommann, would result in only 3,430 avoided deaths, less than half of that predicted by the latter (see footnote above). Given that Cropper et al. use actual data for Delhi to estimate the dose response function their figures would seem more plausible.

[91] They use the accepted metric (computed from U.S. studies) that a 10 $\mu g/m^3$ change in PM10 leads to a one percent change in mortality. Thus, they estimate that a 141.16 $\mu g/m^3$ change in PM10 (which would reduce PM10 to WHO levels), would avoid 7,490 deaths.

[92] In US dollars, this amounts to about $21 to 99 billion ($US1=43 rupees, approximately)

With respect to the role of vehicular emissions in air quality, it was noted in Part I that about two-thirds (67 per cent) of the pollution load in Delhi was from this source (Table 3.8). Applying this proportion to the Cropper et al. estimate of 3,430 avoided deaths one could argue that about 2,300 premature deaths annually in Delhi could be due to excessive vehicular emissions. This back-of-the-envelope estimate could thus serve as an approximate measure of the health benefits of vehicular pollution abatement in Delhi[93].

[93] Given the gaps in data the preliminary nature of this estimate should be emphasised.

6. AN ACTION PLAN FOR REDUCING VEHICULAR POLLUTION IN DELHI

An action plan based on the preceding discussion is suggested for reducing vehicular pollution in Delhi. It is broad-based, recognising the need to address all possible ways of reducing emissions. Two elements make up the action plan: one is an analysis based on cost-effectiveness of the different policy options, and the other is meetings and workshops held with different stakeholders. Inputs from both elements should help form policy choices.

Cost effectiveness analysis of vehicular emissions was considered appropriate because of the need to achieve a predetermined standard with limited resources: all control measures cannot be implemented due to lack of funds. The subject of vehicular pollution is also characterised by inadequate data as well as insufficient knowledge regarding the link between vehicular pollution and health. Even though benefits cannot be quantified adequately, the cost effectiveness analysis, nevertheless, is indicative of the most effective way of reducing emissions. The cost effectiveness analysis is incomplete, however, because of lack of cost data pertaining to the applications of policies in India. The measures proposed by the study are summarised in Table 6.1. The action plan is elaborated below.

Inspection and maintenance

While stricter standards for new vehicles lead to cleaner new vehicles, an inspection and maintenance programme is vital for controlling emissions from existing in-use vehicles and can lead to a significant reduction in emissions. This is possible because I&M helps identify vehicles in which maladjustment and failure of mechanical/electronic components lead to excessive emissions and also discourage tampering with emission control devices.

TABLE 6.1

Action Plan

Abatement Measure	Implementing Agency	Time Frame
Inspection and maintenance	State Transport Authority (STA) or authorised agency	1-5 years
Address gross polluters	STA	Immediate
Reduce the usage of commercial vehicles to ten years	STA	1-5 years
Cleaner fuels like CNG	Gas Authority of India Limited (GAIL)	1-2 years
Introduce stricter parking policy	Municipal authorities (MCD, NDMC)	Immediate
More effective traffic management	Traffic Police, STA, NDMC, MCD	1 year
Overhaul administrative set-up	Govt. of NCT of Delhi	1 year

Emissions from in-use vehicles

- A poorly adjusted engine can cause emissions to increase by more than a factor of four
- CO emissions can increase up to 400 percent through normal drift between services
- A damaged catalytic converter can increase HC and CO emissions by a factor of four or more, whereas NOx emissions can increase by a factor of 3 to 5
- An effective I&M programme can lead to a reduction in emissions by 30 to 50 per cent.

Requirements of an I&M programme

- A suitable test procedure
- Effective enforcement of vehicle compliance
- Adequate attention to repair procedures and mechanical training
- Routine quality control
- Periodic evaluation and review to identify problem areas and develop solutions
- Comprehensive coverage
- Minimise waivers and exemptions

SOURCE: Faiz et. al. 1996

A centralised I&M system should be established with high volume inspection facilities in different parts of the city. These centres should be equipped with automated and computerised equipment to reduce the need for subjective judgement. This system can be supplemented with a system of private inspection facilities at selected service stations. However, automated equipment to reduce the chance of fraud as well as extensive audits will be necessary. In general, as noted in Chapter 5, centralised facilities are more effective than decentralised ones.

The I&M programme should be introduced in conjunction with a system of annual registration which includes registration fees linked to the age and emission characteristics of vehicles. This will serve two purposes. One, it will ensure all vehicles undergo the mandatory inspection and maintenance, and second, older, more polluting vehicles are penalised. This will lead to faster vehicle replacement by consumers.

The costs of the I&M programme are due to start-up costs (cost of land and equipment), operating costs (labour costs and cost of maintaining the equipment), and vehicle repair costs. AIAM has proposed a centralised I&M facility which it plans to start as soon as land is allotted for the purpose. While part of the start-up costs will be borne by AIAM, the operating costs can be recovered from vehicle testing fees. The Pollution Under Control (PUC) certification programme can be suitably modified to be included under a comprehensive I&M programme.

To facilitate random checking, stickers with different colour codes for different years and displaying prominently the month when the inspection is due should be used. Insurance should also be linked to this programme. The programme can be started in conjunction with registration, etc. coinciding with the month when insurance is due.

Annual registration, insurance and I&M

A comprehensive annual programme should consist of the following components:

- Registration of the vehicle with the Transport Authority with an annual fee. This should include the road tax as well as an environmental component which links the fee to the age and make of the vehicle.
- Insurance payment should be made a prerequisite for vehicle registration. Insurance premia may also include an environmental component.
- Testing of the vehicle for safety and roadworthiness as well as for emissions. A system of colour coded stickers with the month inspection is due displayed prominently will facilitate random checking.

Gross polluters

It is estimated that a very small number of vehicles cause a disproportionately large proportion of emissions.

Gross polluters

- 5 percent of vehicle fleet causes 25 percent of all emissions
- 15 percent of the fleet causes 43 percent of all emissions
- 20 percent of the fleet causes 60 percent of all emissions

An effective on-road checking programme will help control gross polluters. While the benefits may be up to 15 to 20 per cent reduction in emissions, the costs associated with this programme will include vehicle and equipment costs and labour costs to the enforcing agency as well as repair costs to the defaulter.

Vehicle replacement programmes

The severity of vehicular pollution in Delhi warrants a replacement and retrofitting programme, especially for commercial vehicles that are used intensively. The current policy requires all heavy commercial vehicles to be scrapped or relocated out of Delhi after 15 years. Most commercial vehicles become excessive polluters after 4 or 5 years due to intensive use and poor maintenance. Moreover, the recovery costs of a commercial vehicle is estimated to be around 7 years after taking into account normal profits. A commercial vehicle can therefore be retired after 10 years as opposed to the current norm of 15 years. The programme can be either for scrapping, retrofitting new engines or emission control equipment, or relocating to other areas.

A suitable annual tax structure can be devised that penalises commercial vehicles that are older than 10 years to discourage retention. In addition, a loan scheme can be formulated to help transporters get loans at softer terms or with less conditions, as was tried successfully in the case of three-wheelers in Pune. However, an argument against the loan scheme is that purchasing commercial vehicles is a business proposition, and if the recovery period is 7 years, there is no need for any special incentives.

Vehicle replacement

- Reduce the usage of commercial vehicles to 10 years
- Devise an annual tax structure for vehicles that progressively penalises older vehicles beyond 5 years, with the progression in rates escalating after 10 years.
- Introduce a loan scheme that helps transporters buy new vehicles.

Fuel switching to CNG

Compressed natural gas is advocated in India as a clean alternate fuel. Currently there are 9 CNG filling stations in Delhi. CNG is sold cheaper than petrol. At current prices, it is estimated that CNG vehicles recoup the CNG conversion kit costs (Rs. 30,000-35,000) in approximately 30,000 kilometres if the vehicle mileage is 16 km/litre. If the mileage is lower, the recovery period is correspondingly shorter. The current price of CNG equivalent to 1 litre of petrol is about Rs. 8 as against Rs. 24 for petrol. The cost of providing CNG depends on the costs of setting up the infrastructure for filling stations. The current plan is to set up a total of 80 filling stations in Delhi.

City bus service conversion to CNG

Converting the entire bus fleet to CNG over the next decade will help reduce emissions substantially. While retrofitting CNG kits on diesel vehicles is not possible, the buses may be replaced by CNG vehicles over a period of time. The cost of CNG buses will have to be compared to the cost of diesel buses, and the running cost of CNG compared with-diesel.

Traffic management

Improving traffic management will help improve traffic circulation, reduce congestion and reduce pollution. Factors that are important are pedestrian traffic, parking, location of bus stops and terminals and encroachments on the roadsides, besides the resources available with the local authorities (S. Gangopadhyay et al., “Traffic Management Measures Around ISBT, Kashmere Gate, New Delhi” in Indian Highways, April 1999). Gangopadhyay et al. find that the traffic problems are mainly due to inadequate width of approach roads, lack of parking controls and regulations, haphazard parking of buses, slow moving vehicles, absence of proper pedestrian facilities, lack of enforcement in controlling/managing traffic, and lack of suitable bus stops. A coordinated effort to widen approach roads (MCD, NDMC), improve parking facilities (MCD, NDMC), enforce parking and traffic regulations (Traffic Police), provide pedestrian facilities such as footpaths and subways (MCD, NDMC), and provide proper bus stops (STA) is required to improve circulation, reduce congestion and reduce pollution.

Establish a unified administrative structure

In the current administrative set-up, there is no one single department that is responsible for the overall formulation or implementation of policies. Various agencies are involved, among them the Delhi Traffic police, The State Transport Authority (STA), the Municipal Corporation of Delhi (MCD) and the New Delhi Municipal Council (NDMC). While the traffic police has the maximum say in traffic flow, the STA is engaged in issuing licenses, registering vehicles and issuing permits to commercial vehicles. Parking policy and improvement in the infrastructure is the responsibility of the MCD and the NDMC. Unfortunately, various official agencies often work at cross-purposes and thus there is no effective transport planning for Delhi. In order to introduce comprehensive traffic planning, a unified administrative structure with a clear line of control needs to be set up. One alternative is to constitute an Authority overlooking the departments of transport and traffic. This Authority would then be able to plan and implement an effective transport policy.

Parking Policy

A parking policy needs to be developed to help reduce congestion and pollution. An effective parking policy must incorporate restricted parking in the congested areas and encourage car pooling and parking near mass transit terminals. This has to be taken in conjunction with improved mass transit facilities and improved traffic management.

Car parking in the congested business areas can be restricted through the use of high parking fees. Traffic flow in the business areas can be controlled through proper circulation policies and with the charge of entry tolls and area-licensing fees as has been done in Singapore.

High parking charges to curb congestion and pollution

Parking charges can be increased substantially to discourage entry of private vehicles into certain areas and to reduce congestion, both of which should reduce vehicular emissions. Under the current system, contracts for city parking lots are awarded through auctions and parking rates are fixed by the MCD or NDMC. The current rates range between Rs. 5 and 10 for cars depending upon the area and jurisdiction of MCD/NDMC. A deterrent effect can be achieved through substantially hiking the parking rates. There are no clear indications of how much this should be. The only example of high parking charges to reduce congestion is at the Indira Gandhi International Airport. There are two parking lots at the airport, general and premium according to the distance from the terminal. The earlier rates were Rs. 10 and 20 for the general and premium parking lots, respectively. Because of heavy rush in the premium lot during peak hours, the rates were hiked to Rs. 50 while rates for the general lot were left unchanged. The result has been a substantial decrease in congestion in the premium lot and a corresponding increase in the general lot.

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Annexes

Annex 1

Reforms in Industrial Policy including Foreign Direct Investment

- Abolition of industrial licensing for all new projects regardless of size, except in 9 designated industries and for projects within 25 kms. of 23 cities with population of over one million. Licenses are not required within this radius if industries are designated as being non-polluting (e.g. electronics, computer software and printing) or where they are located in designated industrial areas. More flexibility is permitted in cities that are industrially depressed.
- Automatic clearance of capital goods imports for delicensed projects if foreign exchange requirements are made available from foreign equity investment or if the requirement is less than 25 percent of the total value of plant and equipment.
- Automatic approval for projects involving foreign equity investment up to 51 percent in high priority industries, provided the foreign exchange for imported capital goods is met from foreign equity and repatriation of profits is covered by export earnings.
- The list of industries eligible for foreign equity investment under automatic approval route by RBI has been expanded in 1997-98. Equity investment up to 100 per cent by NRI/OCBs (Overseas Corporate Bodies) has been permitted in high priority industries. These include 9 high priority industries in metallurgical and infrastructure sectors and 13 other priority industries, hitherto eligible for 74 per cent and 51 per cent equity investment respectively.
- Foreign equity investment in mining (3 categories of industries) has also been allowed up to 100 per cent for NRI/OCBs.
- The existing ceiling of 24 per cent for aggregate portfolio investment limit for NRIs/OCBs/FIIs can now be raised to 30 per cent of the issued and paid up capital.
- Abolition of all pre-entry clearance requirements in the Monopolies and Restrictive Trade Practices (MRTP) Act, which is applied to large or dominant firms. The Act is restricted to focus on policing of monopolistic, restrictive or unfair trade practices as well as consumer protection.
- Elimination of the requirement to enter into a Phased Manufacturing Program (PMP) whereby producers were required progressively to indigenise production of parts and components over time.
- Abolition of the mandatory convertibility clause in terms of loans from financial institutions (conversion of a portion of loans value into equity) for new projects.
- Reduction of the list of industries reserved for the public sector from 17 to 6. Private sector participation is allowed in industries on the reserved list.
- The private sector has been invited to invest in oil exploration and refining.
- The power sector has been opened to both domestic and foreign private investment.
- Streamlining of industrial location policies, limiting the requirement of prior clearance from Government for only such units as are located in 23 cities, each with a population of more than one million.

- Existing industries would be free to expand according to their market needs without prior expansion or capacity clearance from the Government.
- The system of endorsement of capacity expansion under modernisation/renovation has been discontinued except in industries, which are still under compulsory licensing or are located in restricted areas.
- The Chief Inspector of Factories has been designated as the appropriate Government Authority under the stipulations regarding conversion of letters of intent to individual licenses in case of hazardous industries.
- An Investment Promotion and Project Monitoring Cell has been set up to provide information and guidance to entrepreneurs regarding licensing policy, tariff, corporate laws, current status of applications pending with the Department, infrastructure facilities and incentives available at state levels for setting up industries etc.
- The Disinvestment Commission has been set up to identify public sector enterprises for equity disinvestment and work out disinvestment modalities.
- The investment ceiling on plant and machinery for small scale undertakings/ancillary industrial undertakings has been enhanced from Rs. 6 million /Rs. 7.5 million to Rs. 30 million and for tiny units to Rs. 2.5 million from Rs. 0.5 million.
- Fifteen items hitherto reserved exclusively for manufacture in the small sector have been dereserved.
- A Tariff Commission that will advise the Government on appropriate levels of tariffs, tariff-related disputes and non-tariff measures has been set up.
- A high powered Export Promotion Board has been set up to improve the export performance of the industries.
- Enhanced autonomy has been granted to nine selected PSEs referred to as "Navaratnas". Two more enterprises, namely GAIL and MTNL have also been given the same status.
- Greater functional and operational autonomy has been granted to 97 other profit-making PSUs referred to as Mini-Ratnas' for making them more efficient and competitive.

Annex 2

Trade and Exchange Policy Reforms

- The rupee exchange rate was adjusted downward by about 22 percent in July 1991, and is now determined by market forces.
- The exchange rate system has been changed. In March 1992, the system of Exim scrips was abolished and a dual market Liberalised Exchange Rate Management Scheme (LERMS) was introduced. The 1993/94 budget went further and eliminated this in favour of unification. Now all exporters as well as other foreign exchange earners can convert 100 per cent of their earnings at the market rate.
- Import control through licensing has been virtually abolished. Except for consumer goods, which remain restricted, almost all items of capital goods, raw materials, intermediates etc. can be freely imported subject only to payment of customs duties.
- The maximum tariff rate was lowered from 250 percent in 1991 to 65 per cent in 1994 and further down to 50 percent in 1995 and further to 40 per cent during 1996-97.
- The duty on capital goods was reduced from 25 per cent to 20 per cent during 1996-97.
- A number of export incentives, including the cash compensatory support for exports, have been dispensed with.
- Imports of gold and silver have been liberalised.
- Access of exporters to duty free imports has been improved. The system of advance licenses has been strengthened by simplifying and speeding up the process of issuing these licenses, reduction in the number of documents required, larger coverage of items for prescribing norms, specification of the value of an advance license in free foreign exchange, permission to adjust fluctuations in prices of imported individual items within the overall c.i.f. value of the advance license, streamlining the procedure for obtaining bank guarantee and legal undertaking, permission to dispose of the materials imported against such licenses without seeking prior permission of the licensing authority (in cases where no MODVAT facility has been availed of) and removal of substantial manufacturing activity conditions for exports to GCA for these licenses.
- A number of measures to strengthen the development of Export Houses and Trading Houses as an instrument for promoting exports were announced. Advance licenses are available for Export Houses, Trading Houses and Star Trading Houses. All licenses under duty exemption schemes are also transferable.
- The Export Processing Zones (EPZ) scheme and the 100 percent Export Oriented Unit (EOU) scheme was revised after review. The EPZ and EOU schemes have been liberalised and extended to agriculture, horticulture, aquaculture, poultry and animal husbandry. The definition of deemed exports has been streamlined.
- The Actual user requirement in respect of Open General License (OGL) Capital goods and OGL raw materials and components was removed. The condition of having registration/ industrial approval from the concerned authority for import of OGL capital goods, raw materials, components, consumable and spares, has been dispensed with.

- Established exporters have been allowed to open foreign currency accounts in approved banks and exporters have been allowed to raise external credits, pay for port-related imports from such accounts, and credit export proceeds to such accounts.
- Quantitative restrictions on remaining items are being removed on a phased basis. A number of items were moved from the negative/restricted list to OGL and can therefore be imported freely. For example, on 1.4.96 there were 6161 items which could be imported freely. This list has been expanded to 6649 on 1.4.97. An additional 128 items mainly textiles were freed by a notification dated December 31, 1997. Another 340 items have been shifted from the restricted list to the OGL in the revised policy in June 1998.
- Exporters have also been given access to capital goods at reduced or zero duty dependent on a verifiable commitment of exports amounting to a value which is a multiple of the value of capital goods exported. This scheme has been expanded progressively to include an increasing number of exporters. The threshold limit for EPCG zero duty scheme has been brought down to Rs. 10 million uniformly for Agriculture and Allied sector (from Rs. 5 million) and for Electronics, Textiles, Leather, Gems and Jewellery, Sports goods and Food Processing sectors (from Rs. 200 million).
- Setting up of private bonded warehouses has been permitted for exports and imports
- Certain categories of imports and exports such as deemed exports, Export Houses, Trading Houses and Star Trading Houses, manufacturer – exports with ISO 9000 or BIS 14000 series or equivalent certification, and exports to ACU countries would be eligible for the issue of special import licenses in order to enable them to import specified items which are on the restricted list. These licenses would be freely tradable in the market. Under these special licenses, imports of 18 specified consumer durable items listed in the negative list have been allowed subject to payment of normal customs duty.

Annex 3

Major auto manufacturers in India and their market shares (per cent)

TABLE A3.1

Passenger cars

Passenger Cars	1993-94	1994-95	1995-96	1996-97	1997-98
Daewoo Motors India Ltd.	-	-	3	4	2
General Motors India Ltd.	-	-	-	2	2
Hindustan Motors Ltd.	13	10	8	6	5
Honda Siel Cars India Ltd.	-	-	-	-	0
Mercedes Benz India Ltd.	-	-	-	-	1
Mahindra Ford Ltd.	-	-	-	1	2
Maruti Udyog Ltd.	72	75	77	80	83
PAL-Peugeot Ltd.	-	-	3	2	1
Premier Automobiles Ltd.	12	10	6	2	3
Tata Engg. & Loco. Co. Ltd.	3	5	3	3	1
Total	**100**	**100**	**100**	**100**	**100**

SOURCE: Facts and Figures, ACMA

TABLE A3.2

Two wheelers (per cent market share)

Scooters	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**
Bajaj Auto Ltd.	62	62	58	54	50
Kinetic Honda Motors Ltd.	8	9	9	8	9
Kelvinator India Ltd.	-	-	-	-	-
LML Ltd.	17	19	20	21	24
Maharashtra Scooters Ltd.	13	10	10	11	11
Majestic Auto Ltd.	-	-	-	1	0
Scooters India Ltd.	-	-	-	0	0
TVS Suzuki Ltd.	-	-	3	5	6
Total	100	100	100	100	100
Motor cycles	1993-94	1994-95	1995-96	1996-97	1997-98
Bajaj Auto Ltd.	29	30	29	31	28
Escorts Yamaha Motors Ltd.	24	25	23	22	16
Hero Honda Motors Ltd.	32	28	28	27	36
Ideal Jawa (India) Pvt. Ltd.	1	1	1	-	0
Royal Infield India Ltd.	3	3	3	3	2
TVS Suzuki Ltd.	11	13	16	17	19
Total	100	100	100	100	100
Mopeds	1993-94	1994-95	1995-96	1996-97	1997-98
Bajaj Auto Ltd.	15	14	12	10	8
Escorts Yamaha Motors td.	-	-	3	3	2
Kelvinator India Ltd.	1	-	-	-	-
Kinetic Engineering Ltd.	27	24	25	24	24
Kinetic Honda Motors Ltd.	-	-	-	-	-
Majestic Auto Ltd.	23	23	19	19	21
Royal Infield India Ltd.	1	-	-	-	-
TVS Suzuki Ltd.	33	39	41	44	45
Total	**100**	**100**	**100**	**100**	**100**

SOURCE: Facts and Figures, ACMA

TABLE A3.3

Three wheelers (per cent market share)

Three Wheelers	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**
Bajaj Auto Ltd.	96	94	86	84	82
Bajaj Tempo Ltd.	-	-	-	-	5
Greaves Ltd.	-	-	7	9	6
Scooters India Ltd.	4	6	7	7	7
Total	**100**	**100**	**100**	**100**	**100**

SOURCE: Facts and Figures, ACMA

TABLE A3.4

LCVs, MCVs and HCVs (per cent market share)

Light Commercial Vehicles	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**
Ashok Leyland Ltd.	-	2	2	1	2
Bajaj Tempo Ltd.	31	26	22	18	8
Daewoo Motors India Ltd.	3	3	2	-	0
Eicher Motors Ltd.	5	5	5	5	8
Mahindra & Mahindra Ltd.	5	5	3	3	9
M&M Ltd., Zahirabad	2	1	1	1	1
Swaraj Mazda Ltd.	4	4	3	3	5
Tata Engg. & Loco. Co. Ltd.	47	52	60	67	66
Total	**100**	**100**	**100**	**100**	**100**
Medium & Heavy Commercial Vehicles	1993-94	1994-95	1995-96	1996-97	1997-98
Ashok Leyland Ltd.	31	27	27	28	32
Hindustan Motors Ltd.	-	-	-	-	1
Tata Engg. & Loco. Co. Ltd.	69	73	73	72	67
Total	**100**	**100**	**100**	**100**	**100**

SOURCE: *Facts and Figures*, ACMA

Annex 4

Joint Venture for Automotive Vehicles 1991-1998

Name of the Joint Venture (with date of approval)	Foreign Equity Participation	Annual Capacity	Implementation Schedule
Birla Group of Companies (Hindustan Motors) with General Motros of USA	50 per cent	25,000 Cars	Production already launched (Opel Astra)
Premier Automobiles Ltd. with Peugeot of France	50per cent	60,000 Cars	-do- (Peugeot 309)
Telco with Mercedes Benz of Germany	76 per cent	20,000 Cars	-do- Mercedes E-220
DCM with Daewoo Motor Company of Korea	91.23 per cent	1,60,000 Cars	-do- (Ceilo)
Mahindra & Mahindra with Ford Motor Company of USA	50 per cent	1,25,000 Cars	-do- (Escort & Fiesta)
Sriram Industrial Enterprises Ltd. with Honda Motor Company of Japan	90 per cent	30,000 Cars	1997-98 (Honda City Car)
Hindustan Motors with Mitsubishi Motor Corpn. Of Japan	10 per cent	30,000 Cars	1997-98 (Lancer)
Sipani automobiles with M/s. Rovers Group Ltd. Of UK	2.59 per cent	15,000 Cars	The Company was to launch production in 1995-96 but has not yet done so.(Montena, Montego, series car)
Hyundai Motor Company, Korea	100 per cent	1,00,000 2,00,000 Accent MX	1997-98 (Accent 1.3)
Hero Cycles Ltd., Ludhiana with BMW, Germany	51 per cent	10,000 (Motor Cycles)	1997-98 Five new series cars including Land rover & Rover Cars
Maruti Udyog Ltd. with Suzuki Motor Co., Japan	50 per cent	2,50,000 Cars	Esteem, Zen, Gypsy
Kamal Sabre Motors Ltd. with JD automotive design of South America and Sabre International Corpn. of USA	100 per cent EOU	720 (Sports Car)	Not indicated (Arrow & Sabre)
Volvo AB, Sweden	100 per cent	Not Commercial. Vehicles.	1997-98 (Volvo trucks indicated)
Premier Automobiles with FIAT, Italy	1.74 per cent (672 Crores) 2.51 per cent	1,00,000 Cars 45,000	Over a period of 7 years from 1997 (Palio, Siena & 178 Station wagons) (Fiat Uno)
Maini Amerigon Car Co. with Amerigon Inc., USA & Asian Equity, UK.	54.25 per cent V - 80,000	1-6,000 (Electric Car)	Rewa models of electric passenger cars.
M/s. Overseases Concept Auto Ltd., Chandigarh with Concept Industrial Management Ltd., UK	34.43 per cent	2200	1996 (Not commenced) (Evanta & Concept)
M/s. Kirloskar Systems Ltd. Bangalore, with M/s. Toyota Motor Corporation, Japan	74 per cent	50,000 Cars	Multi-utility vehicles

Source: *ACMA Newsletters.*

Annex 5

Controlling vehicular emissions in India: technological options

The focus here is on reducing the volume of emissions from the existing level through improved technology. In particular, we briefly discuss emission control technology that is feasible or may become commercially viable in the future. No attempt is made to offer an exhaustive treatment on the subject. Technological options considered pertain to fuel injection, engine design, exhaust after-treatment, improved fuel and alternate fuels. While most new technology is applicable to new vehicles alone, some of them can be retrofitted to existing in-use vehicles. Incentives to encourage retrofitting are discussed in chapter 4. The rest of this section is devoted to a discussion of technologies that appear promising from the point of view of pollution reduction. These are discussed in turn for petrol driven cars and jeeps, petrol driven two and three wheelers and diesel powered vehicles.

Petrol driven cars and jeeps

Three sources of emissions are associated with petrol driven passenger cars and jeeps. These are: (i) evaporative; (ii) crankcase, and (iii) exhaust emissions, respectively.

(i) ***Evaporative emissions*** in the form of hydrocarbon vapours take place from the carburettor bowl during the hot soak period of the combustion process and from the fuel tank during the filling process. Evaporative emissions are estimated to contribute up to twenty percent of all hydrocarbon emissions, and total evaporative emission from the petrol distribution process alone is 3.92 gm/litre (IIP 1994, Faiz et al. 1996). The methods to deal with evaporative emissions absorb and recycle HC vapours back into the engine. Two different types of devices are available and are in use in countries that have evaporative emission standards. These are: (*a*) charcoal canister for the engine, and (*b*) diurnal soak vent vapour recovery system. While the former absorbs emissions from the crankcase, the latter recycles HC vapours generated during the refuelling processes. There are no standards for this type of emission in India, nor are there any attempts to control emissions from this source by any manufacturer. The technology to reduce evaporative emission is very effective, and in fact 95 percent of the vapours lost during the refuelling of storage tanks and petrol pumps are recovered. The investment in emission control devices is recovered within a span of two to three years through fuel saved. Modification of the petrol dispensing system may also result in substantial reduction of emissions.

(ii) ***Crankcase emissions*** occur while the engine is running. Gases and vapours, mostly unburnt and partly burned hydrocarbons, that escape from the combustion chamber are discharged through a tube and lost in the atmosphere. Crankcase emission control utilises the positive crankcase ventilation (PCV) valve to recycle the HC vapours back into the combustion chamber. Although crankcase emission standards are enforced in USA and Europe, there are no standards in India. Newer vehicles, however, including Maruti, NE 118, and Contessa are equipped with a PCV valve. Since this is a low cost device, costs are recovered quickly in terms of fuel saved.

(iii) ***Exhaust emissions***. Incomplete combustion results in unburned and partly burned hydrocarbons (HC) and carbon monoxide (CO), while high temperature and pressure during the combustion process results in the formation of oxides of nitrogen (NOx). The combustion process

[94] For a detailed discussion see Faiz, et al. 1996.

also results in the formation of sulphur dioxide (SO2) , lead (Pb) and particulates. Exhaust emissions are controlled by (*a*) improved engine design, (*b*) modifying the engine operating variables, (*c*) fuel and fuel supply system and (*d*) exhaust gas recirculation and after-treatment:

(a) *engine design modifications* affect emissions in a number of important ways. Reduced compression ratios lead to lower HC emissions while an improved combustion chamber design leads to faster burning and reduced emissions. Stratified charge engines providing rich air-fuel mixture near the spark plugs in a pre-chamber and lean air-fuel mixture in the main combustion chamber have lower emissions of CO, HC and NOx.

(b) *modifications of engine operating variables* also result in substantial reductions of emissions. The most important variable is the air-fuel ratio, and most engine control systems incorporate this into their designs. Air-fuel mixtures can be stoichiometric, when neither air nor fuel is left over after combustion, or lean when there is more air than fuel, and rich when there is more fuel than air. While rich mixtures lead to relatively higher CO and HC emissions as compared to stoichiometric and lean mixtures, NOx emissions are highest in stoichiometric mixtures. Modern engines use electronic controls to maintain stoichiometry by measuring the air-fuel ratio in the exhaust and adjusting the air-fuel mixture going into the engine. Computer control of spark timing, exhaust gas recirculation, air injection systems, etc., along with the use of three-way catalytic converters lead to a substantial reduction in emissions, although reduction is achieved even without the three-way catalysts. The likelihood of tampering and maladjustment is also reduced in computer controlled engine systems, decreasing the probability of an increase in emissions over time.

(c) the *air-fuel ratio* is also affected by other engine operations including the fuel injection system. Traditionally, carburettors have been used to introduce a rich air-fuel mixture into the engine. Most automobile engines produced in India retain this feature, although this may be modified to provide stoichiometric or lean mixtures. An improvement over this are the fuel injection systems (FI), both mechanical and electronic. They lead to increased power, increased torque, and uniform fuel distribution. They also incorporate precise controls, utilising sensors to vary the amount of fuel injected into the system. Closed loop fuel injection systems maintain the air-fuel mixture by using oxygen sensors in the exhaust system.

(d) while engine modifications result in substantial emission reductions, there is still a need for the *treatment of exhaust gases*. Early systems developed by General Motors used the air-injection reactor. Pressurised air was introduced into the cylinder's exhaust port to oxidise the CO and HC in the exhaust. A later version was the thermal oxidation reactor developed to reduce CO and HC emissions. It operated in very high temperatures and therefore reductions in NOx were not achieved.

Two-stroke petrol engines

Two-stroke petrol engines are used extensively in two and three wheelers in India. They are less fuel efficient as compared to four-stroke engines, but are less expensive and have higher power output. Unlike four-stroke engines, exhaust and intake occur simultaneously in a two stroke engine. This leads to some leakage of fresh mixture into the exhaust causing a high level of hydrocarbon emissions. Another feature of the two-stroke engine is that lubrication is provided by oil mixed with the fuel. Some oil escapes unburned into the exhaust, leading to a high level of particulate matter emissions.

In two-stroke engines, use of electronic fuel injection (EFI) systems can reduce hydrocarbon emissions. Various versions have been developed, some of which have achieved HC emissions comparable to four-stroke engines. EFI systems also reduce HC emissions through reduced misfiring. Exhaust charge control systems also reduce HC emissions. There is also scope for exhaust after-treatment by fitting catalytic converters, although some modification of current converter design is required. Finally, use of electronic oil metering instead of pre-mixed oil and petrol would lead to lower particulate matter emissions.

Compression-ignition diesel engines

In a diesel engine, air is compressed resulting in temperature higher than the self-ignition temperature of diesel. Diesel fuel is injected at very high pressure, leading to the ignition of the air-fuel mixture. The reaction of nitrogen and oxygen at such high temperatures leads to significant emissions of oxides of nitrogen. Other pollutants produced are sulphur dioxide, particulate matter (PM) and hydrocarbons.

There is a trade-off between NOx and PM emissions in a diesel engine. However, modifications in engine design can lead to significant reductions in both NOx and PM emissions. These modifications include turbo-charging, charge cooling, retarding fuel injection timing by introducing a flexible timing system, re-circulating exhaust gas and increasing fuel injection pressure and injection rate.

Exhaust after-treatment devices like the trap oxidiser using a particulate filter can lead to reduced PM emissions, although it has not been very popular. Diesel catalytic converters can reduce HC and CO emissions but not NOx emissions. Catalytic converters have not been used extensively in diesel engines as yet.

More buses on the road will lead to lower pollution since the total pollution load to carry a given number of passengers will be much less as compared to cars, two-wheelers and three-wheelers. Other mass transit systems such as rail systems will be even less polluting.

Volume of short distance trips

Finally, reducing the volume of short distance trips helps reduce HC and CO emissions in the case of vehicles equipped with catalytic converters. This is because catalytic converters are more effective at a slightly higher temperature, and car trips may be too short to enable temperatures to reach optimum levels

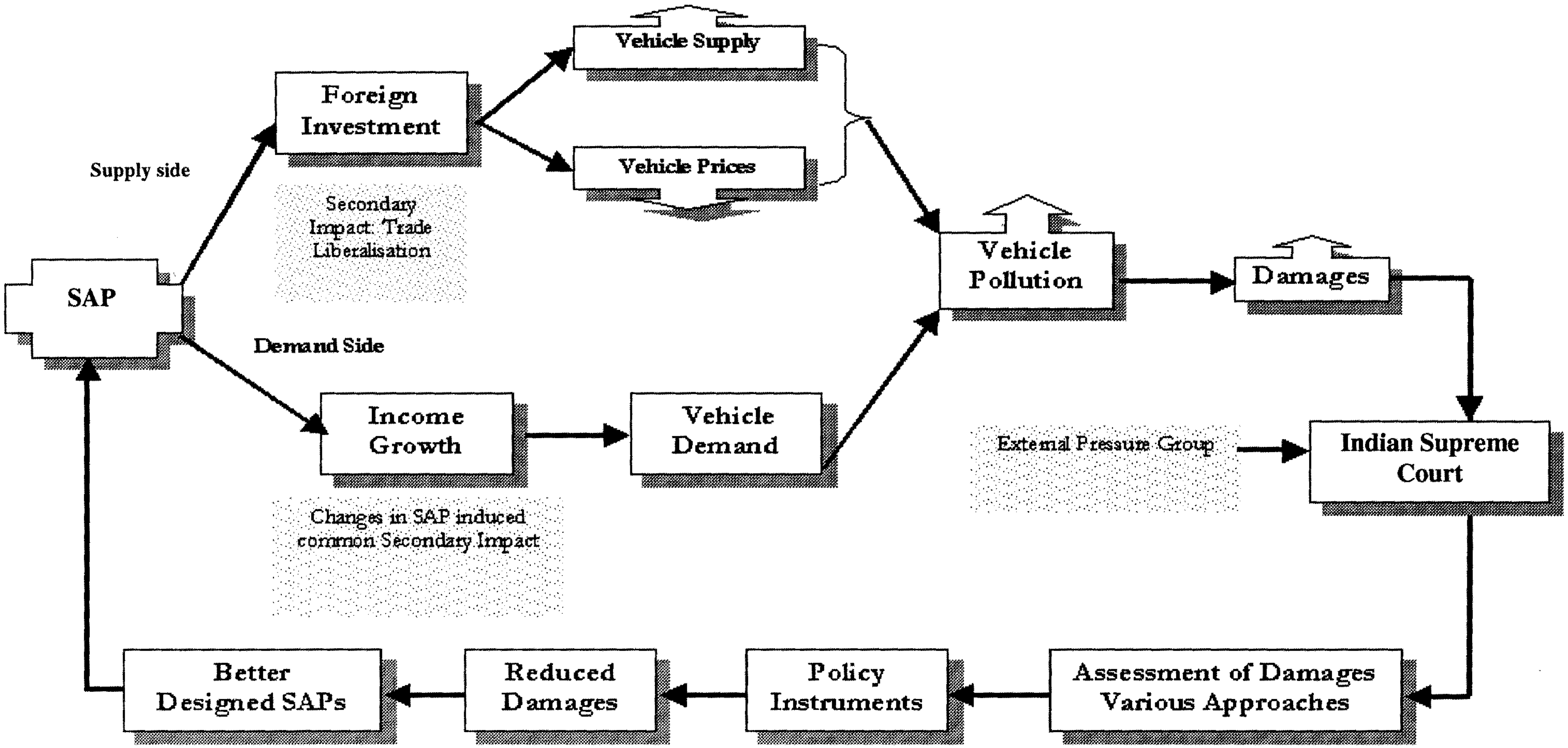
TABLE A5.1

Technological options for controlling emissions from motor vehicles

Vehicle type	Specific emission	Engine type	Fuel	Technological measures	Effectiveness
Cars	Tailpipe emission of CO, VOC, NOx, and lead	4 stroke	Petrol	Three way catalytic converters	Introduction of catalytic converters can reduce 90% of tail-pipe emission of CO, NOx & VOC. Should be used only in conjunction with unleaded petrol.
Motor powered vehicles including autorickshaws & motor cycles	Tailpipe emission of CO, VOCs & lead	2, 3 and 4 Stroke	Petrol and oil mixed lubrication	Oxidative catalytic converters (oxidation catalysts)	Catalytic converters can result in 90% reduction in tailpipe emissions of CO, NOx & VOC. It should be used with unleaded petrol only.
Motor powered vehicles	VOC emissions due to diurnal evaporation of gasoline tank and fuel system	4 stroke	Petrol	Carbon canister (carbon filter)	80% of evaporation emissions controlled.

Annex 6

Structural Adjustment Policy and its Environmental Impact on the Automobile Sector



Annex 7

MBIs versus command-and-control – empirical evidence

There exist a number of simulation studies which indicate the potential cost savings of using MBIs instead of CAC measures to achieve the same pollution target. These are summarised in Tables A7.1 and A7.2 below for air and water pollution control, respectively. In the tables, potential cost savings are shown as the ratio of costs under CAC (howsoever defined) to the lowest cost of meeting the same objective through an MBI. Thus, a ratio of 1.0 implies that the CAC regime is cost-effective and, therefore, there are no potential cost savings. It should be mentioned, however, that though these studies have been conducted carefully, they are simulation studies. In other words, they indicate the cost savings that would take place if MBIs were to be used in place of CAC policies. Further, the actual cost savings realised would depend on the extent to which the actual trading programmes (or other MBIs) approximated the least-cost solution. (Hence the use of the phrase potential cost savings). The actual performance of MBIs is discussed in the following section.

[93] In Table A7.1, pollutants are categorised along two dimensions – whether they are uniformly mixed and whether they are assimilative. For *assimilative* pollutants the capacity of the environment to absorb them is relatively large compared to their rate of emission, such that the pollution level in any year is independent of the amount discharged in the previous years. In other words, assimilative pollutants do not accumulate over time. The situation is just the opposite for *accumulative* pollutants. Most conventional pollutants, however (such as oxides of nitrogen and sulphur, total suspended particulates, and BOD), are assimilative in nature.

In the case of *uniformly mixed* pollutants, the ambient concentration of a pollutant depends on the total amount discharged, but not on the spatial distribution of these discharges among the various sources. Thus, a unit reduction in emission from any source within an airshed would have the same effect on ambient air quality. An example of this would be emissions of volatile organic compounds (VOCs) which uniformly contribute to concentration of ozone in an airshed. *Nonuniformly mixed* pollutants comprise air and water pollutants such as total suspended particulates, sulphur dioxide, and BOD. In these cases the *location* of the discharge matters – all sources do not affect ambient air/water quality in the same manner. In other words, damage costs from nonuniformly mixed pollutants are not uniform. In terms of analysing various kinds of pollutants the easiest category is uniformly mixed assimilative pollutants

TABLE A7.1

Empirical Studies of Air Pollution Control

Study and Year	Pollutants Covered	Geographic Area	CAC benchmark	Assumed pollutant type	Ratio of CAC cost to least cost
Atkinson and Lewis (1974)	Particulates	St. Louis Metropolitan Area	SIP regulations	Non-uniformly mixed	6.00
Palmer, Mooz, Quinn, and Wolf (1980)	Chlorofluorocarbon emissions from non-aerosol applications	United States	Proposed emissions standards	Uniformly mixed accumulative	1.96
Roach, et al. (1981)	Sulphur dioxide	Four Corners in Utah, Colorado, Arizona and New Mexico	SIP regulations	Non-uniformly mixed	4.25
Hahn and Noll (1982)	Sulphates	Los Angeles	California emission standards	Non-uniformly mixed	1.07
Atkinson (1983)	Sulphur dioxide	Cleveland		Non-uniformly mixed	About 1.5
Harrison (1983)	Airport noise	United States	Mandatory retrofit	Uniformly mixed	1.72
Seskin, Anderson & Reid (1983)	Nitrogen dioxide	Chicago	Proposed RACT regulations	Non-uniformly mixed	14.40
Maloney and Yandle (1984)	Hydrocarbons	All domestic Du Pont plants	Uniform percentage reduction	Uniformly mixed	4.15
McGartland (1984)	Particulate	Baltimore	SIP regulations	Non-uniformly mixed	4.18
Spofford (1984)	Sulphur dioxide	Lower Delaware Valley	Uniform percentage reduction	Non-uniformly mixed	1.78

TABLE A7.1 (*continued*)

Study and Year	Pollutants Covered	Geographic Area	CAC benchmark	Assumed pollutant type	***Ratio of CAC cost to least cost***
Spofford (1984)	Particulates	Lower Delaware Valley	Uniform percentage reduction	Non-uniformly mixed	22.00
Krupnick (1986)	Nitrogen dioxide	Baltimore	Proposed RACT regulations	Non-uniformly mixed	5.9
Welsch (1988)	Sulphur dioxide	United Kingdom		Non-uniformly mixed	1.4-2.5
Oates, et al. (1989)	TSP	Baltimore	Equal proportional treatment	Non-uniformly mixed	4.0 at 90 $\mu g/m^3$
SCAQMD (1992)	Reactive Organic Gases/ Nitrogen dioxide	Southern California	Best available control technology	Non-uniformly mixed	1.5 in 1994

Definitions:

TSP = Total Suspended Particulates
SCAQMD = South Coast Air Quality Management District
CAC = Command-and-control, the traditional regulatory approach
SIP = State Implementation Plan (strategy by a state in the US to meet federal environmental standards)
RACT = Reasonably Available Control Technologies, a set of standards imposed on existing sources in non attainment areas

SOURCE: Tietenberg (1985), USEPA (1992) and World Bank (1992)

TABLE A7.2

Empirical Studies of Water Pollution Control

Study and Year	Pollutants Covered	Geographic Area	CAC benchmark	DO target (mg/ litre)	Ratio of CAC cost to least cost
Johnson (1967)	Biochemical oxygen demand	Delaware Estuary - 86-mile reach	Equal proportional treatment	2.0 3.0 4.0	3.13 1.62 1.43
O'Neil (1980)	Biochemical oxygen demand	20-mile segment of Lower Fox River in Wisconsin	Equal proportional treatment	2.0 4.0 6.2 7.9	2.29 1.71 1.45 1.38
Eheart, Brill, and Lyon (1983)	Biochemical oxygen demand	Willamette River in Oregon	Equal proportional treatment	4.8 7.5	1.12 1.19
		Delaware Estuary in Penn., Delaware, and New Jersey	Equal proportional treatment	3.0 3.6	3.00 2.92
		Upper Hudson River in New York	Equal proportional treatment	5.1 5.9	1.54 1.62
		Mohawk River in New York	Equal proportional treatment	6.8	1.22
Opaluch and Kashmanian (1985)	Heavy metals	Rhode Island Jewellery Industry	Technology-based standards		1.8

Definitions:

CAC = Command-and-control, the traditional regulatory approach

DO = Dissolved oxygen: Higher DO targets indicate higher water quality

SOURCE: Tietenberg (1985) and USEPA (1992)

Annex 8

Applications of Market-Based Instruments in Various Countries

TABLE A8.1(*a*)

Direct instruments (Developed countries)

1. Pollution charges

Country	*Medium*	*Description*
Australia (province)	Water	Firms in the province of South Australia pay waste water effluent charges based on pollution load. The charge is imposed on actual measured effluents and levied through discharge licenses. (OECD 1994, p. 68)
Austria	Land	Tax on solid waste disposal (supplied to processors such as landfills and incinerators) at the rate of ECU 2.4/ton, and the revenue is used for treatment and recycling. Hazardous wastes face a charge of ECU 12/ton, and the revenue is used to clean up contaminated sites. (OECD 1994, p. 63-65)
Belgium (regions)	Water, land	In 1990 the Flemish and Wallone regions introduced an effluent charge on firms, based on the pollution load covering BOD, COD, suspended materials, nutrient load, and heavy metals. (OECD 1994, p. 68-69; OECD 1995, p. 41)
		There are also hazardous waste charges in the range of ECU 8-63/ton, and the revenue is used for environmental expenditure. (OECD 1994, p. 65)
Canada (provinces)	Air, water	British Columbia introduced permit fees on pollutant emissions in 1992. The fees are reduced if the actual emissions are less than the permitted emissions. (OECD 1994, p. 57)
		Alberta and British Columbia levy water effluent charges based on actual pollution load. The rates are differentiated according to the degree of toxicity of pollutants. Alberta has reported positive incentive effects. (OECD 1994, p. 68-69)
Denmark	Water, land	City of Copenhagen introduced water effluent charges in 1979. To cover the cost of effluent treatment, a surcharge was placed on firms with discharge worse than the average quality of sewage. Except for Copenhagen, Danish waste water treatment plants are not self-financing. (James 1996, p. 66)
		Solid waste tax introduced in 1987, based on the weight supplied to landfills and waste incinerators. Waste removed from landfills and incinerators is subtracted from the charge base. In 1987-89 the total registered waste supply decreased by 12 per cent and waste removed rose by 7 per cent. However this has led to excessive use of building waste as filling material for road making. (OECD 1994, p. 64)
Finland	Land	There is a tax on hazardous waste at the rate of ECU 270/tonne on average, and the revenue is used in waste processing. (OECD 1994, p. 65)

France	Air, water, land	In 1985, atmospheric emission tax was introduced (extended in 1990) on operators of fuel installations (capacity> 20 thermal MW), waste incinerators (capacity> 3 tonnes/hr), and plants emitting over 150 tonnes/ year of SO_x, NO_x, hydrochloric acid compounds, or non-methane HC, and solvents/VOC. Revenue from the fee (FF 150/tonne) is used for the pollution abatement and monitoring equipment. (OECD 1995, p. 27; Bernstein 1993, p. 47) Water effluent charges were introduced in 1968 (enacted 1964) on suspended and organic matter discharged in the six river basins; later extended to cover salinity (1973), toxicity (1974), nitrogen and phosphorus (1982), halogenated hydrocarbons, toxic and other metals (1992). The value of the charges, per unit weight of pollutant, are set such that the revenue balances the financial assistance provided (for works of common interest, or research in water related matters). The six water agencies contributed US$ 6 billion to water protection projects during 1982-91, which corresponded to approximately 40% of the total cost. (Cadiou and Duc 1994, p. 139, World Bank 1995, p. 67) There is a tax on waste disposal (landfills and incinerators) at the rate of ECU 2.5/ton, and the revenue is used for treatment and recycling.(OECD 1994, p. 63)
Germany	Water	First river authority (Genossenschaft) was set up in 1904 along the Emschen river in Ruhr valley, to treat industrial wastes in cooperatives funded by effluent charges. By 1975, there were 8 Genossenschaft for 8 rivers, with 500 private and public members, and appr. $60 million annual charge revenue (1975$). Later, wastewater charges were introduced in 1981 in three states (under the 1976 Act), later extended nation-wide in 1983 (and to former East Germany in 1993). The tax, based on population equivalent, cover COD, phosphorus, nitrogen, and some organic compounds and metals. Charges vary across municipalities and across industries. Revenue is used to cover expenses in water quality management, and to subsidise projects which improve water quality. General perception has been that the system helps improve water quality. (Smith 1995, p. 25; Bohm and Russell 1985, p. 403-404; Hahn 1989, p. 105; World Bank 1995, p. 67)
Ireland	Water	Water effluent charges are levied through licenses. Local authorities levy sewage disposal charges. (OECD 1995, p. 41)
Italy	Water	Industrial waste pollution charge system is designed to encourage firms to achieve the standards. Effluent charge on firms who do not meet the standard is ten times that on firms who do. Once full compliance is obtained there will be no charge system. (James 1996, p. 67)
Japan	Air	Emission charges on SO_x, differentiated by regions. The rates are partially based on emissions in the previous year as well as that in 1982-86. The charge revenue is used to compensate for health damages from pollution. (OECD 1994, p. 57-58)
Netherlands	Water	Implemented effluent charges based on the amount of pollutant in 1969-70. With an increase in charge rates during 1975-80, the amount of organic pollution removed from sewage discharges increased from 25 per cent in 1975 to 46 per cent in 1980 (96 per cent of this can be statistically explained by the increase in the charge rates and the differences in the regional structure of the industry). Revenue from the charges (different across districts) financed construction and operation of sewage treatment plants. During 1969-85, pollution (in population equivalent) had registered a 90 per cent decline. (Bressers and Schuddeboom 1994, p. 154-57; Hahn 1989, p. 106)

Portugal	Air, water, land	Emission charges are levied on SOx and NOx. The revenue is used for air quality control (OECD 1994, p. 58). Households and firms pay water effluent charges based on pollution load. The households, however, pay a flat fee. Hazardous wastes have a charge, and the revenue is used for waste processing. (OECD 1994, p. 58, 65, 68)
Spain	Water	Firms pay water effluent charges based on actual pollution load. The charge is modelled on the French system. (OECD 1994, p. 68-69)
Sweden	Air	NO_x charge on heat and power producers implemented in January 1992 (excluding industrial process burning), with a capacity exceeding 10MW and producing over 50 GWh. Where emissions cannot be measured, standard emission rates are used: the rates being greater than the average actual emissions, it has encouraged installation of measurement equipment. In 1992 a 30-40 per cent emission reduction was achieved. All revenue is rebated to installation (subject to a charge) based on firm' final energy production. The final revenue impact is zero, but there is redistribution between high emitting and low emitting plants. (OECD 1994, p. 59)
Switzerland	Air	Tax on VOCs was scheduled to be introduced in 1995-96 and expected to rise over time to ECU 3/kilo. It is aimed to reduce smog, ozone problems, and damage to the nerve system. (OECD 1995, p. 15)
Turkey	Water, land	Since 1994, a tax on waste and waste water has been levied on households and firms. The charge is aimed at reducing pollution as also raising revenue. (OECD 1995, p. 14)
UK	Water	Discharge consent (maximum permitted emissions) charges are administered by the National Rivers Authority since 1990. Charges vary according to the content and destination of effluents; and are designed to cover the recurring cost of monitoring effluents and controlled waters. (Smith 1995, p. 32)
US	Air, water, land	Excise tax imposed on each pound of ozone-depleting chemicals (CFCs, halons, carbon tetrachloride, and methyl chloroform) came into effect in 1991. The tax for a specific chemical is determined by its ozone-depleting factor with a base amount for the tax. Since the tax is imposed along with quantity restrictions, it serves to capture part of the profits accruing to those in control of the limited supplies of these chemicals. The tax revenue from ozone-depleting chemicals was $886 million in 1991, and $580 in 1992. (Oates 1994, p. 114; OECD 1995, p. 89) Some states have flat fees for waste water discharge, which does not provide incentive to reduce the volume of waste but deters entry into the activity. During 1972-77, industrial discharges from point sources fell by 70 per cent, and the quantity of oxygen demanding pollutants emitted by municipal treatment plants fell by 46 per cent, despite a 12 per cent rise in pollutants entering these plants. Problems remain with non-point sources and contamination of ground water. Few states have non-uniform fees: New Jersey impose fees based on the quantity and relative risk (to public health) of the pollutants; California has a waste water discharge permit fee based on type and volume of the discharged pollutants. The charge revenue fund environmental programmes. (James 1996, p. 61-62; and Oates 1994, p. 120) Excise taxes (Superfund tax) on hazardous chemicals are also in force. The revenue is used to clean up contaminated sites: in 1992, the revenue from this tax was $254 million. (OECD 1995, p. 98; OECD 1994 p. 65)

2. Tradeable permits

Australia (states)	Water	The states of New South Wales, Victoria, and South Australia participate in the Murray Darling Basin Salinity and Drainage System to control the amount of salt entering the river system. The system works through transferable "salt credits" which are tradable across states, but not across firms and individuals. (OECD 1994, p. 89)
Canada	Air	Emission trades cover acid rain pollutants (SOx, NOx) and CFCs. In Ontario, the electric utility of Ontario Hydro is allowed to shift or "trade" SOx and NOx emissions between its electricity generating stations. Internal trading of CFCs are also allowed, subject to the legislation. (OECD 1994, p. 89)
Germany	Air	New plant emissions (of substances subject to the "TA Luft") have to be offset by reduction in emissions from older existing plants, such that the net effect on ambient air quality is neutral. However, the offset and netting provisions in the air pollution regulation are rarely used, since the areas over which the emissions can be traded are small, and substitution between substances is not allowed. Also in many cases, there are increasing returns to scale and indivisibilities in the abatement costs, such that firms have little freedom to choose between emission levels. Consequently potential trades among sources are small. (OECD 1994, p. 89-90)
Singapore	Air	In 1990, introduced a marketable permits system for rights to import ozone-depleting substances (CFCs under the Montreal Protocol) and to own motor vehicles ("certificates of entitlement"). For CFCs, half the quotas are grandfathered and half are allocated through sealed bid tenders. The auction allows the government to capture a substantial portion of the quota rents, which have been used to subsidise recycling services and diffusion of alternative technology. By mid-1992, the vehicle quota premium for standard cars rose to US$ 12,000. This and complementary policies (eg. ALS) restricted the growth in car ownership and traffic. (O'Connor 1995, p. 16-17)
US (states)	Air, water	Emissions trading was introduced in 1974 (netting), and enhanced over the years to include more types of transactions (bubbles, banking, offsets). Pollutants covered include VOC, CO, SO_2, NO_x, particulates, and CFCs. By 1986, 7,000-14,000 internal trades, and some 200 inter-firm trades had taken place: the abatement cost savings, $935-$12,435 millions, though substantial, was less than expected. Trade in lead credits, to phase out lead in gasoline in 1982-87, performed better. Inter-refinery trading did not discriminate between old/new sources, nor between large/small sources. In 1985, about 15 per cent of the total lead credits in use were traded. In the production and consumption of CFCs, a 50% reduction had been achieved by 1993. Southern California introduced RECLAIM (Regional Clean Air Incentives Market) programme in 1994, and is aimed to reduce NOx and SOx emissions from all major stationary sources by 75 per cent and 60 per cent respectively from 1994 by the year 2010. Smaller sources can voluntarily enter the programme. The RECLAIM trading credits, each valid for a year, have been transacted both bilaterally within firms and through auctions. RECLAIM is expected to reduce control costs by 42 per cent on an average compared to the CAC option for the large firms. (Hahn 1989, p. 99-102; OECD 1994, p. 87-88; CSE 1996, p. 22-23) Tradeable water pollution rights have been implemented in Colorado (Dillon and Cherry Creek Reservoir), Wisconsin (Fox River) and North Carolina(Tar-Pimlico Basin). Wisconsin implemented marketable discharge permits on part of the Fox river in 1981 to control BOD level.

		Till date there has been only one trade, due to the thin market. In Colorado, tradeable rights to discharge phosphorous into the Dillon Reservoir was introduced by the local government. By 1992, there were applications but no trade had been approved. (OECD 1994, p. 89; Hahn 1989, 97; Cropper & Oates 1992, p. 691)

3. Deposit refund

Australia	Land	There is a mandatory deposit-refund scheme for PET bottles and disposable beverage glass bottles. The deposit is about 2-5 per cent of the price, and the return rate achieved for PET bottles is 62 per cent. Beverage metal cans have a deposit of 4-5 per cent of the price, and the return rate is 89 per cent. (OECD 1994, p. 83-85)
Austria	Land	Mandatory scheme for plastic reusable containers, and voluntary deposit refund for beverage glass bottles. The deposit for reusable plastic containers is 20 per cent of the price, and the return rates achieved are 60-80 per cent. (OECD 1994, p. 84)
Belgium	Land	The deposit refund scheme covers beer and soft drinks glass containers. (OECD 1994, p. 85)
Canada	Land	Mandatory deposit refund scheme for plastic beverage containers, and alcoholic drinks glass bottles (sometimes voluntary) in some regions. The return rate for these is more than 60 per cent. For metal cans the return rate is greater than 40 per cent. (OECD 1994, p. 83-85)
Denmark	Land	All soft drinks and beers can be sold only in reusable bottles for which the consumer needs to pay a deposit, according to a statutory order of the Ministry of Environment. PET bottles have a return rate of 80-90 per cent, and beverage glass bottles have a return rate of 90-100 per cent. (Bernstein 1993, p. 55; OECD 1994, p. 84-85)
Finland	Land	Under the deposit-refund scheme of beverage glass containers, a 90-100 per cent return rate has been achieved. PET bottles have a deposit of 10-30 per cent of the price and the return rate is 90-100 per cent. (World Bank 1995, p. 71; Bernstein 1993, p. 55; OECD 1994, p. 84-85)
France	Land	There is a deposit-refund system for beer and soft drink glass bottles. (OECD 1994, p. 85)
Germany	Land	Voluntary deposit-refund scheme for alcoholic- and soft drink glass bottles has a return rate of 90-100 per cent. There is also a scheme for non-refillable plastic bottles. (OECD 1994, p. 84-85)
Greece	Land	Mandatory deposit-refund on car hulks older than 15 years. The system is combined with a tax differentiation, and the refund is payable only if a new car is bought that satisfies EC-emission standards. (OECD 1994, p. 83)
Iceland	Land	Mandatory deposit-refund scheme for plastic and glass (alcoholic beverages, mineral water) bottles. The deposit for plastic bottles is 3-10% of the price, with a return rate of 60-80 per cent. For the mineral water glass bottles the deposit is 18-20 per cent of the price with a return rate of 60-80 per cent. (OECD 1994, p. 85)
Japan	Land	Under the voluntary deposit-refund system, the collection rate of beer bottles in 1989 was 92%. By 1990, recycling rates for waste paper, aluminium cans, steel cans and glass bottles were 49.7 per cent, 42.6 per cent, 44.8 per cent and 47.9 per cent respectively. (O'Connor 1994, p. 44-45)

Netherlands	Land	Voluntary deposit-refund scheme for beer, soft drink and milk glass bottles. The deposits range from 37-45 per cent of price for soft drink glass bottles and 20-50 per cent of price for milk/dairy products bottles. The return rates for beer bottles is 99 per cent, and for soft drink bottles 95-98 per cent. PET bottles have a deposit of 30-50 per cent of the price, and the return rate is 90-100 per cent (OECD 1994, p. 84-85)
Norway	Land	Introduced mandatory deposit-refund system for car hulks in 1978: new car buyers pay a deposit and a larger amount is refunded on return to an official recovery site. Almost 90-99 per cent of car hulks are returned, and the revenues are used for refunds and financial assistance for collection, transportation, and scrapping facilities.(OECD 1992, p. 9; World Bank 1995, p. 71; Bernstein 1993, p. 55). There is mandatory scheme for PET bottles, with a return rate of 90-100 per cent. Glass bottles (beer, carbonated drinks) have deposits ranging from 10-20 per cent with a return rate of 90-100 per cent. Wine and liquor glass bottles have a deposit of less than 2 per cent and the return rate is 40-60 per cent. (OECD 1994, p. 85)
Portugal	Land	Voluntary deposit-refund schemes cover metal and plastic containers, and beverage glass bottles. (OECD 1994, p. 83-85)
Sweden	Land	Mandatory deposit-refund for car hulks, PET-bottles, glass bottles, and voluntary for aluminium cans. The return rates of these are 80-100 per cent. On doubling the deposit charge for aluminium beer cans, the return rate increased from 70 per cent to over 80 per cent (the system is operated by a private company). (OECD 1994, p. 83-85; World Bank 1995, p. 72)
Switzerland	Land	Mandatory deposit-refund scheme for beverage glass bottles. (OECD 1994, p. 85)
Turkey	Land	Deposit-refund system for glass bottles. (OECD 1994, p. 85)
US	Land	Ten states have mandatory deposits on soft drinks and beer plastic/ glass containers (although in use earlier, states “reintroduced” the measures, e.g. Oregon in 1972). A refund of 5 to 10 cents has created enough incentive to achieve a return rate of 80-95 per cent. Studies indicate that such schemes have reduced the volume of beverage container litter by 79-83 per cent, and the volume and weight of overall solid waste by 8 per cent and 6 per cent respectively. (Oates 1994, p. 119; World Bank 1995, p. 71; OECD 1994, p. 84-85) In Rhode Island, US, automobile batteries have a mandatory deposit of $5, paid at the time of sale. The dealers hold the deposit (returned if a used battery is returned within seven days of purchase), and are required to return 80 per cent of the deposit funds they hold to the state. The system is considered to be a success. The state of Maine has a mandatory deposit system for pesticide containers: $5 for containers less than 30 gallon capacity, and $10 for larger containers. The deposit is refunded when the triple rinsed container is returned. (Bernstein 1993, p. 56)

TABLE A8 (*b*)

Indirect instruments (Developed countries)

4. Input/output tax and differential tax rates

Australia	Air	There has been an increase in petrol taxes, and the price differential between leaded and unleaded petrol in favour of the latter. (OECD 1995, p. 14)
Austria	Air, water	Introduced an environmental tax on car registration in 1992, based on price of new cars and its average petrol consumption. Simultaneously, the VAT rate on new vehicles was reduced. (OECD 1995, p. 23)
		Tax on fertiliser and pesticide since 1985-86. In the first year their use declined by 10 per cent, and by another 20 per cent in 1987-88. (Pearce 1991, p. 54; USGAO 1993, p. 13)
Belgium	Land	Tax on disposable-razors/ cameras, and some drink containers which cannot be reused/recycled. Cars not satisfying the emission standards also have higher tax rates. (OECD 1995, p. 14, 70)
Britain	Air	Various vehicle taxes including: sales tax on new cars (17.5 per cent), and annual vehicle excise duty. The taxes on commercial vehicle sales, ownership (vehicle excise duty is based on number of axles and weight) and use are higher and more complex than taxes on private cars. Tax differential between leaded and unleaded petrol has increased over time and now stands at 4.8 pence per litre. The proportion of unleaded in total petrol sales rose to 50 per cent in 1993 compared to negligible share in 1986. The marginal saving in buying unleaded vs. leaded petrol outweighed the fixed costs of converting cars to run on unleaded petrol for all except those doing few miles/year. (Smith 1995, p. 96, 109; McKay, et al., 1990, p. 13)
Canada (provinces)	Land	British Columbia has a tax of C$5 per lead acid battery; Ontario and Manitoba have charges on non-refillable beverage containers; and some provinces have charges on tires. Leaded petrol has been phased out since December 1990. (OECD 1995, p. 86; OECD 1994, p. 72)
Denmark	Air, land	In 1992, a fuel tax was introduced based on CO_2 content at combustion. About 50 per cent of the CO_2 tax was reimbursed to businesses (registered under the VAT law), but not that on diesel used for motor fuels. Aviation, shipping, and gas consumption on refineries are exempt from the CO_2 taxes. Since the mid-1980s, leaded and unleaded gasoline have had differential tax rates. In 1994, the market share of unleaded petrol was nearly 100 per cent. (OECD 1995, p. 27-28)
		New tax on plastic/paper shopping bags of DKr 0.5/bag, following the 1994 tax reform. (OECD 1995, p. 14)
Finland	Air, land	Environmental taxes on cars, based on whether or not they are equipped with a catalytic converter. Tax differentiation in favour of lead-free petrol was introduced in 1986. By 1992, the market share of unleaded petrol was 70 per cent. Since 1993, excise tax on diesel favours sulphur-free diesel fuel. In 1994, an EU-type of carbon/energy tax was imposed on fuels as a revision of the 1990 carbon tax. (OECD 1994, p. 72; OECD 1995, p. 15, 23, 30)
		Charge on non-returnable bottles and containers. (McKay, et al., 1990, p. 12)

France	Land	Product charges on lubricants on the manufacturers and importers. The charge is complemented with regulations on collection, storage and disposal of used oil; and the revenue is used for providing assistance in developing infrastructure of those three functions. The charge being low, the incentive impacts have been insignificant. (Bernstein 1993, p. 59)
Germany	Air, land	Annual motor vehicle tax is structured so as to provide tax incentives to cars meeting the EU emission standards. Rates are differentiated by age of the car. Since 1994, diesel-engine cars face an additional tax compared to the petrol cars. The duty differential between leaded and unleaded petrol is DM 0.10 per litre: the market share of unleaded in total petrol sales rose from 11 per cent in 1989 to 80 per cent by 1993. (Smith 1995, p. 96, 109). In 1992, the city of Kassel introduced a tax on disposable plates, cutlery, and packaging for take-away food/drink. Such taxes by municipalities are allowed so long as the federal government does not have similar taxes. (Smith 1995, p. 67)
Greece	Air	A 1990 law provided exemption from the road surtax and the initial lump sum tax for five years for new cars fitted with a catalytic converter. Exemption was given when the buyer had scrapped his old car. About 300,000 old cars were scrapped and pollution considerably reduced. (OECD 1995, p. 23)
Iceland	Land	Tax on plastic bags, at the rate of 8 IKr/bag. (OECD 1995, p. 88)
Ireland	Air	The excise duty on leaded petrol is higher than that on the unleaded petrol. (OECD 1995, p. 51)
Italy	Land	A product charge on lubricant oils (due to a 1975 EC directive on recycling of waste oils). Waste oils collected increased from 55,000 tons in 1985 to 105,000 tons in 1986. (OECD 1992, p. 9) In 1988 a tax of 200 per cent was levied on plastic shopping bags. Consequently, the plastic bag consumption fell by 20-30 per cent. The tax on plastic carrier bags was abolished in 1994 and replaced with a recycling contribution on virgin polyethylene. (OECD 1994, p. 82; OECD 1995, p. 14)
Luxembourg	Air	Excise and VAT tax rates are higher on leaded petrol than on unleaded petrol by margin of 2-3 per cent. (OECD 1995, p. 52)
Japan	Air	Tax deductions are available for cars with low emissions, electric cars and cars on alternative fuels. (OECD 1994, p. 70)
Netherlands	Air	In 1988, environmental charges were introduced on fuels, and in 1990, a carbon (CO_2) component was added to the tax base. Sales tax on cars that complied with future European standards was reduced, and raised for the dirtier models. In the 1980s, in the small car market (two-thirds of the market), the percentage of future European standard cars increased from 37 per cent to 70 per cent. Unleaded petrol was made cheaper than leaded petrol, and within two months unleaded petrol completely replaced the normal petrol in service station forecourts. The carbon tax on motor fuels is too low for significant incentive effects, its revenue funds government environmental investments. (Bressers and Schuddeboom 1994, p. 156; OECD 1994, p. 73; OECD 1995, p. 31; World Bank 1995, p. 68)
New Zealand	Air	A fee is levied on lead added to gasoline (NZ$0.066 = $0.039 per gram). In effect it is preferential tax treatment of unleaded over leaded petrol. (EPA 1992, 9-3)

Norway	Air, land	Taxes are based on the sulphur, carbon and lead content of fossil fuels. The CO_2 tax was introduced in 1991. The CO_2 tax revenue represents an important element of the national budget, e.g. in 1994 contributed 6 billion NKr to state revenues. Since 1986, the basic petrol tax differentiates between leaded and unleaded petrol. In 1995, rate differential was introduced for leaded petrol based on the emissions of lead per litre. (Bernstein 1993, p. 49; OECD 1995, p. 33) Charge on disposable beverage containers since 1988. Also charges on non-refundable containers, batteries, lubricating oil, fertiliser, and pesticides. (OECD 1995, p. 88; World Bank 1995, p. 68; McKay, et al., 1990, p. 12)
Portugal	Air	The tax differential in favour of unleaded petrol is being phased out, since unleaded petrol sales as a proportion of total petrol sales are about the EU average. There are taxes on batteries, packaging, glass, plastic, coal ash, mining and tires. (OECD 1995, p. 15, 89)
Singapore	Air	Imposed large “additional registration tax” (besides the flat registration fee) levied as a percentage of the cost of the car to restrict ownership (thereby traffic congestion): 100 per cent in 1976, and 150 per cent after 1983. The tax is reduced if an old vehicle is scrapped when a new one is purchased (to discourage older, more polluting vehicles). (Buchan 1994, p. 226)
Sweden	Air, land	Product taxes on all fossil fuels since 1991. In 1993, gasoline tax revenue was more than 40 per cent of environmental taxes (latter constituted 6 per cent of total tax revenue). With a tax differential of 0.51SEK/l between leaded and unleaded gasoline in 1993, the consumption of leaded fuel was reduced to less than half of the total gasoline consumption. In 1991, diesel was classified in to 3 categories by pollution potential, and a special diesel fuel tax differentiated by type of diesel was levied. Other energy taxes include carbon tax, sulphur-in-fuel tax, nuclear and hydro power tax. Energy and CO_2 tax is so high that some district heating plants are changing from fossil fuels to bio fuels. Sulphur content of oil fell by about 30 per cent in 1990-92 as a result of the sulphur tax (the accompanying administrative costs were approximately 1 per cent of the revenue). Vehicle taxes (sales and annual taxes) are based on weight and environmental characteristics. Special tax on cars without catalytic converters, and subsidy on new cars with catalytic converters succeeded in introducing low-pollution vehicles at a rate faster than the normal rate. (Sterner & Lowgren 1994, p. 54-56; OECD 1994, p. 73-74; Bergman 1994, p. 254; OECD 1995, p. 15, 24, 34-35; Bernstein 1993, p. 49) Charges on non-refundable containers, batteries, lubricating oil, fertiliser, and pesticide. The charge on beverage containers, levied in 1973, was abolished in May 1993. (World Bank 1995, p. 68; OECD 1995, p. 89)
Switzerland	Air	With a tax differentiation of ECU 0.04/l in favour of unleaded petrol over leaded, the market share of unleaded was 65 per cent in 1992. (OECD 1994, p. 72)
US	Air	The federal government introduced gasoline tax in 1932, while some states already had such a tax as early as 1919 (Oregon). Gasoline tax served as the most important source of revenue for states in 1930s and 1940s. Most of the revenue is earmarked for transportation programmes (road/ highway construction and maintenance). Federal taxes on motor vehicle usage include: a 12 per cent manufacturers excise tax on trucks and trailers, annual use tax on “heavy vehicles” like trucks, excise tax on tires weighing over 40 pounds, and a “Gas Guzzler” tax on automobiles with unsatisfactory fuel economy ratings. States have a range of auto taxes and fees. In 1989, the state motor vehicle and license fees revenue was $10.15 billion. (Oates 1994, p. 114-115)

5. User and administrative charge

Australia	Water, land	Households and firms pay user charges for sewerage and sewage treatment (flat rates and measurement based rates exist). State of New South Wales levied an environmental charge in 1989-90 (for 5 years) on water and sewage facilities. The charge revenue was earmarked for a programme of environmental measures. Waste disposal and management charges based on weight and volume are levied by State and local governments. (OECD 1994, p. 67; OECD 1995, p. 41, 95)
Austria	Water	User charge on municipal waste. (OECD 1994, p. 62)
Belgium	Water, land	Households pay charges for sewerage and sewage treatment based on water use. Federal charges on export/ import/ transit of wastes, and toxic wastes. Local charges on waste disposal and management. Households pay a flat rate (and sometimes based on actual measurement) on municipal waste collection. (OECD 1995, p. 95; OECD 1994, p. 62, 67)
Canada	Water, land	The domestic sewage charge is calculated on the basis of residential property values or consumption. A flat residential sewage tax is also used. Households also pay user charges (flat as well as measurement based) on collection and disposal of municipal waste. (Bernstein 1993, p. 33; OECD 1994, p. 62)
Denmark	Water, land	User charge for sewerage and sewage treatment based on water use (and excess pollution load for firms): Households pay a flat fee, while firms are charged according to actual measurement. Excise duty on waste delivered to landfill sites and incineration plants. (OECD 1994, p. 67; OECD 1995, p. 95)
Finland	Water	State imposes a water protection charge on heavy polluters, and the revenue is earmarked for water protection activities of the state. There are municipal waste water charges based on actual measurement and the revenue is spent on collection and disposal. Households and firms also pay for sewerage and sewage treatment, based on water usage (and excess pollution load in case of firms). (OECD 1995, p. 41; OECD 1994, p. 62, 67)
France	Land	In 1992, a tax was introduced on dumping of waste, the goal being to phase out all traditional refuse dumps by the year 2002. (OECD 1995, p. 96)
Germany	Water, land	Sewerage service charges are usually based on water consumption. In 1993 the average rate per cubic metre was about DM 2.70. Household waste collection and disposal charges, levied by municipalities, are based on bin size and frequency of collection. The difference in charge rate for bin size is relatively small, providing no incentive to reduce volume of waste. Some states (Nordrhein-Westfalen, Rhineland-Pfalz, Baden-Wurttemberg, and Saarland) are experimenting with volume- and weight-based charges. There are also hazardous waste disposal charges. The municipal waste charge for firms is based on the actual measured waste. (Smith 1995, p. 44, 64; OECD 1995, p. 96; OECD 1994, p. 62)
Iceland	Land	Households pay a flat municipal user charge for waste collection and disposal. The charge rate, however, varies in different localities. (OECD 1994, p. 64; OECD 2995, p. 97)
Ireland	Water	Sewage disposal charges are levied by local authorities. There are also charges on licences for water emissions. (OECD 1995, p. 41)
Italy	Land	Domestic refuse disposal charge, based on the use of the surface. In 1994, the charge revenue was L 420.9 billion. (OECD 1995, p. 97)

Japan	Land	Households pay municipal waste charges for collection and disposal. While there is a flat rate in most municipalities, some base the charge on actual measurement. (OECD 1994, p. 62)
Netherlands	Land	Charges on domestic refuse disposal, dumping wastes at landfill sites, and municipal waste management. In 1995, the charge revenue was estimated to be over 4,000 million Gld. (OECD 1995, p. 97; OECD 1994, p. 62)
Norway	Air, water, land	In 1986, the city of Bergen, Norway, introduced a toll system for motorists entering the city between 6 am to 10 PM on weekdays, to reduce congestion and pollution. The rate is differentiated by the loading capacity of vehicles. The system can be improved by designing higher tolls for the peak hours only. The toll revenue collected (56 million Nkr in 1986, 59 million Nkr in 1988) is used to finance the construction of by-passes through the surrounding mountains in order to keep the long-distance traffic away from the city centre. After the by-passes are completed, the tolls will be removed. (Henry 1990, p. 261). Household pay a flat user fee for sewerage/ sewage treatment (based on water usage) and municipal waste. While firms pay for sewage treatment based on water usage and excess pollution load, municipal waste charges are based on actual measurement. The municipal waste charge revenue is used in collection and disposal of waste. (OECD 1994, p. 62, 67)
Portugal	Water	Waste disposal in sewerage system are subject to municipal charges. Waste water disposal in the natural environment is also subject to charges, based on the pollutant. (OECD 1995, p. 98; OECD 1994, p. 67)
Singapore	Air	Implemented the Area Licensing Scheme (ALS) to reduce traffic congestion in 1975. A vehicle entering the restricted zone (encompassing 620 hectares) required a licence ticket on a daily/monthly basis for the peak hours. By 1989, the fee was highest for company cars, less for private cars/ taxis, and least for motorcycles. The fine for non-compliance was about ten times the daily licence price. In 1988, the average violations/day was 100, while the number of licences/day issued was 12,000. The restricted zone also has higher parking fees, and strict enforcement at 28 points of entry to the zone. Although car traffic rose after 1977, private car traffic was 64 per cent below the pre-ALS flows by 1982 in the peak hours, despite the growth in income and employment. Complemented with other policies, ALS helped reduce the smoke and acidity in the city air. (Buchan 1994, p. 220, World Bank 1995, p. 69; Bernstein 1993, p. 48)
Spain	Water, land	Households and firms pay a flat fee for municipal waste, and a sewerage charge based on water usage (actual measurement). The municipal waste charge revenue is used for collection and disposal. (OECD 1994, p. 62, 67)
Sweden	Water, land	Municipal charge a two-part tariff for treatment of sewage water: a fixed fee, and a variable charge based on consumption. A growing number of households and small industries are attached to the sewer system and water treatment facilities. Apparently industries have an incentive to reduce water use when extending or renewing their plants. Households and firms pay a flat fee for municipal waste collection and disposal. (Bernstein 1993, p. 33; OECD 1994, p. 62, 67)
Switzerland	Water, land	Households and firms typically pay a flat fee for sewage treatment and for municipal waste collection and disposal. Some municipalities, however, base the charge on actual measurement. Sewage fees can also be based on actual water usage. (OECD 1994, p. 62, 67)
Turkey (cities)	Water, land	Izmir and Istanbul, Turkey, have industrial sewer charges. Since the charges are low, they encourage excessive pre-treatment and not enough full treatment plants. (Bernstein 1993, p. 33) In 1994, a solid- and water-waste charge was introduced at the municipality level. (OECD 1995, p. 98)

UK	Water, land	User fees for sewerage and sewage treatment are levied on households and firms, based on water usage (and pollution load for firms). A new tax on waste disposal in landfill sites was announced in 1995 (to be effective 1996). The charge is aimed at reducing waste and to recover more value from the waste produced. Firms have a municipal waste collection and disposal charge based on actual measurement. (OECD 1995, p. 14; OECD 1994, p. 62, 67)
US (local)	Water, land	Households and firms pay user fees for sewerage and sewage treatment based on water usage (and pollution load for firms). Some communities have municipal fees for waste services, based on the amount of refuse discarded (number of containers), or type of waste (collection bags marked by stickers). In 1988, Seattle, Washington, implemented a variable garbage rates scheme, and in January 1989 the monthly waste collection fell by 30 per cent compared to 1988. However, the policy encourages illegal dumping of refuse to avoid the fee. New Jersey, Pennsylvania and Illinois introduced a pay-per-bag system, which has helped to reduce waste. (OECD 1994, p. 67; World Bank 1995, p. 69; Bernstein 1993, p. 55)

6. Subsidies for abatement inputs

Australia	Air, water, land	Deductions for capital expenditures incurred after 18 August 1992 for preventing/ combating/ recycling pollution, or treating/ cleaning up/ removing/ storing waste. (OECD 1995, p. 90)
Austria	Air, water, land	Capital tax exemption for investments in the environmental field. For households, expenditures on energy saving measures are deductible from the tax base (with certain limitations). (OECD 1995, p. 90)
Canada	Air, water	Accelerated depreciation or capital cost allowances for investments in air and water pollution control at sites operating before 1974. Accelerated depreciation is also there for energy saving equipment. (OECD 1995, p. 90)
Germany	Water	Since 1987, a discharger building a treatment plant that reduces effluents to under 50 per cent of the recognised technical rule, can offset half the cost of the investment against effluent charges in the year of construction and the two subsequent years. Similarly, when planning to build a water treatment plant that will reduce effluents by at least 20 per cent, the operator can get a corresponding proportionate cut in charges for the three years prior to building the plant. (Smith 1995, p. 28)
Finland	Air, water	Accelerated depreciation at maximum of 25 per cent of purchase price annually for four years is allowed for investments in air and water pollution control equipment. (OECD 1995, p. 91)
France	Air, water	Accelerated depreciation is allowed for pollution reducing equipment covering: industrial water treatment plants, air cleaning facilities and electrical vehicles. Air pollution charge revenues were returned to the polluters as a subsidy for installing abatement equipment. (OECD 1995, p. 91; Tietenberg 1991, p. 91)
Ireland	Air, water	Accelerated depreciation, and tax exemptions are available for expenditures on pollution abatement, and business contributions to local authority expenditure on effluent control. (OECD 1995, p. 91)
Japan	Air, water, land	Special initial depreciation as a percentage of the acquisition cost, in addition to ordinary depreciation, for pollution preventing/ recycling equipment, and for energy efficiency improving technology. Air, water, and noise abatement facilities get reductions of income, corporate, municipal and fixed property taxes. Asbestos emission reduction facilities are exempt from municipal and fixed property taxes. (OECD 1995, p. 91)

Netherlands	Air, water, land	Since September 1991, accelerated depreciation is allowed for investment in pollution prevention equipment. Subsidies were offered to remove heavy metal in effluents and remove PCBs from certain products in 1980s. The subsidy on water effluent treatment probably improved the relations between the water management and the industry, and enhanced the effectiveness of other policy instruments like charges. 72 per cent of all PCBs were replaced during 1984-89: but the subsidy scheme may account for only 32 per cent of this reduction. (OECD 1995, p. 92; Bressers and Schuddeboom 1994, p. 154)
Norway	Air, water	Industrial investments to reduce air and water emissions, and to handle municipal wastes, are exempt from the usual 7 per cent investment duty. (OECD 1995, p. 92)
Portugal	Air, water	Reduction of charge and subsidies granted on a case by case basis for investments relating to environmental protection of air and water. Expenditures on renewable energy forms are eligible for tax benefits. (OECD 1995, p. 92)
Sweden	Air	System of tax rebate for producers of cleaner diesel fuel since 1991 (two types of clean diesel were distinguished from the standard diesel). In early 1993, about 75 per cent (compared to 1 per cent in 1990) of the total diesel sales constituted of the cleaner types of diesel, and only 25 per cent of the standard variety. (Bergman 1994, p. 255)
US	Land	As of 1991, 23 states have fiscal incentives for recycling: tax credits/ deductions for investment in recycling equipment, sales tax exemptions on recycling machinery, and various loans/grants for related activity. (Oates 1994, p. 119)

7 Enforcement incentive (performance bonds and non-compliance fee)

Australia (regions)	Water, land	Performance bonds are applied on obligation to rehabilitate landscape after mining, and on feedlots and marine environment protection. In the latter case, the bonds are proportional to expected damage. (OECD 1994, p. 91)
Canada	Air, water, land	Non-compliance fees are levied for violation of environmental protection norms, and are proportional to the estimated monetary benefits. Some regions have security deposits (performance bond) for resource exploration and land reclamation. The deposit is proportional to the amount of land distributed and cost of rehabilitation. (OECD 1994, p. 91)
Germany	Water	Dischargers meeting or exceeding the mandatory standards pay only half the normal rate of effluent fees. (Tietenberg 1991, p. 90)
Italy	Water	The effluent charge on non-complying firms is nine times higher than for firms who meet the prescribed standards. The system was scheduled to expire after full compliance had been achieved. (Tietenberg 1991, p. 91)
Japan	Air, water	Fines to compensate victims of environmental pollution (1974 legislation), for specific diseases (Minimata, Itai-Itai, air pollution-related asthma. After the environmental quality improved, the government stopped considering new compensation claims. (James 1996, p. 69; Tietenberg 1991, p. 91)
Sweden	Air, water	Penalty fees are applied to discharges from oil ships, based on the tonnage of discharge. Environmental protection charges are levied based on the non-compliance benefits. (OECD 1994, p. 91)
Turkey (cities)	Water	Izmir and Istanbul, Turkey, have penalty system for non-compliance with environmental standards applied to several industrial polluters. The financial fines have not provided adequate incentive effects since companies often litigate to delay or avoid payment. However, the threat of closure by the municipality has worked better. (Bernstein 1993, p. 35)

US	Air, land	Non-compliance fees on facilities that violate norms in the Clean Air Act in installation/operation of air pollution equipment. The two-part fine consists of: first, the computed economic gain from no-compliance, and second, a fine up to US $25,000/day for the period of violation before detection. Non-conformance charge on heavy vehicles and engines are based on the degree of non-compliance. Firms can also be liable for any damage caused from the pollution. Penalty fees are levied for release of hazardous waste, based on the damage inflicted. (World Bank 1995, p. 72; Bernstein 1993, p. 42; OECD 1994, p. 91)
8. Voluntary instruments		
Denmark	Air	Dansk Industri (an industry association) agreed to undertake measures to cut down on VOCs (chemicals used widely in solvents, paints, etc) after discussions with the Environmental Protection Agency (the original objective being to cut down VOC emissions by 30 per cent by the year 2000 from the 1988 levels). (Wallace 1995, p. 30-31)
Germany	Land	Waste collection and disposal system, Duales System Deutschland GmbH, was set up by large retailers and packaging firms in 1992 (following a federal ordinance in 1991 which makes the manufacturer of a particular product responsible for its whole life cycle until its final disposal). Participation in the dual system ("green dot" products) is voluntary. Since 1992, the overall use of primary and secondary packing fell by appr. 10 per cent, with the most significant reduction in the use of glass and plastics. (Smith 1995, p.71-72)
Japan	Air, water, land	Voluntary agreements on pollution control between the industry and government/local community started in the 1950s. The amendment of the 1967 Basic Law for Environmental Polltion Control in 1993, makes the relationship between industry and government more transparent (Article 8 states that "*corporations are responsible for making voluntary efforts to conserve the environment such as reduction of environmental loads in the course oftheir business activities*"). Local government bodies have considerable autonomy and play a major role in balancing the community and industry interests in environmental management. e.g. The Tokyo Metropolitan Authority recommends specific pollution control and draws up voluntary contractual agreements with companies involved in large scale developments tailored to specific pollution control. At the national level the MITI is responsible for the programme of voluntary measures by the industry, and builds on the existing relationship between local authorities and the industry. By 1991 there were about 37, 000 pollution prevention agreements in effect, some involving citizen participation. (Wallace 1995, p. 104; James 1996, p. 69; Murty 1996c, p. 39)
Netherlands	Air, water, land	The National Environmental Policy Plan (NEPP) identifies ten target groups (agriculture, transport, industry, energy, waste processing, water supply, societal organizations, consumers, etc), and each group is expected to make voluntarily work towards the major NEPP goals. By the end of 1993, about 15 voluntary agreements had been made by different groups. (Wallace 1995, p. 47-49)
US	Air, water, land	The USEPA's Toxic Release Inventory (TRI), following the 1986 Emergency Planning and Community Right-to-Know Act, is a data base of estimated annual releases of all the chemicals reported by the industries. The EPA collects the data, compiles and makes it available to the public through various formats. The US General Accounting Office estimated that following the inventory programme, over half of all the reporting facilities made one or more operational changes designed to reduce toxic emissions. The second information-based incentive is provided by "environmental/ green labelling", where private or public bodies evaluate environmental impacts of consumer products and issue seals of approval for products that meet certain standards. (USGAO 1993, p. 11-12)

TABLE A8.2(a)

Direct instruments (Developing countries)

1. Pollution charges

Country	Medium	Description
Brazil (3 states)	Water	Sao Paulo introduced a charge (sewerage tariff) based on pollution content (not volume) in 1983. This was partially implemented across regions by the sanitation company as a payment for sewerage treatment services. The states of Rio de Janeiro and Parana also have such industrial sewerage tariffs. The charges cover the costs of public water treatment. (Margulis 1994, p. 112; World Bank 1995, p. 66)
China	Air, water	In 1991, air discharge permits were introduced on a pilot basis for *large* firms in 16 cities, and covered 57 cities by 1995. A water discharge permit system for large firms was introduced in 1987 on a trial basis in 17 cities, and by 1995 was extended to 391 cities. The discharge licenses specify both the pollutant concentration and a factory's maximum annual wastewater discharge volume. The trial systems try to address the regional differences in abatement costs and assimilative capacities of local environments. In 1993, a volume-based industrial waste water charge was introduced, at the rate of 0.05 yuan/ton. The firms, however, are not required to pay both an overstandard pollution fee (non-compliance charge) and within standard pollution charge: the non-compliance fee supersedes the wastewater discharge fee when effluent standards are violated. In 1993, the collection from the within standard charge was about 10 per cent of the collections of the overstandard fee. The charges are not indexed to inflation, and in 1993 the average annual fee (penalty plus pollution charge) per paying firm was less than 0.1 per cent of the firm's total output value on average. However, conflicting incentives arise where, the non-compliance fee is applied simultaneously with charges or taxes. Earlier, some enterprises used to shield profits from taxes by paying into the charge system and then recovering 80 per cent of their payments under a rebate programme. (Florig, et al. 1995)
Estonia	Air, water	In 1991, charges were introduced on emissions from stationary sources (stacks, municipal boilers etc) covering approximately 50 pollutants. The tax rate is based on volume and toxicity of emissions, as well as the size of the polluted area and the type of land use in the area affected (eg. whether land use is rural/ industrial/ recreational/urban residential). However, the rates are too low to have adequate incentive effect for pollution abatement, and the revenue raising aspect of pollution charges seems to dominate. (Kallaste 1994, p. 138-46)
South Korea	Air, water	Introduced environmental quality improvement charges (EQIC), notably emission charges, in 1991. The charges were imposed on large facilities (eg. leisure complexes, hotels, department stores), and vehicles (buses and trucks using diesel fuel) which discharge air and water pollutants. The charge on a facility is computed by the cost to treat the estimated amount of pollutants, and that on a vehicle by the price of catalytic converter. In 1993, the revenue from EQIC was about US $45 million (36 billion won), and was used to promote investment in pollution abatement technology and equipment through the Environmental Pollution Control Fund. (Rhee 1994, p. 97)

Lithuania	Air, water	In 1992, a system of pollution charges was developed covering more than 100 air- and 51 water pollutants. Total charges are an increasing function of emissions and rise at an increasing rate (particularly after the source crosses its emission standard). In 1995, the rules of indexation of the charge rates were altered to fully account for the effects of inflation. Total revenue from charges and penalties in 1994 was 21.6 million litas (US $5.4 million), and about 70 per cent of the charge revenue was allocated to municipal government environmental funds. However, the pollution charges are low and unlikely to encourage significant environmental investments. (Semeniene, et al. 1996, p. 4-21)
Malaysia	Water	System of effluent-related licence fees on the BOD load discharged by palm oil mills since 1978. The license mimicked a 2-part tariff, with a variable effluent-related fee and a flat administrative fee: RM 100/tonne for BOD loads exceeding the legal standard and RM 10/tonne for BOD loads equal or less than the standard; plus a non-refundable RM 100 as annual licence-processing fee. Discharge onto land, instead of a watercourse was RM 50/ 1,000 tonnes regardless of the concentration. Between 1978-81, the total BOD load discharged reduced by 94.2 per cent, despite the rise in the number of mills. However, the risk of shutting down rather than the effluent fee seems to explain the result, since the regulations became mandatory during 1979-81. (Rahim 1994, p. 69)
Poland	Air	Stationary sources of air pollution require emission permits, and the fees are based on type and volume of air pollutants (eg. US$80 per tonne of SO_2 in 1992). This is the principal instrument of air pollution control from stationary sources. Fees apply to emissions not exceeding the standards, and polluters are liable for any damage caused by pollution. The emission charges are an important source of environmental project financing. However, since the charge rates are lower than the marginal cost, they do not provide the right incentives for pollution abatement. (World Bank 1995, p. 67; Bernstein 1993, p. 47; Zylicz 1994, p. 94-95)
Russia	Air, water, land	Pollution charges were introduced formally in Russia in 1991 (in 1988-91 on an experimental basis in the ex-Soviet Union) accompanying the standards. Three types of charges, based on whether: discharges are within the maximum permitted, beyond the maximum permitted but within the temporary permitted, or beyond the temporary permitted. The last two types of charges were to be paid out of the firm profits. The actual charge revenue fell short of the estimate due to the government's inability to collect the charges: in mid-1992 the actual revenue was 2.5-3 billion rubles, while the estimate had been 7 billion. The system was accompanied by non-budgetary environmental fund and taxes on the use of natural resources. (Lvovsky, et al. 1994, p. 16, 22, 26)
Yugoslavia	Water	The effluent charges are based on concentration levels. The system has been ineffective, since the charges are well below the costs of pollution abatement. Also, the charges are not adjusted to the inflation, nor always collected since many public enterprises face severe financial problems. (Bernstein 1993, p. 33)

2. Marketable Permits

Chile (Santiago)	Air	In 1990, the city allocated bus transit rights and auctioned routes based on fares and types of buses. A tradeable permit system for industry was also introduced on fixed sources, with emissions exceeding 1,000 m^3/hr. Emission trade-off, however, is not allowed beyond a day, nor across seasons, and property rights are not well defined. (Margulis 1994, p. 116)

3. Deposit refund

Estonia	Land	Deposit-refund scheme for glass bottles function poorly, probably due to insufficient return outlets. (OECD 1994, p. 136)
Hungary	Land	Glass bottles require deposit fees. (OECD 1994, p. 140)
South Korea	Land	Deposit-refund on products that can be recycled (food/beverage containers) or which produce toxic wastes/ voluminous amount of waste (mercury/ silver oxide batteries, tires, lubricant oil, electric home appliances). The deposit being low, the refund rate by 1992 was only 8 per cent. (Rhee 1994, p. 99)
Taiwan	Land	In 1989, implemented a recycling system for 12 types of solid waste (including PET/glass bottles, aluminium cans, waste paper, used tires, lubricant oils, mercury batteries etc.). A deposit of NT$ 1/PET bottle increased the recovery rate from 36 per cent in 1989 to 80 per cent by 1992. (Pan 1994, p. 90)

TABLE A8.2(b)

Indirect instruments (Developing countries)

4. Input/output tax and differential tax rates

Hungary	Air	In May 1992 a tax of 0.7 per cent of the price was introduced on motor vehicle fuels. The revenue is earmarked (through the Central Environmental Fund) mostly for environmental expenditure relating to vehicle traffic, and the remainder for nature conservation and to raise environmental awareness. The tax rate on lead-free petrol is lower than the leaded variety (market prices inclusive of taxes are almost equal), and consumption tax for new cars with catalytic converters has a discount of Forint 50,000. (OECD 1994, p. 139)
South Korea	Land	In 1993, implemented product charges (under its waste disposal charge system) on toxic goods and goods generating large quantities of waste. Items include insecticides, cosmetics, confectionery, batteries (other than mercury and silver), antifreeze solution, fluorescent light tubes, chewing gum, paper diaper, and plastics. (Rhee 1994, p. 104)
Mexico (City)	Air	In 1990 the price difference between leaded and unleaded gasoline was reduced from 40 per cent to 11 per cent (leaded gasoline being cheaper than the unleaded). By June 1994, the excise tax on leaded petrol was higher than that on the unleaded (though the VAT rate was 10 per cent on both). (Margulis 1994, p. 114, OECD 1995, p. 52)
Taiwan	Air	Started promoting unleaded gasoline in 1984. In 1989, the price of unleaded gasoline was cheaper than the leaded by a margin of NT$ 1/litre. Complemented by other regulations on new cars and emissions, the market share of unleaded gasoline increased from 18.7 per cent in 1990 to 51.84 per cent in 1993. The average lead content in ambient air in Taipei decreased from 0.46 g/m in 1989 to 0.18 g/m in 1992. (Pan 1994, p. 91)
Thailand	Air	In 1991, began subsidization of unleaded gasoline to make it slightly cheaper than leaded, in order to reduce atmospheric lead content (1990 USAID study estimated a loss of up to 700,000 IQ points collectively of Bangkok children by age 7, due to elevated blood lead levels). A surtax on leaded gasoline finances the subsidy on unleaded. In Bangkok, unleaded gasoline accounts for 40-50 per cent of the gasoline market. (O'Connor 1994, p. 46)

5. User and administrative charge

Chile	Water	Introduced a system of tariffs for water supply and sewerage collection in 1991, to increase the efficiency in water use, promote equity among consumers, and to self-finance the Sanitary Services. The tariff incorporates the marginal cost of service expansion, seasonality of consumption, adjustment for self-financing, and indexation to other prices. By 1994, nineteen enterprises had their tariffs set by the system, serving about 10 million urban dwellers. (Margulis 1994, p. 117)
Colombia	Water	Sewerage tariffs are set at 60 per cent of the water tariff in Cali, 50 per cent in Cartegena, and 30 per cent in Bogota. (World Bank 1995, p. 68)
Russia (cities)	Air, water, land	In 1988-91, charges were used on an experimental basis at the oblast (regional) and city levels. In 1989-90, Kostroma oblast had an user charge (license) for emissions, effluents, or disposed waters within permissible limits, accompanied by a penalty system. In 1990, 70 per centof the charge revenue (6.1 million rubles) went to a special fund for environmental protection. (Lovsky, et al. 1994, p. 5-6)

6. Subsidy for abatement inputs

China	Air, water	Eighty per cent of the revenue from effluent fines is placed in banks for borrowing by enterprises making pollution control investments. This forms an important source of earmarked pollution control funding. Also, on an average 70-80 per cent of the water effluent fees are rebated to the firms for environmental protection improvements. (Bernstein 1993, p. 47, 32)
Estonia	Air, water	Tax allowances are offered when the polluter invests in cleaner technology or, end-of-pipe equipment. Subsidization does not have a standard procedure, and tax allowances are designed on an individual basis. (Kallaste 1994, p. 140)
Hungary	Air, water, land	Corporate tax allowance of 40 per cent for investments in emission abatement equipment (for air/ water/ hazardous waste). Equipment for environmental protection is liable for accelerated depreciation in 3 years. Scheme for tax allowance was available for joint ventures (foreign capital) producing equipment for environmental protection (100 per cent for first 5 years, and 60 per cent for next five when investment exceeds 50 million forint with more than 30 per cent of foreign capital). Applications for the scheme were considered until 1992. (OECD 1994, p. 140)
India	Air, water	In 1983 accelerated depreciation for pollution control machinery was introduced. In 1990-91, the Ministry of Finance introduced rebates in custom and excise duty for various pollution control equipment: monitoring instruments, and abatement machinery for air/ water pollution. (Mehta, et al. 1994, p. 13-17; Murty 1996a, p. 21-22) The import concessions, however, were removed as of July 1996.
Indonesia	Water	Ministry of Population and Environment provides concessions on import tax duties for waste water treatment equipment. (James 1996, p. 73)
South Korea	Air, water, land	Established environmental fund in 1983, which primarily provides cheap credit for firms investing in control technologies and for operators of private environmental facilities like sewage treatment plants. Investment tax credit is 3 per cent (10 per cent for equipment made in S.Korea) of the value of the investment which are restricted to facilities increasing productivity, energy-saving, anti-pollution, preventing industrial hazards, etc. (O'Connor 1995, p. 15; World Bank 1995, p. 69)

Lithuania	Air, water	Provision for environmental investment subsidies through rebates of pollution charges when emissions decline by at least 25 per cent from the previous year. An environmental fund is scheduled to be created in 1996, to provide access to subsidized credit for investments having environmental benefits. (Semeniene, et al. 1996, p. 26)
Mexico	Air, water, land	Accelerated depreciation, at the rate of 50 per cent/year, for investment in equipment used to control environmental pollution. Also immediate deduction of 91 per cent on investments in new fixed assets (environmental pollution control) permanently located out of the three most polluted cities (Mexico, Guadalajara, Monterrey). (OECD 1995, p. 92)
Taiwan	Air, water, land	Provides import tax exemption on all pollution control equipment, and tax reductions for specific types of investment. In 1992, the total value of import duty exempt equipment was NT$ 14,245 million (total estimated monetary saving on duty by the industry estimated at NT$ 1,068 million). Almost 40 per cent of the value of import exemption was for air pollution control equipment, and 32 per cent for solid waste treatment equipment. In 1992, the total value of investment eligible for concession was NT$ 7,058 (industry saving estimated at NT$ 1,141). Other provisions include: accelerated depreciation in pollution control equipment, and low interest loans for the installation of abatement equipment in the private sector. (Pan 1994, p. 89; James 1996, p. 71)
Thailand	Air water, land	Since 1983, import duties have been reduced up to 10 per cent for water pollution abatement equipment. Partial grants and low-interest loans are provided to set up treatment facilities. An environmental fund, established in 1991, provides credit to firms investing in abatement technology, and to operate sewage environmental facilities like treatment plants. Semi-government organization, Industrial Finance Corporation, offers concessional financing of pollution abatement equipment purchases and lends appr. $8 million/year through the Environment Portfolio. (Kaosa and Kositrat 1994, p. 179; O'Connor 1995, p. 15; James 1996, p. 74)
Yugoslavia	Air, water	Pollution control equipment are exempt from customs duties. Subsidies are also provided for pollution reducing technology, often in the form of reduced interest rates. However, the policies have not had a significant effect on industrial pollution abatement. (Bernstein 1993, p. 35)

7. Enforcement incentive (non-compliance fee)

Brazil	Air, water	Penalty system for violation of air and water pollution standards since 1981. However, fines on atmospheric emissions are arbitrary (the level of pollution from a firm/truck is generally visually assessed: a lot of/ some/ little smoke, as in Rio de Janeiro, Curitiba, Fortaleza, Belo Horizonte) and related to the frequency of violation rather than intensity or toxicity. Revenues from the penalties are insignificant. Also state-owned firms are exempt from fines on violation of water pollution standards. (Margulis 1994, p. 110)
China	Air, water, land	In 1979, introduced a legal charge on industrial emissions exceeding the norms, based on amount and concentration. In 1981 the system was extended nationwide. The penalty charge is increased by 5 per cent per year, after a grace of 3 years, for firms that do not respect discharge norms. New facilities built after the 1979 law and old firms that fail to operate control equipment, face double the rates for non-compliance. A fine of 0.1 per cent per day is levied for delays of more than 20 days in paying discharge fees. Penalties are also imposed for false effluent and emission reports.

		The system is administered by local Environmental Protection Bureaus, and the charges vary across provinces. Sources are penalized for only the worst-offending pollutant; and the percent deviation of the discharges from the effluent standards is used in calculating the charge. In 1982-86, the compliance rate of steel industry with discharge standards increased from 33.5 per cent to 60.4 per cent. Between 1987-93, the water levy succeeded in reducing the provincial COD intensities at a median rate of 50 per cent, and total COD discharges at a median rate of 22 per cent. (Wang and Wheeler 1996, p. 1-2) The charges, however, are not pegged to inflation, and often lower than the marginal costs of abatement. The system thus has not uniformly effective: firms often pay the fee in the beginning of the year on the basis of the previous year's emissions, and ignore the system for the rest of the year. Where fines are negotiable, firms that cannot afford the fee do not pay. (Potier 1995; Florig, et al. 1995; Bernstein 1993, p. 47)
Estonia	Air, water	Non-compliance fees for exceeding the mandated limits are set as a multiple of the emission tax. The multiplier (5, 50, or 500) depends on the toxicity of the pollutant. (Kallaste 1994, p. 140)
Hungary	Air, water, land	"Environment protection penalties" are levied for violation of standards for waste water, drainage, air pollution, hazardous waste, noise and vibration. The charges are differentiated according to the toxicity and/or degree of environmental damage inflicted. Data on actual measurement, however, is lacking. (OECD 1994, p. 140)
South Korea	Air, water	Introduced a charge system on industrial air and water discharges exceeding the mandated norms (based on concentration rates, location, number of violations etc) in 1983. The fines partly finance the Environment Pollution Prevention Fund, but are not high enough to provide the disincentive to pollute beyond the standards. (Rhee 1994, p. 98; James 1996, p. 73)
Lithuania	Air, water	Penalty system accompanies the standard-cum-charge scheme for air and water pollution, and applies when emissions exceed standards. Preferential rates are given when emissions are below the standards. Misrepresention of emissions carries a ten-fold fine. However, penalties are rarely applied (in 1994, penalty rate is estimated at 4 per cent). (Semeniene 1996, p. 14-26)
Mexico	Water	Fines are set according to the severity of pollution, and are adjusted for inflation. Repeated offences lead to closure. Combined with public pressure, the penalty system has proved to be effective. (Bernstein 1993, p. 35)
Russia (cities)	Air, water	A penalty system was introduced along with the pollution charge system in the oblasts (regions) and cities in 1988-91. Eg. in Nizhniy Novgorod, the fines were set up as a function of emissions exceeding the norms. (Lvovsky, et al. 1994, p. 5-7)

8. Voluntary instruments

Bangladesh (district)	Water	Significant local community pressure on two urea fertiliser factories in Narsingdi, Bangladesh probably encouraged cleanup efforts by the firms since 1980 (no formal regulation). The firms share a first-stage treatment lagoon (lack of knowledge of toxic pollutants in the community has prevented the initiation of second stage treatment). (Huq and Wheeler 1993, p. 6)
China	Air, water	In 1990 (following the 1989 amendment of the Environmental Protection Law of 1979, which specifies that government at all levels should be responsible for environmental quality in their jurisdiction) a contract system was started in which officials from mayors to firm managers agree to work towards environmental goals. There are rewards for meeting contract goals (but no penalties for failure to do so), like grants, bonuses, or special status with tax breaks and control of foreign exchange. (Florig 1995, p. 271A)

Indonesia	Water	In 1989, a clean river programme, PROKASIH was introduced between provincial governors and company directors; and targeted the 20 dirtiest rivers. More than 1,000 industrial operations entered into agreement and the majority undertook measures to reduce pollution loadings. Firms with the heaviest pollution loads were asked to draw up pollution abatement plans. In 1990-94 there had been a drop in BOD levels in the rivers, but the levels have increased since. Another programme, PROPER, encourages industry to meet industrial standards on effluent discharge: government publishes environmental ratings of firms based on pollution performance, to generate positive publicity. PROPER has had some positive impact on industry performance. (O'Connor 1995, p. 17; James 1996, p. 73)

SOURCE: MOEF 1997

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Annex 9

Proposed rates for environmental excise duty

To arrive at these rates, ideally we would have liked data on the cost of various technologies along with the amount of emissions reduced by them (essentially to derive a cost curve). This information, however, is unavailable. Therefore, we take as a starting point the assertion by vehicle manufacturers that all vehicles currently meet the 1996 standards. In other words, the current level of vehicle emissions are assumed to be equal to the 1996 standard. Aggregating across the three pollutants[94], current emissions are 8.1 gm/km, 12.15 gm/km and 16.76 gm/km, for 2 wheelers, 3 wheelers and cars, respectively[95]. The corresponding emission figures for the 2000 standards are 3.5 gm/km, 5.5 gm/km, and 3.69 gm/km, for 2 wheelers, 3 wheelers and cars, respectively.

The difference between the two sets of numbers provides an estimate of the extent of reduction in emissions required for attaining 2000 standards, namely, 4.6 gm/km, 6.65 gm/km, and 13.07 gm/km for 2 wheelers, 3 wheelers and cars, respectively.

Predicting what technology(ies) will be used to attain these reductions in emissions and at what cost, is difficult. A technological breakthrough could upset all calculations. Moreover, even experts disagree on which technology is better. Nevertheless, with respect to technologies for reducing emissions, it can be assumed that EED will induce manufacturers to go in for the one with least cost.

For 2 wheelers, we assume that at a minimum, some form of fuel injection system may have to be added to 2-stroke engines to attain the targeted reduction in emissions. We assume this costs approximately Rs. 5,000 (and would buy a 4.6 gm/km reduction in HC+CO+NOx). Thus, the cost of reducing emissions by 1 gm/km is Rs. 1087 (approximately 1100). In other words, faced with EED of Rs. 1100/gm/km a manufacturer would be indifferent between paying the duty or phasing in the cleaner technology. Since new technology cannot be phased in instantly, a three year window is provided by setting the current rate at half the desired rate with a 33 per cent escalation every year. Finally, for emissions not exceeding the 2000 standard, the rate is an order of magnitude less.

For 3 wheelers, the emissions reduction target is higher (6.65 gm/km), but so is the cost of achieving it, since 3 wheelers carry a heavier load and consume more fuel and pollute more (Centre for Science and Environment 1996). We assume these factors cancel out and therefore we retain the same EED for 3 wheelers as well.

For cars, it is assumed that electronic fuel injection (EFI) along with a 3-way catalyst will be required to meet the 2000 standards. It has been estimated that these will increase a car's price by about 13 per cent (Faiz, et al. 1990). Taking an average net dealer price for lower end cars such as Maruti and Premier Padmini of Rs. 130,000, the cost works out about Rs. 16,900 or Rs. 1300 per gm/km. As in the case of 2 wheelers, the initial rate is set at half this amount.

While these numbers are quite approximate at the moment, they could be made more precise as better data on the cost of emission reduction technologies becomes available. What is more important, however, is to establish the rationale for and the nature of an environmental excise duty.

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[94] This aggregation implicitly assigns equal weight to all three pollutants. In any case, the 1996 and 2000 emission standards do not distinguish between HC and NOx. Once better data is available these numbers can be disaggregated and pollutant-specific EEDs can be estimated.

[95] The 1996 standard for cars is actually a range, 11.68-16.76 gm/km. We take the upper end of the range which understates the EED.

Annex 10

Driving in Delhi: A Statistical Profile

TABLE A 10.1

Fuel Usage by Vehicle Type

Vehicle Type	Leaded Petrol	Unleaded Petrol	Diesel	CNG
Car	37.89	53.21	8.23	0.67
Jeep	16.42	7.96	75.62	0
Van	53.24	43.06	3.70	0
Scooter	93.26	6.34	0.35	0.06
Motor cycle	92.08	7.38	0.27	0.27
3 Wheeler	94.06	5.01	0.92	0
LCVs	10.43	0	89.57	0
HCVs	1.16	0.58	96.26	0
	63.66	23.47	12.61	0.27

TABLE A 10.2

Average Kilometres Travelled per Month by Vehicle Type

Vehicle Type	Less than 500	501-1500	1501-3000	More than 3000
Car	9.87	36.50	35.73	17.89
Jeep	4.48	32.34	36.82	26.37
Van	10.19	34.26	31.48	24.07
Scooter	21.77	48.21	22.70	7.32
Motor cycle	17.76	47.81	27.60	6.83
3 Wheeler	5.28	23.09	33.91	37.73
LCVs	1.74	10.00	29.57	58.70
HCVs	2.91	5.23	10.47	81.40
	12.75	36.77	29.78	20.73

TABLE A 10.3

Frequency of Pollution Check-up (as reported by respondent)

Check-up Done	Percentage of total vehicles
On Due Date	81.54
15 days late	6.33
1 month late	2.01
More than one month late	7.31
Never	2.81

TABLE A10.4

Willingness to Go for Check-ups Without Regulation

Willing:	71.76
Unwilling:	28.24

TABLE A10.5

Frequency of Servicing

Frequency	Percent of total vehicles
3 months	71.37
6 months	10.90
1 year	2.20
No fixed schedule	15.52

TABLE A10.6

Location of Servicing

Location	Percent of total vehicles
Company Authorised Service Station	45.68
Other Service Station	25.32
Near House	13.67
Local Mechanic	14.26
Other	1.07

TABLE A10.7

Average Monthly Expenditure on Fuel

Monthly Expenditure in Rupees	Percent of Respondents
Less than 500	9.89
501-1000	26.48
1001-2000	24.08
2001-3000	14.42
3001-4000	13.53
More than 4000	11.61

TABLE A10.8

Average Monthly Expenditure on Maintenance

Monthly Expenditure in Rupees	Percent of Respondents
Less than 500	63.46
501-1000	28.59
1001-2000	6.50
2001-3000	0.88
More than 3000	0.57

TABLE A10.9

Willingness to Retrofit Catalytic Converter for Rs. 10,000
(*by Occupation*)

Occupation	Percent of respondents willing
Own Business	15.29
Professional	13.28
Service Sector	13.11
Trader	3.92
Private Corporate Sector	8.59
Housewife	33.33
Government Service	10.99
Self-employed	12.06
Student	8.67
Aggregate	11.68

TABLE A10.10

Willingness to Retrofit Catalytic Converter for Rs. 10,000
(*by Income Group*)

Annual Household Income in Rupees	Percent of respondents willing
Up to 100,000	5.90
100,000 – 200,000	12.30
200,000 – 300,000	17.01
300,000 – 600,000	20.92
Above 600,000	37.70
Aggregate	11.68

TABLE A10.11

Willingness to Switch to CNG if Distribution Improves
(*by Income Group*)

Annual Household Income in Rupees	Percent of respondents willing
Up to 100,000	24.27
100,000 – 200,000	34.43
200,000 – 300,000	42.44
300,000 – 600,000	47.22
Above 600,000	53.70
Aggregate	35.10

TABLE A 10.12

Willingness to spend on CNG kit ('000 rupees)

Annual Household Income in Rupees	Less than 10	10 - 15	15 - 20	20 - 25	More than 25
Up to 100,000	83.44	12.66	1.62	1.30	0.97
100,000 – 200,000	62.72	22.65	8.89	2.61	3.14
200,000 – 300,000	60.83	17.51	9.20	5.93	6.53
300,000 – 600,000	49.74	24.62	12.82	7.69	5.13
Above 600,000	35.34	46.55	5.17	4.31	8.62
Aggregate	62.75	21.57	7.71	3.86	4.12

TABLE A10.13

Frequency of Emission Norms Exceeded According to Frequency of Servicing
(*frequency exceeding emission norms*)

Frequency of Servicing	Once	Twice	Thrice	Often	Never
3 months	14.61	12.07	2.98	15.80	54.55
6 months	21.85	13.25	1.32	13.91	49.67
1 year	19.05	11.11	6.35	14.29	49.21
No schedule	19.62	18.77	3.08	14.77	46.46
Aggregate	16.36	13.97	2.98	15.21	51.49

Table A10.14

Frequency of Emission Norms Exceeded According to Location of Servicing
(*frequency exceeding emission norms*)

Location	Once	Twice	Thrice	Often	Never
Company Authorised Service Station	13.89	10.56	3.89	11.00	61.67
Other Service Station	19.76	13.64	2.37	16.60	47.63
Near House	12.73	15.45	5.45	10.00	56.36
Local Mechanic	13.42	15.26	2.89	17.37	51.05
Other	23.53	17.65	0	14.71	44.12

Annex 11

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fuel type

fuel quality

engine type

abatement technology

congestion

road condition

feet size

number of trips

population

income

transport mode

age of feet

fuel efficiency

vehicle load

passenger capacity

urban density

length of trips

urbanization pattern

Emission per liter of fuel

temperature

altitude

Liters of fuel per passenger kilometre

Passenger lkilometres traveled

Emissions from Passenger Transport

Total emissions = emissions per liter x liters per passenger km x passenger kms traveled.

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