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MOTOR VEHICLE TAXES AS ENVIRONMENTAL INSTRUMENTS:

THE CASE OF SINGAPORE *

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ABSTRACT

With small geographical size, land scarcity poses a potential constraint for economic growth in Singapore. Restraining car ownership and car use through motor vehicle taxes is part of the land-transport policy to ensure smoother traffic flow. The scale and scope of the motor vehicle taxes used have implications on government revenue and the environment. This paper analyses the use of motor vehicle taxes as environmental instruments. It compares the effectiveness of ownership versus use tax as tools to internalise congestion externality. Economic issues arising from motor vehicle taxes are also highlighted. It concludes that motor vehicle taxes offer Singapore a double dividend.

Keywords: congestion externality, double dividend, environment, motor vehicle taxes, ownership and use tax,

1. INTRODUCTION

Economic growth with rising incomes leads to increase in demand for cars and roads to transport goods and people. Orfeuil (1996, p.163) notes that the rate of transport growth in developed countries has roughly paralleled the rate of GDP growth, but for developing countries and rapidly emerging economies, growth rates have been about 2 or 3 times that of GDP. This growth in road transport activity has an adverse impact on the environment. Bahl and Linn (1992, p.191) also show that growth in car population has outstripped economic growth in most developing countries.

Rapid growth in car population and car use leads to more demand for road space. If the demand is not adequately managed, it will lead to road congestion, which will result in economic costs in terms of productivity loss due to time lost in transit. Hewitt (1987) estimates the economic cost to be 15 billion pounds a year for Britain. Lomax and co-workers (1988) estimate that for the city of Los Angeles alone, economic loss amounts to $6 billion a year or about $3 a day per vehicle on the road. A recent research by the OECD (1994) reports that economic loss due to time lost in transit at about 2-3% of GDP for OECD economies, noise costs at about 0.3%, accident costs at about 1.5-2% and local environment pollution at about 0.4%, putting the total cost at 4-6% of GDP.[1] This implies that significant gains can be achieved if these motoring externalities are internalised through some forms of Pigouvian taxes (Pigou, 1920) or green taxes as they are now popularly known.

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[1] The environmental consequences of transport are well documented in the British Royal Commission on Environmental Pollution (1995).

Repetto and colleagues (1992) suggest that green taxes, such as congestion tolls, are effective in achieving environmental goals and may deliver multiple dividends. Many OECD countries, especially the Scandinavian members, have undertaken environmental tax reform to co-ordinate environment and tax policies. In the OECD (1995) survey, green taxes[2] as percent of total tax revenue is seen to gain importance. Taxes alter the relative prices to ensure that economic agents take into account the external cost of transport. Tax instruments are better than command and control measures, as they are self-regulating, since once implemented, it allows market forces to operate and regulate.

Although Singapore does not have an explicit environmental tax policy, the scale and scope of motor vehicle related taxes are both extensive and comprehensive. These taxes, which are part of the land transport policy, form about 20 percent of the government operating revenue. In April 1998, changes were made to rationalise the two-decades old motor vehicle tax structure, restructuring it to one that is based on use rather than on ownership. Does this change also imply that the policy, which has arisen as part of the land-use policy, has now been shifted to one that is based on environmental considerations?

Although private cars are not the only contributor to motoring externalities, they are singled out in most motor vehicle tax policies. In terms of energy use, private cars are the least efficient, consuming more coal per passenger kilometre as compared to other forms of transport, such as long distance jet, inter-city rail,

[2] This includes both taxes on energy and motor vehicles, which have environmental dimensions as well.

urban rail and buses (Baron, 1980). Furthermore, cars (though have a capacity of 4 or 5 people, but often occupied by one only) uses between one-third and one-half of the road space of a bus or a mini-bus with bigger passenger capacity.

2. CAR OWNERSHIP AND CAR USE MANAGEMENT IN SINGAPORE

Singapore is a very small country (an area of 641 square kilometres only), with per capita income of US$26,730 in 1995. With 220 vehicles per kilometre, it has one of the highest vehicle density in the world, after Thailand (260 vehicles per km), as compared to Britain (67), Canada (17) and the United States (34).[3]

In the area of transport policy, Singapore's policy makers are willing to experiment and implement innovative fiscal and regulatory measures to restrict both car ownership and car use. Ownership taxes (e.g. the one-off sales and excise taxes on new vehicles) have more indirect impact on the environment whereas use taxes (e.g. fuel tax and road pricing scheme) affects car use behaviour and hence have a direct effect on the environment.

2.1 Car Ownership Restraints

Ownership taxes include (a) one-off tax on sales or initial registration of motor vehicles and (b) annual or recurrent taxes on registration.

====== Insert Table 1 =========

a. One-off sales tax

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[3] Calculated from "Living with the car," *The Economist*, 6th 1997.

Table 1 indicate the types of motor vehicle related taxes currently administered in the OECD countries. Generally, one-off sales tax on motor vehicle is higher than sales tax on other goods, and/or is imposed in addition to the general sales tax. By taxing according to the "environmental" attributes of different vehicles, the one-off ownership tax can take on some environmental dimension. Of the OECD countries, Denmark, Finland, Germany, Netherlands and Norway have more comprehensive systems of motor vehicle taxes. These include differentiated taxes on car types, depending on whether they are equipped with catalytic converters (which convert carbon monoxide and hydrocarbons to carbon dioxide and water and also reduces nitrogen dioxide to elemental nitrogen and oxygen). The United States has a so-called 'gas-guzzler" tax, ranging from US$1000 to US$7700 per car, which is levied on the sale of a new car with above average fuel consumption (i.e. with fuel efficiency less than 22.5 miles per gallon). In January 1992, Austria introduced a new tax on car registration with an explicit environmental consideration - the tax rate depends on the average petrol consumption while the tax base is the selling price of the car.

Singapore, though not unique in using one-off ownership tax, administers such a tax with more breath and depth than that found in OECD countries, as seen in Table 2. Ownership taxes in Singapore include an import duty, a lump sum registration fee, an additional registration fee, an annual road tax and the Certificate of Entitlement (COE) premiums under the vehicle quota system (VQS).

====== Insert Table 2 ========

An import duty of 41% is levied on the open market value of cars, in addition to the 3% Goods and Services Tax. Since 1980, the lump sum registration fee was kept at S$1000 until April 1998, when it was reduced to S$140 to reflect the actual administrative cost of vehicle registration.[4] The up-front cost of car ownership is inflated by the Additional Registration Fee (ARF), which is levied at 140% of the open market value (OMV). As compared to most OECD countries, the ARF is a very high one-off tax. Among the OECD countries, Netherlands has the highest one-off tax -- 45.2% sales tax on net values operating on top of the 17.5% VAT. Japan has the lowest one-off sale tax on cars, with an Automobile Acquisition Tax at 5% of purchase price, levied on top of the 3 % consumption tax.

b. Recurrent or annual ownership tax

Recurrent or annual ownership tax commonly takes the form of annual car licence or road tax. Recurrent charges can also be designed with environmental considerations, by varying charges according to vehicle engine size or to other factors affecting fuel use such as cylinder capacity. In Germany, for example, the annual road tax is based on cylinder capacity, with the rates depending on the dates of registration, pollution emissions and engine types (petrol-engines versus diesel-engines). These taxes are likely to affect the types of car ownership but unlikely to affect the marginal cost of car trips. However, in Britain, the annual car licence is at a flat lump sum of 135 pounds and does not distinguish between cars of different sizes.

[4] This is part of the vehicle tax rationalisation, representing a shift from using high ownership taxes (such as registration fees) to one that relies more on usage management by increasing the

All registered cars in Singapore are subject to annual road tax, which is levied progressively according to engine capacity (see details in panel 2 of Table 2). This progressivity not only reflects the principle of social equity, but also has environmental implication since larger engine capacity vehicles, which tend to contribute more to the urban air pollution, are taxed at a higher rate. The road tax structure also takes into account the pollution contributions of older cars. Cars more than 10 years old are subject to an annual road tax surcharge of 10% for each additional year; for example, a 13-year old car faces a surcharge of 30%.

Table 3 compares the motor vehicle tax reliance with conventional tax reliance for Singapore and for some selected OECD countries. The importance of ownership tax in Singapore is evidenced from the revenue collected, at 17% of total operating revenue.

====== **Insert Table 3** ========

c. Vehicle Quota Scheme (VQS)

Table 4 shows the various adjustments on ownership taxes over the period 1970 to 1996. Despite these changes, car population grew at an annual rate of 7.3%. Phang and Chin (1989) attributed this to the strong income effect arising from the double-digit economic growth during the 1980s, which offset the price effect from fiscal measures. This suggests that policies targeting at the up-front cost of car ownership may not be adequate. In May 1990, an important instrument, a vehicle quota system (VQS), was introduced to regulate the quantity of automobiles directly.

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marginal cost of car trips.

====== Insert Table 4 =========

Under the vehicle quota scheme, every buyer of new vehicle must first bid for a certificate of entitlement (COE). The tender is held monthly. The Land Transport Authority (LTA)[5] predetermines the yearly quota, which will allow vehicle population to grow at an annual rate of 3%. The number of COE available depends on road capacity, traffic condition, and the number of vehicles de-registered in the last calendar year. With a pre-set quantity (the supply), through the bidding mechanism (the strength of demand), a market-clearing price (the quota premium) is determined. The successful bidder pays the lowest successful price, instead of the bid price.

The VQS has limited car ownership growth in Singapore. Using elasticity estimates from an econometric model, Chin and Smith (1997) projected that the number of private automobiles registered in 1993 would have been 7.4% higher if VQS was not implemented.

Although there were some public unhappiness that led to several rounds of fine-tuning, the quantity-rationing scheme is considered acceptable by the public (Phang et. al. 1996). The government is seen as one who sets the quantity with the quota premium depends on how prospective car-owners bid. Although the "tax burden" on the individual has increased, this is regarded as a direct outcome from market mechanisms.

2.2 Car Use Restraints

For the last three decades, the design of motor vehicle taxes has placed a heavier burden on car ownership than on car use. Motorists thus face very high fixed up-front cost and lower variable use cost. For example, for a typical medium-sized car, ownership cost (includes the OMV, custom duty, ARF, road tax and the COE) forms about 70% of its overall cost (add fuel, parking, insurance, and road pricing charges).

Although economic instruments targeting at car ownership have somewhat controlled car population growth, congestion externality has not been fully addressed. When the VQS was introduced in May 1991, the average traffic speeds during the morning peak improved for all expressways except one (refer to Chart 1). However, after the motorists had adapted to the VQS, road use surged again and by May 1995, traffic speeds for all expressways were in fact slower as compared to pre-VQS traffic speeds.

======= Insert Chart 1 =====

To address the motoring externality directly, there is a need to restructure motor vehicle taxes away from ownership and towards use. In March 1998, motor vehicle tax rationalisation was announced. The annual road tax was reduced, the ARF was lowered from 150% to 140% and the Electronic Road Pricing (ERP) scheme was phased in. Through more use taxes, the LTA hopes to achieve a 50:50 ratio for fixed and usage costs.

From an economic efficiency point of view, taxing car ownership does not address the motoring externality since it is not the stock of cars but car use that

[5] The LTA is a statutory board under the Ministry of Communications, set up in September 1995. It integrates several government agencies involved in land transport and administers all demand

lead to congestion and environmental pollution. Ownership taxes, particularly the vehicle quota system, only check on the growth of the "stock" of private automobiles. Use taxes will encourage more discriminating use of cars. Taxes on car use adheres closest to the "polluter pays principle" and proxies more closely to an eco-tax since the tax paid bears a direct relationship to the environmental costs imposed by the journey. However, a first best tax will be one that charges according to the amount of pollutants actually emitted.[6] The incentive instruments used to restrict car use include (a) fuel taxes (b) parking charges (c) road-congestion pricing and (d) the off-peak car scheme.

a. Fuel tax

Fuel tax is a more direct form of eco-tax since the tax varies with the amount of fuel consumed, which in turn affects the amount of vehicle emissions. Compared to ownership taxes or other use tax such as parking charges, fuel tax targets motoring externalities more directly. Fuel consumption tends to be higher in congested urban traffic where there are more stops/starts, resulting in higher pollutant concentration. It is also simple to administer, difficult to avoid or evade and can be modified easily. Road users may respond by reducing the number or the length of trips or by switching to more fuel-efficient vehicles or driving in a more fuel-efficient way. Most OECD countries have fuel taxes (see Table 1).

Fuel tax may have limited effect on car use in Singapore. Ang (1989) concluded the demand elasticity of petrol in Singapore to be price inelastic. This

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management schemes such as congestion pricing and the VQS.

[6] The German Council of Environmental Advisors has put forward proposals for a system of charges that would be directly related to quantities of pollutants emitted. Data on the use of a car

is not surprising since with high up-front ownership cost, fuel cost is a small proportion of the total monetary cost so that fuel tax is likely to have a small price substitution effect. To be effective, fuel tax is complemented with regulatory policy to inhibit cross-border topping up (see Table 5, panel 1).

When compared to congestion tolls, fuel tax is less effective as an eco-tax. Fuel tax, being a flat rate tax, does not give consideration to the different extent of environmental damage between peak and non-peak use and between more and less congested localities. It is, however, possible to implement a quality tax differential in favour of unleaded petrol as incentive for using less environmentally damaging fuels. As part of the environmental tax measures, some Scandinavian countries also introduce separate carbon and sulphur taxes on motor fuels (see Table 1).

b. Parking Fees

Parking fee differential is used to reflect the geographical distribution of congestion. Within the Central Business District (CBD), hourly-rate charges are used to favour short-term parking (e.g. by shoppers or commuters), and against all-day parking (e.g. by workers in CBD). However, whether high parking fee will deter car use depends on the cost of parking relative to the total cost of operating a car.

c. Road pricing schemes

Road pricing or congestion pricing is used primarily as a direct solution to congestion. In principle, roads can be priced not only to reflect congestion costs,

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during the year would be stored in an electronic engine management system, read out as part of the annual test on emissions and passed on to the tax authorities.

but also to give a broader indication of environmental costs in certain areas (mainly, but not exclusively, urban areas) and at particular times. Compared to increasing road capacity to cope with demands, congestion pricing is more cost-effective since it shifts demands to other periods or to other modes of transport. Furthermore, many economists[7] believe in the operation of the fundamental law of traffic congestion, i.e., "On urban commuter expressway, peak-hour congestion rises to meet maximum capacity" (Downs, 1962). It is believed that there are some "latent demands" for highway travel, so that whenever road capacity increases, extra drivers will appear to fill the new capacity so that congestion will set in again.

Singapore is the first city in the world to experiment with road-pricing schemes. As early as 2 June 1975, a congestion zone-pricing scheme for the city centre under the Area Licensing Scheme (ALS) was introduced. The ALS is a manual, simple and low-tech scheme, under which a single charge is levied for vehicles entering the restricted zone (RZ), covering a well-defined boundary of 720 hectares with 27 entry points. About 70% of jobs are concentrated within the RZ. All cars (including taxis) are required to display a paper licence on the windscreen. Panel 3a of Table 5 shows the fee structure of ALS and on how the ALS was fine-tuned over the two decades of administration.

====== **Insert Table 5** ========

In 1995, the Road Pricing Scheme (RPS) was introduced to relieve congestion on specific stretches of the expressways and to distribute traffic to

[7] For example, Repetto et.al. (1992).

other time periods and to alternative routes. It also helps to prepare motorists for more road pricing under the ERP. The RPS was levied during the morning peak hours on three major expressways, on the stretches leading to the city centre (see panel 3b of Table 5 for details).

In April 1998, the scale of use tax increased when the electronic road pricing (ERP) was implemented. Singapore is again the first city to introduce an electronic toll that varies according to the time and location of travel and to the occupation of road space. The RPS points on the East Coast Expressway were replaced by the electronic toll in April 1998. Recently, in September 1998, the ERP replaces the manual ALS in the city centre and all remaining RPS points. The second phase of the ERP will start one to two years after the first phase with electronic tolls being applied to other choke points on the expressways and arterial roads.

The ERP system utilises a sophisticated technology combining radio frequency, optical detection, imaging and Smart card technologies.[8] The ERP technology allows roads to be priced to reflect both the direct and indirect environmental and economic costs of driving. Roads are priced according to the time of travel, with higher rates for travels made during 'the peak within a peak" period, i.e. from 8am to 9am. To spread this peak, and to smooth peak traffic

[8] The ERP system consists of three main components: the In-vehicle Unit (IU), the gantry and the central computer system. All vehicles are fitted with the IU, which is an electronic smart card reader, on the windscreen. The IU has a LCD screen displaying the stored-value balance and confirms every transaction with a beeping sound. The ERP gantries work in pairs in two zones. The first antenna at the first gantry will check the validity of the stored-value smart card and execute debiting instruction. The second antenna in the second gantry deducts charges and photographs rear licence plate of violating vehicles (no Smart card or insufficient balance in Smart card) and transmit record to the Central Computer System in the ERP Control Centre in LTA office.

flow to ensure better utilisation of the expressways, shoulder pricing is used. Lower shoulder rates apply to travels made on the less congested hours of the morning peak. The ERP charges also vary according to the passenger-car unit (PCU) ratings of the various categories of vehicles. The PCU is the amount of space a moving vehicle takes up. Panel 3c of Table 5 shows the charges for two major expressways.

Unlike the existing manual ALS system, the technology of ERP allows charging different rates for different expressways and for different entry gantries into the city centres. The toll is $3 per entry for the most congested and $0.50 for the least congested corridors. The price differentiation is likely to have impact on the modes and the time of travel.

Impacts of road pricing on traffic volume and traffic speed

The experience of Singapore shows that tolls may be the most effective way to deal with peak hour congestion. But it will have to be fine-tuned periodically, as new information becomes available. Chart 2 shows the impact of ALS on traffic volume into the city centre. When it was first implemented, traffic volume into the city centre reduced by more than halve. But by May 1976, traffic volume into RZ started creeping up. Even with an increase in fee to $4 from $3 in 1977, traffic volume continued to increase. It seems that the income effect (from strong economic growth) has offset the substitution effect. Menon and Lam (1992) found that not only had peak hour traffic volume increased, inbound traffic volume into the RZ during the pre- and post-restricted time had also

increased. To smooth traffic flow, in June 1989, the congestion toll was extended to the evening peak hours.

====== **Insert Chart 2** ========

The ALS had ensured satisfactory traffic flows during the morning and evening restricted hours. But during the non-restricted hours, there was an increase in traffic volume and a fall in traffic speed so that average traffic speed in the RZ during the peak hours was higher than during off-peak hours. In January 1994, the ALS was changed into a "Whole-day" ALS, which marked the start of a more extensive use of road pricing to regulate traffic by using differential pricing for different time periods (see Panel 1a of Table 3). The implementation of Whole-day ALS reduced traffic in the city area by 9.3%.

Similarly, when Road Pricing Scheme (RPS) was introduced, traffic volume dropped by almost 40% and traffic speed improved from 40 kph to 67 kph (LTA, 1997, p.12).

Traffic monitoring after the introduction of the ERP indicates a fall in overall traffic volume on the ECP by 15% (from 16,000 to 13,000 vehicles). Average speeds have increased to between 50 and 60 kph during the peak hour, which is considered respectable for expressways during the peak hours. Motorists are also taking advantage of the reduced shoulder rates during the periods 7.30am – 8.00am and 9.00am – 9.30am so that average traffic volume is reduced by 22% for the peak-within-peak hour, thus helping to spread the peak hour traffic.

d. Off-peak car scheme

Singapore implemented an off-peak car scheme in October 1994 as a regulatory measure to directly restrict car use to non-peak hours and weekends only. Tax concessions through savings in the ARF, custom duties, road tax and lower COE premiums made the scheme very attractive as they lower the up-front cost of car ownership. Car use restriction was enforced with stiff penalties imposed on violators (see details in Table 5, panel 4). In principle, the scheme reduced peak period congestion and therefore effectively checked on pollutant concentration during the peak hours. The off-peak car scheme has now been replaced by the ERP.

3. ENVIRONMENTAL IMPACT OF MOTOR VEHICLE RELATED TAXES

The design of motor vehicle tax policies in Singapore, though an outcome of land-use policy has direct impacts on air quality. The OECD (1997) reports that in OECD transport accounted for 20% of carbon dioxide emission in 1995 compared to 14% in 1980. The major culprit being the energy transformation activities, which accounted for 40% of total carbon dioxide emission as compared to 35% in 1980. However, in Singapore, Kahn (1994) estimated that automobile emission accounted for about 65% of air pollution in Singapore, compared to power generation and industry, which respectively contributed 25% and 10%. Restricting car use and to a certain extent, reducing car ownership have reduced pollutants from mobile sources. The various road-pricing schemes

have distributed traffic away from the congested places and times and lowered the peak hour pollutant concentration.

When the ALS was introduced in 1975, changes in the ambient air quality were monitored. Table 6 shows that a lower level of nitrogen oxides was registered although the reduction in carbon monoxide and smoke levels was marginal (see Table 6).[9]

======Insert Table 6=======

Congestion tolls cause commuters to reschedule trips and/or to change the modes of transport. Between 1990 and 1996, the average weekday ridership on the Mass Rapid Transit (MRT) increased by 41% for the three major stations within the CBD -- Orchard, Raffles Place and City Hall (Department of Statistics, 1996). The reduced traffic volumes and increased traffic speed imply fewer stops/starts and lower pollution concentration.

Charts 3 to 7 show the extent of air pollution in Singapore. The levels of carbon monoxide, sulphur dioxide and nitrogen oxide, smoke and average lead concentration in Singapore are well within the World Health Organisation (WHO) and the US Environmental Protection Agency (EPA) standards.

========Insert Charts 3,4, 5, 6,7 =====

Chart 3 shows that the ambient carbon monoxide level in the urban area in Singapore has fallen significantly since 1976. The roadside levels of carbon monoxide are low. The 8-hourly average levels are within the WHO long-term goal and within the USEPA standard of 9 parts per million (p.p.m.).

[9] Since then, no follow-up measurements have been undertaken.

Charts 4 to 7 show that after 1992, air pollution from sulphur dioxide, nitrogen oxide and particularly from smoke has worsened. This is due to cross-border externality from the forest fires in Indonesia. The proportion of 'Good' days (with Pollutant Standard Index (PSI) readings of 0-50) has dropped as compared to 'Moderate' days (PSI of 51-100). In 1996, there were fewer 'Good' days, 64% as compared to 77% in 1992, and more 'Moderate' days, 36% as compared to 23% in 1992.

3.1 Other Regulatory Policies

While economic instruments via tax instruments help to restrain car ownership and use, they are complemented by other command and control policies, which regulate vehicle emissions directly. These two sets of policy instruments reinforce each other. In the United States, although the EPA has lobbied for "more stringent limits on gasoline volatility, control hydrocarbon vapours that evaporate during vehicle refuelling, tighten tailpipe emission standard and require improvements in Inspection and Maintenance program", the EPA concluded that these measures will not be sufficient (EPA, 1993a). The only way to ensure healthy air is to switch to cleaner fuel or to markedly reduce car use. The EPA concluded that "cars are getting cleaner but people are driving more, hence offsetting progress in ozone pollution control". Although the average per vehicle emissions has been reduced sharply, the increased in vehicle miles travelled offset the positive environmental impact.

In Singapore, regulatory policies that are used to complement the tax instruments include (a) fuel policies (b) vehicle emission standards (c) vehicle inspection and maintenance program and (d) scrapping of old cars.

a. Fuel Policies

As discussed earlier, although fuel tax in Singapore may have limited effects on lead level through restricting car use, controlling fuel quality may have more immediate impact. Since the 1980s, actions to reduce lead levels in petrol were implemented progressively. In June 1987, lead in petrol was regulated to be at 0.4g/l to 0.15g/l, which led to lower average lead levels recorded. In January 1991, fuel tax differential between leaded and unleaded petrol was introduced. As at the end of 1996, unleaded petrol accounted for 70% of total petrol sale (Pollution Control Department (PCD), 1997). Chart 7 shows that since 1992, lead level has stabilised in the range of 0.1 to 0.2 $\mu g/Nm^3$ and has since remained low, well below the USEPA standard of 1.5 $\mu g/Nm^3$

There is also tax differential between diesel and petrol (Panel 1, Table 5). Diesel is taxed at a lower rate because it is regarded as an intermediate input in commercial activities and in public transport. However, diesel-driven cars (including taxis) are subjected to road tax six times that of petrol-driven cars. Compared to diesel, emissions from petrol cars have higher nitrogen oxide, much higher volatile organic compounds and carbon monoxide but lower sulphur dioxide and much lower particulate.

The quality of diesel is also regulated. As of 1 July 1996, the permissible level of sulphur in automotive diesel is reduced from 0.5% by weight to 0.3% by

weight. This helps reduce smoke emission from diesel vehicles, as sulphur in diesel impedes combustion and increases smoke emission.

b. Vehicle Emission standards and regulations

The PCD works closely with the LTA and the Traffic Police to monitor the level of vehicle emissions. More stringent standards are adopted to govern emissions from motor cycles, scooters and vehicles using petrol and diesel. The standards are revised from time to time, in line with latest available technology, to minimise air pollution.

As of 1 October 1992, all motor cycles and scooters must comply with specified limits of carbon monoxide and hydrocarbon emission over a test cycle. In July 1992, a stricter emission ruling for imported new cars was adopted. Before these cars can be registered, they must comply with the UN/ECE R83 or the Japanese JIS78 emission standards. To comply with the new standard, only cars fitted with catalytic converters are imported. From July 1994, the UN/ECE R83 was replaced by the more stringent Consolidated Emission Directives (CED) adopted in the EC countries (PCD, 1997, p.8).

Besides setting stringent emission standards, there is also strong law enforcement to ensure compliance. The mobile police officers and the Smoke Test Teams patrol the roads daily. Through spot checks, vehicles emitting black smoke in excess of 50 Hartridge Smoke Units (HSU) are booked and fined.

c. Vehicle Inspection and Maintenance Programs

Inspection and maintenance (I/M) program is an effective way to ensure that the emission control system on a vehicle is working properly. All cars sold

already met the stringent pollution standards, but the low pollution profile can be retained if the emission control and engine are working properly. According to EPA (1993b), the average car on the road emits three to four times more pollution than the standards allowed for new cars. All vehicles on the road in Singapore are subject to statutory periodic inspection. The schedule of inspection depends on the age and type of vehicles, with the frequency of inspection being shorter for older and diesel-driven vehicles.

The I/M program is constantly upgraded. Since June 1993, all vehicles must comply with the environmental standard of carbon monoxide emission in the exhaust system. The carbon monoxide level must not be more than 6% by volume for vehicles registered before 1 October 1986 and not more than 4.5% for those registered on or after October 1986.

d. Scrapping of old cars

High registration fees on new cars discourage car owners from replacing their cars, or encourage them to buy old cars. This implies an ageing fleet of cars, which in turn will have environmental impact since older cars are not fitted with catalytic converter and may not meet the environmental standards. Older cars tend to emit more pollutants, are noisier and less safe than newer vehicles. To encourage earlier retirement of older cars, a negative tax or subsidy for early retirement of older cars under the Preferential Additional Registration Fee (PARF) was introduced in December 1975. Car owners in return for scrapping or exporting an old car, which must not be more than 10 years old, enjoy a bonus. The bonus can be used to offset the additional registration fee of any new car

they buy. The PARF bounty is a percentage of the OMV and varies with the age of the scrapped vehicle. Scrappage bounty is also a mechanism to control the car population, since with every new car registered, an old car is de-registered (scrapped). The PARF benefit of de-registering a vehicle of less than 10 years is given in panel 4 of Table 2.

One consequence of scrappage bounty is the creation of a market for scrap cars. The prices of which varied by engine capacity category and according to the demand and supply conditions for scrap cars. For example, in 1990, price inflation for scrap car is created because of low supply of scrap cars (which were registered in 1980) because of measures undertaken in the late 1970s to curb car ownership. But in 1998, the drop in the number of new cars registered because of the Asian economic turmoil coupled with excess supply of cars (registered in the economic boom years of 1988 and 1989) due to be scrapped have depressed the price of scrap cars. To address this problem, the scrappage bounty can now be used to offset the COE premium and the registration fee, on top of the ARF. The bounty can also be split up and used for registering more than one vehicle.

If new cars become more unaffordable, then existing cars may be kept for a longer period. A shift in the age distribution of cars is observed recently. In 1991, only 4% of the car population were 15 years or older. But in 1996, older cars account for 11% of the car population (Department of Statistics, 1996). This has implications on road safety, fuel consumption and vehicle emission levels. The financial incentives under the PARF may need to be revised in order to

encourage people to retire older cars. With a restructuring towards more use tax, the up-front cost of car ownership can be reduced by having a lower ARF, while keeping the quota premium system as a check on the growth rate of car population.

4. INTEGRATING ENVIRONMENTAL AND TAX POLICY

Besides the direct impact on the environment, motor vehicle taxes have other wider economy-wide implications. The design of motor vehicle taxes cannot be considered in isolation, but must be co-ordinated with the overall tax policy. While motor vehicle related taxes, contributing to more than one-fifth of Singapore's total operating revenue, seem buoyant, there are some tax issues that need to be addressed. First, regarding the financial viability of relying on revenue from motor vehicle taxes. Motor vehicle taxes, in general, tend to be pro-cyclical. The economic slowdown resulted in collections from motor vehicle taxes falling short of the initial official estimate. Total collection was $1.74 billion, below the estimated $2.2 billion, while licenses and permits provided $2 billion, $200 million below estimates (Straits Times, 17 July 98). The shortfall is due to weaker demand for new cars, over-estimation of COE premiums and rebates on road tax as part of the vehicle tax rationalisation to lower upfront cost of car ownership.

This brings us to the second issue, regarding how the revenue is recycled? Given its pro-cyclical nature, earmarking of motor vehicle revenue for highway maintenance programs can be neither efficient nor effective. Motor

vehicle tax revenue in Singapore goes into the general revenue. If the revenues generated are offset by lower conventional taxes, which create excess burden by distorting labour supply, savings and investment decisions, then motor vehicle taxes are welfare improving since they not only internalise motoring externality but also have capacity output effect. The overall tax burden ratio is relatively low for Singapore, at 16.2%, compared to the average of 17.4% and 20.6% for the Asian and OECD countries respectively.[10] Compared to some developed countries (Australia, Canada, United States and the United Kingdom) whose income tax, on average, forms about 10 to 15% of GDP, Singapore's income tax burden (at 6.73%) is relatively low, though slightly higher than the Philippines and Thailand.

Given the magnitude, motor vehicle taxes have implication on the overall revenue structure. Since collections from COE and ARF are currently classified as non-tax revenue, it is not surprising that Singapore has the highest ratio of non-tax revenue as a percentage of GDP, at 9.7%, as compared to the average of 3.6% for the Asian countries and 2.1% for the selected OECD countries.

The next tax issue relates to the efficiency of motor vehicle taxes, particularly to the "appropriate" level and mix of motor vehicle taxes. The theoretical underpinning of congestion tax is straightforward. To internalise externality, the level of tax must be set exactly equal to the congestion externality, i.e. the difference between the marginal and average trip costs. In practice, it is difficult to implement optimal congestion pricing, as the implementing authority must have exact information on the marginal social costs.

[10] See Chia (1998) for details.

McCarthy and Tay (1993) produce estimates that the ALS fees may be too high and warn that it may be a traffic restraint policy, so that road system may actually be under-utilised during the operational hours, leading to inefficiency. This result is not surprising since ALS, being a flat-rate toll, is set to the value of externality imposed on a commuter under average congestion levels. If congestion pattern is such that it will build up to some peak and then subside, then commuters travelling at the beginning or the tail of the peak will be overcharged, while those commuters who are travelling at the peak itself will be subsidised. This problem is likely to be rectified when the ERP replaces the manual ALS. With advanced optical scanning technology, the optimal toll can vary with the level of congestion. With variable tolls and shoulder pricing, ERP will improve efficiency.

Given that the implementing authority may not have complete information, tax rates and even tax base may have to be revised as new information or data become available. For example, both the rate and base for the RPS were adjusted to reflect the congestion externality more accurately. When first implemented, the RPS was S$1 in June 1995, and was revised to $2 in May 1997 in order to produce stronger incentive effect. Besides the east-west running East Coast Parkway (ECP), the RPS has also been extended to the other two major expressways -- the east-west running Pan Island Expressway (PIE) and the north south running Central Expressway (CTE). However the different fee structure on different expressways in a manual system can lead to confusion for commuters and more cost uncertainty for some businesses, such as those involved in delivery services or taxis services.

This is also true for the ERP on the Central Expressway (CTE) which was implemented in August 1998. Traffic volume on the CTE increased by 23%, largely because there are 64% more commercial vehicles and 90% more taxis as they pay lower tolls than other vehicles. To relieve congestion, their tolls were doubled from November 1998.

The next issue relates to the optimum tax mix to internalise congestion externality, particularly with respect to optimum composition of ownership and use tax. In fiscal year 1985 (FY85), revenue from ownership tax was 57%, which was just slightly higher than revenue from use tax. But by FY95, more than three-quarter (83%) of the motor vehicles related revenue came from ownership taxes. The challenge is to achieve an optimal tax mix that will internalise externality while minimising other economic distortions.

The efficiency of motor vehicle taxes has to be re-examined. A tax is efficient in a fiscal sense if it does not distort economic decision. Efficiency in environmental terms, according to OECD (1996,p.12), refers to a policy that "induces agents to change their behaviour with the least economic costs, in order to meet environmental goals." If the reduction in peak hour congestion is due to staggering of work-start time and not due to changes in alternative modes of travel, then there is other welfare implications. Changing work-start time has two opposing effects on marginal productivity. The first effect operates because of agglomeration economics of scale, which suggest that marginal productivity of workers may be greatest when workers are all present at the same time since productivity depends upon direct face-to-face interaction and communication.

On the other hand, if time spent on commuting yields negative utility and fatigue, then the marginal productivity is lower for workers travelling during peak hour congestion. Wilson (1988) shows that the effect of urban scale economies dominates the marginal productivity effects especially for professional workers for Singapore. If that is so, then we have to examine the effect of motor vehicle taxes on work-start time. Wilson (1989) estimated the welfare effects of congestion pricing in Singapore and concluded that although congestion toll leads to reduce travel times, but commuters are shown to incur rescheduling costs as a result of the toll. However, the result must be interpreted with care, as the study was based on the 1975 survey data. Since then, as part of the four-pronged approach to land-transport policy in Singapore the public transport system has improved significantly. The Mass Rapid Transit (MRT) system started operating in 1987. These alternative modes of transport may lead to lower rescheduling cost than what Wilson had estimated.

Next, relates to the equity aspect of a tax. Motor vehicle taxes are designed to internalise congestion externality, and are designed to place the burden directly on those responsible for it. This adheres to the "polluter pays principle" and may be interpreted as "principle of fairness". If we regard environmental quality as luxury good, then environmental internalisation is pro-rich. But the incidence of motor vehicle taxes in Singapore seem to be progressive, with tax burden borne mainly by the higher income group as they are the main car owners and car users. The 1995 Household Survey shows that working persons travelling by car to work had the highest median income of

S$3,750 per month. The median income of a working person using other types of transport was much lower, at S$2,866 per month for those taking taxis, S$1,950 for those taking the Mass Rapid Transit (MRT) only, and $1,795 for those taking the MRT/public bus combination. Those who did not require any form of transport to work had the lowest median income from work of $595 per month (Department of Statistics, 1997).

Finally, there is a need to co-ordinate policy so that current tax provisions that encourage polluting activities will be modified and/or eliminated. For example, the use of company cars for commuting to the place of work and free (or reduced costs of) parking space provided by employers are not considered as taxable benefits. As part of the revamp in the vehicle tax structure, operating expenses and capital costs of company cars are no longer tax deductible in Singapore.

5. CONCLUSION

The design of motor vehicle taxes has focused primarily, if not exclusively, in raising revenue. But some OECD countries are beginning to co-ordinate fiscal and environmental policies. Denmark, Finland, Norway, Sweden and the Netherlands, for example, have introduced carbon taxes on motor fuels as part of the overall carbon tax schemes. Systematic taxation of fuels according to their environmental characteristics is a comparatively new idea.

Although design of motor vehicle tax structure in Singapore is based on land-transport policy for sustainable development, it has also achieved some

environmental goals. The recent restructuring towards more use taxes and giving tax concessions to vehicles providing public transport indicate a move towards the environmental objectives.

Motor vehicle taxes and charges have allowed Singapore to enjoy "double dividends". Motor vehicle related taxes and fees account for almost a fifth of the total operating revenue, and a quarter of the total tax revenue. The success in congestion pricing for the city centre and the major expressways has minimised peak hour congestion and pollutant concentration. The overall average levels of carbon monoxide, lead, sulphur dioxide and nitrogen dioxide are all within the air quality standards established by the WHO and the USEPA.

Fiscal restraints on car ownership and car use through motor vehicle taxes is but one of the four-prong approach to optimise land-transport use in Singapore. There seems to be political will and public acceptance to support the "expensive-to-own-and-use-a-car" policy because it is accompanied by three other policy approaches. These are:

(1) developing systematic satellite towns as part of land-use planning to minimise the need to travel;

(2) investment in an extensive and comprehensive network of roads and expressways which are augmented by traffic management measures and

(3) a viable and efficient public transport system.

The latter is particularly important. Public transport system will continue to be developed as the cornerstone of Singapore's land transport strategy since this

is the most efficient transport solution for a highly urbanised and densely built up city-state. Plans are underway to improve the performance of bus and taxi services, to extend the Mass Rapid Transit (MRT) to serve the heavy traffic corridors and the Light Rail Transit (LRT) to serve as feeders to the MRT network.[11] The fares for public transport are regulated by the Public Transport Council, a statutory board established under the Public Transport Council Act. The Council is a watchdog safeguarding the interests of the commuters while ensuring the financial viability of public transport operators.

To achieve the goal of a comprehensive rail network, the government has also committed itself to improve the public transport infrastructure by adopting a new financing framework for the rail system. Under the old financing framework, the government only paid for the initial capital cost for rail and operators had to rely on fare collections to cover the current operating costs plus the second set of operating assets. While such policy is prudent in that it allows only self-sustaining systems to be built, it exerts pressure on operators to raise fares to stay viable. Under the new financing commitment, part of the second set of operating assets will be financed from fare revenue (which covers the historical cost of the first operating assets) and the rest will be co-financed by the government. This would keep public transport affordable and at the same time maintain intergenerational equity. The new financing framework allowed the construction of the $5 billion Northeast MRT Line to be brought forward by four years. It has also allowed the LTA to consider further expansion of the MRT network and the construction of more LRT lines.

[11] This is outlined in the White Paper presented by the LTA (1996) to the Parliament.

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Table 1:
Environmentally related taxes and charges in the OECD countries

Environmental Tax Measures	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Iceland	Ireland	Italy	Japan	Luxembourg	Mexico	Netherlands	New Zeal.	Norway	Portugal	Spain	Sweden	Switzerlan	Turkey	U.K.	U.S
One off vehicle ownership taxes																									
Sales/Excise/Registration tax differential (cars)			x	x	x	x			x	x	x	x			x	x		x	x		x	x	x		x
Road/Registration tax Differential (cars)			x	x	x			x		x	x	x	x		x	x		x		x	x	x	x		
Motor Fuels																									
Leaded/Unleaded (Differential)	x		x		x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	
Diesel (Quality differential)					x	x												x			x				
Carbon/Energy taxation					x	x										x		x			x				
Sulphur																		x			x				
Other excise taxes (excluding VAT)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Other Energy Products																									
Other excise taxes	x	x	x		x	x	x	x	x		x	x	x	x	x	x		x		x	x	x		x	x
Carbon/Energy taxation					x	x										x		x			x				
Sulphur tax					x		x											x			x				
NOx charge							x														x				

Source: Adapted from OECD (1996).

Table 2:
Motor vehicle ownership tax and charges in Singapore, 1998

1. **Customs duty:** 41% of open market value (cost insurance freight, handling, and other incidental charges paid.
2. **Good and services tax:** 3% CIF plus customs duty payable.
3. **Registration fee (RF):** S$140
4. **Additional Registration fee (ARF):** 140% of the open market value of cars.

Scrappage Bounty -- Preferential Additional Registration Fee (PARF)

- To offset the discouragement effect on new car ownership arising from ARF, scrappage bounty was introduced in December 1975.
- Car owner registering a new car could use PARF benefit to offset the ARF, the RF and COE premiums of any new car if he would scrap (or export) an old car, which must not be more than 10 years of age.
- The PARF benefits vary with the age of vehicle at de-registration:

Age of vehicle at de-registration	PARF benefit (% of OMV)
Less than 5 years	130%
Less than 6 years	120%
Less than 7 years	110%
Less than 8 years	100%
Less than 9 years	90%
Less than 10 years	80%

Imported cars are not eligible for PARF benefits.

5. **Annual road tax**

- Levied progressively based on engine capacity as follow:

Engine capacity (EC)	Road Tax formula
EC ≤ 600 cc	$500 (flat rate)
600 < EC ≤ 1,000 cc	S$500+0.25x(EC-600)
1000 < EC ≤ 1,600 cc	S$600+1.0x(EC-1000)
1600 < EC ≤ 3,000 cc	S$1200+1.8x(EC-1600)
EC > 3,000 cc	S$3720+2.5x(EC-3000)

- Road tax surcharge for vehicles over 10 years, at 10% surcharge for each additional year.

6. **Certificate of entitlement (COE) under the Vehicle Quota System (VQS):**

- A motor vehicle quota system was implemented in 1 May 1990. To register a new car, car buyer must bid or tender for a license or COE, under the appropriate vehicle category. There are 7 vehicle categories. Tender is held monthly. (See Table 4 in Chia (1998) for an example tender result).
- The number of new vehicles allowed for registration is pre-determined annually, taking into account the road capacity, traffic conditions and the number of vehicles de-registered in the last calendar year so as to allow vehicle population to grow at an annual rated of 3 %.
- The price of the COE depends on demand conditions and the successful bidder pays the lowest successful price, instead of the bid price.
- Owner of a 10-year-old vehicle who wants it to remain on the road for another 10 years has to pay the prevailing quota premium.
- Company-registered cars and heavy vehicles pay double the quota premiums.

Table 3
Motor vehicle tax reliance relative to conventional tax reliance for selected OECD countries and Singapore

Countries	Year	One-off vehicle tax	Motor fuel tax	Income Tax	Value added tax
Australia	1992/93	1.6	0.0	72.2	10.4
Canada	1991/92	0.1	0.0	58.6	13.3
Denmark	1993	4.3	0.0	45.3	28.2
Finland	1994	1.8	0.0	31.6	28.9
Netherland	1993	3.0	3.4	33.5	15.0
Norway	1993	3.2	4.7	19.7	26.4
Singapore	**1995**	**17.4[a]**	**3.4[a,b]**	**41.5**	**32.9**
Sweden	1993	1.8	9.2	7.1	25.7
UK	1993/94	1.7	0.0	37.5	20.8
US	1993	1.2	1.9	54.4	n.a.

Source: Data for OECD countries is compiled from OECD (1995). Data for Singapore is compiled by the author.

Notes:

a. Percent of operating revenue which includes both tax and non-tax revenues. Collections from the ARF and COE premiums (ownership tax) are classified as non-tax revenues.

b. Include also other taxes and charges relating to car use such as congestion tolls and traffic fines.

Table 4
Changes in car ownership taxes in Singapore, 1968 to 1998

From: To:	1968 Oct 72	Oct 72 Dec 73	Jan 74 Mar 75	Mar 75 Dec 75	Dec 75 Feb 80	Feb 80 Oct 83f	Oct 83 Oct 84	Oct 84 Nov 88	Nov 88 Nov 90	Nov 90 Feb 91	Feb 91 May 97	May 97 Mar 98	April 98
Import Duties (% of OMV[a])	30	45	45	45	45	45	45	45	45	45	41	41	41
Registration Fee (S$)	15	15	15	15	15	1000	1000	1000	1000	1000	1000	1000	140
Additional Registration Fee (percent of OMV)	15	25	55	55	100	150	175	175	175	160[b]	150	150	140
Annual Road Tax (cents per cc)[c]													
• Up to 1000cc	10	10	14	20	35	40	52	60	70	70	70	70[d]	$500+0.25(EC[e]-600)[f]
• 1000 -1600cc	10	12	15	25	40	50	65	75	90	90	90	90[d]	$600+1.0(EC-1000)
• 1601- 2000cc	10	15	2	30	45	60	78	90	105	105	105	105[d]	$1200+1.8(EC-1600)
• 2001- 3000cc	10	20	25	40	50	70	91	105	125	125	125	125[d]	$1200+1.8(EC-1600)
• above 3000cc	10	30	60	65	80	100	130	150	175	175	175	175[d]	$3720+2.5(EC-3000)

Source: Table 1 in Chia (1998)

Notes:

a. OMV = Open Market Value
b. With the introduction of the car quota system in May 1990, the additional registration fee was reduced.
c. From 1975, company cars were subjected to 200% of private car road tax. As from 1 September 1998, both company and private car pay the same rate.
d. In a move towards charging according to car use under the Road Pricing Scheme, rebate on annual road tax was introduced in May 1997, with rebates of $60 for cars or commercial vehicles, $20 for motor cycle and $10 for weekend/off-peak car.
e. EC = engine capacity
f. This road tax structure takes effect in September 1998, when the Electronic Road Pricing (ERP) replaces the manual road pricing schemes -- the ALS and RPS. The annual road tax is a flat $500 for engine capacity smaller than 600cc. Road-tax rebate of S$200 is given for every car, with annual rebates expected for several years.

Table 5
Motor vehicle use taxes and charges in Singapore

1. Fuel taxes

- Differential tax for leaded and unleaded petrol.
  Unleaded petrol tax: 60 cents per litre; leaded petrol: additional 15 cents per litre.
- Differential tax rate for petrol and diesel. Diesel tax: 7 cents per litre. (Scheduled public buses exempted from diesel taxes.)
- "Three quarter tank" rule was introduced to restrict cross-border topping up so that it is an offence for Singapore-registered car to enter Malaysia with less than 3/4 tank of petrol.

2. Parking fees

- The rates charged by the two main public sector operators of car parks are :
  Within CBD: 90 cents per half hour between 8:30 am to 5:00 pm
  45 cents per half hour between 5:00 am to 10:0.0 pm
  Outside the CBD: 45 cents per half hour between 8:30 am to 10:00 pm

3. Congestion Tolls

a. Area Licensing Scheme (ALS)

- All vehicles must pay for a license to gain entry into the restricted zone.
- Initiated in 1975 and had gone through many rounds of fine-tunings which include:
  - May 1975 -- applied to morning peak hours (7:30 - 9:30), fee at $3 per car.
  - August 1975 -- morning peak extended to 7:30 am - 10:15 am
  - August 1977 -- fee adjusted to $4 per car.
  - June 1989 -- evening peak introduced 4:30 pm - 6:30 pm
  - May 1997 -- whole day ALS implemented with two types of licenses: a Part-Day license for off-peak hours (9:30 am to 4:30 pm on weekdays) and a Whole-Day license for peak hours (7:30 am to 7:00 pm on weekdays) and vary for different vehicles.

  ALS license fees differ for different vehicles.

	Part day	**Full day**
Motor-cycles	S$0.70 /day	S$1 / day
	S$14 /month	S$20 /month
Private car & other vehicles	S$2 /day	S$3 /day
	S$40 /month	S$60 / month
Company cars	S$4 /day	S$6 / day
	S$80 /month	S$120 / month

- Vehicles entering the restricted zones are closely monitored for the valid licenses and hefty fine of S$70 for not displaying the license is implemented.

b. Road Pricing Scheme (RPS)

- RPS is a expressway congestion pricing introduced in 1 June 1995. It initially applied to 2 points of the East Coast Parkway during the morning peak (7:30am - 8:30 am).
- In 5 May 1997, RPS was extended to the Pan Island Expressway (PIE) and the Central Expressway (CTE). The peak hours were extended to 7:30am -9:30am.
- Motorists using these three highways leading to the city, during morning peak, have to purchase and display a RPS license. The license has a similar fee structure as the part -day ALS.
- The RPS license can be used for entering the CBD as an ALS license during the off-peak period. Except for the north-south CTE, a valid ALS license can also be used as a RPS license for the other two east-west highways --the ECP and the PIE.

c. Electronic Road Pricing (ERP)

- First phase was introduced in 1 April 1998. In September 1998, the ERP replaces all manual road pricing schemes and the off-peak car scheme.
- Electronic tolls vary by the time and location of travel and the road space occupied by moving vehicles.
- ERP charges at the ECP from 1 April 1998 for the different vehicle types are as follow:

Vehicle Type/Time period	7.30 -8.00	8:00 - 9:00	9:00 - 10:00
Motor cycle, scooter (PCU = 0.5)	$0.50	$1.00	$0.50
Car (PCU=1)	$1.00	$2.00	$1.00
Taxi (PCU=1)	$0.35	$0.70	$0.35
Light Good Vehicles (PCU=1)	$0.25	$0.50	$0.25
Heavy Good Vehicles, Bus (<30 seats) (PCU=1.5)	$0.40	$0.80	$0.40
Very Heavy Good Vehicles Bus (>30 seats) (PCU = 2.0)	$0.50	$1.00	$0.50

- The manual RPS allows unlimited passage through the gantries with a single license, whereas under the ERP, motorists are charged for each passage.

4 Off peak car

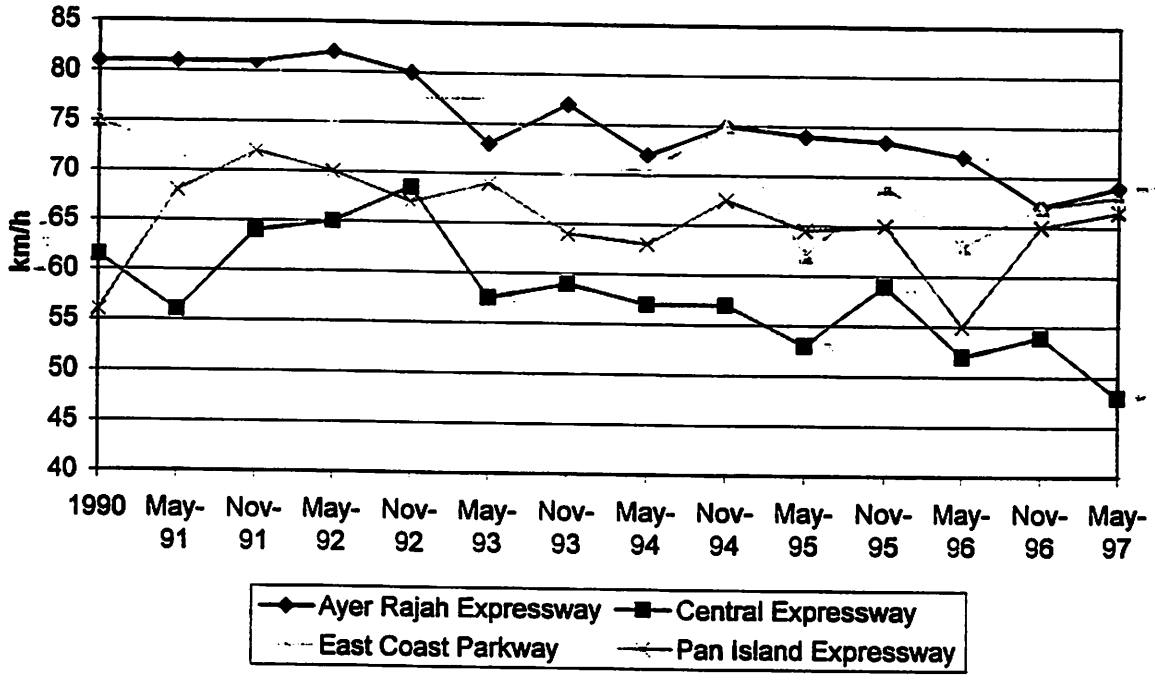
- Introduced in October 1994 as the revamped version of the weekend car scheme. Off peak cars are identified by a red number plate, which is required to be welded onto the vehicle and sealed by an authorised inspection centre.
- Buyers of off-peak cars enjoy tax rebates of S$17,000 on car registration fee and import duty; and a flat discount of S$800 on the annual road tax. But buyers have to bid in the same COE category as those buying cars for normal use and pay the same COE price.
- Use of off-peak cars are restricted to Sundays and public holidays and during off peak hours (between 7 pm and 7 am on weekdays and after 3 pm on Saturday). A day license at $20 to be displayed on the windscreen is required if the car is used outside the permitted hours. Five free day license are given for each year.
- The penalty for using an off-peak car outside the permitted time and without proper license is a fine equal to half the annual road tax for an equivalent normal car for a first offence. For second and subsequent offences, the fine is equal to the full annual road tax for an equivalent normal car. The penalty for tampering with the number plate of the weekend car is a fine equal to twice the annual road tax for an equivalent normal car.

Table 6:
Air quality before and after the implementation of the ALS

	Pre-ALS April (morning peak)	Post-ALS June (morning peak)
Total Nitric oxide	167 $\mu g/m^3$	144$\mu g/m^3$
Average level of carbon monoxide	7 ppm	4 ppm
Smoke level	189 $\mu g/m^3$	172 $\mu g/m^3$

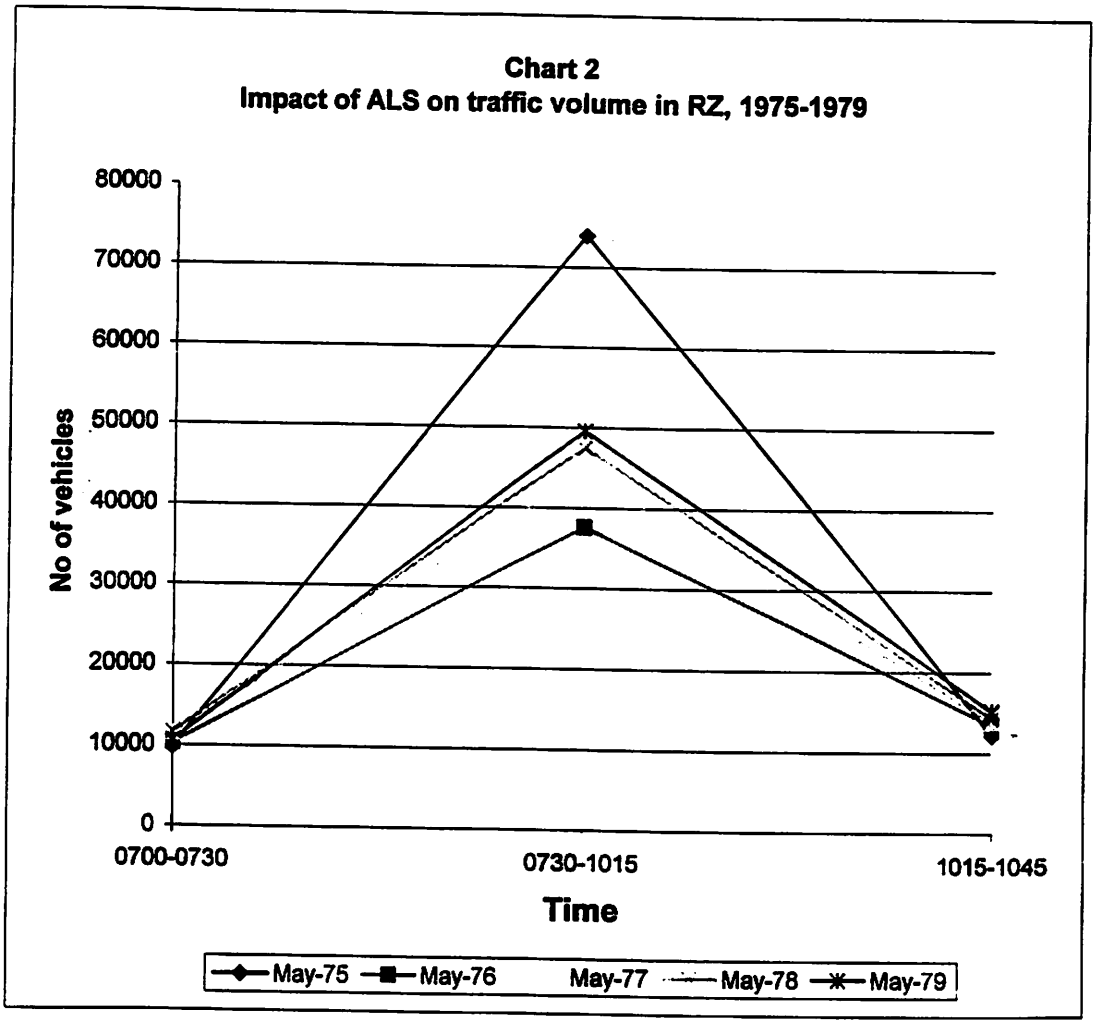
Source: Anti Pollution Unit, Annual Report 1975.

Chart 1
Average traffic speed (morning peak) on major expressways



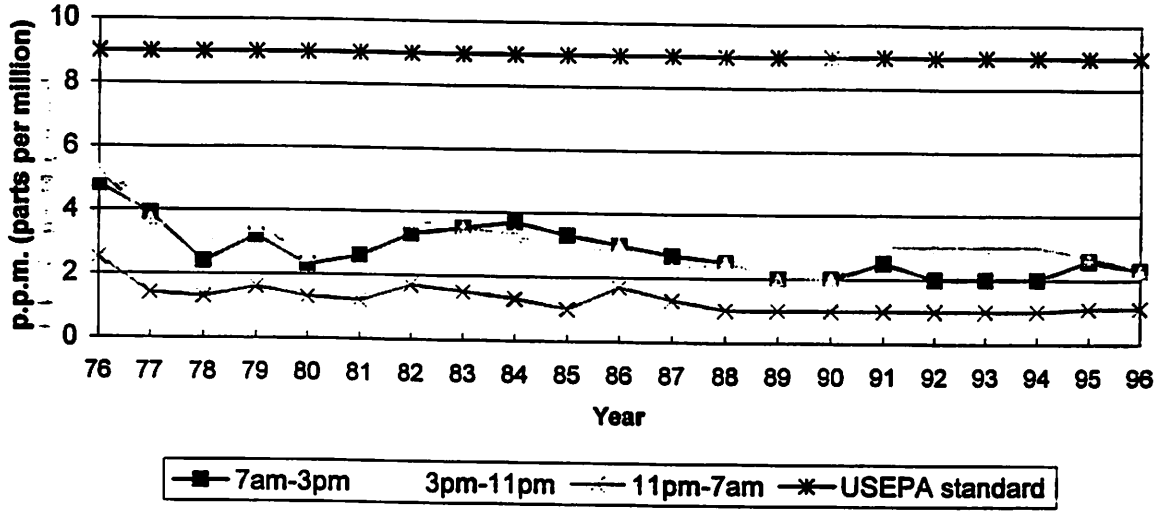
Source: Land Transport Authority (1997).

Notes: In June 1995, Road Prcing Scheme (RPS) was introduced on the East Coast Parkway for the morning peak hours.
In May 1997, RPS was extended to the Pan Island Expressway and the Central Expressway.

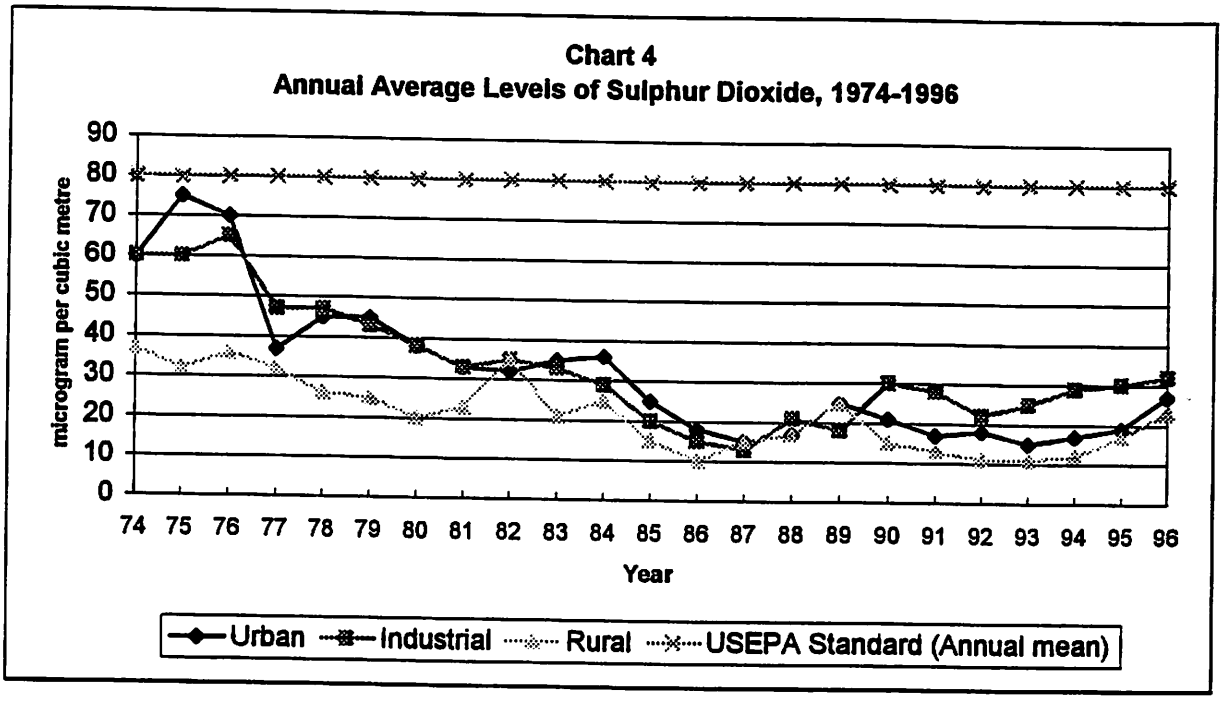


Source: From data presented in in Seah (1980)

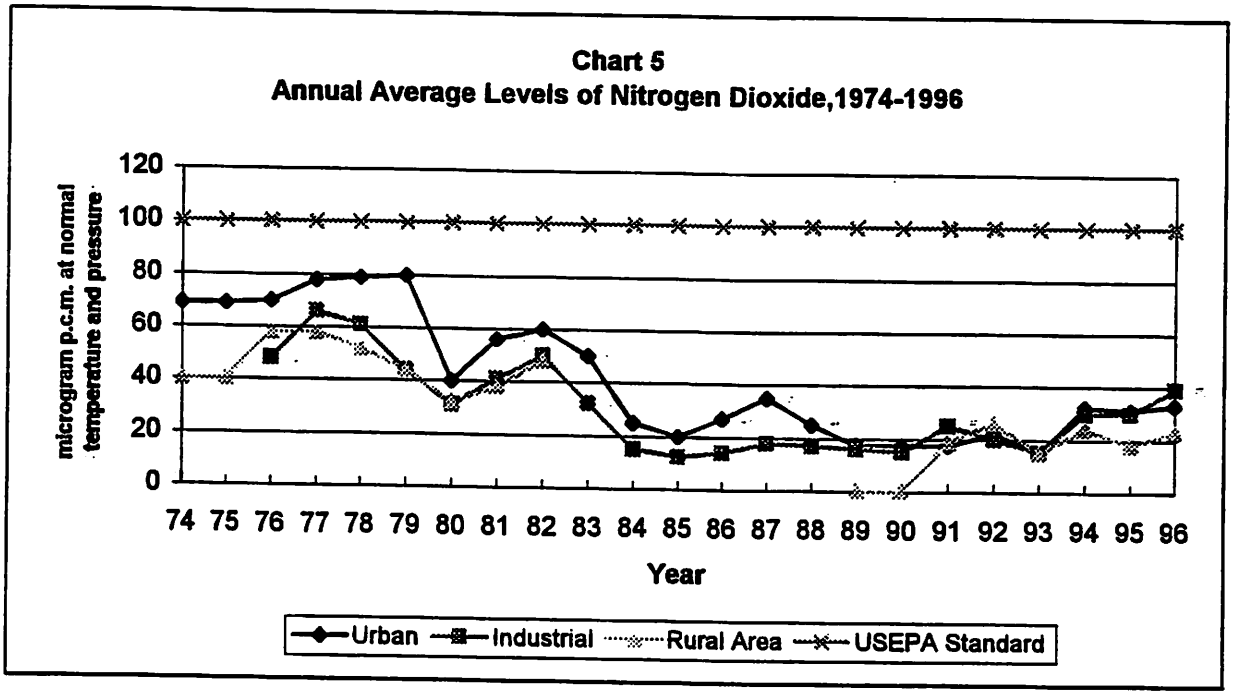
Chart 3
Ambient carbon monoxide level in urban area



Source: Anti-Pollution Unit, Annuals; Pollution Control Departments, Annual Reports and Department of Statistics, Yearbook of Statistics.

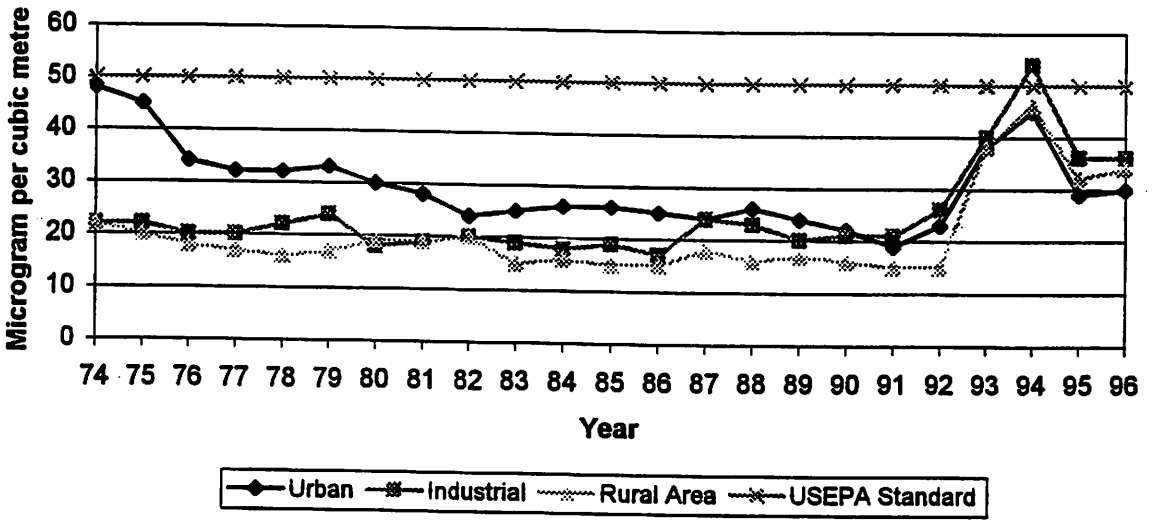


Source: Same as Chart 3.

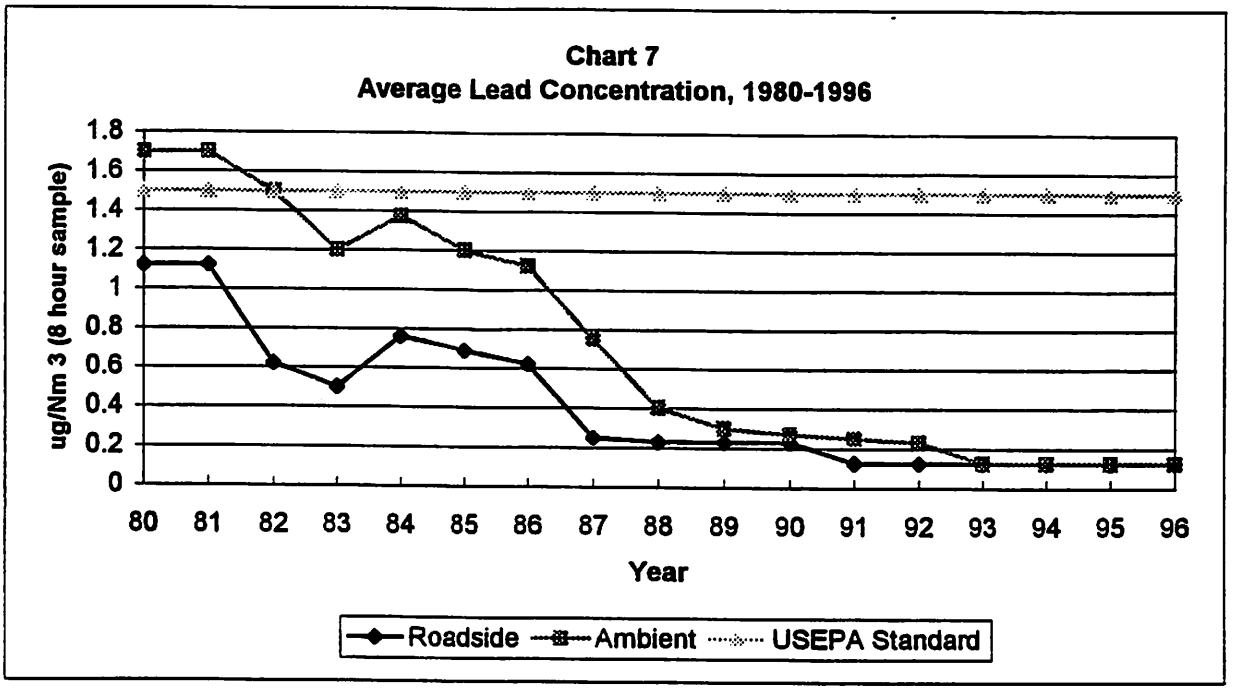


Source: same as Chart 3.

Chart 6:
Annual Average Levels of Respirable Suspended Particles (PM10)



Source: same as Chart 3.



Source: Pollution Control Unit, Annual Report, various years.
Note: In June 1987 lead in petrol was 0.4g/l to 0.15g/l.
In Januray 1991, unleaded petrol was introduced.