



## **Electronic road pricing and the economics of traffic congestion control in Singapore**

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### **Abstract:**

Singapore is about to become the first country to introduce comprehensive electronic road pricing (ERP). In this paper past and proposed policies for managing traffic congestion in Singapore are evaluated to assess their effectiveness in controlling congestion and their possible case-study relevance for other countries. The potential advantages of ERP over certain past policies are emphasised. Three types of policies are considered: (i) supply-oriented policies, (ii) policies which reduce the demand for vehicular transport and (iii) pricing policies which reduce the quantity demanded of vehicular travel. We conclude that, while Singapore's pre-ERP pursuit of a package of traffic control options has been effective in controlling congestion, such policies have had complex welfare consequences and raise the prospect of traffic flows being excessively restricted to those with high incomes and substantial travel demands. In the past there has also been excessive reliance on non-use related charges. ERP should be introduced to offset this criticism. The relevance of past Singaporean policy and particularly ERP to other countries is limited by the unique geography and political institutions of Singapore. This suggests limited transferability – at least unless less weight is placed on pricing components of transferred policy packages.

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## Introduction

Singapore is a small, compact country with high population density. Its 3.1 million people live on 640 sq km of land with a population density of 4844 per sq km. Singapore has experienced rapid economic growth since World War 2 and is now approaching developed-country living standards with per capita incomes of around US\$24,610: see Asia Week (June 5, 1998, page 78).

87% of Singapore's 1.5 million workers require some form of transport to work but only 32% do so in private vehicles. More than 57% use public transport such as bus chartered buses/vans, or the MRT: see Lau (1994).

Private vehicle transport demands in Singapore show high income elasticities (Toussaint (1992) cites estimates between 1.96 and 2.02) and low price elasticities (-0.4). Therefore, with the high income growth that has occurred, Singapore faced the prospect of unacceptably high traffic congestion.

Singapore has responded with a package of supply and demand-oriented policies designed to limit car ownership and to reduce congestion. Moreover, it is now introducing comprehensive electronic road pricing (ERP). This paper surveys past policies as well as proposed policies and assesses their efficiency and equity implications. The relevance of Singaporean policies for other countries is also considered.

## Road Supply Policies

Singapore has a well-developed road network and a high road density – about 12% of land is used for roads and road-related purposes: see LIA (1996, page 2). There are 3072 km of roads most of which (2988 km) are asphalt-paved. However, while road networks have increased by 14% over the last 10 years, the private car fleet has grown by 64% to be 362,142 at December 1996. The resulting increased congestion has been partly offset by an increased provision of expressways. These have grown in length by 81% and now cover 139 km. There are now 8 expressways linking Singapore from north to south and east to west.

There are substantial planned road network expansions. Over the next five years the government will spend S\$1.1 billion expanding the network by 225 km. In particular 3-tier road networks are being built to maximise the productivity of land used for transport. More 3-tier interchanges are being constructed (some are already in use). These include an underground road network, ground level roads, and above ground networks. 4-tier interchanges have an additional MRT tunnel. The government is also considering the feasibility of an underground road system – the Singapore Underground Road System (SURS). A major cause of congestion in Singapore is cross or through city traffic so a SURS costing S\$4.8 billion would provide 40% more road capacity in the city. It would consist of two concentric rings of underground roads roughly 15 km apart each with 33 entrances and 8 interchanges.

Apart from physical expansions of the road network, Singapore is also adopting technologically innovative approaches to traffic management, which increase network effectiveness. Pendakur (1989) claims that use of computer controlled CBD traffic management has increased travel speeds there by 10-25% in peak hours. The *Green Link Determining* (GLIDE) system coordinates traffic flows across 1250 traffic signals island-wide. On expressways the *Expressways Monitoring and Advisory System* (EMAS) promptly advises of traffic delays. The turn-left-on-red (LOR) scheme saves waiting time at traffic lights while closed circuit television in the city enables traffic monitoring there. In addition, the Automatic Network Travel Time System (ANITS) allows traffic monitoring communications between traffic lights, buses, and taxis. Ultimately this type of data can feed into intelligent vehicle systems that can advise on traffic, road works, parking and optimal route selection.

In short, while Singapore is acknowledged as a leader in implementing demand-based congestion management programs, it has also employed active and innovative supply side measures including modern traffic control technologies. These supply decisions have not so far been linked to road pricing but, once comprehensive ERP is introduced, this can be done by relating toll revenues to expansion plans: see e.g. Newbery (1988).

### **Demand-Shift Policies**

These are *indirect* policies which limit the demand for vehicular transport without increasing direct travel costs. In some instances these are policies impacting on non-usage costs. Examples include policies influencing car ownership costs, fuel costs, and public transport fares. Finally, land-use and staggered-working-hour policies influence commuting demands.

#### **Charges on Automobiles.**

Up to the present the main instrument used to control traffic congestion in Singapore has been the high cost of *owning* rather than of *using* a vehicle. Several schemes operate to increase car ownership costs.

*Vehicle Quota Scheme (VQS)*: Introduced in 1990 as a direct curb on car ownership, the VQS arose from the observation that car numbers in Singapore were growing faster than road space. Therefore the government decided to control the growth in car numbers each year and to auction off a quota of vehicles by means of *Certificates of Entitlement* (COEs) which allow vehicle purchases. Every month individuals can bid for a COE in one of seven vehicle categories. Bidders then pay the lowest successful bid price. The COE lasts ten years after which, should the owner wish to keep the vehicle, they would have to pay the then current COE bid price for vehicles in that category.

Since different potential owners have a distinctive willingness-to-pay for vehicles such an auctioned quota system has efficiency advantages over a pure (non-auctioned) quota

system. Vehicles end up in the hands of those with highest willingness-to-pay. On the other hand, those on low incomes face prohibitive costs to purchasing a vehicle.

The VQS scheme is not specifically congestion targeted since car ownership is only indirectly linked to car usage. However, the VQS does have practicality in the absence of comprehensive road pricing of the ERP type. For example quantitative limits on car ownership can limit congestion in areas which cannot be priced for transactions cost reasons. Also, if vehicles are demanded *because they are expensive* (for status-seeking reasons vehicles are often 'positional goods') the high taxes implied by stringent VQS quotas impose no burden on consumers at all: see Ng (1987), Ireland (1994). Given limitations in the Singaporean domestic tax base – the maximum income tax rate is only 28% – this is an important argument for VQS.

Ignoring status-seeking issues, once ERP has been introduced the case for a stringent VQS quota and high car prices becomes weaker from the viewpoint of eliminating externalities. In fact, with ERP the COE charge acts more like the fixed component of a two-part tariff on road use. As a fixed charge, it does nothing to reduce vehicle usage once paid. Instead, it acts primarily as an efficient rent extraction device by government.

After ERP, VQS will not be removed though there will be a reduction in VQS charges because of an increased VQS quota. The value of COEs will decline with ERP since quotas will be relaxed (by between 15-20,000 annually) once congestion is better controlled. Moreover, VQS's will be announced two years in advance to provide greater stability in COE prices.

*The Off-Peak Scheme (OPC):* The VQS, as noted, is not specifically directed to dealing with vehicle usage levels and therefore congestion. However, with the *Off Peak (OPC)* scheme the VQS has been adapted to deal with differences in the intended *timing* of car usage which gives the VQS a specific congestion-targeting component.

The OPC scheme provides cars at a lower cost to those not using their cars during peak hour periods. With the OPC, car owners pay a lower registration fee, customs duty, COE and sales tax. The OPC will be retained following the introduction of ERP. While the rationale for OPC is part congestion-related it is also equity-related since it enables a broader group of income earners to enjoy car ownership provided they do not significantly add to congestion.

*Other Vehicle Charges:* Apart from COE charges the Singapore government levies a substantial array of import duty, car registration, road tax and GST charges. Specifically:

- Import duties are 41% of market value.
- Registration fees have been one-off charges of S\$1000 for private cars and S\$5000 for company cars plus an Additional Registration Fee (ARF) of 150% of open market value.

- Annual road taxes are substantial. On a private 1300cc compact car, the fee is currently S\$1170. On larger private vehicles, the charge exceeds \$5000. Company owned cars incur double these fees and surcharges apply to older vehicles.
- A GST of 3% applies

In conjunction with the COE these charges increase the price of a vehicle costing S\$29,103 duty free to S\$266,287: for details see Appendix 1. These mainly non-use related charges currently constitute around 67% of total car usage plus ownership costs.

There is some congestion targeting in these charges since road taxes increase with vehicle size. With the introduction of ERP, road taxes, Registration Fees and ARF are to be reduced. Road taxes will be related specifically to road damage and congestion costs. The intent is to have a tax structure related to the congestion contribution of a vehicle.

The aim is to reduce non-use-related costs to around 50% of total costs. Under the new policies road taxes will be set on the basis of the number of Passenger Car Units (PCUs) a vehicle occupies, the contribution of the vehicle to road damage (a surcharge applicable to heavy vehicles only) and a progressivity element reflecting social equity considerations. The PCU system works as follows: a car will be 1 PCU, a larger vehicle 1.5 PCU and so on. Compared with current rates, the PCU-linked road tax structure will impose lower charges on cars and commercial vehicles though motor cycles will pay more. Heavy vehicles will be subject to additional charges though buses will still enjoy road tax concessions. Taxis will enjoy no road tax concessions and differences in tax rates related to class of user (company cars, private vehicles) will disappear.

This new package will be revenue neutral – the aim is not to generate government revenue but to influence driving behaviour to control traffic congestion.

One reason for linking car costs more directly to usage are the high car usage levels in Singapore. Singaporeans travel 20000 km per year compared to 14000 km in France and 10000 km in Japan: see *The New Paper*, July 29, 1997 page 8. High usage levels reflect low petrol and low car toll fees – in other words, low usage costs. However, usage costs will not be altered much by varying road taxes since these are use-independent. Increasing usage costs calls for increases in toll and petrol charges. However increases in toll charges have for the moment been ruled out (though in the longer-term they will rise under the proposed ERP: see LTA (1996, page 35)) while duties on petrol have remained unchanged for many years.

Singaporean policymakers seem unclear on the rationale for the high vehicle usage levels observed. The LTA (1996, page 33) state “The Singaporean motorist is quite rational. Having invested heavily upfront on a car which is cheap to use, he then “capitalises” on his investment and drives as much as he can.” This is the ‘sunk cost fallacy’ popularly debunked by microeconomists. It is not that motorists spend a lot in upfront charges that causes excess usage but rather that usage costs are so low. The high upfront charges encourage those with substantial travel needs (measured as desired distance to be traveled) to buy vehicles at high prices. The reason for being pedantic here is that reducing upfront charges will not reduce usage by long-distance travelers –

usage costs must rise for this to happen. Reducing upfront charges only allows the with more limited travel demands to enter the vehicle market and hence will reduce average travel distances with increased total congestion.

Finally, note that the economic theory of road damages suggests that road depreciation *should* be linked to the *weight per axle of a vehicle* rather than the PCU. The nature of this link is subject to theoretical dispute – damage is claimed to be proportional to the third (or fourth) power of the axle load not the PCU: see Winston (1991). The effect of such rules is to tax strongly heavy trucks and to leave private cars virtually untaxed a way of recouping road maintenance costs. Cars generate very low road damages. It is important that the new road taxes imposed on Singaporean heavy vehicles reflect these considerations.

Another unsatisfactory aspect of proposed policies are the continued road toll concessions for buses. Buses generate substantial road damage (and congestion) so they should be taxed to internalise the costs they generate.

### Charges on Gasoline

Given the restrictions on car ownership it is surprising that petrol charges are so low in Singapore. At about S\$1.15 per liter for unleaded petrol the petrol price is distinctly low compared to costs in most European countries. It is, admittedly, quite high compared to other neighboring Asian countries – Singaporean taxes account for about half the retail cost of gasoline. Levying taxes on petrol consumption is a direct substitute for congestion pricing provided petrol use is proportional to congestion. Petrol taxes are a practical complementary pricing policy in the absence of comprehensive road pricing, less advantageous than comprehensive road pricing such as ERP but superior to even less congestion-targeted measures such as high upfront charges: see Clarke (1997).

It may be that Singapore has kept petrol prices low because of non-vehicular uses of petrol in economic sectors which authorities would be loath to tax. It is difficult however to identify what such sectors are. It may just be that Singapore relies on foreign direct investment that is attracted by generally low input costs and high quality infrastructure.

An alternative explanation might be that congestion is primarily a peak hour phenomenon and that higher petrol charges have a non-specific impact in terms of the timing of journeys. As mentioned, while this is so, petrol charges do have a more specific congestion targeting component than the extensive non-use-related charges applied to Singaporean car ownership.

### Land-Use, Staggered-Working-Hour and Other Policies

It was the success of early housing and urban renewal policies which led to great demands for commuting from home to work place resulting in congestion problems during the 1960s and 1970s. In recent decades, Singapore has incorporated

transportation issues into land use planning. Housing and Development Board (HDB) flats (where 86% of people live) are constructed some distance from the city center but connected to the city by efficient roads, expressways, and public transport. This avoids urban sprawl and inner city congestion. Parking fees at HDB flats further inhibit car ownership (these are S\$600-\$700 per year for a three bedroom apartment) while strict parking controls throughout the island together with paid parking, close to most MRT and bus interchanges, encourage the use of public transport.

Park-and-drive policies based at MRT stations were abolished but have now been reintroduced. The parking stations at the MRT enable passengers to take a train (or bus) to the city but, as parking charges are quite high (S\$30 per month), the scheme has not been very successful.

Casual parking charges in the CBD (around Orchard Road) are about S\$10-15 per day while season parking in the business and banking area (Raffles Place) is around S\$200 per month. Quantitative restrictions are absolute in the CBD and high levels of respect for laws mean few problems of enforcing parking restrictions. Even outside the CBD there are strong quantitative restrictions on parking. Generally, parking policies are not very congestion-oriented because they are only directed towards terminating traffic – they do not stop *through* traffic.

The 1991 *Revised Concept Plan* employed two land use planning strategies. Commercial and other economic activities are being decentralised and located at MRT stations to best utilise the MRT network. In addition, employment centers are being located near residential areas. All new towns in suburbs are serviced by bus and MRT.

Staggered working hour policies have been promoted since the 1970s to even out traffic flows during peak periods. Also, the use of integrated transit link cards eliminates the need to buy tickets on different carriers and the need of bus drivers to sell tickets. The policy of staggered working hours and integrated ticket purchases reduces (but does not eliminate) rescheduling costs faced by motorists shifting their travel from peak periods.

As Downs (1962) has noted, these policies are subject to *triple convergence* difficulties because they release latent travel demands. However, such policies have proven useful in the Singaporean case. Here latent travel demands are not substantial because of effective congestion management policies. In themselves, these auxiliary policies do not deal comprehensively with traffic congestion, though they do assist by complementing other supply and demand-oriented policies.

### Public Transport Policies

The main components of public transport policy in Singapore relate to buses, MRT, light rail transit and taxi policies

The Singaporean bus service is highly regulated. There are two main bus operators: SBS (Singapore Bus Services) and TIBS (Trans-Island Bus Services) while CSS (City

Shuttle Services) operates in the city center. A luxury minibus service – Bus-Plus – also provides up-market services for executives during peak hours. SBS is privately-owned and was formerly subject to substantial government control: it is now part of the DelGro group which has diversified its operations into many other fields. Still however the Public Transport Council must approve fare increases and the two firms must ply all routes at prescribed frequencies

The bus policy is to provide a profitable bus service not subject to what is seen as destructive competition. The government felt the need to service low profitability routes and to realise economies of scale in a small market. While this last point is debatable – Winston (1985) and others have argued that economies of scale in busing are low – the Singaporean market is small and regulations strict.

Bus operations in Singapore are comfortable, safe, punctual, and fast. Good service is a prime government policy objective. Bus lanes are used and buses have priority at traffic signals. Global Positioning Systems (GPS) enable tracking of buses on route and the minimisation of delays: by 1999 about 1000 bus stops will have *Bus Stop Display Units* which use GPS to advise passengers exactly when their bus will arrive or if one has been delayed (*Straits Times*, 20<sup>th</sup> September 1997 page 56). Profits from buses contribute toward the historical cost component of the replacement cost of the fleet with the rest paid by government. Buses are part exempted from road tax payments.

An MRT with 85 trains covering 83 km with 48 stations was in full operation in 1990. The MRT serves 877000 passengers daily at 3 minute intervals during peak periods and 6 minute intervals off-peak. A 6.4 km extension to Changi will be completed by 2001 while a 20 km north-east line with 16 stations will be completed by 2002.

The MRT is owned by the Land Transport Authority (LTA) who lease the assets of the MRT under license to a private company – the Singapore MRT Ltd. (SMRT). The SMRT is responsible for replacing the historical cost component of the value of its operating assets. The government funds any residual replacement cost and agreed to pay for infrastructure and the initial set of operating assets. The effect of this policy is to ensure that only current generations pay for the services of currently used assets.

A private company Transit Link integrates MRT and bus systems using a common bus-rail ticket.

Light rail transit (LRT) serves three purposes in Singapore: as a feeder for the MRT; as a short-distance link and as an inter-town link for light transport. LRT is driverless and with an average speed of 25 km per hour, it arrives at 3 minute intervals during peak hour. The new Bukit Panjang line will be in operation by 1999 and covers 8 km with 13 stations.

Finally, there are four groups of taxi operators providing services in Singapore. Together they operate a fleet of 16,857 taxis. Fares are low by international standards and operations efficient – some have already upgraded to satellite navigation and automatic vehicle location techniques to minimise cruising times. Further, a fully



automatic vehicle location and dispatch system (SKYTREK) was launched in 1995. It combined satellite tracking, interactive voice response and computerised dispatch thereby reducing congestion, operating and waiting costs and by improving operational efficiencies.

While the government in the past has given substantial road tax and other concessions to taxis, it is increasingly concerned by their contribution to congestion. This is related to the observation that 35-40% of taxi time is spent empty cruising rather than waiting at taxi ranks. The government will phase ERP charges in for taxis over a number of years to inhibit cruising. In addition the LTA has indicated it will be recommending the deregulation of all taxi fares when the new vehicle tax structure and ERP are implemented in September 1998. This has already been implemented for the Premier Taxi Services which provide specialised commuter services.

Generally, with respect to public transport, the government will meet *initial* infrastructure and capital costs though fares must cover operating costs. Network expansions (e.g. MRT tunnels, viaducts, and stations) are financed by the government provided operating costs are covered by fares. These operating costs include the historical cost part of the replacement cost of operating assets. The government will meet the difference between total and historical replacement cost – in effect increases in capital costs.

As a matter of government policy, public transport in Singapore does not receive direct subsidies though it does receive various forms of public assistance. Bus fares have risen only slightly over the past 15 years partly because the government has taken measures to keep operating costs low. Bus companies enjoy concessions from road taxes and exemptions from COEs. Also, bus interchanges and bus stops are mainly government funded. That roads are uncongested has also reduced bus operating costs.

The question of whether these implicit subsidies are large enough is a keenly discussed issue in Singapore today: see *The Straits Times* July 30, 1997 page 23. From an efficiency viewpoint provided most congestion and other externalities have been internalised there is no 'second-best' argument for subsidies. With an effective ERP system the case for subsidies almost disappears.

While public transport improvements in congested systems are often derided as having 'triple convergence' problems of the type discussed in Downs (1962) they are useful in Singapore because (as mentioned above) there are not high levels of *latent* vehicular demand.

### **Pricing Policies.**

The literature on ideal forms of road pricing is vast: for a survey see Hau (1992). In the past, Singapore has employed two forms of road pricing. The Area Licencing Scheme (ALS) was designed to deal with congestion in the CBD while the Road Pricing Scheme (RPS) was designed to deal with congestion on expressways outside the CBD. Shortly

Singapore will replace these partial schemes with ERP. It will then become the only country to comprehensively price road use.

We review the historically important ALS and RPS schemes before discussing ERP.

## ALS

Also known as the cordon pricing scheme this policy was introduced in 1975 and was directed at controlling traffic in a 725 hectare CBD area. It requires road users to purchase a daily (or half-daily or monthly) license to enter the CBD during the peak period 7.30am to 9.30 am and 4.30pm to 7.00pm Monday to Friday and 9.30am to 2.00pm on Saturdays and the eve of public holidays. The intention is to spread travel demands into non-peak periods.

At only S\$3 for peak period charges and S\$2 for off-peak charges, this might seem a limited means of controlling congestion. However, ALS has controlled peak period congestion in the CBD even though the vehicle population has more than doubled since 1975. Moreover, ALS does not involve a pure congestion charge. The charge is a once-and-for-all charge for entry and so cannot be considered a precursor to comprehensive road pricing even in the CBD.

The ALS creates 'boundary problems': see Toh (1977), Clarke (1997). Specifically, even if the license fee internalises the marginal social costs of making journeys within the CBD, it creates 'second-best' distortions in areas on the boundary of the licensed area as traffic diverts around the CBD. Toh (1992) argued that the congestion problem has not been eliminated but only shifted and that, during peak periods, roads were left underutilised by ALS. Field (1992) claimed that congestion problems on unpriced adjacent streets have worsened as commercial development has spread outside of the CBD. Finally, Wilson (1988), (1989) has argued that job rescheduling costs imply that the ALS need not increase welfare because workers had to stagger their trips and incur higher costs so that road expansions – even if they do not reduce travel times – would better promote welfare.

Also the enforcement officers positioned at the 27 gantry points mean that the scheme is labour-intensive and expensive. The work itself is tedious: see Tay and McCarthy (1992).

ALS will be abandoned once ERP is introduced.

## RPS

Singapore's three expressways are currently the only priced roads in Singapore and are dealt with by the RPS. RPS was introduced in 1995 for the ECP (East Coast Parkway) and was extended to cover the CTE (Central) and PIE (Pan Island) expressways in May 1997. It is designed to deal with congestion outside the CBD. Daily or monthly access licenses are issued for travel during peak periods.

Like ALS, this is a manual labour-intensive scheme. It has temporary historical importance as a precursor to ERP. With an ALS license, travel is free on the expressways (except for the Central Expressway) anyway.

The cost of using an expressway is calculated per day (or per month) so repeated use does not involve additional charges. Charges are modest (S\$2 per day) and are not specifically use-related. However, they do seem to have impacted significantly on expressway usage. Since they were introduced usage has declined 16% (about 7,000 vehicle trips) with motorists switching to other roads (about 3,000), car pooling, taking public transport or changing their travel times: see *The Straits Times*, July 30, 1997.

RPS is a temporary scheme that will disappear (or rather be integrated) with ERP.

## ERP

This is an automated road pricing system that, from April 1 1998, will operate on the East Coast Parkway (ECP). It will gradually be extended to all ALS areas and expressways by September 1, 1998. Initial charges for road use will be S\$1 for travel from 7.30 to 8.00am, \$2 from 8.00-9.00am and \$1 from 9.00-9.30am. The lower 'shoulder rates' here are an attempt to smooth out the 'peak within the peak' on the ECP. Once ERP covers the three expressways and the CBD it will, after 1-2 years, be extended to all congested roads islandwide.

The ERP system consists of three units: the In-Vehicle Unit (IU), gantries that record the passage of vehicles and a central computer system. Pricing of road use is time and congestion sensitive and depends on a vehicle's PCU. Thus, charges are intended to reflect instantaneous social marginal costs. Each time a vehicle passes a gantry the IU deducts the appropriate charge from a stored-value CashCard. This card must be maintained with a positive balance by motorists who can top-up the card from banks, post offices and CashCard Auto Machines. This facility reduces the transactions costs to customers of ALS or RPS which required daily or monthly license payments. ERP also eliminates the need for personnel at gantries and is error-free. Unpaid (and illegal) users of roads will have their registration plates photographed and be penalised.

ERP does involve substantial capital costs to the government – Toh (1992) estimates the capital cost (in 1990) of sensors, cameras and computers at US\$60 million which is many times more than the ALS infrastructure. This suggests a much higher opportunity cost of collection than the current ALS.

Based on current travel patterns the Land Transport Authority (LTA) claims that charges will not exceed those set by current schemes: see *The Sunday Times* September 27, 1997, page 33. While the LTA (1996, page 35) have emphasised that ERP charges must rise to reflect the social costs of congestion net savings to most motorists are feasible because road tax and registration charge cuts. The 76 per cent of vehicles which do not pass through RPs or ALS gantries during operational periods will enjoy the full

benefits of road tax reductions while those making one pass through gantries per day will not be worse-off. The only group to lose are the 9 per cent who make 2 or more ALS passes per day: see the LTA Website (<http://www.Lta.gov.sg/vehicle/4.html>)

Fitting IU devices is not compulsory and they need not be fitted by those not seeking to use ERP roads during ERP operational hours. The LTA began fitting IU's in September 1997 in 120 installation and 40 mobile centers. A schedule of fitting times on toll free telephone numbers and on the LTA Website. As a one-off concession to owners of vehicles registered before August 1998 and to encourage orderly installation of devices fittings are initially free if done at the scheduled fitting time. This will cost the government S\$100 million. Subsequent fittings will cost S\$150.

Taxis and commercial vehicles (buses and trucks) will face ERP charges phased in over 3-4 years to reduce adjustment costs and 'in recognition' of their public transport role.

A major policy objective of introducing ERP is to moderate the demand for road space so that more COEs can be released

Note that the proposed ERP scheme is envisaged to be used for about a decade. An updated ERP system will then be introduced, possibly use satellite or GPS technology to manage road usage more sensitively.

## **Evaluation and Final Remarks.**

### **Effectiveness**

One issue often raised in relation to Singapore's congestion planning is the overall assessment of the welfare implications of its complex mix of policies. Phrases used in much official literature suggest roads should be uncongested with traffic *flowing freely*. Road pricing theory however suggests there should be some optimal degree of congestion since both congestion and building roads is costly. If traffic flows are charged at above their marginal social costs there are welfare losses to society from insufficient charging. In the limit if marginal social costs are zero, because there is no congestion, then roads should be provided free to motorists as a pure public good. One can ask therefore whether there is *insufficient congestion* on Singapore's roads? Indeed, even up to 1988 the ALS was claimed (by Toh (1977)) to cause a wasteful underutilisation of roads. Traffic speeds in 1988 in the CBD were 36 km per hour compared to 11 km per hour in New York and 18 km per hour in London. Toh argued for a substantial reduction in ALS charges. Tay and McCarthy (1992) note that pricing under the ALS causes higher traffic in off-peak than in peak periods which again suggests a misallocation of resources.

A related issue of concern is the high fraction of total car costs that are non-use-related. Even with ERP the fraction of total car costs dependent on use will only be 50%. High non-use costs are inappropriate if most externalities associated with vehicle ownership are use-related. This is inefficient because it prevents the marginal utility of car use from being equated across users. For example if only the rich buy cars because of high

upfront purchase costs and if consequent usage costs are low then the rich will undertake economically inefficient journeys with low marginal utility. However, poorer citizens who only seek to car use for important journeys are denied use because of high upfront costs.

There still remains a case for reorientation of Singaporean congestion policies once ERP is introduced. VQS and a diminished road tax system are the only major traffic control policies that will then remain. Their impacts will be reduced through a reduction in tax rates and an increased COEs quota. It can be argued however that VQS and road taxes should be further diminished to emphasise usage costs. Then COE supplies can be further expanded with much higher ERP charges and perhaps petrol charges. In Appendix 2 we show that such policies unambiguously increase welfare provided vehicle charges (net of all government charges) are low.

High non-usage charges have been favored in the past for mainly political reasons. First, they are non-recurrent and therefore perceived as being less painful. Second, road pricing is an imprecise means of controlling the car population since car purchases are very dependent on the state of the economy. Finally, it is politically easier to vary the COE quota than to alter ALS charges: see Toh (1992).

#### Policy Transferability

Only Singapore has adopted comprehensive ERP. Hong Kong trialed an ERP scheme but abandoned it because of concerns over traveler privacy. Many very partial ERP schemes are now operating worldwide. Why has the Singaporean road pricing experience been successful? Can this success be transferred to other countries?

One of the reasons for Singapore's success in restricting private use of vehicles has been its development of an efficient public transport system. In addition, its well-developed set of ring roads has limited the development of boundary problems associated with cross city traffic.

More importantly, stable political institutions provide one reason for Singapore's success with tough transport pricing policies. The People's Action Party (PAP) has been in power for 33 years since Singapore's independence. It has acted decisively in the past with policies that have transformed Singapore to a modern society. The PAP has substantial respect and support from its citizenry. It does not have to contend with much political opposition or other regional government structures: see Chien (1993).

In addition, the transport pricing issue itself is a tractable policy task because of Singapore's geographical status as a compact island state. This reduces the dimensions of planning problems by reducing boundary problems that stem from the pricing of only a subset of roads.

For these institutional and geographical reasons it is probably doubtful that much can be learned by other countries from Singapore's congestion controls. Singapore's experiences with modern technology are of interest to other countries and the historical

importance of VQS and other schemes to cities like Bangkok are of interest. In addition, the far-sighted attitudes toward providing a convenient and efficient public transport system are of interest to all developing and developed countries. The catch with road pricing lies in its distribution implications that can provide substantial objections in less decisively managed societies than Singapore.

**Appendix 1.** A Toyota Camry 2.2 GLE automatic with ABS brakes has an open market value in Singapore of \$29,103. Assume the vehicle is held for exactly 10 years when a new COE payment would fall due. The cost a consumer would pay in February 1998 would be \$119,627 made up of the open market value, import tax of \$11,932, additional registration fee of \$43,654, a GST of \$1,231 and a dealer markup of about \$33,707. There would also be a COE of \$30,100 as at February 1998, registration fee of \$1,000 and road tax of \$2,750 per annum. Insurance is compulsory and of the order of \$1,562 per annum for a Mercedes Benz. Excluding insurance, the non-usage (ownership) cost to the motorist of this vehicle over 10 years would be \$178,227.

Usage costs include fuel costs. Given that the average Singaporean travels 20,000 km per year and that the Camry averages 12.2 litres per 100 km at a speed of 90 km/hour fuel costs over 10 years would be \$28,060 or about \$234 per month. We estimate other servicing costs (lubrication, checkups etc) at about \$28,800 over 10 years while parking charges would be \$24,000 over 10 years if parking occurred in the CBD. ALS charges over 10 years based on a \$60 per month licence would be \$7,200. Total usage costs (excluding insurance and road use charges) would be \$88,060.

Thus total ownership (non-usage) and usage charges come to \$266,287 of which usage charges of \$88,060 which is 33.1% of the total. This calculation confirms the *Straits Times* estimates (29 July 1997) that current vehicle usage costs are about 30% of total costs while non-usage costs are 70%. Data here are taken from AAS *Highway* (March/April Issue 1998).

**Appendix 2. Proposition:** In a linear congestion model, relaxing an auctioned VQS quota by admitting more vehicles reduces COE costs but increases optimal congestion charges on vehicle usage. If the marginal cost of a new vehicle is small enough this change promotes a potential Pareto improvement in welfare.

Let  $f$  denote traffic flow so speed is  $1/f$ . Let individual private travel costs  $c$  depend only on the inverse of speed so  $c = a + bf$  where  $a, b$  are positive constants. Aggregate social travel costs are  $C = f(a + bf) = af + bf^2$ . Then the social marginal cost of travel is  $dC/df = a + 2bf = C + t$  where  $t$  is the congestion tax which internalises all social costs. Suppose the demand for travel is  $f = N(d - e(c + t))$  where  $N$  is the car population,  $d$  and  $e$  are positive constants and where  $\Delta = d/e - a$  is assumed positive (otherwise the choke price for travel falls short of minimum marginal cost so that no travel will occur).

Suppose congestion charges internalise social marginal costs. Then optimal traffic flows  $f^*$  occur when the demand price for travel,  $c+t = d/e - f/Ne$  equals social marginal cost so  $f^* = \Delta / (2b+1/Ne)$ . The associated optimal congestion tax is  $t^* = bf^* = b\Delta / (2b+1/Ne)$ . The value  $W$  of net consumer surplus plus taxes collected from congestion tolls (a transfer) is then:

$$W = b\Delta^2 / (2b+1/Ne)^2 + \Delta^2 / [2(2b+1/Ne)^2 Ne] = \Delta^2 (b+1/2Ne) / (2b+1/Ne)^2$$

The number of vehicles on the road is increased by increasing the VQS and hence by reducing the COE. Computing the partial derivative of  $W$  with respect to the number of vehicles on the road:

$$\partial W / \partial N = \Delta^2 (0.5 + 1 / (2bNe + 1)) / [(2b+1/Ne)^2 N^2 e] > 0$$

so increasing the VQS quota increases welfare. This ignores the increased purchase costs under an increased VQS quota. Ignoring the tax component of such charges these rise by the marginal cost of importing a vehicle. If this is small enough there is unambiguously a net welfare gain.

Note here that social marginal costs and optimum tolls here are increasing functions of  $N$ . Thus welfare improvements occur even though society bears increased congestion charges, increased congestion and therefore reduced traffic speeds

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