ROAD PRICING FOR MANAGING TRAFFIC IN SINGAPORE

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ABSTRACT

Singapore used road pricing as a tool to manage traffic as early as 1975 albeit a manual scheme when it started. Converted to an electronic system in 1998, it continued as a tool to manage traffic with varying charges and varying operational time of day, all determined based on travel speeds that are used as a proxy for traffic conditions on the roads. The scheme was also expanded its scope geographically and in intent over the years. Home-based trips in the evenings on the most congested expressway in the north-bound corridor were priced to better distribute traffic flow. In the city, new pricing lines, creating sub-cordons, were introduced to better manage intra-city traffic. In expanding the scope of the ERP, there was a need for continuous engagement with the various stakeholders on various issues, including the alternatives, equity, privacy and that ERP is not a revenue tool for the Government.

1. INTRODUCTION

Road pricing has long been associated with Singapore, starting way back in June 1975 with its Area Licensing Scheme and then in 1998, changing to the Electronic Road Pricing Scheme. The economic principles for road pricing to manage and optimize traffic flow however, continues to be valid even as the charging structure kept evolving to have the scheme remain effective, and deriving benefits to the community as a whole.

This paper describes the Electronic Road Pricing scheme as it is in operations presently in Singapore, and gives some lessons learnt from its implementation that could be useful for other communities contemplating similar pricing schemes to manage traffic.

2. COMPONENTS OF THE ELECTRONIC ROAD PRICING (ERP) SCHEME

The ERP scheme is a Dedicated Short-Range Communication (DSRC) system that has three major groups of components.

The first centred around the in-vehicle Unit (IU) and the stored-value smart-card. While the IUs were produced specifically for the ERP system, the smart-cards were marketed by a consortium of local banks for multiple uses, as a form of micro-payment system for cashless transactions. Called CashCards, these can have its value topped up at various banks' automated teller machines, dedicated top-up machines and many convenience stores.

The second group comprises equipment installed in the field – at the ERP gantries. These include the antennae, the vehicle detectors and the enforcement camera system. Data

collected is transmitted back to the Control Centre continuously through leased telecommunication lines.

The third group of components is at the Control Centre, and includes various back-end computers, monitoring systems as well as a master-clock to ensure that the timing at all the ERP gantries are synchronised. All the financial transactions and violation images are processed here.

3. USING THE ERP SYSTEM

The ERP system is designed to be simple to use. With the smart-card inserted into the IU, the appropriate ERP charge would be automatically deducted whenever the vehicle passes through the ERP gantry. There would be a short beep to signify a successful transaction.

Whenever a smart-card is inserted, there is a diagnostic check to ensure that the IU is working, and alerts the user if the remaining cash balance in the card is below a threshold (set at S$5 presently). The smart-card can be top up at many bank teller machines or at convenience stores.

Should there be insufficient cash in the smart-card or should there be no smart-card in the IU when going through the ERP gantry, the enforcement cameras located there will take a picture of the rear of the vehicle. A similar enforcement picture would also be taken of any vehicle that had no IU installed. The vehicles' registration numbers would be automatically read using OCR techniques and the vehicles' owners issued with letters asking for payments of outstanding charges, inclusive of administrative fees. Failure to pay the charges and fees after an extended period of time could result in the offender being called up to appear in the Courts.

4. VEHICLES COVERED AND THE CHARGES

With the ERP system, all vehicles are required to have IUs fitted if they intend to pass through the ERP gantries. However, it is not mandatory and indeed, there were some vehicle owners (e.g. of vintage cars) who opted not to have the IUs installed. ERP charges are applicable for all types of vehicles during the operating hours, with the exception of emergency vehicles (ambulances, fire engines and police cars). The charges vary from $0.50 to $3.00 per passage through the ERP gantries when the system was first launched.

4.1 Foreign Vehicles

Singapore, being on an island, has an advantage when it comes to managing foreign vehicles under the ERP scheme. There are only 2 road-bridge links to its neighbouring country to its north, and hence all visitors could be given the necessary information on the operations of the ERP when they come across.

Regular visitors can opt to have the IUs installed on their vehicles, much like Singapore-registered vehicles. Indeed, many of the regular visitors do so. For the less regular visitors, there was a scheme that permit them to rent a temporary IU at a small sum per day, and this payment is on top of the normal ERP charges that are payable.

Foreign vehicles to Singapore have, traditionally been subjected to a Vehicle Entry Fee (introduced to offset the significantly lower taxes for car ownership in the neighbouring country), payable on weekdays. This was automated in 2000 with a smart-card-based solution, and this was used for ERP payments subsequently. Under this scheme, foreign-vehicles without an installed IU would be photographed when they pass through an ERP gantry. Their licence-plate would be read, and a daily ERP charge (currently set at S$5 per day) would be included into the total fees payable (including the Vehicle Entry Fee) by that vehicle. This would be collected at the Checkpoints when they leave Singapore through the smart-card.

4.2 Varying the Road Pricing Charge

The ERP system, being less dependent on manpower, allowed more frequent changes to be made to the road pricing charges. This helped to better optimise usage of road space in the network. The rates are set to ensure that flow rate are kept as high as is practicable (and thereby allowing the maximum number of road users to benefit), and this is measured using average speeds as the proxy. On urban roads, the average speeds should be between 20 km/h to 30 km/h while that for expressways, the speeds should be between 45 km/hr to 65 km/hr.

The computation of these optimum speed ranges are based on speed-flow curves derived from empirical data collected on expressways and arterial roads. The lower speed threshold is a value close to the apex of the speed-flow curves that gives the maximum traffic flow. On expressways, this is 45km/hr and on arterial roads, this is 20 km/hr. The lower value for arterial roads is due to the presence of traffic signals and various side-friction caused by various road-side activities such as on-street parking and the picking up or dropping off of passengers. The upper speed thresholds were chosen to allow stability in the ERP rates, as too narrow a range is likely to give oscillating ERP rates each time they are reviewed. When speed goes above the upper threshold, too few vehicles are deemed to be using the roads and hence, the road space available is not being optimally used. Hence, the road pricing charge can be reduced to allow more vehicles to use the roads. Conversely, if the speed falls below the lower threshold, too many vehicles are on the roads and this is a signal that the road pricing charge can be increased.

This ERP rate review is conducted every 3 months based on the average of speeds measured on the roads. However, this meant that there would be motorists who were still experiencing speeds below the average, and the ERP rates were deemed acceptable. Recently, the method of computing the speeds for evaluation based on the threshold values was revised, and is now based on the 85^{th} percentile value (i.e. 85% of motorists would have speeds above the assessed speed). Hence, the ERP rates became more effective as it resulted in at least 85% of the motorists travelling above the threshold speed.

Over the years due to the regular monitoring and adjustment in ERP rates, the ERP charges have stabilized with only a handful of gantries having their rates adjusted each time the ERP rate review takes place.

5. EXTENDING THE COVERAGE OF ERP

With the launch of the ERP in 1998, transport planners started to investigate its use to manage congestion outside the city. An Outer Cordon that runs somewhat along the Outer Ring Road system was planned to deal with increasing congestion levels on the roads outside the ERP-charged CBD. It was, however, decided that each of these roads entering the Outer Cordon would only have ERP gantries implemented when travel speeds on each of these roads fall below the threshold. Hence, the Outer Cordon gantries were introduced gradually, starting from 1999. As at end 2008, 15 ERP gantries of a total 21 needed to complete the Outer Cordon are in use to manage traffic during the morning peak period on weekdays.

5.1 Managing Home-Based Trips

The ERP gantries installed up to early 2005 were effective in managing traffic flows into the city and on major expressways. However, these ERP gantries do not affect traffic flows flowing out of the city, and consequently some of the major corridors taking traffic away from the city towards major residential areas became congested. Hence, the pricing strategy had to be extended to deal with home-bound trips during the evening peak period. In Aug 2005, an ERP gantry was introduced on a major expressway leading from the city to the north, at its most congested stretch. Traffic re-distributed to other roads and other time periods, with traffic volume dropping by around 25% initially on this major expressway during the peak period from 6 to 8 pm on weekdays.

However, over time the traffic came back onto the expressway, and a significant portion of the traffic actually left the expressway just before the gantry. This behaviour meant the on this expressway, upstream of the ERP gantry, congestion became prevalent. Hence, two years later in Nov 2007, another ERP gantry had to be introduced upstream of the existing one. Based on the traffic flow profile on this expressway, this new ERP gantry has to operate from 5:30pm to 10:30pm on weekdays. Traffic volume on this stretch of expressway reduced by about 20% during this 5-hour period, and congestion cleared up.

5.2 Managing Intra-City Traffic

5.2.1 In the Shopping Zone

The CBD pricing cordon covers a part of the city that is predominately shopping in nature, and had traffic characteristics somewhat different from the office-based city roads. This is the Orchard Road shopping belt and since most of the shops opened after 10:30am, there was low traffic flow there during the morning peak period. However, from mid-day onwards, heavy traffic with recurring congestion was normal, on both weekdays and on Saturdays.

About 35% of the traffic on the main shopping thoroughfare was found to be through traffic – i.e. going beyond the shopping area and to the office-dominant area in the CBD.

Hence, the ERP scheme for this area was refined in 2005, with the shopping belt made into a separate zone with additional gantries at its boundary with the office-dominant CBD area. These new gantries allow three pricing strategy changes to respond to the traffic flows in the shopping belt.

First, the ERP charges for traffic going into this shopping zone during the morning peak period were removed since there was no congestion there at that time of the day. Second, from mid-day onwards, the ERP charge for traffic going through the shopping zone into the office-dominant area had to go through 2 ERP gantries and the total charge was set to be higher than that for going into the office-dominant area directly via other roads. This cut down the amount of through traffic on these shopping streets, reducing from about 35% to 20%. To ensure that this change was not to discourage shopping trips, the ERP charge for those destined for the shops was actually reduced. As a result, the volume of destination traffic remained unchanged. Third, the shopping zone was now priced on Saturdays without having the office-dominant area (which had no congestion on weekends) to be charged as well.

The outcome of this pricing strategy change was in line with expectations. Hourly traffic on the shopping streets was reduced by 14 – 36 % during the priced periods on weekdays and reduced by 19 – 34% on Saturdays, and this came predominately from a reduction in through traffic. Indeed, a survey of vehicles entering the car-parks in the shopping area showed a slight increase on both weekdays and Saturdays. In addition, the car-parks there on Sundays also showed increased usage. The pricing strategy change has also influenced some of the weekday/ Saturday shoppers to do their shopping on Sundays, while the relief of traffic congestion on weekdays/Saturdays has attracted new shopping traffic into that premier shopping zone.

5.2.2 During the Evening Peak in the CBD

In mid-2008, the office-dominant CBD was divided into 2 parts with a new pricing line along the Singapore River involving just 5 ERP gantries. Traffic crossing this line in either direction was subjected to ERP charges (see figure 1) but this was only during the evening peak period from 6 – 8pm, since it was only during this time that congestion was severe enough. Following this change in pricing strategy, the hourly traffic going across the city passing this line dropped by between 28 – 37% during the evening peak period.

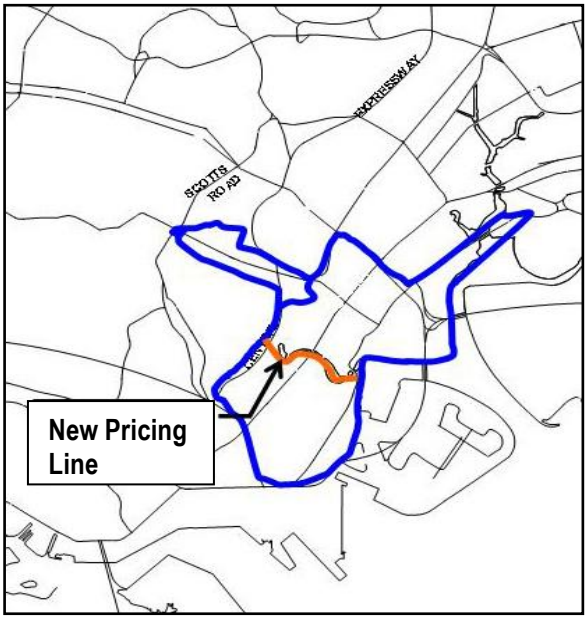

Figure 1 - Managing Intra-City Traffic Congestion With a New Pricing Line

6. RELATED ISSUES

6.1 Availability of Alternative Travel Options

Road Pricing works on the premise that some of the motorists at the margin will be diverted elsewhere, both temporally and spatially. In the engagement process with stakeholders, it is necessary to show that there are alternatives being provided for these users at the margin. This often comes in the form of improved public transport – and includes both bus and mass rapid transit (or subway) services. This improved public transport system must be visible and effective. In recent years, there has been a strain on the existing public transport system in Singapore with significantly-increased patronage; and an alternative approach dependent on private buses to double up as public transport during the peak periods was introduced. Termed premier bus services, it allowed private bus operators to provide seated-only services with limited stops from residential areas to centers of employment.

6.2 Privacy of Road Users

Road pricing schemes and the issue of privacy for road users are always linked. Hence, there was much done to allay the fears of motorists. Being an active system, there was no necessity for the central computer system to keep track of vehicle movements since all charges were deducted from the inserted smart-card at the point of use. Records of such transactions were kept in the memory chip of the smart-card that belonged to the individual. The authorities also took a further step to assure the public that all records of transactions required to secure payments from the banks were erased from the central computer system once this was done – typically within 24 hours.

6.3 ERP is not a Revenue Tool

The ERP in Singapore has always been positioned as a traffic management tool and revenue was and is never a consideration. But this does not mean that the public has not questioned this and the Government had to take pains to continuously said so over the years. Indeed, when the ERP system replaced the ALS in 1998, the revenue collected was only about 60% of what it used to be. Nevertheless, there had to be a continued effort to publicise that ERP is not a revenue-generating tool, and to drive home this point, there were reduction in vehicle up-front taxes and recurring annual licence fees whenever there were major changes in the ERP scheme.

7. LESSONS LEARNT

One of the major lessons learnt from Singapore's experience must be the importance of being flexible and adaptive, and be ready to make changes to the road schemes to target specific groups contributing to traffic congestion on the roads e.g. managing intra-city traffic or home-bound trips during the evening peak periods.

Road pricing should give outcomes that are in line with the experiences of the motorists as they travel on the roads. In Singapore, travel speeds experienced on the roads under the influence of the ERP pricing gantries are used to decide on the introduction of ERP, and to the adjustment of the rates. The provisions to made adjustments to the rates 6 times a year to

deal with changing and seasonal traffic patterns is useful to convince motorists that the road pricing scheme is a traffic management tool and not a revenue-generating one.

While a road pricing scheme may be justified from a technical and transport economics perspective, it is necessary that the rationale of the scheme must be communicated effectively to road-users and the communities including the businesses. The importance of this communication exercise cannot be taken lightly. In Singapore's case, even with intense publicity and communications, there are still instances where motorists would claim ignorance or continue to challenge the validity of the scheme.

There should always be viable alternatives for motorists who cannot or who decide not to pay the road pricing charges – it might be an alternate route or alternate time of travel. For those who decide not to drive, there has to be a viable public transport alternative. In the latest revisions to the ERP pricing strategies in 2008, significant effort was expanded to increase public transport capacity, with premier buses (private buses offering seated bus services almost from door-to-door during peak periods), reduced headways on public buses and on the underground trains and expanded bus lanes & bus priority schemes.

Road pricing schemes are not the ultimate solution to traffic congestion in urban areas. Ultimately, it has to be a combination of schemes. Travel demand has to be managed also in other ways e.g. through appropriate land-use planning and de-centralisation policies, in car-ownership policies and in an increasingly more effective (public) transport alternative. Road network capacity must still be improved but perhaps more selectively, and technology used to continuously optimise the available capacity. These includes the dissemination of traffic information for motorists to make informed and advanced travel decisions, the allocation of appropriate resources to deal with obstructions caused by accidents and traffic incidents on the road network, as delays in clearing these obstructions will only mean more congested roads in the network, with or without road pricing.

8. CONCLUSION

Since road pricing was introduced to manage traffic on Singapore's roads, starting with the ALS in 1975 and then the ERP from 1998, there was a recognised need that the pricing strategies to keep traffic flowing have to be continually evolved to meet changing traffic conditions. The pricing strategies have also to be sensitive to specific needs of the community, be it the residents, the commercial owners/operators or the office workers. Over the past 36 years, Singapore has been refining and making changes to the pricing strategies to meet the changing circumstances but the principle of road pricing as a traffic management tool to tackle traffic congestion has remained unchanged.

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