Road Congestion Pricing in Singapore: 1975 to 2003

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Source: *Transportation Journal*, SPRING 2004, Vol. 43, No. 2 (SPRING 2004), pp. 16-25

Published by: Penn State University Press

Stable URL: https://www.jstor.org/stable/20713563

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Abstract

Facing traffic congestion in the Central Business District and enormous demands on scarce land resources by the growing number of motor vehicles, Singapore, a small island city-state the size of Seattle, embarked on a bold decision to reduce road congestion by implementing the famous Area Licensing Scheme in 1975. This was a manual system of tolls for multiple entries into the Restricted Zone. While achieving the intended effect of cutting down on the volume of vehicular traffic in the Restricted Zone, the authors (and others) found that the problem of congestion had merely shifted in time and place. Many changes were implemented, including shoulder pricing (reduced tolls before and after the peak period) to even out traffic flows in 1994, and the Weekend Car Scheme (1991) and Off Peak Car Scheme (1994) to encourage people to use the roads during off-peak hours. The Road Pricing Scheme was introduced in 1995 on a congested highway to familiarize the public with linear passage tolls.

In 1998, Singapore discarded the manual system of road pricing in favor of Electronic Road Pricing, which permitted the charging of tolls per entry, based on vehicle size, route taken, and time of the day. This article traces the rationale for the various measures and discusses the successes and shortcomings for the various measures over a twenty-eight year period from 1975 to 2003.

Singapore is an island city-state, about 685 square km in area, strategically located at the crossroads of commerce and tourism at the southern tip of the Malay Peninsula. With a population of around 4.17 million, it has a very high population density of about 6,086 persons per square km. Economic growth has been impressive over the past three decades, averaging about 8 percent per year. Singapore's per capita gross domestic product in 2002 was S$37,333 or US$20,856 (where US$1 = S$1.79), a level comparable to that of the United States and most western countries. From a transportation perspective, this economic success has not come without a price. Because the country is hot and humid, the demand for air-conditioned private transportation is very high and income-elastic.

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To allocate rights to car ownership and usage, Singapore has combined market mechanisms with taxation and active restrictions designed to contain traffic congestion. The rationale for such an approach is simple: Roads already constitute 12 percent of the island's area, about the same percentage as housing, so room for continued expansion is clearly limited.

This article provides an overview and analysis of the road congestion measures adopted over the last three decades: the Area Licensing Scheme (ALS) and Road Pricing Scheme (RPS); the Weekend Car Scheme, which was replaced by the Off-Peak Car Scheme; and Electronic Road Pricing, which replaced the ALS and RPS.

Area Licensing Scheme

In the early 1970s, the problem of traffic congestion, especially with the unrestrained growth of car ownership due to rapidly rising incomes, was perceived to be serious (Smith

1974). In 1975, during the morning and evening rush hours, traffic in the Central Business District (CBD)—one of the most congested parts of the city, with an area of about 5.59 square kilometers—crawled at an average speed of only 19 km per hour. The authorities decided, among other things, to dissuade the entry of private passenger cars and taxis into the CBD during the morning peak by instituting a manual system of toll collection. The famous Area Licensing System (ALS), the world's first comprehensive road pricing scheme, was born.

The ALS was implemented in June 1975, defining a Restricted Zone (RZ) in the CBD with initially twenty-two vehicular entry points manned by human monitors. All vehicles except those in the exempt categories (public service and military vehicles, goods vehicles, motorcycles, and buses) were required to buy and display a special paper license in the form of a mountable decal (obtainable from roadside sales booths), costing S$3 per day or S$60 per month (company-registered cars pay double) in order to enter the RZ during the restricted times from 7:30 a.m. to 9:30 a.m. Monday through Saturday. The original target was to reduce traffic volumes by between 25 percent and 30 percent during the morning peak hours. It was also hoped that the morning restrictions would have a ''mirror image'' effect on the evening return flow.

To encourage carpooling, vehicles with four or more passengers were exempted. Parking fees in the RZ were raised by almost 100 percent, and the Park-and-Ride Scheme was implemented, under which motorists could park their cars for a small fee in fifteen fringe car parks with a total of 15,000 parking spaces, and then shuttle into the city center.

Theory of Road Pricing

The theoretical foundations of road congestion pricing for allocative efficiency are well documented (see Toh 1977; Toh and Phang 1997). Economists argue that traffic congestion arises because marginal users of a crowded road consider only their private cost and ignore the fact that their vehicles slow down and inconvenience others—thus the marginal social cost exceeds the marginal private cost. Therefore economists argue for a Pigovian toll (Pigou 1920) on the use of congested roads to increase the individual cost of usage by an amount equal to the external diseconomies imposed by one driver on all others, in order to equate marginal social cost with marginal social benefit. Hau (1992) provides an excellent comprehensive review of the theory of road pricing.

Initial Results

Table 1 documents the entry of motor vehicles into the RZ according to different peak periods. Note that by the fourth week of operation, the total number of motor vehicles entering the RZ during the original restricted times fell by a phenomenal 43 percent, causing underutilized roads, wholly on account of the 76.2 percent reduction in the number of non-exempt cars (see Table 1).

Three new traffic patterns had emerged. First, affected motorists shifted their trips to just before and just after the restricted hours to avoid the ALS fee. Second, the usual morning peak hour traffic was diverted to new ''escape corridors'' around and bypassing the RZ. Third, the ''mirror image'' effect hoped for did not materialize because motorists were not compelled to retime their exits from the RZ in the evening. Moreover, those who took circuitous routes to their destination in the morning added to the cross-town traffic in the evening.

Summarizing, the introduction of the ALS had the following results. First, there was wasteful under utilization of the roads in the RZ during the restricted hours, resulting in the rationing of resources that were no longer scarce. Second, the problem of traffic congestion had not been eliminated–it had merely been shifted in time and location. Third, motorists were inconvenienced by being compelled to stagger their trips and work hours, and incurred higher costs by traveling longer distances to circumvent the RZ. Fourth, there was an increase in the number of exempt goods vehicles to avoid paying the fees (note that in Table 1 the reduction in the ''other vehicles category'' was primarily due to the reduction in the number of non-exempt taxis entering the RZ).

Given the initial results, all indications pointed toward a reduced toll for improved efficiency. But on August 1, 1975, the restricted hours were extended by forty-five minutes to 10:15 a.m. The total number of motor vehicles entering the RZ during the extended

Table 1. Motor Vehicles Entering the RZ Before and After the ALS

Time	Motor Cars		Other Vehicles		Total	
	March 1975 (Before ALS)	June 1975 (After ALS)	March 1975 (Before ALS)	June 1975 (After ALS)	March 1975 (Before ALS)	June 1975 (After ALS)
7:00 a.m. to 7:30 a.m. (Before Restricted Hours)	5,384	6,565 (+21.9%)	4,146	5,011 (+13.5%)	9,800	11,576 (+18.1%)
7:30 a.m. to 9:30 a.m. (Restricted Hours)	32,421	7,727 (-76.2%)	22,892	22,545 (-1.5%)	55,313	30,272 (-45.3%)
9:30 a.m. to 10:00 a.m. (After Restricted Hours)	7,059	7,479 (+5.9%)	5,716	7,561 (+32.3%)	12,775	15,040 (+17,7%)

Sources: Adapted from the "New Time Limits," New Nation, July 10, 1975

restricted hours fell from a March 1975 (pre-ALS) daily average of 74, 000 to an October 1975 (post-ALS) daily average of 41,500, amounting to a 44 percent reduction in total traffic–more than the targeted 25 to 30 percent reduction. Also, on December 31, 1975, the daily ALS fee for private cars was increased from S$3 to S$4, and then to S$5 on March 1, 1980, again with double rates on company cars.

Further Developments

The total number of motor vehicles entering the RZ during the hours of operation increased from a daily average of 41,500 in October 1975 to 51,000 in 1988, clearly a move toward optimality. However, many changes were implemented on June 1, 1989. Because the "mirror image" reduction of traffic in the morning did not materialize, the ALS was extended to the evening peak hours from 4:30 p.m. to 7:30 p.m. (later shortened to 6:30 p.m.) on Mondays through Fridays. The toll was reduced from S$5 to S$3, but carpools, private and school buses, commercial vehicles, and motorcycles were now required to pay the ALS fee to enter the RZ, leaving only scheduled buses, police, military, and emergency vehicles on the exempt list.

All of these reduced evening inbound traffic by 44 percent. By November 1989, the number of motor vehicles entering the RZ during the operating hours in the morning had fallen 14 percent to 43,700, almost the same level as in October 1975, soon after implementation of the ALS. The government announced that the average speed along the major roads within the RZ had increased by 20 percent. In May 1991 the average motor vehicle speed during peak hours in the city center had reached 35 kph, compared to only 10 kph in New York and 18 kph in London. In other words, the roads had once again been emptied out.

Traffic surveys in November 1992 revealed that demand for entry into the RZ was higher just before the restricted hours than during them. To smooth out the peaks and troughs, in January 1994 the government responded to this distortion by introducing Whole Day ALS from 7:30 a.m. to 6:30 p.m. from Monday to Friday, and from 7:30 a.m. to 3:00 p.m. (later shortened to 2:00 p.m.) on Saturday, with a two-tier shoulder pricing system (this refers to reduced tolls during the "shoulder" periods immediately before and after the peak demand times). Motorist were allowed to purchase part-day licenses for S$2, which were good from 10:15 a.m. to 4:30 p.m. Monday through Friday, and from 10:15 a.m. to 3:00 p.m. on Saturday.

The results were exactly as predicted and hoped for. After the shoulder-priced Whole Day ALS was implemented, half an hour before and after the previous two-tier restricted periods, traffic volumes went down, and half an hour into and before the end of the two-tier restricted periods, traffic volumes went up. Furthermore, after the implementation of the Whole-Day ALS, morning traffic increased from 49,000 to 60,000 vehicles, afternoon traffic decreased from 168,000 to 143,000 vehicles, and evening traffic increased from 28,000 to 34,000 vehicles. These results suggest that it is possible to smooth out the peaks and valleys in traffic volumes by appropriate timing and shoulder pricing of tolls, which reduces the incentive to bunch up travel during unrestricted hours.

Table 2. The Initial Singapore ALS and Subsequent Modifications

Implementation date	Weekday hours of operation	Daily license fee in Singapore Dollars				
		Private Car	Company Car*	Taxi	Commercial Vehicle	Motorcycle
Initial Scheme						
2 June 1975	7:30 a.m.-9:30 a.m.	3	3	0	0	0
23 June 1975	7:30 a.m.-10:15 a.m.					
I August 1975				3		
Subsequent Changes						
I January 1976		4	8	4		
1 April 1977				2		
1 March 1980		5	10			
13 February 1984						
19 November 1986						
1 June 1989	7:30 a.m.-10:15 a.m.					
	4:30 p.m.-7:00 p.m.	3	6	3	3	
1 July 1989						1
1 December 1989						
31 January 1990	7:30 a.m.-10:15 a.m.					
	4:30 p.m.-6:30 p.m.					
3 January 1994	Whole Day license M-F: 7:30 a.m.-6:30 p.m. Sat: 7:30 a.m.-3:00 p.m.	3	6	3	3	1
	Part Day license M-F: 10:15 a.m.-4:30 p.m. Sat: 10:15 a.m.-3:00 p.m.	2	4	2	2	0.70
2 May 1995	Restricted hours end at 2:00 p.m. instead of 3:00 p.m. on Sat					

* No tax allowance/deductions are allowed for cost/expenses incurred by motor cars registered as company (business service) passenger vehicles from April 1, 1998. With this rationalization, the tax rates/fees on company cars are now similar to those for private cars.

Sources: Gomez-Ibanez and Small (1994), p.70, and *The Strait Times*, various dates. Reprinted from Phang and Toh (1997).

Since its inception, the ALS has undergone numerous modifications to the restricted hours, fees, and categories of restricted and exempt vehicles. These are shown in Table 2.

Road Pricing Scheme

A Road Pricing Scheme (RPS) was introduced on the East Coast Parkway (an expressway) in June 1995, partly to familiarize Singaporeans with linear passage tolls. Between 7:30 a.m. and 8:30 a.m. on weekdays except public holidays, drivers of all vehicles except scheduled buses, police, and emergency vehicles entering the East Coast Parkway at two locations were required to purchase and display an RPS license costing S$.50 a day for motorcycles and S$1 a day for other vehicles. Again, the monthly license was twenty times the cost of the daily license, double for company-registered cars. A valid ALS license may be used

in lieu of an RPS license. The implementation of the RPS resulted in a significant reduction in traffic volume from 12,400 vehicles in May 1995 to 7,300 vehicles in August 1995 during the restricted hours. Travel speeds increased from an average of 29 kph to 64 kph on the expressway.

Successes and Shortcomings of the ALS/RPS

As discussed above, the ALS and RPS had succeeded in curbing road congestion in the CBD and East Coast Parkway, increased travel speeds, and also led to a modal shift from private transportation to public transit, which increased its share from 33 percent in pre-ALS days to 69 percent. But the well-intentioned objective of clearing congested roads may have worked too well. The prices were considered to be above the optimal rate, since the initial 45 percent reduction in traffic during the peak hours in the RZ far exceeded the original target of a 25 to 30 percent reduction, leading to underutilized roads.

Studies done on the ALS in the 1970s, 1980s, and 1990s (Armstrong-Wright 1986; McCarthy and Tay 1993; Toh 1977; 1992; Watson and Holland 1978; Wilson 1988) all arrived at the same conclusion. Toh (1977) and Wilson (1988) noted the congestion had shifted to just before and after the restricted hours and to the peripheral ring roads. Henderson (1985) notes that people who retime their entry into the RZ to avoid the fees may incur implicit scheduling costs due to inconveniences, and Wilson (1988) adds that those who shifted to just before and after the restricted hours adversely affected those who normally travel during those times, and further noted that those who had switched to buses contributed to increased travel times for all bus riders. Thus, using the Nash social welfare function as well as the Bentham and Sen welfare measures[1] and World Bank data, he showed that all three measures indicated a decline in overall welfare.

Contrary to *all* earlier findings, a relatively recent study by Li (1999), based on the values of time relevant to *car drivers* rather than the general population, and incorporating the results of other research on the values people attach to time in driving and time while waiting at intersections, claimed that by 1990, the $3.00 ALS fee was not too high. This was based on 511 car trips measured during a three-day period in February 1990, showing that the average number of vehicles per lane per hour in the Restricted Zone was 450 during the restricted hours and 600 during the unrestricted hours. Two reasons that may explain Li's contradictory findings is that he used the average wage rate for car owners, which is higher than the average national wage rate, and the study was done with data collected in 1990, fully fifteen years after the ALS and the $3.00 fee were implemented.

Capital Costs and Revenues

Manual road pricing (using human observers stationed at gantries) in Singapore had achieved its intended effect of restraining traffic volumes during peak hours and within congested areas and expressways. Whether it went too far has been debated. But what is undeniable is that the alleviation of traffic congestion has been achieved at minimal capital and operating costs. Capital costs associated with the original ALS totaled S$6.6 million in 1975, while capital costs for the revised ALS in 1989 amounted to only S$.17 million. In contrast, revenues from the sale of area licenses amounted to S$47 million in fiscal year 1993, while expenses related to selling, enforcement, and maintenance were only 9 percent of revenues. Thus the ALS, for all its successes and shortcomings, was efficiently put into place and maintained.

Weekend Car Scheme and Off-Peak Car Scheme

In May 1991, Singapore implemented an unusual program called the Weekend Car Scheme (WCS) to encourage the use of cars only during non-congested off-peak periods. Motorists were given financial incentives such as a 70 percent discount on the annual road tax and rebates on the registration fee and import duty if they registered their cars as weekend cars, which can be used only from 3:00 p.m. on Saturday and the whole of Sunday and public holidays, as well as from 7:00 p.m. to 7:00 a.m. on weekdays. These cars are identified by red license plates fixed with tamper-proof special screws and coded seals, which if replaced by a false normal license plate would lead to a minimum fine equal to twice the annual road tax. If a weekend car is caught

being used during restricted hours, the minimum fine is equal to the annual road tax. To accommodate emergencies, the owner of each weekend car is given five free daily coupons per year, and additional daily coupons can be purchased for S$20 each.

Although the WCS was implemented in response to popular public demand and was well intentioned, it had unintended effects. Owners of luxury cars as well as households owning more than one car benefited the most from the scheme. The owner of a Porsche 911 (3,600 cc) would enjoy a S$4,400 saving on the annual road tax, which alone would pay for a lot of S$20 daily licenses. The redistribution effects were thus widely perceived to be unfair to the less wealthy. The Malaysian government also announced that it would not allow Singapore-registered weekend cars to use Malaysian roads during the hours of restriction that would have applied in Singapore–perhaps fearing they were so registered for this very purpose.

Responding to public dissatisfaction with the side effect such as rich people purchasing luxury weekend cars for daily use, the government revamped the scheme in October 1994. The new Off-Peak Car Scheme (OPCS) with the same hours of restriction offered the same incentives regardless of car engine capacity—a flat S$800 discount on the annual road tax, among other things.

Electronic Road Pricing

As previously described, the ALS/RPS was successful in curbing urban congestion in Singapore. But the schemes were manually operated and had become more complicated over time, with sixteen types of licenses (Whole-Day, Part-Day, ALS/RPS/OPCS, and daily and monthly licenses for three categories of restricted vehicles, privately and company owned). Motorists had to figure out what type of license to buy, and visual enforcement by the police had become difficult, as vehicles were not obliged to slow down as they approach the gantry (entry) points. Moreover, the different licenses could be illegally switched among vehicles, and enforcement in this regard was by the honor system. The ALS and RPS were also labor-intensive, requiring more than 120 personnel to manage the system and man the 35 gantries. But perhaps the most important drawback of the ALS/RPS from the perspective of allocative efficiency pertains to the unlimited number of entries into the RZ, resulting in under-penalized contributions to traffic congestion, and making it difficult to equate marginal social benefits to marginal social costs (Walters 1961). This was the motivation to switch to Electronic Road Pricing (ERP).

Following many years of trials and extensive preparation, the government achieved a smooth transition from the ALS/RPS to ERP between April and September 1998, at an initial cost of S$200 million (less than S$300 per vehicle in the then existing fleet). The technology involves a combination of radio frequency, optical detection, imaging, and smart card technologies. Transponders called In-vehicle Units (IUs) are fitted permanently on the windscreen of vehicles, and each IU is unique to each vehicle. Half of the total S$200 million cost of the ERP scheme was for the fitting of IUs, which was provided free of charge to vehicles. Motorists have to insert smart cash debit cards into the IU before making trips that will involve ERP charging. Foreign vehicles from Malaysia entering Singapore at three possible entry points (two land connections and a ferry terminal) may rent temporary IUs at designated service outlets. Regular visitors have found it more cost-effective to purchase and fit a permanent IU to their vehicles.

ERP relies on a pair of gantries where the first gantry has antennas that check smart cards on approaching vehicles and then debits the cards, without the vehicle having to slow down. The second gantry pinpoints the location of the vehicle, identifies the vehicle type, and verifies that the correct deduction has been made. The IU has a liquid crystal display indicating the smart card's stored value balance, and confirms every transaction with a beep. No central billing is involved. A controller links information from the antennas and detectors to check for possible violations (no smart card or insufficient balance on the card), and a camera transmits an image of the rear license plate to a central computer in the event of a violation. The fine for a violation (no cash card or insufficient balance) is an administrative surcharge of S$10 plus the ERP charge, payable within two weeks of the violation.

ERP charges are levied on a per-pass basis. Charges vary by type of vehicle, time, and location. All vehicles except for emergency vehicles (ambulances, fire engines, and police cars) are subject to ERP. Charges by vehicle type vary according to their Passenger Car Unit (PCU), defined as the road space occupied by the moving vehicle with respect to a moving car. The PCU ratings for various categories of vehicles were determined in a study done by Fan et al. (1997). Thus motorcycles have a PCU of 0.5 and their ERP rates are half of that for cars (PCU of 1.0) for the same time period and location. Big trucks with a PCU of 2.0 have ERP rates twice of that for cars.

Initially (September 1998) the location of the ERP gantries duplicated the ALS/RPS gantries and charges were lower at between S$0.50 and S$2.50; the charge for the ALS was S$3.00 for peak periods and S$2.00 for the inter-peak period. However, traffic volume into the CBD initially fell by about 10-15 percent during the ERP operation hours, as compared to the ALS scheme. This was a result of a reduction in multiple trips made using the same ALS pass, estimated at about 23 percent of trips into the CBD during the ALS days (Chin 2002).

A year later (September 1999), ERP was extended to another seven locations along expressways and the outer ring road area. As of January 2003, the ERP system has a total of forty-five gantries covering the Restricted Zone (operating Mondays to Fridays between 7:30 a.m. and 7:30 p.m.), four expressways, and four major arterial roads (operating Mondays to Fridays between 7:30 a.m. and 9:30 a.m.).

Starting from April 1999, the Land Transport Authority (LTA) instituted a regular ERP rate review mechanism. LTA conducts quarterly travel speed reviews to adjust charges to yield targeted speed ranges of 45 to 65 kph for expressways, and 20 to 30 kph for arterial roads. These speed ranges were set based on the engineering capacities of the expressways and arterial roads, respectively, and correspond mainly to Level of Service E (that is, ''traffic flow near capacity with vehicles unable to change lanes because there are few usable traffic gaps'') and a small part of the next higher service level (Tan 2001; Willoughby 2000). For a comprehensive list of ERP charges by time, location, and vehicular types on arterial roads as well as expressways, see Goh (2002) or visit the official Web site: http://traffic.smart.lta.sg/erprates.htm.

Rate adjustments are made quarterly in January, April, July, and October. Thus, for example, ERP charges were reduced in October 1999 for various periods at a number of specific points when average speeds were found to have been above the target range. Moreover, rates are also lowered during the school holiday periods in May-June and November-December as significantly fewer trips are made, and as many families head overseas for holidays.

Table 3 shows a comparison of the charges for cars by time and gantry location under ALS/RPS, and ERP charges upon implementation (September 1998), and as of January 2003. According to Willoughby (2000), ''the significant reduction in rates that has been effected under ERP appears to confirm the earlier research findings that ALS prices were often above the optimal level ....'' It is, however, interesting to note that evening congestion along the Central Expressway (CTE) has caused speeds to drop to 10 kph especially between 7:00 p.m. and 8:00 p.m. Some frustrated drivers have suggested that the morning ERP along the CTE be extended to the evening peak hours as the quickest, most effective way to solve the problem. However, the government has announced that evening ERP to ease congestion on the CTE will be introduced only after the opening of the North-East MRT Line.

As of February 2003, ERP charges were further fine-tuned to discourage motorists from slowing down or waiting at road shoulders in anticipation of a downward adjustment in charges, or speeding to avoid paying higher charges. Instead of discrete changes in ERP rates that could be as much as $2.00 from one second to the next, the absolute amount of change in rates has been made smaller. For example, ERP rates at an expressway gantry used to be $3.00 from 8:30 a.m. to 9:00 a.m. and $1.00 from 9:00 a.m. to 9:30 a.m. The rates from February 2003 for the same gantry and time period have been adjusted to $3 from 8:30 a.m. to 8:55 a.m., $2 from 8:55 a.m. to 9:00 a.m., $1.00 from 9:00

Table 3. Comparison of ALS/RPS and ERP Charges (Sep. and Apr. 1998 and Jan. 2003) for Cars (Restricted Zone and East Coast Parkway)

<table>
<tr><th rowspan="2">Time Slot</th><th colspan="3">Restricted Zone</th><th colspan="3">East Coast Parkway</th></tr>
<tr><th>ALS</th><th>ERP (Sept 98)</th><th>ERP (Jan 03)</th><th>RPS</th><th>ERP (Apr 98)</th><th>ERP (Jan 03)</th></tr>
<tr><td>07:30 - 08:00</td><td rowspan="4">$3.00</td><td>$2.00</td><td>$0.00*</td><td rowspan="4">$2.00</td><td>$1.00</td><td>$0.50</td></tr>
<tr><td>08:00 - 08:30</td><td>$2.50*</td><td>$2.00*</td><td rowspan="2">$2.00</td><td>$1.00</td></tr>
<tr><td>08:30 - 09:00</td><td>$3.00</td><td>$2.50</td><td>$1.50</td></tr>
<tr><td>09:00 - 09:30</td><td>$2.50</td><td>$2.00</td><td></td><td>$1.00</td><td>$0.50</td></tr>
<tr><td>09:30 - 10:00</td><td rowspan="13">$2.00</td><td rowspan="16">$1.50</td><td>$1.00</td><td rowspan="25"></td><td rowspan="25"></td><td rowspan="25"></td></tr>
<tr><td>10:00 - 10:30</td><td rowspan="4">$0.00</td></tr>
<tr><td>10:30 - 11:00</td></tr>
<tr><td>11:00 - 11:30</td></tr>
<tr><td>11:30 - 12:00</td></tr>
<tr><td>12:00 - 12:30</td><td>$0.50</td></tr>
<tr><td>12:30 - 13:00</td><td rowspan="10">$1.00</td></tr>
<tr><td>13:00 - 13:30</td></tr>
<tr><td>13:30 - 14:00</td></tr>
<tr><td>14:00 - 14:30</td></tr>
<tr><td>14:30 - 15:00</td></tr>
<tr><td>15:00 - 15:30</td></tr>
<tr><td>15:30 - 16:00</td></tr>
<tr><td>16:00 - 16:30</td></tr>
<tr><td>16:30 - 17:00</td><td rowspan="5">$3.00</td></tr>
<tr><td>17:00 - 17:30</td></tr>
<tr><td>17:30 - 18:00</td><td rowspan="2">$2.50</td><td>$1.50</td></tr>
<tr><td>18:00 - 18:30</td><td>$2.00</td></tr>
<tr><td>18:30 - 19:00</td><td>$1.50</td><td>$1.00</td></tr>
</table>

* Rates at Nicoll Highway gantry are $0.50 more

Source: Singapore Land Transport Authority Web site at www.lta.gov.sg

a.m. to 9:25 a.m., and $0.50 from 9:25 a.m. to 9:30 a.m.

A positive outcome from the implementation of the ERP has been the reductions in road taxes and motor vehicle registration fees, among other things. A rebate of $200 per vehicle was given on the annual road tax payable for September 1998 to August 1999, and the rebate was increased to $250 for September 1999 to August 2000. Road tax rates for cars were lowered by 20 percent in 2002. The total car population, which is controlled through a motor vehicle quota scheme (Toh 1992), has been allowed to increase from 375,217 in 1998 to 404,274 in 2002.

ERP has without doubt permitted much finer tuning than the ALS/RPS, with less complexity and inconvenience for road users, and at lower administrative and labor costs to the government. It has certainly moved road pricing in Singapore much closer to optimal pricing.

Conclusions

Clearly, as a commercial center and tourist attraction, Singapore cannot be allowed to become another Bangkok, where two-hour one-way commutes at average speeds of six miles per hour on congested streets are not uncommon. Thus, since 1975, Singapore has introduced a series of measures to slow down the growth as well as the usage of motor vehicles in a land-scarce country. While some of the measures have been successful in their intended effects, some problems have merely been shifted. In particular, as we have shown, the ALS shifted the problem of traffic congestion in time and place. The Weekend Car Scheme led to some undesirable redistributional effects (since partially remedied by the Off-Peak Car Scheme).

In earlier research, the first author found that the income elasticity of demand for the *ownership* of cars was 1.0 (Phang and Chin 1990), while the second author found that the price elasticity of demand for the *usage* of cars was very high (Toh 1977). Thus, whereas an increase in the price of cars will not seriously discourage their purchase, a city-wide system of automatic tolls will seriously discourage their usage. Since it is usage and not ownership that causes traffic congestion, we believe that the newly instituted ERP is the best solution for Singapore's traffic congestion problem because it is non-intrusive and allocatively efficient in that appropriate charges can be levied at different times and locations on different categories of motor vehicles, putting Singapore in the first-best world of Pareto optimality. It is also operationally non-intrusive and extremely flexible. Although there are still problems, the authorities are to be commended for their realization that the problem of traffic congestion cannot be solved—it can only be managed. Thus the recent relaxation on the restrictive actions toward ownership and usage of cars has achieved traffic flows at reasonable but not highway speeds. This is appropriate because Singapore is not so much a country as it is a city-state. As such, it is not much different from such cities as New York, London, and Tokyo, and therefore must expect and be willing to tolerate a reasonable amount of road congestion.

As a postscript, it should be noted that Singapore was not the first country to engage in area-wide ERP. That distinction belongs to Hong Kong, which conducted experiments from July 1983 to March 1985 (Hau 1990). The decision was not to proceed because among other things, there were privacy concerns, since motorists would receive periodic bills indicating where they went and at what time and date. But Singapore has the distinction of having implemented the most comprehensive system of quotas and tolls in the world to curb both the ownership and usage of motor vehicles. Officials from Brunei, China, Hong Kong, Japan, Malaysia, the Republic of Korea, Taiwan, and the United Kingdom, among many others, have come to study Singapore's road congestion pricing measures, while other Asian cities including Bangkok, Seoul, and Kuala Lumpur have contemplated area-wide congestion pricing.

The success of the draconian measures in Singapore can be partly attributed to the fact that Singapore is a very small island with a transportation grid largely insulated from foreign motorists, has a strong unwavering government committed to solving the problem, and is populated by an obedient law-abiding citizenry. But can the measures successfully undertaken by Singapore be implemented in the United States, Europe, and elsewhere? Exploration of this question exceeds the scope of this article. Those interested in a detailed discussion of road congestion pricing in the United States and the rest of the world should see the article by Morrison (1986), and books edited by Gomez-Ibanez and Small (1994) and Button and Verhoef (1998).

Endnote

[1] These social welfare functions represent three different approaches of aggregating individuals' utilities into social utilities. The multiplicative Nash welfare function is written as $W = |\Pi_i E(U_i)|^{-1}$ where $E(U_i)$ represents the expected utility of the i^{th} individual. The Bentham-type welfare function is additive, $\Sigma_i E(U_i)$, and the Sen function is $|\mu|^{-1}$ (1-G), where μ is the mean utility level and G is the Gini coefficient (Wilson 1988).

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