

Measuring the impacts of Singapore's area license scheme

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INTRODUCTION

Research on transport policy suffers from the impracticality of setting up closely controlled laboratory experiments with and without whatever policy measure is to be investigated. Comparisons between different countries or (in urban transport) different cities with or without some specific policy are confounded by differences in many factors other than the one to be studied. Before-and-after studies in one city are usually hampered by a lack of advance knowledge that would permit gathering an adequate data base before the policy change takes place.

One of the rare exceptions to the last statement was the case of the Area License Scheme instituted in Singapore in 1975. With more than a year's advance notice, members of the World Bank's Transport Research Division, in cooperation with the Government of Singapore and with support from the United Nations Environment Programme and the United States Department of Transportation, were able to design and carry out an extensive program of empirical data collection before the Scheme went into effect and a follow-up program afterward. This made before-and-after comparisons possible on many different impacts of the measures.

At the most general level of impact monitoring, one might say that the only requirement is to measure vehicle flows -- distinguishing types, time of day, location, and the occupancy of cars. This would be more than enough information to show whether the target, set in terms of reduced entries into the central part of the city, is being met. However, a more basic purpose underlying the target was a reduction in congestion. Hence it is desirable also to measure vehicle speeds as a measure of how freely the traffic moves or how much it is slowed by congestion. Beyond simply monitoring the effectiveness of the policy measures, the Bank's research program was intended to learn the differential impacts on different groups of people, to do some elementary evaluation of these impacts, and to gather and analyze information on underlying relationships that would help in designing and assessing the merits of restraint schemes for other cities. For these broader purposes, travel behavior interviews were conducted at several thousand households, interview surveys were made of business conditions and public opinion, and observations were made on pedestrian movements and air pollution.

SINGAPORE - BACKGROUND INFORMATION

The main island of Singapore is situated about 150 kilometers north of the equator at the tip of the Malay

Peninsula. It is diamond-shaped, measuring 42 km from east to west and 22 km from north to south with an area of about 584 square km. The City of Singapore is located on the southern coast of this island and approximately 70% of the island's population and 70% of jobs can be found within a radius of 8 km around the central area. The population of Singapore is about 2.25 million, of whom about 74% are Chinese, 14% Malay, and 8% Indian. Singapore's strategic position in Southeast Asia has given it considerable importance. Its port is the fourth busiest in the world and an active industrialization policy has resulted in rapid economic growth.

At the end of 1975, 280,378 motor vehicles were registered in Singapore. 143,155 were private cars - a ratio of one car to 16 persons. 4,585 were buses, 41,391 were goods vehicles, and 83,145 were motorcycles or scooters. From 1962 to 1973 the average annual growth rate of private cars had been 8.8% per annum. In more recent years, government efforts to limit the growth of ownership of private cars through heavy taxation have stabilized the fleet at around 143,000 cars.

Two major transport studies were carried out in Singapore between 1967 and 1974. The first was a comprehensive land use and transportation study and the second was the first phase of a study which involved a more detailed examination of Singapore's public transport requirements. Both studies independently reached the conclusion that restraints on both car ownership and car usage would be necessary before 1992. This implied radical changes in terms of both the policies of the Government and the attitudes of individuals toward car ownership and usage. Both would have to be re-oriented towards a more widespread use of public transportation. Against this background, a transportation strategy for Singapore emerged. The measures adopted included:

- a) land use development strategies to minimize the need to travel,
- b) the implementation of a modest road construction program,
- c) traffic management measures to promote better utilization of existing road capacity,
- d) rationalization and improvement of existing public bus services, including expansion of the bus fleet, improved maintenance, and the introduction of 14 km of reserved bus lanes in the central area,
- e) the provision of supplementary bus services during peak hours by using the school bus fleet and other private buses to carry commuters,
- f) increases in the various taxes on private car ownership,
- g) revision of regulations on car parking within the central area, to discourage commuter traffic while catering to the needs of business and shopping for short time parking,

The views expressed in this paper are those of the authors and not necessarily those of the World Bank.

- h) prohibition of all large vehicles with three or more axles within the central area during peak hours, and
- i) a national campaign to promote and encourage staggered work hours and car pooling.

A high level, interministerial Road Transport Action Committee was set up to coordinate the transport planning measures and to formulate future policies. Early in 1974, the committee considered the problem of growing traffic congestion in the central area and concluded that it would be appropriate to introduce restraints on the use of private cars in the central area as soon as possible.

THE TRAFFIC RESTRAINT SCHEME

The Singapore Government set itself the specific goal of designing a scheme to reduce peak-hour traffic by 25 to 30 per cent. It was estimated that this reduction would restore reasonably good traffic conditions equivalent to those found during off-peak hours. At the same time, several constraints were recognized. First, accessibility to and mobility within the central area should be maintained to protect the economic vitality of the area. Thus, efficient and reliable alternative modes of transport should be available to those commuters who would be discouraged from driving into the central area. Second, the mobility of the private car should be recognized as a benefit, and restrictions should apply only when and where they are needed to combat local congestion. Third, the scheme should be easy to administer and enforce. Fourth, it should not require a subsidy.

Several alternative policies were considered. General fiscal measures, such as import duties or gasoline taxes, do not discourage the use of cars at specific times or in specific areas; vehicle metering requires the use of special equipment that is not currently available in quantity; applying tolls to city streets requires collection facilities that take up too much urban space and themselves contribute to congestion. The Government rejected these alternatives and based its traffic restraint scheme primarily on area licensing supplemented by increased parking fees, combined with a park-and-ride scheme to provide motorists with an attractive alternative mode of transport. The Government was confident that it could deal with the problems of administering and enforcing these measures.

In the Singapore context, the key concept underlying the area license scheme is that a special, supplementary license must be obtained and displayed if a motorist wishes to enter a designated restricted area within which congestion is to be reduced.

The Restricted Zone

The Restricted Zone includes the areas with congestion problems, leaves diversion routes for motorists who do not have destinations in the zone, minimizes the number of entry points that have to be monitored, and takes advantage of existing facilities for use as fringe car parks. The zone covers about 500 hectares and has 22 entry points.

The License

The Government had no previous experience to guide it in setting the license fee. Thus, it was necessary to set the fee by judgment. Licenses were initially sold for S\$60 (US\$26) a month or S\$3 (US\$1.30) a day. They have since been raised to S\$80 a month and S\$4 a day.

Categories of Vehicles

The requirement to display an area license does not apply to buses or commercial vehicles, in order to favor public transport and maintain commercial activity. To encourage higher vehicle occupancy and more efficient use of road space, car pools (defined as cars carrying at

least four persons) are also exempt from the license requirements, as are motorcycles. These exemptions also counter objections that driving into the center becomes a luxury only the rich can afford; others can also do it if they form car pools or ride motorcycles. Taxis are not exempt.

Restricted Times

The aim of the Singapore Government was to reduce the congestion arising during the peak hour, and it was thought that applying restrictions during the morning peak would significantly reduce traffic both then and in the evening peak. Therefore, the scheme was designed to operate from 7:30 a.m. to 9:30 a.m. After implementation, congestion developed after 9:30 and the time period was extended to 10:15 a.m.

The Park-and Ride Scheme

In order to provide an alternative mode of transport for motorists who had become accustomed to driving into the central area, a park-and-ride scheme was designed to complement the Area License Scheme. Ten thousand spaces in car parks around the periphery of the restricted zone were opened to commuters, and special shuttle buses were introduced to carry commuters from the fringe car parks to the central area. The shuttle bus routes had limited stops, and only seated passengers were carried in an attempt to provide a fast, comfortable alternative to the car. The combined monthly cost of parking and using the shuttle was set at S\$30 (US\$13). This service attracted very few patrons.

Parking policy

The third element of the scheme was an increase of about 100 per cent in parking charges at public car parks within the restricted zone. Previously, there had generally been a flat rate of S\$0.40 (US\$0.18) an hour. The new rates are higher and are designed to reflect the geographical distribution of congestion and to favor short-term as opposed to all-day parking. In the most congested part of the Restricted Zone, the rates are:

1st hour	S\$0.50 (US\$0.22)
2nd hour	S\$1.00 (US\$0.44)
Each subsequent 1/2 hour	S\$1.00 (US\$0.44)

The monthly rate for all-day parking in the central area has also been increased from S\$40-60 to S\$50-80.

MONITORING THE DIRECT IMPACTS

Traffic Flow Measurements

The Singapore Public Works Department scheduled extensive measurements of traffic volumes, composition, and occupancy. Therefore, the Bank undertook no flow measurements except those that came as a byproduct of the speed measurements described below. The Government's program started about three months before introduction of the Area License Scheme and was continued on a monthly basis for about six months afterward, and then on a quarterly basis. Some of the traffic counts were done by observers, who recorded the types of vehicles and on some occasions, the occupancy of cars. Other counts were made by automatic machines, which record only the total numbers of vehicles without distinguishing types. The primary focus of the monitoring was on morning traffic entering the Restricted Zone, but some data were also collected in the afternoon, mainly on outbound traffic.

These measurements showed that the number of cars entering the Restricted Zone between 7:30 and 10:15 a.m. fell by 73 per cent from 42,790 in March to an average of 11,363 in September and October 1975. The volume of cars entering during the half hour before 7:30 a.m. rose by 23 per cent as people started their trips

earlier to avoid paying the Area License fee. The exemption from the license requirement for cars with four or more occupants ("car pools") induced a large increase in occupancy during the restricted hours. The absolute number of car pools entering during the 7:30 - 10:15 period increased by about 60 per cent at the same time that the total number of cars including car pools was falling by 73 per cent. The proportion of car pools thus jumped from less than 7 to 37 per cent for those hours.

Before these changes, cars had constituted about 60 per cent of all motor vehicles entering the area during these hours, the other 40 per cent being taxis, goods vehicles, buses, motorcycles, and scooters. Taxis were at first exempt from the license requirement, and the number of them entering the Restricted Zone during restricted hours increased dramatically. Three weeks later, their exemption was rescinded, and the number entering between 7:30 and 9:30 a.m. fell to 17 per cent of the level before the scheme began. By September and October, during the extended restricted hours, the number of taxis entering seemed to have stabilized at 35 per cent of its original level. Flows of other vehicle types either increased or decreased by much smaller proportions, and the net result was a 44 per cent reduction in total traffic during the 7:30 to 10:15 restricted period.

A surprising finding from the flow counts was that traffic flows in the evening peak (4:00 to 7:00 p.m.) changed very little. It had been expected that reductions in the morning peak flows would be reflected by a sizeable reduction in the evening. It was assumed that much of the reduction in flow in the morning would be the result of commuters using other modes of travel and leaving their cars home. These cars, then, would not be available for the homebound trip after work. When the flow data showed only a 6 per cent decline in the evening peak, it could not be explained until a detailed analysis of the home interview data gave enough clues to piece together the explanation.

The main factors were "trans-Restricted-Zone trips", trip scheduling and taxi trips. The term "trans-Restricted-Zone" refers to trips with an origin on one side of the zone and destination on the other. It was found that many car drivers making work trips of this type used the ring road to bypass the zone in the morning but returned home through the zone in the evening when the restrictions were not in effect. Another group of commuters, with work places in the Restricted Zone, took to driving in before 7:30 a.m. thus contributing to the reduction in traffic during the restricted hours, but still drove home during the evening peak. Taxis, as mentioned earlier, entered the zone in greatly reduced numbers in the restricted period, but of course the logic that suggests a reflection in the evening of reduced morning commuting traffic does not apply to taxis. In fact, it seems that the number of taxis operating during the evening peak may have increased markedly. This is not known with certainty, since the data on evening flows before the license scheme started do not distinguish vehicles by types, having been obtained from mechanical counters.

Vehicle Speed Measurements

An important indicator of performance of the traffic system is mean vehicle speed. The speed, of course, depends on the level of congestion, and one of the purposes of congestion-reducing measures is to allow traffic to move faster. It should be recognized that there are other purposes, including reduction in annoyance and frustration of vehicle-users, improvement in pedestrian conditions, in air quality, and in the general ambience of the city. Nevertheless, the expected increase in traffic speed was one of the important effects to measure.

In order to measure mean speeds with confidence and to obtain a measure of the distribution around the mean, we decided that relatively large numbers of observations should be obtained on any road link at any time. To accomplish this, we adapted a method of license plate matching which has previously been used mainly on uninterrupted stretches of highway. Several observers at each end of a segment read license numbers and occasional time signals into hand-held cassette tape recorders. Observations were made for ten minutes out of each quarter hour, continuing for an hour or sometimes longer.

Afterward, the information on the tapes was used in a computer process which related the license observations to the time signals and calculated the average speed of each vehicle whose license number was recorded at the successive stations. The computer program also screened out implausible values that sometimes resulted from errors in recording or coding and computed mean speeds and standard deviations for each vehicle type in each ten-minute period on a particular road segment.

Obviously, reliable results from this procedure depend on accurate recording of time, including the establishment of a common time scale for observers at different locations. The procedure that was eventually developed made use of several digital electric watches. The watches were synchronized within less than half a second before each observation session, and one was issued to each group of two or three observers stationed on the same corner of any intersection. In this way, the problem of the common time scale was solved. The use of digital watches also practically eliminated error in reading the time, which had evidently occurred rather frequently in earlier operations using either conventional stop-watches or sweep-second-hand watches.

Unfortunately, this procedure was not perfected until after the Area License Scheme was in effect. Data collected before that time proved unusable because of many errors in time recording and in determining the corrections necessary for synchronizing time scales. Thus, before-and-after comparisons were not possible. However, in the later period reliable data were obtained at different times of day, so that comparisons could be made between restrained and unrestrained conditions.

Because of the earlier problems, we decided in the final survey to conduct moving-car observations at the same time as the license recording, so that results from the two methods could be compared. Eight moving-car circuits (loops) were laid out so that they covered a sample of routes within the Restricted Zone, along radial roads, and along part of the ring road. Each circuit included segments selected as suitable for license-matching observations. The operations were scheduled so that whenever licenses were being matched on a given segment, the moving car was surveying the loop that included it.

In general, the speeds from the two methods were scattered over the same range for each segment, although the number of moving-car runs accomplished during an hour of observations was usually only three or four. There was no systematic bias between the mean speeds from the two methods.

From comparisons between restrained and unrestrained conditions, inferences have been drawn about changes due to the Area License Scheme. Mean speeds within the Restricted Zone were 22 per cent higher during the restricted hours than during the evening peak (33 kilometers per hour compared to 27). It seems plausible that the speed during the morning peak before the Area License Scheme was about the same as that in the evening, and therefore that there has been a 22 per cent improvement within the zone during the restricted

hours. On the ring road, speeds were 20 per cent lower in the morning restricted period than in the evening peak, and this is taken to imply a 20 per cent slowdown in the morning due to the Area License Scheme. On inbound radial roads in the morning, the flow with the License Scheme in effect is relatively uncongested and travels at almost the same speed as in the evening. It is assumed that before the License Scheme was instituted the speed inbound in the morning was approximately the same as that observed on the outbound radials in the evening. On the basis of this assumption there was a 10 per cent increase in speed on inbound radials during the restricted hours, from 29 kph to 32 kph. Presumably, the speeds on outbound radials were not affected by the scheme, inasmuch as outbound flow volumes diminished only slightly.

Travel Behavior Impacts

The direct impact of the traffic restraint scheme on travel behavior falls on those car owners who formerly drove into the Restricted Zone. However, many other groups - bus riders, pedestrians, as well as other motorists - are also affected to some degree. Changes in the travel behavior of those directly impacted by the scheme have widespread ramifications on other groups of travelers. For example, traffic diverted away from the central area cause congestion on peripheral streets.

Thus, to provide an overall picture of the impact of the traffic restraint scheme on travel behavior, it was necessary to obtain information on the characteristics of trips by users of all modes traveling into, through, or outside the Restricted Zone before and after implementation. It was also necessary to obtain data on the characteristics of the travelers in order to be able to classify impacts by socio-economic groups.

A household survey program was carried out to obtain this information. A sample of 2,053 households was selected, made up of 1,554 vehicle-owning households and 449 non-vehicle-owning households. The former contained households selected at random from the data files of the Registrar of Vehicles and supplemented by a sample selected at random from households owning cars that were observed crossing the Restricted Zone cordon before the Area License Scheme was introduced. The supplementary sample was added to ensure adequate representation for the primary impact group -- households whose members drive cars into the Restricted Zone. The non-vehicle-owning households were selected at random from a local sample frame. Each household was interviewed once before the introduction of the Area License Scheme and again four to six months later. A household informant provided information on the household and each person was then interviewed to obtain personal information as a detailed record of all trips made on the day preceding the interview.

The data were analyzed at two levels. The first was at the macro-level; this is convenient for examining the overall changes in the proportions of people making different decisions, for example, the proportion of people traveling by bus before and after the introduction of the Area License Scheme. Analysis at the second, or micro-level, was carried out on a sub-sample of 719 people who made home-to-work trips to the Restricted Zone both before and after the introduction of the scheme. The micro-level analysis makes it possible to observe the complex and sometimes opposing changes in individual behavior that underlie the global results.

Impacts on People Making Work Trips

The most important impacts in this category were expected to be on the choice of mode and on travel times of people who traveled to work in the Restricted Zone.

For these people, the monthly cost of commuting by car rose from S\$153 (US\$65) to S\$228 (US\$97). In response, the proportion of trips that members of vehicle-owning households made by car fell from 56 per cent to 46 per cent while the bus share rose from 33 per cent to 46 per cent. Within the declining car mode, the car pool share rose by a factor of three, from 14 to 41 per cent of all car trips. In addition to the modal changes, there was an important change towards earlier starting times. The proportion of work trips that were started before 7:30 a.m. rose from 27 to 40 per cent for car drivers and from 17 to 28 per cent for car passengers. The data indicate that about the same numbers of people from vehicle-owning households chose the options of changing to the bus, joining or forming car pools, and making the trip at a different time. People from non-vehicle-owning households did not change their behavior -- 90 per cent of them traveled by bus both before and after the introduction of the Area License Scheme.

The changes in travel time for travelers who did not change mode were very small. Car drivers, on average, took about one minute longer; bus riders from vehicle-owning households reported taking, on average, half a minute longer. However, bus riders from non-vehicle-owning households, who constitute the vast majority of bus riders in Singapore, reported taking, on average, about one minute less. Car drivers who changed to the bus took an average of nine minutes longer, and bus riders who changed to the car took an average of nine minutes less.

The second group to be significantly affected were travelers who traveled to work through the Restricted Zone to destinations on the other side of the city. For these people, the proportion of trips made by car fell from 53.5 per cent to 50 per cent, but the proportion of car trips made in car pools rose from 9 to 28 per cent. The proportion of trips started before 7:30 a.m. rose from 50 to 60 per cent. Of course these travelers had the additional option of detouring around the Restricted Zone. Before the introduction of the scheme, 88 per cent of trips passed through the zone. Afterwards, only 66 per cent of them drove through the zone, and of these, only 13 per cent drove through during the restricted hours. The remainder changed time to avoid the fee.

Impacts on People Making Shopping Trips

The number of shopping trips made to destinations in the Restricted Zone fell by 34 per cent, but not all of this can be attributed to the Area License Scheme, since the number of shopping trips outside the zone also fell by 14 per cent. The information gathered in the business survey indicates that the remaining 20 per cent is due to recession, decentralization of jobs and residences, and the increased parking charges associated with the Area License Scheme. It seems unlikely that the contribution of the increased parking charges could account for more than about 5 per cent.

Impacts on People Traveling Outside the Restricted Zone

It is useful at this point to note that over 70 per cent of all trips and over 60 per cent of work trips are made outside the Restricted Zone. The majority of trips to work outside the Restricted Zone are made by bus, and the majority of shopping trips are made on foot. The people making these trips have been unaffected by the Area License Scheme. Those motorists who use the ring road have been adversely affected by the increased congestion and reduced speeds.

LESS DIRECT EFFECTS

Flow counts, speed measurements, and household interviews provided the data on the changes in traffic

performance and the changes in people's travel behavior underlying the traffic effects. For a general evaluation of the scheme, research was also conducted on some other effects.

Impacts on Business

Many people have expressed concern that a scheme like Singapore's would hurt business in the central area of the city. After exploring the possibilities of collecting before-and-after data on retail sales and other business transactions or on physical indicators of activity, we concluded that the available data in Singapore were not sufficiently comprehensive to yield a direct measure of business conditions, and that it would be too costly to design and carry out a reliable quantitative survey of transactions. Instead, in-depth interviews were conducted with selected leaders in the business community, including store managers, bankers, wholesalers, and property agents. Members of this group generally agreed that the Area License Scheme had not had an adverse impact on the business climate. It was believed that the increased parking charges had further depressed central area retail sales that were already suffering from recession and decentralization. It was also believed that the restrictions on car travel to the center were accelerating the existing trend towards decentralization. In both cases, the Area License Scheme and the increase in parking charges were viewed as adding to existing problems and not creating new ones.

Certain industries and business have been specifically affected. Some companies have been involved in additional expenses to buy licenses for company cars. Taxi operators report that business is now very poor during the morning shift. They are not able to recoup their losses later in the day. Wholesalers and retailers, on the other hand, report that they have benefited from easier movement of goods in the central area during the morning when many deliveries are made. The bus company also enjoys higher revenues and improved conditions in which to operate. They claim to be able to meet schedules better and avoid delays as a result.

Effects on Pedestrians

In order to assess the effects of the traffic restraint policies on conditions for pedestrians, observations of pedestrian movements at various times of day were made by time lapse photography at a number of different locations within the Restricted Zone. It was originally expected that reduced traffic would result in reduced delays to pedestrians trying to cross busy streets and that measuring crossing times before and after the traffic restraints were imposed would yield a measure of any improvement in conditions. Results in these terms proved inconclusive, and a careful study of the films indicated that, with less traffic, many people were crossing in more leisurely fashion, so that longer crossing times did not necessarily mean delays due to traffic or indicate worse conditions. Analysis of the films in terms of the frequency with which pedestrians had to change pace or back up in response to challenges by motor vehicles showed that the ease of crossing streets had clearly improved. One of the advantages of using time lapse photography was the feasibility of re-examining the films in terms of different criteria than had originally been thought adequate.

Air Pollution

Although air pollution had not been considered a problem, the Singapore Government's Anti-Pollution Unit made measurements of air pollutants at several downtown locations before and after inauguration of the Area License Scheme. The most clearcut result was the

not surprising fact that carbon monoxide levels varied through the day in much the same way as traffic flows. The level during restricted hours, which had formerly been a peak, was reduced below that in the middle of the day. All-day average levels were also lower.

Public Opinion

One of the ultimate objectives, but a somewhat intangible one, was to improve the quality of the central city for the people who worked, lived, shopped, and did business in it. To probe this dimension as well as to find out whether the policies viewed as fair or unfair to particular groups, opinions were solicited from people in on-street interviews carried out in the central area and on the outskirts thereof.

The public opinion survey revealed that Singaporeans believed that the Area License Scheme had relieved congestion and improved conditions in central Singapore. Pedestrians, bus riders, taxi riders, and motorcyclists believed that they personally were better off as a result of the scheme. Central area residents reported that it was easier and safer to cross roads, that general conditions in the Restricted Zone had improved, and that the amount of fumes had been reduced. Motorists reported that they were worse off but not greatly so. All, including the motorists, believed that the effect on Singapore as a city was favorable.

EVALUATION AND CONCLUSIONS

The various impacts of Singapore's Area License Scheme are set forth above in terms of a wide variety of variables measured on different scales or, in some instances, assessed qualitatively. The increased ease of crossing streets for pedestrians, cleaner air, and people's perceptions that downtown Singapore has been improved are important benefits, but do not lend themselves to evaluation in economic terms without strong and arbitrary assumptions. The impact of the scheme on business was identified only qualitatively, not only because of a lack of statistics but perhaps even more importantly because the impact of the Area License Scheme could not be quantitatively separated from the effects of the general recession or from the existing trend toward decentralization.

Because of interest in having some portion of the evaluation done in economic terms even if many important elements were omitted, a calculation was made of the value of net time savings to trip-makers. It must be stressed that the debate over the value of small time savings is unresolved. It is the view of the authors that time savings such as those derived from the household survey are too small (a) to be perceived by the travelers and (b) to be considered of value in an economic evaluation. Nevertheless, for the purpose of arriving at a figure comparable to those resulting from analyses of other sorts of projects, all time savings and losses, no matter how small, were valued at the same rate. Like all value-of-time analysis, this one also involves a value judgement about the social value to society of time saved by individuals. For the present analysis, this was assumed to be independent of individual income levels. Thus all time savings and losses were valued at one Singapore dollar per hour, which is between 25 and 30 per cent of the average wage rate. Based on these assumptions, and the investment expenditures for fringe car parks, shuttle bus facilities (but not buses), signs, and ticket booths, the minimum estimate of the rate of return in the first year was 15 per cent. This counts only net travel time savings as benefits, omitting savings in fuel and other vehicle operating costs as well as the other benefits that are even less easily converted into economic terms. Moreover, the benefits will increase each year, since, without the traffic

restraints, congestion would have continued to get worse. Thus, without putting a precise figure on it, we may conclude that the economic rate of return is more than adequate to justify the investment. Had it been possible to foresee the actual demand for space in the fringe car parks, about three-quarters of the investment cost could have been saved, thus multiplying the rate of return by a factor of four. (In fact, some of the initial cost has already been recovered by converting car parks to other uses).

The economic rate of return based on the value of time savings may seem rather abstract. Public officials are more likely to be interested in cash costs and revenues. In these terms, the revenues from license sales exceed operating costs (including special police for enforcement, and the printing and distribution of licenses) by about S\$500,000 per month or S\$6,000,000 a year, which amounts to an annual cash return to the Government of more than 90 per cent of the total capital cost.

Rather than either economic or cash flow considerations, it was the more general objective of changing people's attitudes toward the use of cars for commuting that motivated the planners of the Area License Scheme. The aim was to prevent the existing moderate congestion from growing progressively worse. The penalties of congestion were described by Singapore's Road Transport Action Committee in these words:

"Daily traffic congestion results in delay and frustration to motorists, bus commuters, goods and emergency vehicles, and poses danger to pedestrians and other road users. It also causes deterioration to the environment through noise, air pollution, and visual blight".

To solve the problem, the planners perceived that they had to, first, explain the rationale behind the need for more widespread use of public transport and other high occupancy vehicles, and second, induce motorists to re-view and fundamentally change their attitudes towards the ownership and use of cars. This revision of motorist's attitudes and, hence, behavior was expected both to reduce the problem caused by congestion and at the same time create an environment in which public transport services could be improved.

In order to translate this objective into practical and measurable terms, a target was set at a 25 to 30 per cent reduction in traffic entering the central area in the morning peak. This target was more than achieved. Therefore, it is clear that the Area License Scheme has forced motorists to modify their behavior, at least in the short run. The Area License Scheme has reduced congestion in the central area, largely by inducing a shift towards public transport and car pools. Whether these are simply short-term behavior modifications or whether they represent fundamental changes in the attitudes of motorists cannot be determined at this point. It seems likely, however, that the continued use of such measures will result in a more widespread acceptance (rather than tolerance) of public transport and car pooling in the long run.

The benefits of meeting these general objectives cannot be valued in money terms. However, the creation of a breathing space and of a high probability that both the streets and the economic life of central Singapore can be prevented from being completely choked by automobiles is clearly an important and valuable achievement.