as the automobile disincentive measure is difficult to predict with any certainty. This is particularly so because we are considering pricing levels that are significantly beyond the realm of current experience in the United States. Consequently, it is difficult to predict with certainty the impacts on the business activity, on low-income travelers, and on long-term locational and other behavior. Some questions regarding the enforceability and legality of such policies in the United States also remain unanswered. Thus, the guesses made today are less than convincing for the decision makers.

The current activities of the Service and Methods Demonstration Program of the Urban Mass Transportation Administration in the area of road pricing are aimed at developing more experience in the United States. The purpose of an experimental demonstration is to generate more relevant information in an American environment and to determine with greater confidence the applicability and potential of road pricing in this country.

Congestion Pricing: The Example of Singapore

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For many years it has been suggested by economists that attempts to solve urban transport problems by a continual expansion of road capacity are doomed to failure. Rather, they have argued, the problem should be attacked by making people pay more for making journeys that result in congestion—hence the terms congestion pricing and road pricing. Although the concept has been theoretically respectable for many years, putting it into practice has until now been put off because of potential problems of implementation, enforcement, and equity. There is one exception. Between 1967 and 1974, Singapore carefully examined its transport problems and decided that the time had come to restrain the use of private automobiles in congested areas. The policy instrument selected was a form of congestion pricing called area licensing.

Singapore is a rapidly growing city-state. Seventy percent of its 2.2 million inhabitants live within a radius of 8 km of the central business district of the city. A similar proportion of the city's jobs are located in the same area. By 1974, there were more than 250 000 registered motor vehicles, almost 150 000 of them private cars. A large proportion of these vehicles operate in the central area, leading to a significant level of congestion. It is estimated that population growth and rising incomes will lead to a more than threefold increase in the number of cars by 1992. Aware of the extreme levels of congestion implied by such growth, the government of Singapore set out to develop a coordinated transport policy.

Two major transport studies were carried out from 1967 to 1974. Both concluded that limitations on the ownership and use of private motor vehicles would be required in Singapore. In the meantime, several plans were put into action. Land use plans attempted to coordinate the location of new housing, employment, and services in new industrial centers outside the city of Singapore to reduce the need for transport. Some road construction was undertaken. A mass transit system and an area traffic control system were studied. Bus services were improved by the provision of several kilometers of exclusive bus lanes, the use of school buses to expand the peak-hour fleet, and a major administrative reorganization in the bus company. A policy of restraining the rate of growth of automobile ownership by taxation was implemented. To raise public awareness of traffic problems, a campaign to promote staggered work hours and car pooling was launched. All this involved an extensive publicity effort and government-business seminars.

With the exception of a few critical areas, these policies were adequate to deal with present-day congestion. The government, however, was not satisfied that these measures would prevent congestion from becoming a serious problem in the future.

It became clear that a radical change was required in both public and private attitudes toward the ownership and use of private automobiles, and the government declared its intention of restricting the use of automobiles in congested areas. While the short-run objective of this policy was to relieve congestion in central Singapore, the long-run objective was to persuade motorists to reconsider their attitudes toward automobile ownership and use. The government believes that modification in travel behavior over time can be achieved once the motorist understands and accepts the rationale behind the need for more widespread use of public transport.

THE TRAFFIC RESTRAINT SCHEME

The government of Singapore therefore set itself the goal of designing a scheme to reduce peak-hour traffic by 25 to 30 percent. It was estimated that this reduction would restore reasonably good traffic conditions. 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, an efficient and reliable alternative mode of transport should be available to those commuters who would be discouraged from driving into the central area. Second, since the mobility of the private automobile was recognized as a benefit, the restrictions should apply only when and where they were needed to combat local congestion. Third, the scheme should be easy to administer and enforce. Fourth, it should not require a subsidy.

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Several alternative policies were considered and rejected. General fiscal measures, such as import duties or gasoline taxes, do not discourage the use of automobiles 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. Thus, the government was left with two alternatives—parking fees, which do not discourage through traffic, and area licenses, which are allegedly difficult to administer and enforce. These two policies were chosen as the bases of the Singapore traffic restraint scheme, together with a park-and-ride scheme to provide motorists with an alternative mode of transport.

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

The first task was to delineate the boundary of the restricted zone. It had to include the areas with congestion problems, leave diversion routes for motorists who do not have destinations in the restricted zone, minimize the number of entry points that have to be monitored, and take advantage of existing facilities that can be used as fringe parking areas. For Singapore, the zone covers 62 hm^2 and has 22 entry points.

The second task was to set the license fee. The government had no previous experience to guide it, and a panel of experts convened by the World Bank was unable to find adequate empirical data on the response of motorists to large cost changes. Thus, it was necessary to set the fee by judgment. In this situation, it is of course essential to be prepared to modify the fee by trial and error if it proves not to have been set correctly. In Singapore, licenses are sold for $26/month (S$60) or $1.30/d (S$3).

In order to favor public transport and maintain commercial activity, the requirement to display an area license does not apply to buses or commercial vehicles. To encourage higher vehicle occupancy and more efficient use of road space, car pools (defined as a group of at least four persons in an automobile) are also exempt, but, after a few weeks of operation, this exemption was removed.

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

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. Some 10 000 spaces in parking lots around the periphery of the restricted zone were opened to commuters, and special shuttle buses were introduced to carry commuters from the fringe parking lots to the central area. The shuttle bus routes had limited stops, and only seated passengers were carried in order to provide a fast, comfortable alternative to the automobile. The combined monthly cost of parking and using the shuttle bus was set at $13 (S$30).

The third element of the scheme was an increase of about 100 percent in parking charges at public lots within the restricted zone. Previously, there had generally been a flat rate of $0.18/h (S$0.40). The new rates are much higher and are designed to reflect the geographical distribution of congestion and to favor short-term over all-day parking. Thus, in the most congested part of the restricted zone, the rates are $0.22 (S$0.50) for the first hour, $0.44 (S$1.00) for the second hour, and $0.44 (S$1.00) for each subsequent half hour. In the remainder of the restricted zone, the rates are $0.22 (S$0.50) for the first hour and $0.22 (S$0.50) for each subsequent half hour. The monthly rate for all-day parking in the central area has also been increased from about S$40 to S$60 to about S$50 to S$80.

The government has also acquired powers to levy a surcharge on private parking lot operators in order to induce them to raise their charges without permitting them to simply collect a rent that reflects the difference between public and private charges.

MONITORING THE IMPACT

Singapore was the first city in the world to introduce a scheme of this type. The World Bank, in cooperation with the government of Singapore, the United Nations Environmental Program, and the U.S. Department of Transportation, set up an extensive monitoring program that consisted of traffic counts, household interviews, speed and flow measurements, interviews with businessmen, observations of pedestrian and parking behavior, and pollution measurement. This information has three uses: (a) to provide data on responses to the scheme so that short-run modifications can be made; (b) to provide the basis for a comprehensive evaluation of the impact of the scheme on travel behavior, traffic performance, business activity, and the environment; and (c) to provide a basis for developing mathematical models or other procedures that will be useful in using the Singapore experience as an example for other cities that may be interested in developing similar schemes.

The three components of the scheme were implemented in mid-1975—the increased parking charges on May 1, the park-and-ride scheme on May 14, and the area license scheme on June 2. The implementation was carried out very smoothly, and no serious problems were observed. The people of Singapore responded well, justifying the government's confidence that Singaporeans respond favorably to national campaigns and civic projects designed for the benefit of society.

Until data on household travel patterns are collected and analyzed, little can be said about the responses of different socioeconomic groups. The overall picture can, in contrast, be determined from comparisons of traffic volumes in March with those in August. In March, 42 790 automobiles/d entered the restricted zone between 7:30 and 10:15 a.m.; in August, 11 130 automobiles/d entered the zone—a reduction of 74 percent.

The number of other vehicles entering the zone increased by 1.7 percent; most of these were commercial vehicles taking advantage of less congestion in the central area. Overall, the volume of traffic entering the restricted zone during the scheme's hours of operation was reduced by 40 percent. The situation that these statistics represent—extremely light traffic in the central business district during the morning rush hour—is very unusual. In this respect, the area license scheme has been highly successful, but it is necessary to be concerned about the underutilization of street capacity and the high license fee.

EFFECT ON UNRESTRICTED TRAFFIC

But what of other time periods? For the half hour before the restrictions go into effect (7:00 to 7:30 a.m.), the volume of traffic entering the restricted zone was 23 percent higher in August than in March; the number of auto-

mobiles entering increased by 32 percent. However, the volume of automobiles during that half hour was only 7078, compared with 9214 in the most congested half hour in March, and actual congestion was limited to a very short period at one site in the restricted zone.

For the period after the restricted hours, considerable congestion was observed during the first few weeks of the scheme, but the extension of the restricted period to 10:15 a.m. has eliminated most of this congestion.

It was initially thought that the morning restrictions would produce a mirror-image effect on the evening peak, assuming that people who stopped driving into the area during the morning peak would not drive out in the evening. But in fact the evening traffic volumes have only fallen between 3 and 4 percent. Several factors appear to contribute to this. The major one is thought to be through traffic, which travels around the restricted zone during the morning peak but in the evening returns home through the zone when the restrictions are not in effect. In addition, some motorists park just outside the restricted zone in the morning, and then move their automobiles into the zone during the day so that they can be used for the journey home. Finally, some motorists who use public transport or car pools in the morning are picked up in automobiles by members of their households in the evening.

Although the evening traffic volumes are heavy, traffic moves well, and congestion is observed at only a few sites; moreover it clears up more quickly than it did in March. Nevertheless, the question of whether some form of evening restriction may become necessary in the future has to be considered.

And what of traffic outside the restricted zone? During the first few days following the introduction of the scheme, congestion was heavy on the ring road as motorists avoided the restricted zone. This problem was quickly solved as the timing of traffic lights was modified to favor circumferential movements rather than radial inbound traffic.

The exemptions for car pools (automobiles with at least four occupants) have proved to be popular. In May, an average of 2137 car pools a day entered the restricted zone from 7:30 to 9:30 a.m.; in August, 3880 entered during the same period—an increase of 82 percent. If we assume that three of the four members in a car pool formerly drove automobiles themselves, the increased number of car pools accounts for more than 5000 of the automobiles that drove in the restricted zone before June. It is not yet known, however, what proportion of car-pool members were actually attracted from public transport.

The park-and-ride scheme, on the other hand, did not prove to be at all popular. Apparently, motorists were not willing to accept the inconvenience of driving to a parking lot and transferring to a bus. In addition, they appeared to prefer the lower fares and service levels of the ordinary buses to the high cost and superior service of the shuttle buses. The government acted quickly to extend the shuttle bus routes to serve housing projects beyond the fringe parking lots and to reduce fares. Patronage has not improved, and the shuttle buses are regarded more as a part of the general Singapore bus system. Some of the fringe parking lots have been converted to other uses.

At this point, data are not available on the impact of the scheme on the regular public transport service. Fragmentary evidence indicates that travel times by bus have been reduced by 25 to 30 percent during the morning peak. Overall, regular bus service patronage has probably increased by 10 to 15 percent, and riders are benefiting from faster rides and more reliable schedules.

Preliminary evidence also indicates that important reductions in air pollution have resulted from the scheme, and no reports have been received on unfavorable impacts on business activity.

For any scheme of this type, it is appropriate to ask who benefits and who bears the costs. In Singapore, most people either walk or take the bus to work. These people have benefited from the improved environment in the central area and from increases in the speeds for buses. Those who buy area licenses are also benefiting from increased travel speed and less congestion, although the costs are high. For those who cannot afford the area license, car pools or staggered hours can be used if they wish to continue to drive, or the park-and-ride scheme can be used. Overall, it would appear that benefits accrue to the majority of commuters; for the others, reasonable steps have been taken to provide alternatives and minimize the disadvantages.

The scheme is administratively easy to operate, with licenses easily available from post offices and elsewhere. Current monthly sales of about 7000 licenses yield a revenue of $183 000 (S$420 000). Apart from the capital costs of constructing the fringe parking lots—$3 million (S$7 million)—and erecting road signs, the costs of the scheme are limited to parking lot attendants and the police who monitor the entry points. Enforcement has not proved to be a problem. Two to four policemen are on duty at each entry point. The license numbers of cars that do not display an area license are recorded and the owners are subsequently fined $22 (S$50). Currently about 100 infringements a week are being reported.

PROBLEMS ENCOUNTERED

Singapore was the first city in the world to implement a scheme of this type, and it is clearly a great success. Nevertheless, some problems have arisen.

The Singapore government set out to reduce the peak flow of cars into the center by 25 to 30 percent; the actual overall reduction was 40 percent. This fact, together with the deserted downtown streets in the central area, indicates that the price was set too high, leading to a severe underutilization of existing capacity, which is economically inefficient. It was noted above that a government should be prepared to raise the license fee if it was set too low. If it was set too high, the government must choose between reducing the fee to achieve a more efficient solution or leaving it too high to avoid future increases and to promote the broader goal of modifying motorists' attitudes to the use of the car. Singapore chose the latter alternatives.

The next problem relates to the evening peak. In Singapore, the expected mirror-image decrease in evening peak traffic did not occur. Since the major factor in this situation appears to be through traffic, it is clear that a knowledge of traffic patterns, especially those of through traffic, is required before a decision can be made about evening restraints. That decision must also consider whether evening restraints should be on entry to the zone (to discourage through traffic) or on exit (to discourage commuters from collecting their automobiles at lunchtime or from being picked up by other motorists). This problem is currently under examination by the Singapore government.

Then there is the park-and-ride scheme. In Singapore 10 000 fringe parking spaces were provided for those of the 42 000 motorists who formerly drove into the central area who might use the park-and-ride services. Very few motorists chose to use this alternative. However, the provision of this park-and-ride capacity was, in effect, a form of insurance taken out by the government. The error was in providing too much service, which it judged to be preferable to the risk of providing too little. The

provision of possible excess capacity and the ability to convert it rapidly to other uses if it is not required illustrate the pragmatism and willingness to proceed by trial and error that are required of a government that wishes to implement such an innovative scheme.

If central area roads are underutilized, it is likely that parking facilities are also. At present, no information is available on parking utilization in Singapore. In general terms, however, it seems clear that a traffic restraint scheme should be coordinated with a policy that regulates the supply of parking.

Since one of the alternatives open to motorists who formerly drove through the restricted zone is to drive around it, some congestion on bypass routes was to be expected. In Singapore it was possible to solve this problem, to a large extent, by adjusting the timing of traffic lights. Elsewhere, it would be necessary to examine the extent to which road improvements on bypass routes might be required.

SUCCESS OF SCHEME

How well does the scheme work? As noted before, data were being collected before implementation and are still being collected on travel behavior, traffic performance, business activity, and the environment. The World Bank will analyze these data to produce a comprehensive statement of the impacts of the scheme. Preliminary conclusions that can be drawn at this point indicate that the scheme has been very successful in reducing traffic congestion in the restricted zone during the hours of restriction. Benefits have accrued to some car drivers and to bus riders, and the central area has been improved for pedestrians and vehicle users alike. The administration and enforcement of the scheme proved to be manageable. To a considerable extent, this has been due to the care devoted by the Singapore government to the design and preplanning of the scheme and to the gradual implementation of complementary transport policies and the publicity that preceded the scheme.

Overall, this type of scheme clearly has considerable promise as a component of an urban transport policy. It is flexible enough to be tailored to the needs of a wide variety of cities, creates revenues, and requires little capital to implement. It seems possible that an area license policy might be a way to break the spiral of increasing congestion and decreasing public transport service by creating a situation in which public transport can operate more efficiently and give better service. As Singapore government officials have pointed out, however, success requires a fundamental restructuring of the public's attitudes toward the owernship and use of the private automobile. It also requires policy makers who are imaginative and innovative in developing urban transport strategies.

Supplementary Licensing: An Evaluation

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The Greater London Council (GLC) recently published the results of a study on supplementary licensing (1), a proposed new method of traffic restraint that would require drivers of certain vehicles to purchase special licenses to use their vehicles at specified times in designated areas. The study, conducted by officers of the GLC, the U.K. Department of the Environment, the Metropolitan Police, and the London Boroughs Association, considered the proposal as a means of providing traffic restraint in inner London; reviewed the effects of a number of alternative schemes on traffic patterns, on the environment, and on the social and commercial framework of London; and determined the practical requirements of these alternatives. This article summarizes the methods used and the results obtained; a fuller description can be found in the technical report of the study (2).

Traffic restraint is being seriously considered as a vital part of an integrated transport policy in most cities in the United Kingdom, although the needs and objectives differ from city to city. As a result, considerable effort has been spent in designing restraint methods that are flexible (to meet differing and changing needs); efficient (so that undue restriction is avoided); selective by type, area, and time of journey; fair and acceptable to the community at large; simple to administer and enforce and not open to abuse; and easy to understand and to follow for both casual and regular travelers.

Parking controls have been the most widely used form of restraint, and at present they form the mainstay of the GLC's restraint policy (3). However, parking controls do not operate on through traffic and are only fully effective on terminating traffic if control can be imposed on the operation of all parking spaces. Figure 1 demonstrates the effect of these limitations in central London. Although parking controls have reduced the amount of peak-period traffic that uses on- and off-street public parking facilities in central London by 30 percent in the last 12 years, traffic that uses private parking facilities and through traffic have both doubled. Supplementary licensing has often been advocated as a method for imposing controls on such traffic (4, 5, 6), and one or two cities, such as Valletta, have for some time operated simple schemes in which the annual license is more expensive for vehicles used in the city. A detailed study has been conducted for Caracas, and a complex scheme is being implemented in Singapore. However, neither of these proposals provided sufficient information to determine the effects of introducing supplementary licensing in a city the size of London.

The GLC study was designed to determine which alternative schemes might be appropriate for inner and central London, what their effects would be, whether they would be practicable, which would be the most satisfactory alternative, and how soon it could be introduced.