# APPROACHES FOR EVALUATING ALTERNATIVE METHODS OF RESTRAINT

Edward P. Holland, International Bank for Reconstruction and Development

This paper examines various methods for restraining city traffic including an electronic point-pricing system; peak and off-peak prices for crossing boundaries of a few large zones; and parking charges, which could be varied according to location and time of day. It is necessary to devise specific design patterns for a particular city and analyze the costs, problems, and performance in a specific network rather than try to choose among different methods of pricing in terms of abstract characteristics. A model similar to those presently in use in traffic and public transport studies is examined in comparison with the performance of other suggested pricing systems. The simulation model would set standard levels and match individual costs with marginal social costs all over the network.

•IN SPITE of "firm congressional guidance" that recently blocked plans for parking surcharges in Washington and 7 other cities in the United States (1), an increasing number of professionals agree that restraining city traffic by some form of pricing restraints is desirable. However, experts differ widely on the methods that should be used. Some still believe that urban congestion can be dealt with by high taxes on the purchase and ownership of automobiles and high prices including taxes for fuel. But this paper addresses restraining by price the operation of automobiles in certain localities during times when congestion exists.

Various systems of localized pricing have been proposed, and there is a need for ways to select a good combination for application in a particular urban area. Each of the following approaches has its advocates:

1. An electronic point-pricing system designed to equate individual cost with marginal social cost on each link of the street network at all times;
2. A less elaborate electronic system providing a set of cordons around many small areas with different prices for crossing different cordons and changes in the set of prices for different times of day;
3. Peak and off-peak charges, which might be registered electronically or collected at toll booths, for crossing the cordons around a few large zones;
4. Charges, which would be implemented through a daily license, for operating within a similar zone pattern rather than for crossing boundaries; and
5. Parking charges, which could be varied according to location and time of day.

Some of the discussion on the merits of these approaches has focused on the hardware requirements and the difficulties of administration and collection for different systems. Some say that the best system is that which is simplest to administer and enforce and uses the least sophisticated hardware. In contrast, proponents of complex systems, like the first one listed, say that their difficulties and costs would be minor when compared with their potential benefits. Theoretically, if individual cost could be made equal to marginal social cost everywhere at all times, trip-makers would be induced to make the decisions that would yield an economically efficient allocation of road space. The closer the actual system approaches the ideal pattern of unit costs the better.

But these statements are oversimplified. What is best for a city will depend on many characteristics including size of the city; geographical distribution of residences, shopping districts, and workplaces; corresponding densities of population, sales, and employment; street layout; ownership of private cars; characteristics of public transportation; and behavior of the people. In the complicated patterns of land and street use in a city, different methods of pricing restraint will have distinctive effects. The use of high parking charges in a zone will inhibit trips ending in that zone but not trips passing through it. Charges for crossing a cordon around a zone would affect trips both into and through the zone but not those that take place entirely inside it.

Rather than choose among different methods of pricing in terms of their abstract characteristics, it is better to devise design patterns for a particular city and analyze the costs, problems, and performance in a specific network. Some instructive simulation experiments have been done, comparing several pricing methods and levels in a purely hypothetical network. The results offer some insights that could be helpful in guiding the designer, but they do not lead to general rules that would do away with the need for studying real cities individually (2). It is desirable to compare a large number of alternatives and refine each design through trial and modification, but techniques for doing this quickly and cheaply have yet to be developed. The only valid way to compare the performance of different pricing systems is to simulate traffic flows for different price levels in each system by using a suitable model that also computes travel times and costs, financial revenues, and other information for evaluating economic benefits.

What is a suitable model for simulating the effects of different pricing patterns? Probably the best answer is a model like those currently being used in traffic and public transport studies where vehicle ownership, trip generation and distribution, modal choice, and route assignment are simulated sequentially with some repetition. But some models of this type would not do the job; certain sophisticated features are required. Because congestion is part of the problem, it must be a model in which speeds are adjusted and traffic is rerouted as individual links reach capacity. The model must include the realistic effects of prices on trip-makers' decisions. Trip-generation functions should provide for some trips to shift from peak to off-peak periods if prices are made higher during peak periods. Trip distribution and route assignment should respond to central-zone pricing by diverting some trips to different destinations or around certain zones to avoid higher costs. Modal choice for any trip should be influenced by cost. Even car ownership should be affected because car purchase decisions are influenced by the relative costs of commuting by car and by public transport. Thus the sort of model that is needed for comparing the effects of different restraint systems is one in which congestion feeds back to modify speeds, trip times, and costs and in which changes in trip time and cost affect all stages of the trip-makers' decisions. This requires a lot of repetitive adjustment, and it is important that the procedures yield convergent solutions.

Of course, price-responsive decision functions have not been well established and are difficult to estimate empirically. One of the first tasks will be to look through other researchers' empirical studies for evidence on the price elasticities of various elements of trip decisions. But price variations are usually correlated with other changes so that it is hard to separate the effects. A certain amount of judgment will have to go into determining some of the coefficients.

Once we have a model that can simulate trips by public and private transport and the corresponding vehicle flows under different pricing systems, how shall we use it? The easy answer is that we try out alternative schemes and see what happens. But there must be some rational order in the experimentation and the "what happens" part must be put in terms that are meaningful for making comparisons. Before we can say that one system performs better than another, we must define criteria by which performance can be assessed. The objectives of a traffic restraint policy are usually congestion and air pollution reduction. But if congestion and pollution were reduced by making it costly and inconvenient for anyone to go anywhere, that would not be satisfactory. Transportation itself must be recognized as a component of social and economic welfare, and if a reduction in congestion does not result in better transportation at lower social cost, why should we want to reduce congestion? Let us beware of the unconscious assumption that we are going to have easier driving because other people will be forced to stay off the road.

It is possible to derive economic values for transportation differences in different systems including congestion costs and disbenefits to those who, because of the pricing system, do not travel, change destinations, or use a less convenient mode of travel. The point is that there is a way to use information generated by the model to arrive at a number representing the economic benefits of a tested design pattern and restraint level. The initial and continuing costs of hardware installation and administration have to be estimated in conventional ways and considered against the benefits.

There are also benefits from reduced air pollution and reduced noise. The differences in pollution and noise can be estimated quantitatively by physical measures and could be considered with the economic criteria. But, rather than assigning them values and adding them in with economic benefits, it is better to consider them as extra dimensions.

Other dimensions that should be considered include the financial costs and revenues of each system (these may be quite different from the economic costs and benefits) and the effects on operations and finances of the public transit system. All this information can be computed in the model and printed out so that different systems and different price levels can be compared.

When systems are compared, total figures are useful indicators; but, because they could mask some important local problems or opportunities for improvement, the more detailed results should be available for analysis. The research analysts should have access to all the information they want. Most likely this would include maps of volume-to-capacity ratios on each street at different times of day, details of bus and other public transit ridership on particular routes, and numbers of cars parked in different areas. On the basis of such information, price differentials between different zones might be adjusted, boundaries might be moved, and other improvements might be made to each system tested.

Now that we have a suitable simulation model and have included in the computer program provisions for printing out the chosen criteria of performance and more detailed outputs, what we need is a testing strategy. We must choose a future year that the simulations will represent. Contemplated changes in streets, freeways, busways, and other transit facilities have to be included in the model. Data related to trip generation and distribution, such as populations, retail stores, jobs in each zone, income levels, and family sizes, must be projected for the future year. Then each restraint system to be tested must be coded into the network in terms of trip-end parking fees and tolls on links that cross cordon lines or pricing points. These charges should be programmed so that prices at different points can be readily changed by putting in new data.

Now that everything is ready, one of the first runs has to correspond to the situation without special restraints. This does not mean without ownership or annual taxes, fuel taxes, or parking fees. Those should be set at standard levels—those levels set by authorities if they were not trying to restrain traffic—or higher levels corresponding to components of the restraint program and complemented by locally variable charges. Because either definition of standard requires a subjective judgment, it may be necessary to vary them in sensitivity tests but, for most of the other comparisons, they should be held constant. This run is the base relative to which costs and benefits of all other systems will be measured as differences.

The next set of runs should use a finely spaced point-pricing system to match individual costs with marginal social costs all over the network. This process would have changes at one point causing repercussions elsewhere, so I am not sure it can be done within a reasonable number of trials, but I would attempt it for two reasons. First, to have some idealized standard with which to compare the performance of the practical systems is helpful to indicate whether there is room for improvement in the performance of the latter. Second, the resulting geographical pattern of price levels may be useful for the layout of zones and cordon lines and the choice of patterns and initial levels of prices for the other systems that are the objects of the rest of the experiments.

Finally there is a need for comparing restraint systems in more than 1 year and at several times of day. To run such a complex model through all these conditions for every change in price level and every pattern of restraint methods would be cumbersome, costly, and unnecessary. A good deal of exploration, refinement, and preliminary comparison can be done in terms of a single year and peak period. These partial comparisons must be done, however, without forgetting that the relation of all-day effects to peak-period effects will be different for a time-varying meter-recorded change than for a daily sticker system and that a method aimed too sharply at dealing with congestion in a predefined peak period may create secondary peaks just outside that time period. These and other differences between different approaches must be brought out and analyzed.

This outline should help get us started in studying traffic restraint measures. Carrying out such a study will simultaneously serve to help design a system for a particular city and add to our general understanding of traffic restraint systems.

## ACKNOWLEDGMENT

This paper expresses the views of the author and is not an official publication of the International Bank for Reconstruction and Development.

## REFERENCES

1. Washington Post, Jan. 11, 1974, page A1.
2. Wigan, M. R., and Bamford, T. J. G. A Comparative Network Simulation of Different Methods of Traffic Restraint. Transport and Road Research Laboratory, England, Rept. LR 566, 1973.