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THE purpose of this paper is to review briefly the pricing rule applied to public facilities and to services such as transportation, then to examine the current pricing practices and some resultant problems in transportation, and finally to present some results of our empirical investigation of the mass transit operation in the Milwaukee area.

## PRICING RULE

The pricing rule of public facilities and services should be aimed at increasing the economic welfare of society by achieving efficient allocation of resources and equitable distribution of income. Pricing in transportation should, therefore, be used as a possible means to achieve a balanced and smooth flow of traffic and to achieve distributional equity.

Therefore in order to give a meaningful discussion of the pricing policy of public facilities and services such as transportation, a model is needed which incorporates all three strands of economic disciplines: welfare economics, public finance, and regulatory institutions.

As it is well known, congestion results from not using a proper price mechanism: too low a price is charged so that an excessive number of road users is on the roads. This would imply inefficient

allocation of road users, for congestion results from too many users during the peak hours and fewer users during the off-peak hours.

If the peak-hour users are persuaded to switch to the off-peak hours, the problems of congestion may be solved. This is where the price mechanism comes in. (The fact that people have to use roads during the peak hours to get to work is ignored here.) A relatively higher price charged during the peak hours and a relatively lower price during the off-peak hours would accomplish the transfer of some of the peak-period users to the off-peak periods.

The proper use of the price mechanism may, therefore, solve the problem of congestion, but it will create another formidable one—the problem of inequity. A higher price charged to the peak-period users reduces congestion but at the same time prevents the poor from using the roads. A situation may be conceived where the peak-period road use is limited only to the rich, and the poor are forced to give up the use of their automobiles in favor of mass transit. Therefore, the choice of various combinations of efficiency and equity must be faced, and a pricing rule is needed to balance efficiency and distributional equity.

It is well accepted in this respect that price should be set equal to marginal social cost in order to maximize economic welfare of society with balanced efficiency and distributional equity. According to the marginal cost pricing rule, the charge for the service of the road should measure the value of resources used up in providing that service. The rule suggests, therefore, that a toll should be levied on users during congested hours, and that these tolls must be such that the private cost of the trip is equal to its marginal social cost.

## DEPARTURE FROM MARGINAL COST PRICING AND CURRENT PRICING PRACTICES

Marginal cost pricing yields maximum social welfare only under very restricted circumstances. There must be no market distortions and the economy must be a perfectly competitive one where all market sectors follow the marginal cost pricing rule.

Under the current pricing practices in transportation systems, then, what is required is not a price that is set equal to marginal

social cost, but a price that deviates systematically from marginal social cost. This departure of price from marginal social cost is necessary to increase the economic welfare of society not just by achieving efficiency but also by establishing equity.

Three situations are now considered in relation to a two-travel modes model of private automobiles and bus transit where prices are required to deviate from marginal social cost.

*Peaking of Demand*

The demand for transportation service varies substantially from hour to hour, day to day, or season to season. According to the marginal cost pricing rule, the price for the peak-hour travel should be set higher than the price for off-peak travel, reflecting a widely varying marginal social cost. Keeping price continuously equal to marginal social cost as it varies when the demand for travel changes is, however, not possible because of administrative difficulties. The current pricing practice is to keep a single price throughout the demand cycle. Under this practice the optimal price that maximizes the welfare for society is not the price which is equal to marginal social cost, but a price set between the marginal cost of the peak-hour travel and the marginal cost of the off-peak hour travel.[1]

*Scale Economies and Financing*

The idea behind marginal cost pricing was to set user charges equal to marginal social cost and thus to confront the user with the true cost of his choice when he makes it. But user charge may not be large enough to pay back the full investment cost in the facilities he uses. This can often happen when there exist scale economies. It should be understood that the rule of self-liquidation as a general guide to efficient operation and investment must be put aside in the presence of scale economies. In a case where the deficit limit is imposed, the optimal price should be set higher than marginal social cost.[2]

1. Herbert Mohring, "The Peak Load Problem with Increasing Returns and Pricing Constraints," *American Economic Review,* Vol. 60, No. 4 (September 1970), p. 700.

2. Mohring, "The Peak Load Problem," p. 697; William Baumol and David Bradford, "Optimal Departure from Marginal Cost Pricing," *American Economic Review,* Vol. 60, No. 3 (June 1970), p. 270.

As shown later in connection with the operation of the Milwaukee bus transit system, it is extremely important to take into account scale economies and diseconomies in order to understand the financial problems of transportation operations.

*"Highway biased" Financing and Underpriced Private Automobile Travel*

It has been charged that in deciding between private and mass transportation, the American consumer has been presented for years and years with a market heavily rigged in favor of use of his own car. In this connection public policy has been criticized.

It should be noted, however, that public policy is not necessarily biased in favor of private automobiles and against mass transportation simply because of heavy governmental investment in highways in metropolitan areas. What truly deserves criticism is the method of financing highways and the consequent underpricing or subsidization of the peak-hour central-business-district-oriented private automobile use.

A public mass transit system must recover most of its cost from charges imposed on those who ride in the peak hours, since other users are relatively few. In other words, the peak-hour users of mass transit system are asked to pay the full cost of maintaining the system. In contrast, a freeway system has its cost spread over a larger group, since freeways tend to peak less sharply.

Moreover, in most cases the only price the users of highways are aware of paying for their use of highways is the gasoline tax which is only a small part of the true cost. The peak-hour CBD-oriented private automobile users are heavily subsidized from gasoline taxes and other user charges collected from the off-peak period automobile users and those who use nonurban highways.[3]

Under a situation where automobile use is underpriced, the optimal price for mass transit system use is not the one equal to marginal social cost, but rather the price which is less than marginal social cost, and, under some circumstances, the price which is less than average social cost. In other words, under the current pricing practice of underpricing automobile use, mass transit systems and/or mass transit users should be subsidized.[4]

3. Dick Netzer, *Economics and Urban Problems: Diagnoses and Prescriptions* (New York: Basic Books, 1970), p. 143.

This is not to say "Charge mass transit below its marginal social cost, because private automobile is priced below its marginal social cost." It is not an argument of "two wrongs make a right." It is an argument based on the theoretical formulation of social welfare maximization: a bus subsidy will improve economic welfare when automobiles are underpriced.

In summary, the above three cases can be compared with the ideal case (price equals marginal social cost) as follows:

1. No price differential between peak and off-peak periods
   Price > marginal social cost of the peak period
2. Financial constraint case
   Price > marginal social cost
3. Underpricing of automobile case
   Bus fare < marginal social cost
   or bus fare < average cost (subsidy is justified)

### SUBSIDIZATION OF MASS TRANSIT SYSTEM

The above discussion has demonstrated distorted pricing practices of the current transportation system and remedies—the "second best" pricing to maximize social welfare.

One frequently discussed "solution" to urban congestion is to charge the automobile users considerably more, in view of the fact that it is automobiles that cause congestion, pollution, and other intolerable nuisances.

The imposition of higher charges on the use of private automobiles may persuade automobile users to abandon their cars and ride the public mass transit system. But, as mentioned before, under such a pricing scheme the lower-income people are victimized. The upper-income people would still use their cars in the face of higher charges and might even benefit from the opportunity to be able to use less congested highways. In other words, charging the automobile users more may well increase the welfare of the high-income people but is almost certain to lower the welfare of the low-income people.

In view of the inequity associated with such a proposal to solve

4. Roger Sherman, "Congestion Interdependence and Urban Transportation Fares," *Econometrica,* Vol. 39, No. 3 (May 1971), pp. 565–576. Also his "Subsidies to Relative Urban Congestion," in *Journal of Transport Economics and Policy,* Vol. 6, No. 1 (January 1972), pp. 21–31.

urban traffic congestion by setting higher charges on the private automobile users, proposals have been advanced to subsidize the mass transit system (or users) and even to provide a free transit. In recent years there has been growing interest in the reduction of fares as an incentive to use mass transportation systems, and also to help provide ghetto residents with accessibility to job centers. Massive investments in rapid transit facilities are being proposed as a solution to the urban transportation problems, for it is argued that improved transit service will divert travelers from auto to public transit, thereby reducing highway congestion, parking problems, and air pollution, as well as decreasing the need for new highway construction so that land takings and their attendant disruptions can be reduced.

Kraft, Domencich, and Valette investigated the problem of free transit.[5] Their principal conclusion was that while free transit contributes to solution of urban transportation problems, improved transit service is generally a more efficient means of solving these problems. Their study showed that transit ridership was more responsive to improvements in service than to reductions in fares; and reductions in access times to and from the transit station, as well as transfer and waiting times, are likely to be particularly important.

But, as these three investigators noted, to identify and evaluate the effectiveness of any transit subsidy program, a solid understanding of the behavior of urban commuters is needed. A fully satisfactory statistical demand function which analyzes the behavior of urban commuters in relation to their reactions to performance variables of a transportation system has not been developed, mainly because of the paucity of data.

In the following some results of an empirical investigation into the demand and supply relations of the Milwaukee area bus transit system are presented, using available data.

## A CASE STUDY: THE MILWAUKEE BUS TRANSIT OPERATION

Like virtually all mass transportation systems in this country,

5. Gerald Kraft, Thomas Domencich, and Thomas Valette, "Estimation of Urban Passenger Travel Behavior: An Economic Demand Model," *Highway Research Record No. 238* (1968).

the transit system in the Milwaukee area has been caught in an unending cycle—continuing decline in patronage, constantly rising costs of labor and equipment, and an almost periodic increase in bus fares. There is a reasonable fear that this cycle will lead to the ultimate extinction of mass transit service in the Milwaukee area if it is allowed to continue unchecked.

The investigation reported here finds that a lowered bus fare together with improved service will substantially increase transit patronage. This in turn will reduce the cost of operating bus transit as a consequence of the existence of economies of scale. Also investigation into the socioeconomic characteristics of United States urban mass transit riders has shown that the majority of the transit riders are captive riders—riders with no means of transportation other than mass transit.[6]

These findings substantiate the contention that mass transit service should be substantially improved—fares as well as services—to attract more automobile users to mass transit and to provide better transportation services to the poor. The empirical foundations of these conclusions are discussed in detail below.

*Demand for Transit Service in the Milwaukee Area*

The demand side of the transit service was first examined to find out whether or not a relation exists between the quality of service and the level of transit patronage.

Time series data obtained from the Milwaukee and Suburban Transport Corporation for the period of 1955–1970 was used.[7] Some results of our regression equations are as follows:

$$\text{Log } X_1 = 9.5210 + 0.8947 \log X_2 - 3.0809 \log X_4 - 0.2046 \log X_5 \quad (1)$$
$$(8.0084) \qquad (-3.6102) \qquad (-2.8385)$$
$$R^2 = 0.9954$$

$$\text{Log } X_1 = 9.7038 - 2.2141 \log X_2 + 3.0603 \log X_3 - 0.2367 \log X_5 \quad (2)$$
$$(-2.1971) \qquad (3.1870) \qquad (-3.2770)$$
$$R^2 = 0.9948$$

6. Masatoshi Abe and Kumares Sinha, "Pricing and Quality of Service in Urban Mass Transportation," *Journal of American Society of Civil Engineers,* forthcoming.

7. Milwaukee and Suburban Transportation Corporation, *Annual Report,* each year 1955–1970.

where

$X_1$ = the number of revenue passengers
$X_2$ = bus miles of route coverage
$X_3$ = bus hours of service
$X_4$ = headway factors
$X_5$ = average fare
$R^2$ = coefficient of determination

and numbers in parentheses are t-statistics.

The results are statistically significant with high $R^2$'s and t-statistics. It should be noted that the signs of estimated coefficients are correct—or what would be expected—with exception of $X_2$ in equation 2; negative signs of $X_5$ indicate that a rising fare has indeed reduced the patronage volume, while a negative sign of $X_4$ and a positive sign of $X_5$ imply that a faster and wider service of transit operation would increase the ridership. We would expect a positive sign from $X_2$, which would suggest that a wider coverage of transit service would increase the patronage. The sign of $X$ is negative in equation 2. However, this is due to the fact that $X_3$, bus hours, another service variable representing transit coverage, was used in the same equation in addition to $X_2$, and that the effect of $X_2$ is overshadowed by $X_3$.

It should be noted that the contribution of $X_5$, bus fare, is not as great as the contributions of the other service variables. Since regression analysis was applied in the logarithmic forms, each coefficient represents the coefficient of demand elasticity of a respective variable. Therefore, a 1 percent reduction in bus fare, for example, will increase the ridership only by 0.2 percent, while 1 percent reduction in headway factors will increase the patronage volume by 3.08 percent.

In sum, the implications of these regression equations are obvious: the transit patronage in the Milwaukee area can be increased by improving transit services (coverage and speed) and by reducing bus fares.

*Supply of Transit Service: Economies of Scale*

The supply side of transit service was then explored to find the effect of changes in the service variables on the cost of providing

transit service. The cost per unit service, i.e., cost per bus mile, may be critically dependent upon service variables which affect patronage volumes. The crucial point here is the existence of economies or diseconomies of scale in transit operation. If deteriorating service and a resultant reduction in transit patronage should yield an operation with a higher cost per unit, it would indicate that the transit company was suffering from diseconomies of scale in transit operation. To explore the existence of scale economies, $Y_1$, operating cost per bus mile deflated by the Bureau of Labor Statistics consumer index of transportation, was plotted against $X_1$, the number of revenue passengers. The resulting curve was U-shaped. To confirm this, the following regression equation was tested:

$$Y_1 = 13.7003 - 0.1362\,X_1 + 0.0072\,X^2_1 \quad R^2 = 0.8351 \qquad (3)$$
$$(-8.0427) \quad (7.8911)$$

The result is statistically significant and shows that the curve is U-shaped. The U-shaped curve indicates that scale economies exist in the bus transit operation. It should be noted that since around 1960 the transit company in the Milwaukee area has been operating in the range of diseconomies of scale. It can be argued, therefore, that the further reduction in the number of patronage will consequently raise the unit operating cost of transit.

A simple diagrammatic presentation will clarify this point. Figure 1 shows the U-shaped average cost curve and three demand curves. Considering the U-shaped cost curve of the transit system, increased fares and deteriorating services have shifted the demand to the left from $D_1$ to $D_2$, thus raising the average cost of operating the transit system. Subsidies to the transit users or to the transit system, and other measures of improving transit service, would encourage the transit use by shifting the demand back from $D_2$ to $D_1$ and to $D_3$ as the analysis of the demand function for bus transit indicates. Improved transit service may shift upward the average cost (AC) curve, but the final outcome is most likely to trace such points as A, B, and C. An increased number of transit users will reduce the average cost of operating the transit system.

## CONCLUDING REMARKS

This article started out by stating that the pricing rule of public

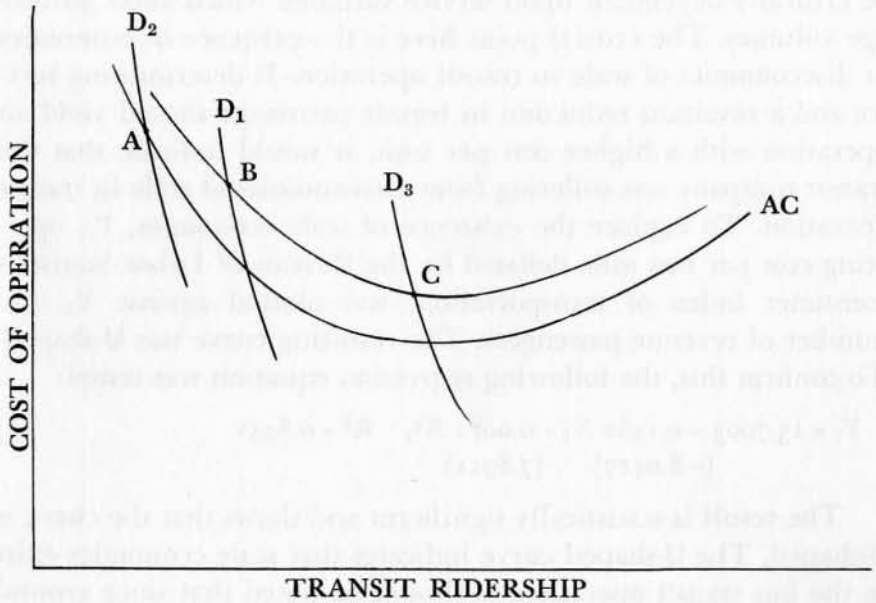


Figure 1. Schematic diagram of demand and average cost relationship

facilities and services such as transportation should be aimed at maximizing economic welfare of society by achieving not only efficiency in resource allocation but also distributional equity. For this reason the marginal cost pricing rule has been proposed: charge of the service of the road should reflect the value of the resources used up in providing that service.

Then the fact that the present pricing practices necessitated the optimal price level to deviate from marginal social cost was discussed. That is, the present situation is in the area of the "second best." In the face of the underpriced private automobiles, it was argued, therefore, that the subsidization of mass transit systems was justified. It was emphasized that price for mass transit should not be below its marginal social cost simply because the automobile users are paying a price below marginal social cost. A subsidy is required for mass transit in order to increase economic welfare of society.

The case study of the bus transit service in the Milwaukee area has shown that improved bus service—lower fares as well as wider

and faster coverage which would be affected by subsidies—will not only attract more commuters from automobiles to bus transit, but in doing so will also reduce the average operating cost of bus service as a result of utilization of economies of scale that exist in transit operation.

In view of the fact that the majority of transit users are captive riders, it was argued, therefore, that in order to rescue the deficit ridden bus transit operation in the city of Milwaukee, massive subsidies or even a government take-over of transit operation is a highly recommended measure. This measure is proposed because it will increase the economic welfare of the community.

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