Congestion Tolls—An Engineer's Viewpoint

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This paper deals with the proposal for adoption, in the central cities of metropolitan areas, of a system of motor-vehicle taxes or tolls commonly known as congestion tolls, based on the concept that the marginal costs of congestion (operating, time, and accident costs resulting from congested traffic) should determine the magnitude of user charges.

The concepts of marginal-cost pricing and their particular application to government-provided services are reviewed and the fact is brought out that numerous economists do not regard highly this method of pricing government services, and even call into question the primacy of marginal costs as a determinant of prices in private industry. The formulations of those advocating congestion-cost pricing are then reviewed and discussed. Some exceptions are taken, both to the reasoning employed and to the handling of data.

Various implications of congestion-cost pricing are considered. The contention is advanced that a model relating benefits, costs, and prices in the form of user taxes and tolls should be a dynamic model, taking account of variations over time, rather than a static model expressing only the relationships existing at one time. The current status and prospects of urban highway finance are examined, and it is concluded that the existing combination of Federal and State user-tax revenues with local revenues, both user and nonuser, is adequate and efficient for the purpose of financing programs of highway and street improvement. Examination of the nature of urban highway traffic, evidences of improvement in travel times and average speeds resulting from completion of freeways and improved traffic engineering, and prospects of further improvement, indicate that congestion tolls would make no significant contribution to solution of urban congestion problems. Income effects are discussed and it is shown that congestion tolls discriminate against the low-income motor-vehicle user. The point is made that the effects of congestion tolls on business, whether favorable or unfavorable, are a part of the total complex of benefits and costs to be considered in making a decision. Finally it is pointed out that the imposition of prohibitive taxes on motorists at the city center could well defeat the alleged purpose of congestion tolls, by causing both workers and business to seek outlying locations not burdened by such charges.

In view of this series of adverse findings it is concluded that congestion tolls do not promise to make a significant contribution to the solution of urban congestion problems.

•IN RECENT YEARS certain ideas about highway user charges, by no means new in themselves, have been presented with greater urgency than in the past and with a

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persuasive plea of timeliness, particularly in urban transportation financing. These ideas relate, first, to the determination of user taxes or toll charges on the basis of marginal rather than average costs, and second, to the proposition that the extent of congestion caused by the use of the highways should replace public outlays for highways as the principal determinant of the level of user charges.

Because the adoption of highway financing policies based on these ideas might bring about marked deviations from present practices in user taxation, the question of their soundness and adequacy is indeed timely. For this reason a panel session of the Highway Research Board was organized to bring the ideas of so-called congestion pricing before a suitable forum and subject them to discussion from a variety of viewpoints.

This paper is written from the standpoint of the highway engineer or official having the responsibility of planning or administering highway programs, including their financing, or of participating responsibly in such activities. To attempt a treatment of the subject from this angle is in itself a formidable task, inasmuch as highway engineers and officials hold a wide variety of views. There is, however, some unity in the engineering approach, and some consistency in the ideas which engineers and highway officials bring to the solution of the problems that confront them. The progress that has been made in highway research and planning over the last 30 years, together with advances in the arts of highway construction, maintenance, and operation, form the background of this attitude. Although it is believed that the highway engineer is by no means impervious to economic and social considerations, the treatment here does not attempt to grapple directly with the economic principles and mathematical formulations that underlie the theory of congestion charges or tolls. This work is left to the economists, except for some descriptive treatment and the citation of comments by a number of economists.

THE FORMULATIONS

To understand the ideas involved in congestion-toll theories, it is necessary to present and discuss some of the economic concepts involved and at least some of the simpler mathematical formulations with which they are supported. Only the more elementary formulations, the first steps, so to speak, are dealt with here, inasmuch as to elaborate these theories would be not only to copy the presentations set forth by the economists, but also to attempt demonstrations outside the competence of the writer. Beyond the presentation of the simpler formulations this paper merely states the directions and steps in the more advanced development of these theories.

Marginal Costs of Highway Provision

There has long been controversy as to whether the financial support of highways and other publicly-provided services should be determined on the basis of average costs or marginal costs. It is true, of course, that costs must be met in some way, and in that sense the financing must be on the basis of average costs. The question at issue, however, is that of user charges. Many economists contend that benefits are maximized and the economic allocation of scarce resources is served when charges to users of a service are based on marginal costs.

Marginal Costs Under Perfect Competition. —The marginal-cost principle can be illustrated by citing the example of a commodity of which 500 units can be produced for \$30 and 600 units for \$33. The average cost of the 600 units is \$0.055, but the cost of the additional lot of 100 units is only \$0.03 per unit. Marginal cost is commonly expressed as the cost of producing one additional unit, but the idea is conveyed by the example.

Figure 1 shows the essential cost-price relationships involved in the operation of a firm under perfect competition. Curve AFC is that of average or unit fixed costs. Because total fixed costs are, by definition, constant in the short run, the product of output and fixed costs per unit is a constant, and the curve is a rectangular hyperbola. The curve of average variable costs, AVC, is typically U-shaped. For example, when a plant is running well below capacity employment of both labor and equipment is likely to be inefficient in terms of cost per unit of output. As capacity

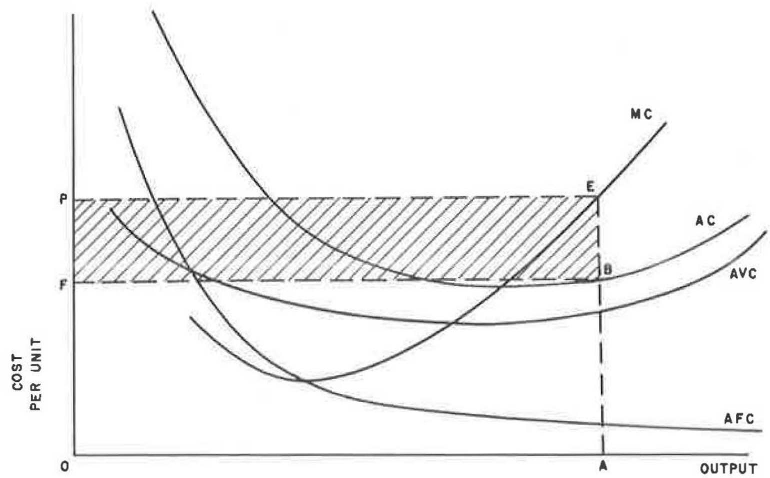

Figure 1. Short-run cost curves and price-output relationships under perfect competition.

is equaled or exceeded a point of maximum efficiency is reached and average variable costs begin to rise. The average total cost curve, AC, is of the same shape, but reaches a minimum at a point to the right of that of the average variable cost curve. The curve of marginal cost, MC, the cost of producing one additional unit at any given volume of output, is also U-shaped, but of sharper curvature, reaching a minimum at a point to the left of the minima of curves AVC and AC, and passing through those minimum points.

For a single firm the price is given—i.e., fixed by the market. In Figure 1 price is represented by OP. If output is set at OA, the point where price equals marginal cost, the firm will operate at maximum profit: if more units are produced the price will not repay the cost of producing them, and if less units are produced there will remain additional units that could have been produced at a profit. The total revenue of the firm is represented by rectangle OPEA, total costs by rectangle OFBA, and net profits by shaded rectangle FPEB.

Under different market conditions the price may be such that the firm cannot produce at a profit. If, however, the price is less than total cost but more than variable cost, output set at the point where marginal cost equals price will produce net revenues (excess of total revenues over variable costs) that will cut loss to a minimum. In the long-run condition fixed costs become variable and curve AFC disappears. Normal profits are included in the cost curves. Output is set at the point where price, P, equals long-run marginal cost, LMC; but, under perfect competition, the price and corresponding output are forced down to the point of minimum average cost, LAC, where average cost and marginal cost are equal (1, chs. 11, 14, 15).

The Case of Highways.—The objective in applying the principles of welfare economics to governmental decision making is to maximize utility, welfare, benefits, or consumers' surplus[1], or any or all of these closely related attributes. More broadly stated, the objective is to achieve an optimum allocation of resources in the governmental and government regulated sector of the economy. One cannot quarrel with these aims. It is necessary to note, however, that both the postulates and the formulations of welfare economics have been the subject of much controversy among economists, particularly during the last 30 years. One is not, therefore, constrained to

[1] If the demand for a product increases as price drops, it follows that there are numbers of people who would be willing to pay more than the market price. A man who pays $2.00 for a product he values at $5.00 enjoys an excess of satisfaction equal to $3.00. Thus the area between the demand curve and the rectangle representing output times price is defined as consumers' surplus.

accept findings and recommendations in this field as given; one can subject them to tests of logic and of applicability to the particular situation or problem.

Public enterprises and public utilities subject to governmental regulation have the attribute that prices are not set by the market, whether under perfect or imperfect competition, but are determined by government or under government surveillance. A second attribute common to many of them, of which highways are a prime example, is that of decreasing costs. The fixed costs of the existing plant are so great in relation to variable costs under most circumstances that marginal costs, in the normal range of use, are decreasing, and often very low. The cost, in public outlay, of admitting one more vehicle to the traffic stream on a highway is imperceptible; nor is any measurable cost incurred in admitting one more passenger to a railroad train.

Ordinarily the setting of prices in such an enterprise is governed by the necessity to recover the expenses of capital charges, maintenance, and operation—i.e., average costs. Welfare economists contend that utility will be maximized, even in this situation, by setting prices equal to marginal costs. Figure 2 shows the case of an enterprise with decreasing costs, which for the present purposes may be taken as representing the operation of a highway system. Output may be taken as vehicle-miles of highway service. Marginal costs are less than average costs within the entire range of the chart. The demand for highway services is represented by line D.

It is held that utility will be maximized if prices are set at the point where the demand curve intersects the marginal cost curve, MC. If the price is below this point users will be provided with service at less than they would be willing to pay. At a higher price users who would be willing to pay more than the additional cost of a larger quantity are deprived of the opportunity. Output is represented on the diagram by OA, price by OP, and total revenue by rectangle OPEA. Average cost, on the other hand, is represented by OF and total cost by rectangle OFBA. There is, in short, a deficit represented by the shaded rectangle.

The existence of a deficit is held justified by the value or utility of the total service provided, which is measured by the area under the demand curve, OKEA. If this

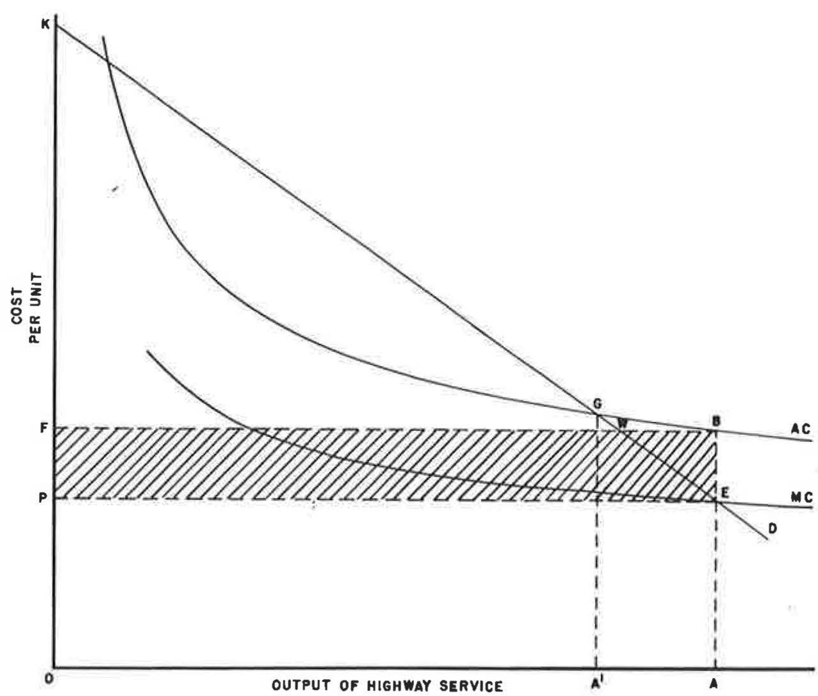

Figure 2. Highways: case of decreasing costs.

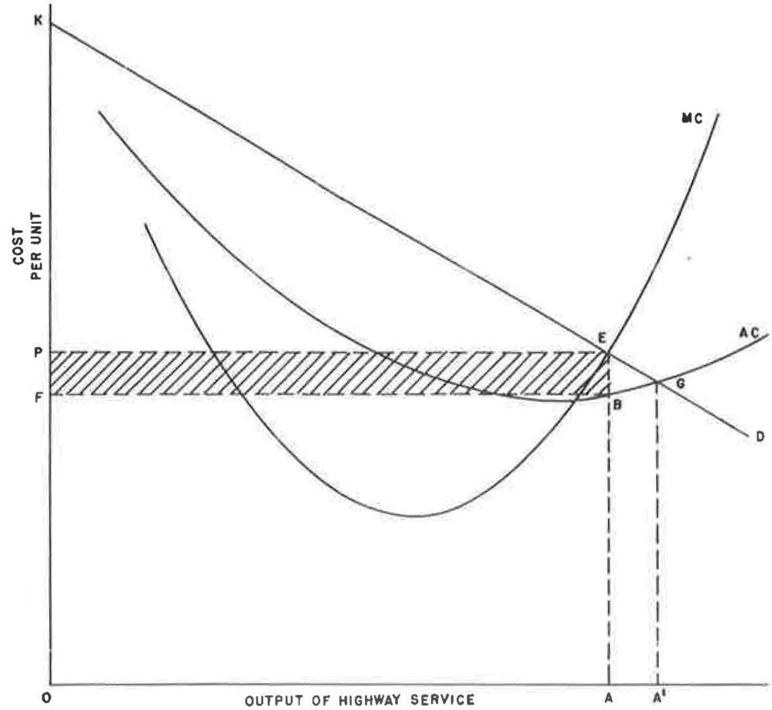

Figure 3. Highways: case of increasing costs.

area exceeds the cost, OFBA—or, cancelling areas common to both, if FWK exceeds EWB—the pricing is justified under the concept of consumers' surplus. The problem of overcoming the deficit remains. If the price is set by point G, where the demand curve intersects the average cost curve, AC, output is reduced to OA′ and the advantages of marginal cost pricing are forgone; but the enterprise meets its costs, with a comfortable amount of consumers' surplus.

Figure 3 illustrates the case of increasing costs, with cost curves much like those of Figure 1. The unit price, OP, is set by the intersection of the demand curve, D, and the marginal cost curve, MC. Total revenue is given by rectangle OPEA, total cost by rectangle OFBA, and there is a surplus. If the price were set by point G, the intersection of the demand line, D, with the average cost curve, AC, total cost and total revenue would be equal, but the added units of output, AA′, would be sold at a price less than the cost of producing them.

From the foregoing it may be reasoned that, in an enterprise characterized by decreasing costs, prices should be set at marginal costs and a subsidy provided to cover the deficit. Conversely, if the enterprise is subject to increasing costs, the surplus brought about by marginal-cost pricing may be turned over to general funds, or to some cherished nonhighway purpose. In the happy event that marginal costs equal average costs the problem vanishes.

Hotelling's Proposition. —Reasoning from the condition of decreasing costs, Hotelling (2) advanced the following thesis:

> ...that all taxes on commodities, including sales taxes, are more objectionable than taxes upon incomes, inheritances, and the site value of land; and that the latter taxes might well be applied to cover the fixed costs of electric power plants, waterworks, railroads, and other industries in which the fixed costs are large, so as to reduce to the level of marginal cost the prices charged for the services and products of these industries.

Hotelling's proof rests on the contention that a commodity tax (e.g., a gasoline tax), by increasing the price and thus reducing the demand, causes both consumers' surplus and producers' surplus to diminish. He demonstrates by diagram that the net sum of benefits under the conditions of a commodity tax will be less than that under the conditions of no commodity tax by an amount proportional to the square of the tax rate. His thesis is stated in more general terms as follows:

> If government revenue is produced by any system of excise taxes, there exists a possible distribution of personal levies among the individuals of the community such that the abolition of the excise taxes and their replacement by these levies will yield the same revenue while leaving each person in a state more satisfactory to himself than before.

It is odd that advocates of substantial public or nonuser participation in highway tax support have not seized upon the Hotelling article as justifying a truly prodigious nonuser share. Perhaps the thought that railroads and other utility enterprises would partake in like manner has deterred them.

Criticisms of Marginal-Cost Pricing. —Hotelling's proposition has been criticized both within and outside the fraternity of welfare economists. Those who are inclined to look coldly on the tenets of this group have attacked on two flanks: First, by assaulting the very fundaments on which the structure of welfare economics is erected; and second, by chipping away at the structure, stressing the difficulties and uncertainties of applying marginal-cost pricing to public utilities and government services, or even to modern business firms. Welfare economists have departed from Hotelling's thesis by reinterpreting the costs of alleged decreasing-cost industries—highways in particular—in such wise that marginal costs exceed or at least equal average costs, as revised.

Little, in a 1951 paper (3), held that the validity of Hotelling's thesis depends on the condition that the supply of labor is not a variable, and concluded as follows:

> If any general conclusion can be risked, it is simply that the best taxes are those on goods for which the demand is least elastic. The same holds true for subsidies. Income tax, which is a subsidy on leisure, is not exceptional. Only in so far as the demand for leisure is highly inelastic is it a good tax. The purely theoretical "case against indirect taxation" is an illusion.

Little's most telling strictures against welfare economics are found in his treatise, "A Critique of Welfare Economics" (4), much of which is devoted to establishing that modern welfare economics, as well as the earlier utilitarian economics, is based on value judgments and is thus prescriptive rather than descriptive in intent. He then proceeds to analyze and restate its basic propositions, which under his hand are shown to be of much less significance and certainty than they appeared to be as originally stated. Directly to the current purpose is Little's comment on marginal-cost pricing in his conclusion (p. 278):

> In particular, we found that the theorem that output ought to be adjusted until price equals marginal cost is extremely shaky, and we did not feel justified in taking much notice of it except in a few special cases. This theorem is the most important and the most controversial conclusion of welfare theory. It lies behind many of the widely accepted practical implications of economic theory. It is highly controversial because it is the only one of the 'optimum' conditions which also has serious political implications. The fact that I cannot bring myself to believe that the distinction between average and marginal cost is, more than very seldom, of the slightest importance to the welfare of society, has led me to the view that this branch of economics—pure static welfare theory—is, or rather should be, of little or no political import.

And again (4, p. 279):

> The commonsense argument that if the market value of one thing is twice that of another, then it is usually worth producing if it does not cost more than twice as much—ambiguous though it is—is probably just as valuable, and is certainly less misleading than such conclusions as 'price ought to equal marginal cost'.

Samuelson (5) devoted a chapter to an exposition of welfare economics. If anything, he is even more genial in his approach than Little, although he is equally insistent that the ethical content of welfare economics be recognized and acknowledged by its practitioners. In his conclusion he emphasizes two points: First, that in the real world adjustments must be made to compensate for the fact that a number of the optimum conditions essential to the application of economic welfare principles will not be realized; and second, that "...the introduction of dynamic conditions into our analysis necessitates a considerable change in the statement of optimal conditions." Of marginal-cost pricing he states:

> Thus, in a world where almost all industries are producing at marginal social cost less than price (either because of monopoly or external economies) it would not be desirable for the rest to produce up to the point where marginal cost equals price.[2]

Coase (7) discussed the views of Hotelling and similar views advanced by Lerner (8), Meade and Fleming (9), and others. Although admitting the theoretical advantages of marginal-cost pricing, even under conditions of decreasing costs, he adds: "But for the same reason it can be argued that the consumer should pay the total cost of the product. A consumer does not only have to decide whether to consume additional units of a product; he has also to decide whether it is worth his while to consume the product at all rather than spend his money in some other direction. This can be discovered if the consumer is asked to pay an amount equal to the total costs of supplying him; that is, an amount equal to the total value of the factors used in providing him with the product." Elsewhere he says: "We thus arrive at the familiar but important conclusion that the amount paid for a product should be equal to its cost." Coase also objects to the fortuitous redistribution of national income that would occur as a result of subsidizing the customers of decreasing-cost industries at the expense of the customers of increasing-cost industries.

To the dilemma he describes Coase finds a solution in multi-part pricing, "... well known to students of public utilities...," in which the consumer is made to pay the total cost of providing the product or service by a system of one or more charges additional to, and applied differently from, the basic charge subject to marginal-cost pricing. It is evident that something like this has occurred in the pricing of highway services, where motor-fuel taxes, the basic charge for use, are supplemented by weight-graduated registration fees at the State level and by manufacturers' excise taxes at the Federal level. Additional use charges are (a) the Federal taxes on tires, tubes, and rubber, (b) State mileage or weight taxes, and (c) toll charges. It can hardly be said, however, that the use charges, or any of them, are, by design, pitched at the level of marginal costs of highway provision.

The multi-part pricing position was taken by Brownlee and Heller (10), who stated:

> The problem contains elements of the well-known difficulty of a decreasing cost industry where, if prices were set equal to marginal costs, total receipts would be less than total costs. If prices were set equal to average costs, too little of the service would be used. In such cases charges for the privilege of using the system and prices equal to marginal costs have been considered

[2] Samuelson's gentle but skeptical appraisal is further evidenced by his remark, in an appreciation of Hotelling's work (6), "Suffice it to say that Hotelling's theorems can be defended from all criticisms, and form the springboard for an attack on the more difficult problem of what is the best compromise when all price and marginal costs cannot be equated for feasibility reasons."

> the desirable solution. However, in the case of highways, what constitutes the marginal costs of any service is far from settled.

It should be recorded that Brownlee in a later paper (11) states, "One will contend that, for the most part, highway services are such that if they were priced and if costs were computed appropriately, one would be supplying his 'needs' when one produced that amount such that the price—the amount charged for a passage by a particular vehicle—equals the cost resulting from that passage."

Numerous economists have spoken irreverently of the rule, as Lerner named it, of marginal-cost pricing. Radomysler (12) attacks the basic tenets of Lerner's "Economics of Control" (8) on the ground that they are not abstractions from reality, but abstractions from unreality. For example, he says: "Propositions like these, it is usually believed, are only part of the truth; there are in reality, it is usually argued, many disturbing factors. This qualification, however, does not make these propositions any more true than they were before; for what is wrong with statements like these is that they contain no truth at all."

Gordon (13) proceeds, in a sense, to document this charge. His article is primarily addressed, not to government enterprises and decreasing-cost industries, but to marginal-cost pricing as applied to price and output decisions in private industry. He considers and deals with four "essential characteristics" of marginal-price theory, of which only two need be discussed here. The first is that "...business men seek always to maximize profits...." He points out that business men are often guided by non-pecuniary and semi-pecuniary motives as well as by the criterion of maximum profits. The necessity for strategy in dealing with competing firms, with organized labor, and with those from whom capital is to be got, continually dilutes and deflects the pure profit motive, as do the personal traits and limitations of the executive and the pervasive urge for liquidity and security. "These conditions suggest that many business men are likely ... to substitute the principle of satisfactory profits for that of profits maximization. These considerations also suggest ... that business men may seek to use average total rather than marginal cost as a guide in pricing in order to achieve satisfactory profits."

A second essential principle of welfare economics is stated by Gordon (13) as follows: "Profits are maximized in a limited number of directions and it is sufficient in many cases to consider adjustment in only one direction (output)." He points out that business decisions depend on a wide variety of interrelated variables, and battles vigorously against the practice (and implied belief) of economists in picturing demand, cost, price, etc., as single-valued continuous functions of output (the familiar geometric representation illustrated in Figs. 1, 2, and 3). As a particularly disturbing variable he mentions selling costs as distinguished from production costs. One immediately envisions the raucous-voiced washing-machine salesman and the not-so-hidden body of the girl demonstrating an "improved" home permanent—for a million dollars spent on high-pressure advertising can completely alter the cost-price-demand-output relationships of a given product.

These thoughts bring one at once to the central thesis of Galbraith (14) that, through advertising, the demand for goods and services is created along with the goods and services to satisfy it; and that the modern economy, or at least its private sector, is thereby sustained and enabled to function:

> As a society becomes increasingly affluent, wants are increasingly created by the process by which they are satisfied .... If production is to increase, the wants must be effectively contrived. In the absence of the contrivance the increase would not occur. This is not true of all goods, but that it is true of a substantial part is sufficient. It means that since the demand for this part would not exist, were it not contrived, its utility or urgency, ex contrivance, is zero. If we regard this production as marginal, we may say that the marginal utility of present aggregate output, ex advertising and salesmanship, is zero.

There is, of course, no shortage of economists to defend the orthodox position in pricing theory, and to insist that, with the sophisticated methods of analysis now available, the propositions of welfare economics can be extended to account for the numerous variables that tend to invalidate the simpler theorems. The criticisms cited and discussed in the foregoing do suggest that (a) the structure of welfare pricing theory is not impregnable but rather a bit shaky; (b) the engineer or public official with planning responsibilities is not obligated, under either equity or theoretical considerations, to accept out of hand a taxing or toll scheme based on marginal-cost pricing; (c) in any situation where a marginal-cost pricing scheme is urged as a substitute for existing financing based on the recovery of public outlays, the burden of proof rests on those proposing the substitution; and (d) all such proposals should be examined and tested closely for their social and popular acceptability, for their soundness as elements of the structure of public finance, for the consistency of their objectives with observed trends in the growth and development of the affected area, and for the conformity of those objectives with long-range regional plans tested by the same standards. In short, the criteria of enlightened public policy do not appear to depend very heavily on marginal-cost pricing.

Mohring's Formulations

Because of its simplicity and directness Mohring's demonstration (15, p. 70ff) will serve well to introduce the principle of congestion-toll pricing. It starts with the concept that the average speed of a vehicle in traffic is a continuous, single-valued function of the volume, as exemplified by the lower curve of Figure 5 of the "Highway Capacity Manual" (16, p. 31), which expresses the relation of average speed and volume on main highways as a line fitting the following equation:

$$\text{Average speed} = 48 \text{ mph} - 0.009 \times \text{vehicles/hour}$$

Here time is taken as the element of cost, and Mohring illustrates the marginal trip-time cost by taking the case of a 48-mi trip and finding the sum of all trip times at traffic volumes of 700 and 699 vph and taking the difference. With trip time equal to distance divided by average speed the calculation is $(N + 1) \frac{48}{48 - 0.009\,(N + 1)} - N \frac{48}{48 - 0.009\,(N)} = (700) \frac{48}{41.700} - (699) \frac{48}{41.709} = 805.7560 - 804.4302 = 1.3258$ hr $= 79.55$ min.

This, in terms of time, is the cost of adding one more vehicle to the traffic stream, as distinguished from the average time cost or travel time, which is 805.756/700 = 1.15108 hr, or 69.06 min. The difference, 10.49 min, is the additional time cost imposed on the other 699 vehicles by the 700th, or marginal vehicle, because it will consume 69.06 min on its own trip.

Figure 4 illustrates the application of marginal-cost theory to this situation. The average and incremental or marginal time-cost curves are plotted to scale from the example previously discussed. The demand-function curve is imagined. The significance of the diagram may be explained in Mohring's words:

> If no tolls were charged, D′ trips per hour would take place. At this level, some driver would just be willing to make a trip if it cost him only the travel time associated with D′ trips per hour. At any level of traffic above D, however, some drivers would be making trips with net values to them of less than the additional costs these trips impose on the remaining drivers. Only at an hourly traffic volume equal to or less than D would each driver place a net value on his trip equal to or greater than the total costs it imposes on other drivers. Only at D, then, would total benefits (the area under the incremental travel time cost function) be maximized.
>
> At this optimum traffic level, the incremental cost and demand functions intersect each other. This level of traffic would develop only if the total cost of a trip is DB. However, if D trips are taken, the travel time cost of a trip is only DA. If only D trips are to be made, an additional amount equal to AB must be charged each driver.

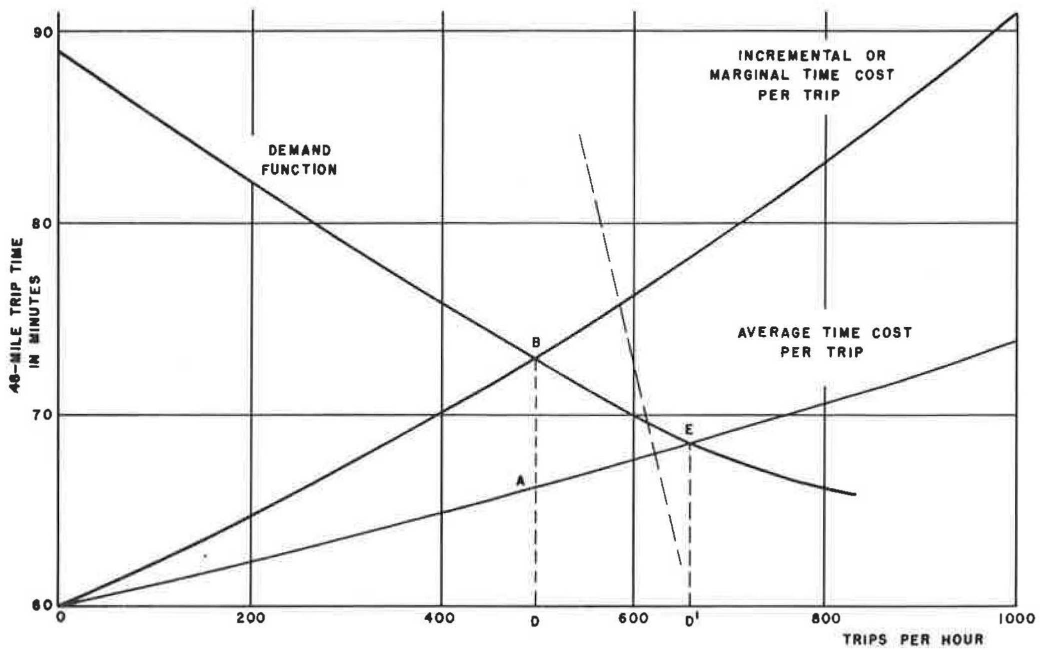

Figure 4. Illustration of average and marginal trip time costs.

Comments on the Congestion-Toll Concepts. —Although Mohring and others have carried the development much further, introducing costs of highway provision as well as other "social" costs into the equations, it is well to pause and examine this elementary formulation, as it underlies all of the more advanced formulations. It presents, ostensibly at least, a simple case of marginal-cost pricing. Because marginal costs exceed average costs, time-delay or congestion costs offer the opportunity of converting the decreasing-cost situation prevailing in public outlays for the provision of highways into a situation of increasing costs.

There is, however, a quirk in this formulation to which the lay observer, particularly one who regards himself as a road user, reacts at once. The motorists are to be charged for the time delays they cause each other. It seems adding insult to injury first to recognize that time delay is a cost to him, and then to say that he must pay, in order to maximize his own benefits, a tax that will cause the cost to leap from the average to the marginal point. This is an unfair attribution, inasmuch as Mohring states (15, p. 79): "Such a tax would, of course, also provide funds to cover the capital costs of the highway." Indeed, he seems to regard the congestion-cost principle primarily as providing a rationale for the existence of user taxes rather than as the occasion for increasing their magnitude.

Another glance at the example previously given may prove rewarding. The total time delay caused to the other 699 vehicles by the presence of the 700th is $10\frac{1}{2}$ min; but the time delay paid for is $10\frac{1}{2} \times 700$, or 7,350 min, inasmuch as each user is taxed for the delay caused by the single unidentifiable marginal vehicle. This seems odd, but it is consistent with marginal-cost pricing, which sets the unit price at the cost ($10\frac{1}{2}$ min plus the actual travel time of 69.06 min) of producing one additional unit.

To put it another way, the removal of the 700th vehicle would reduce the travel time for the 48-mi trip from 69.0648 min to 69.0498 min, a reduction of 0.0150 min (or 0.90 sec) in the travel time of each vehicle making the 48-mi trip. At the AASHO "Red Book" (17) rate of $1.55 per hour or $0.0258 per min for the value of time, the toll charge of 10.49 min amounts to about $0.27. This seems a high price to pay for so small a savings in travel time. Again this is unfair to the author, for the toll is not proposed as a charge for the time savings but as (a) a toll for the trip itself, (b) a means of rationing and thereby reducing travel, and (c) a source of funds for financing the highway.

But still this seems a rather strange way to handle time savings. Engineers are wont to think in terms of the rather extraordinary savings in travel time brought about by road improvements, and to stake their financial plans on the willingness of users to pay money in taxes or tolls for the time saved. To invoke what appears to be a penalty charge on congestion is likely to impress them as a negative approach.

In concentrating on the desirability of reducing travel time and other vehicular or so-called social costs, those urging congestion pricing have tended to neglect the prime objective of a highway, and indeed to neglect the product. The product, as Figure 4 will remind one, is trips, vehicles per hour, or, in the broadest sense, vehicle-miles. As a reasonable social objective one may perhaps advance that of maximizing the number of trips, the number of units of product that the road may deliver within a given time. It is shown in the "Highway Capacity Manual" (16, p. 38) that the practical capacities of highways are reached at average speeds well below the desired speeds of motorists. It is therefore necessary for the highway planner, the design engineer, and the traffic engineer to arrive at compromises between the ideal of swift, unimpeded travel and the ideal of the efficiency of a road in delivering vehicles per hour, per day, or per year.

Some quotes from the "Highway Capacity Manual" (16) may clarify this point. On page 45 it is stated:

> On most main rural highways, operating conditions are considered satisfactory for the average driver when the operating speed is 45 to 50 miles per hour during all but a few of the peak volume periods in a year.

The manual goes on to state that under these conditions about 70 percent of the drivers will experience some effect of congestion; and cites the exception of toll roads, other high-type rural facilities, and regions in which congestion is rarely experienced, where "... drivers might consider a highway unreasonably congested when those who so desire could not average 50 to 55 miles per hour ...." The statement is then made (p. 46):

> On urban facilities with uninterrupted flow, an operating speed of 35 to 40 miles per hour, resulting in an average speed for all traffic of 30 to 35 miles per hour, is considered reasonable.

A two-lane road, under ideal conditions, will accommodate 900 passenger cars per hour at operating speeds of 45 to 50 mph; but, "The corresponding figure for an operating speed of 50 to 55 miles per hour is 600 passenger cars per hour." Thus a gain of 5 mph in operating speed is accompanied by a one-third reduction in the maximum practical capacity of a two-lane road. On multilane highways capacities are greater, but the same principle holds (p. 47):

> The maximum practical capacity of multilane freeways in urban areas, when access and egress facilities are not a factor, is 1,500 passenger cars per lane per hour in the direction of the heavier flow. At this volume, drivers who so desire can safely maintain an overall speed of 35 to 40 miles per hour, although the average speed of all vehicles will be 30 to 35 miles per hour. Also, exceptionally high volumes that occur frequently for short periods can be handled without complete congestion.

Thus, the practical capacity of a road can be realized only at a sacrifice of average speeds, an increase of average trip times. Since publication of the "Highway Capacity Manual" in 1950, progress in vehicular and highway design has tended to increase both lane capacities and the average speeds at which they can be attained; but the principles of highway capacity remain the same.

In a static situation (no road improvement in prospect) the highway official tends to optimize on the basis of maximum practical capacity, which maximizes the output of vehicles per hour at an acceptable level of congestion. In achieving this end the official recognizes that during offpeak hours average speeds will rise and trip times will be reduced; that there will be brief periods of high congestion when the word "tolerable" must be substituted for "acceptable;" that semioccasionally, due to weather, accident, or some other contingency, there will be a real traffic jam; and that he is accepting a calculable level of accident incidence.

In planning and designing a highway construction program, the highway official's objective is to provide equal or greater capacity at higher speeds; but he is again mindful of the necessity to compromise by allowing for maximum capacity consistent with an acceptable level of congestion during peak periods. This concept is built into the principles of highway design; an example is the 30th highest hour proviso.

Are these rules of engineering conduct exemplified in Figure 4? Does the point of intersection of marginal time costs with demand represent the compromise between capacity potential and desired speeds described in the quoted excerpts from the "Highway Capacity Manual?" The answer seems to be that, since the functional relation between capacity and speed was not utilized in the diagram or in the underlying mathematics, it would be only a coincidence if the two points were identical. If they are, then the diagram exemplifies present conditions and practices, except for the suggestion of a toll charge to protect the road from exceeding its practical capacity.

If the points are not identical, and the output OD is below the practical capacity of the road, one has the problem of those potential users whose presence would swell the traffic to practical capacity, but whose valuation of the trip is less than that represented by line DB. Most of these would-be users would be found among those less able to meet the stipulated expense. Without grieving unduly over their plight, and disregarding for the moment the fact that Figure 4 deals with time costs only and not with costs of highway provision, one may pose the question whether equity might not be better served, and indeed a truer maximization of benefits achieved, by setting the price of admission at average highway costs, rather than including a surcharge based on the marginal costs of congestion. (In nontechnical language, it will be hard to convince the layman that a poor man's car should be ruled off the road when he can pay the average costs but cannot afford to pay the marginal congestion costs.) This leads to the further question of whether this model, and the more advanced ones that follow, are not incomplete, in that the demand function, taken alone, fails to account for the social utility of traffic service up to the point of practical capacity.

If the shape of the traffic demand function is greatly different from that portrayed in Figure 4, numerical relations will be altered without disturbance of the theory. The almost vertical dash line on Figure 4 is not Mohring's, but was drawn to suggest the condition of a quite inelastic demand in the region where it intersects the marginal and average cost curves. Under these circumstances very little reduction in traffic volume would be brought about by the surcharge, and the chief motivation for setting the price at marginal congestion costs would be to produce a surplus for use in some desired nonhighway enterprise (assuming highway costs are accounted for).

Pigou's Two-Road Problem

A problem or illustration by Pigou (18) has become a classic, indeed a sort of basing point for the application of marginal-cost theory to highway pricing. A demonstration of the Pigou two-road problem is given in a 1956 treatise by Beckman, McGuire, and Winston (19, pp. 83-87). As stated by Pigou, it is the case of two roads between two points, one of them broad enough to carry all the traffic that may wish to use it, but of poor quality; the other a much better road but narrow and of limited capacity. The total flow between the two points is assumed fixed. In the absence of a toll an equilibrium between the traffic on two roads is established at the point where the average costs to the users are equal. It is demonstrated that this equilibrium point is not the point of minimal total costs because of the social costs imposed on all users of the better road by marginal users. Beckman's proof is the more general in that it does not assume the inferior road to have indefinitely great capacity.

Formulations Involving Capital Costs

Until quite recently studies of the efficiency of roads and road networks and of "efficiency" or congestion tolls have been directed toward optimizing the use of the existing road network, and have been concerned little or not at all with the problem of relating congestion-based charges to the cost of providing a continuously expanding road network. The early theorem of Pigou (18) and the more recent work of Beckman, McGuire, and Winston (19) are cases in point. The very recent work of Mohring and Harwitz at Northwestern University (15), of Mohring at the University of Minnesota (20), and of Strotz at Northwestern (21) includes capital highway costs as a term in the equation of net benefits to be maximized, thus producing a marked advance over those treatments assuming a fixed highway plant.

Mohring's One-Road Fixed-Demand Theorem. —Mohring's main contention, implemented by a series of theorems using successively less restrictive assumptions, is that, in the absence of noncompetitive elements:

> Employment of two quite simple operating rules would lead to both a Pareto-optimal utilization of an existing (perhaps non optimum) transportation network and, ultimately, a long-run optimum network. These rules are: (a) Establish short-run marginal cost prices for the use of each link in the existing network; and (b) alter the size of each link to the point where toll revenues equal the costs to the authority of providing that link ....[3]

His first and most simple example is that of a single road between two cities. The rate at which trips are taken depends only on the private cost of a trip, hourly, daily, and seasonal variations being ignored. Private trip cost has two components—whatever toll, T, is charged, and the value of the time required for a trip. Other trip costs are ignored, and the unit value of time, v, is assumed to be the same for all travelers. Travel time per trip depends on N, the number of trips per hour and the quality of the road as indicated by its capital value, K.

If f(n) is defined as the demand function (i.e., the demand price associated with an output of n trips per hour), t(N, K) is defined as the trip time associated with N trips per hour, and r is the rate of interest associated with highway investments, then the equation for the net social benefit of using this highway can be written as

$$B = \int_0^N f(n)dn - Nvt(N, K) - rK \tag{1}$$

The optimum toll is obtained by differentiating this equation with respect to N, or

$$\frac{\partial B}{\partial N} = f(N) - vt(N, K) - Nv\frac{\partial t}{\partial N} = 0 \tag{2}$$

By definition f(N) is the demand price associated with N trips. If this expression is equated to the private cost of a trip, so that f(N) = T + vt (N, K), then substitution in Eq. 2 gives:

$$T = Nv\frac{\partial t}{\partial N} \tag{3}$$

The right-hand expression, giving the value of the optimum toll, can be shown, as in the case of the fixed-plant solution, to be equal to the difference between the average and the marginal time costs of a trip.

[3]Strotz (21, p. 4) defines the Pareto-optimal situation as follows: "By a Pareto optimum is here meant a state such that no change in the decision variables under public consideration could make any individual better off without making someone else worse off."

The optimum capital value for the highway is obtained by differentiating B in Eq. 2 with respect to K and equating to zero, giving

$$-Nv \frac{\partial t}{\partial K} = r \tag{4}$$

To quote Mohring (20, p. 6): "In words, the capital value of the highway should be altered to the point where the congestion cost saving per time period resulting from an increment in capital value just equals the capital charge on that increment."

The final step in the demonstration is to show, by the use of homogeneous functions that (a) if providing the road entails constant returns to scale (i.e., simultaneous increases of the same percentage in traffic and capital value would leave trip time cost unchanged) the total toll collections equal the capital charges; (b) if providing the road entails increasing returns to scale (less than proportional costs for a given increase in traffic) toll collections will fall short of capital costs; and (c) there will be a surplus if providing the road entails decreasing returns to scale.

Steps in Generalizing the Theorem.—The second step in the demonstration is to move from the one-road, fixed-demand case to the one-road, variable-demand case, taking account, in particular, of the hourly variation of traffic volume. This is accomplished by expanding the nomenclature so that the significant variables are expressed in terms of the time period, i, and the equation of net benefits involves the summation of benefit and congestion cost terms from i = 1 to i = m. The result is a generalization of the proposition to cover the more complex condition. The analysis then moves to the two-road and two-mode cases. In the two-road case, in which the sum of traffic on the two roads is assumed constant, the object is to determine the optimum difference in tolls between the two roads; and it found that the difference in tolls should be such that the difference in time costs by roads A and B to the individual who, by reason of the toll differential and his own valuation of time, is indifferent between the two, should equal the difference between the costs an additional trip on roads A and B would respectively impose on the remaining A and B drivers. It is further found, under the conditions of constant return to scale, that the difference in optimum interest costs per trip "... precisely equals the optimum difference in the tolls per trip on these roads. Thus, if the highway authority levied 'equitable' tolls—i.e., if it charged each driver on each road the interest costs incurred in his behalf ... —it would not only just cover the costs of the two roads but would also guarantee a cost minimizing allocation of traffic between them" (20, p. 14).

The two-mode case, dealing with the problem of the toll differential between two modes of travel, such as auto and bus, occurring on the same highway, is essentially the same. There the demonstration shows that the difference in bus and auto tolls should equal the difference between the costs an additional trip by auto would impose on the remaining travelers and the costs an additional trip by bus would impose on them.

Further Steps in Mohring's Analysis.—Under "The Costs of Urban Transportation" Mohring (20, pp. 17-23) develops functions and values for average and marginal operating, time, and accident costs, as functions of the volume-capacity ratio. A striking feature is the facility with which data from traffic and other highway engineering research are adapted to an economic analysis. The author's purpose is to illustrate rather than to prescribe and he freely acknowledges instances where he makes bold assumptions or incurs the liability of bias. It is not unfair, however, to cite points in the analysis where, if he had taken a different turn in the road, he would have arrived at more moderate results.

Mohring develops approximations of the average unit value of time from a refinement of the trade-off method, which assumes that a motorist who travels, or desires to travel at, say, 70 mph values time at a rate such as to compensate him for the extra cost of driving at 70 rather than at a lower rate.[4] For this purpose he derives from curves shown in the AASHO "Red Book" (17, pp. 100-126) equations relating gasoline consumption, oil

[4] Mathematically it is a question of minimizing costs. If C = costs per mile, S = speed in miles per hour, v = value of time in dollars per hour, and other costs are represented by a function of speed, f(S), then $C = v/S + f(S)$. Differentiating and equating to zero, $dC/dS = -vS^2 + f'(S) = 0$; $v = S^2 f'(S)$.

consumption, and tire wear to desired speed, and solves for the value of time by the trade-off method. The combined effect is to produce travel-time values varying from -$0.02 per hour at a desired speed of 20 mph to $0.62 per hour at 40, $7.38 per hour at 60, and $67.82 per hour at 70 mph.

The extraordinary upswing of these values at high speeds is explained by the parabolic equation for gasoline consumption, miles per gallon = $13.2 + 0.40S - 0.0076S^2$ (S being the speed) which gives a value of 4.0 miles per gallon for an automobile at 70 mph. This is much below values encountered when measurements have been made, and calls to mind the danger of extrapolating values from parabolic curves in the vicinity of their reach toward the infinite.

Haikalis (23) uses the variation of operating costs with speed to develop, by the trade-off method, unit values of time varying from zero or a slight negative value at 20 mph to $1.86 at 60 mph. A refinement of his procedure, produced by smoothing slightly the operating cost values, passing a parabola through them, and differentiating to obtain the value of v, yielded values varying from a slight negative at 20 to $0.54 at 40, $2.57 at 60, and $4.44 at 70 mph. This parabola has no greater claim to validity than Mohring's, but at least the extrapolation does not run wild at 70 mph.

Using a reference to the "Highway Capacity Manual" (16, p. 32) indicating that "... desired speeds on high quality, straight level rural highways are approximately normally distributed with mean and standard deviation of 48.5 and 8 miles per hour respectively...," Mohring integrates his time-value differential equation, and obtains a mean value of approximately $2.80 per hour. This figure is by no means out of range of recent efforts to estimate the mean of values that motorists place on time savings; but it is clear that this mean, as computed, is heavily weighted by the very high values of high speeds produced by the parabola previously discussed. The value of $2.80 is cited as indicative that the $1.55 per hour value recommended in the AASHO "Red Book" is too low. Although there is no reason to accept the AASHO figure as sacred, the Haikalis values indicate that relatively low figures for the unit value of time may not be amiss.

In the absence of a body of evidence to the contrary, Mohring accepts indications in the AASHO "Red Book" of a counterbalancing effect of traffic volume and speed on operating costs under rural operating conditions. In the application to urban arterials, however, he invokes the findings of Haikalis and Joseph (24, p. 55), to the effect that "... both vehicle and accident costs for a trip segment were found to be negatively related to the average speed for that segment..." (20, p. 27). The Chicago Area Transportation Study function for accident costs shows them to vary from $0.0675 per vehicle-mile at 5 mph to $0.0180 at 20, $0.0055 at 30, and $0.0015 at 60 mph.

In the analysis Mohring, by matching the accident-cost, speed values with average speeds at different values of the volume-capacity ratio for arterial streets, obtains a steep variation of accident costs with increased percentage of capacity. There is grave doubt whether this is a legitimate procedure. Of this curve Haikalis (23, pp. 10-12) says in part, "Streets with low average speeds have high accident rates, and faster arterials and expressways have better safety records. A range of typical route segments was examined.... Accident rates were converted to costs based on the average cost per accident previously described." It is quite evident that this curve was developed from successive sets of accident cost data from ordinary streets, arterial streets, and expressways, and that the indicated speed variation is representative of average speeds on these three classes of highway, each of them designed for a different speed level.

In an earlier CATS report Hoch (25) goes somewhat more thoroughly into the implications of the data on which the Haikalis accident cost vs speed curve is based. One of Hoch's conclusions is as follows (25, p. 2):

> 3. There is some evidence that accident rates increase with traffic volume. Thus, if traffic volume on a street doubles, the number of accidents will more than double. This implies that, in the absence of expressway construction, average accident costs will increase over time.

The text discussion dealing with this relationship is rather less positive:

> In examining the scatter diagrams relating volume and accidents, there was some evidence that rates increased as volume increased. However, the evidence was not too strong. About half the streets examined appeared to have increasing rates with volume, while the other half appeared to have stable rates. Thus, Figure 3, page 25, plots the data for Cicero Avenue; accidents here appear to rise more than proportionately with volume. However, in Figure 4, page 26, for Ashland Avenue, accidents appear to increase proportionately with volume. (25, p. 24)

An increase of accidents at a rate proportional to traffic volume means that the rate per vehicle-mile is constant as the volume increases and hence constant at all average speeds. The most reasonable inference to be drawn is that, if adequate data were available, a separate and different curve of accident costs per vehicle-mile vs traffic volume or volume-capacity ratio could be drawn for each class of road and street—expressways, arterials, minor streets, 2-lane rural, etc.—and that only the average values for each class would become points on a curve such as that presented by Haikalis.

The foregoing suggests that if the calculations of congestion tolls were made with the greatest of care, the results would not be so frightening as they often are. Mohring's analysis results in a schedule of optimum tolls for arterial streets based on marginal operating, accident, and time costs. For a value of time of $1.55 per hour (AASHO rate) the optimum toll varies from $0.007 per mile at a volume-capacity ratio of 0.1 to $0.171 per mile at a volume-capacity ratio of 0.9. At a value of $3.00 per hour the toll schedule varies from $0.012 to $0.288 per mile (22, p. 17).

Mohring (20, pp. 33-52) offers a demonstration of the effects, in reducing daily congestion costs, or variable costs as they are called, of substituting successive increments of freeway capacity for arterial street capacity to carry the existing traffic load in Minneapolis-St. Paul. A rough calculation gave $2.25 million as the cost of freeways that would provide a vehicle-mile capacity equal to 1 percent of existing arterial street capacity. For the first 10 percent freeway increment, the daily savings in variable costs, at a time value of $2.80 per hour, is estimated to be $223,000, or $9,900 per $1,000,000 invested. At a time value of $1.55 the saving is $145,000, or $6,400 per million. At the higher rate the variable cost savings would recover the principal in 101 weekdays. For each successive increment the savings in variable costs is lower, but even at the final increment of going from 80 to 100 percent freeway substitution the savings at the $2.80 rate is $2,000 per $1,000,000 invested, and at the $1.55 rate it is $1,200, for a payout period of 833 days. He concludes: "Finally, even if no value were placed on travel time savings, the operating cost savings provided by this last increment of freeway capacity would aggregate to its capital costs in approximately ten years." (20, p. 52).

All this seems at first glance to be very good news for the freeway advocates—their rosy predictions of freeway benefits doubled and redoubled. The catch is that these striking results are produced by the enormous congestion costs on arterial streets that were built up in the course of the analysis. The implication is that congestion tolls on arterial streets, at the indicated high rates, should be used to finance the freeway system. It may reasonably be suggested that a more modest scale of charges, such as the existing user-tax system, Federal and State, would amortize the freeways at a more normal pace.

The Strotz Formulations.—Strotz (21) covers much the same ground as does Mohring's analysis. However, his treatment is more general, is more difficult for the amateur analyst to follow, and contains some features that appear to advance the theory a few steps further. His first "parable" deals with the one-road fixed-demand case; the second, with the two-road case. The latter differs from Mohring's two-road case (and from its progenitor, the Pigou two-road case) in that it does not assume the combined number of trips on the two roads to be fixed, the solution being therefore more general and less definitive. The fourth parable takes up the one-road variable-demand case, with the results in the same tenor as those of Mohring.

A distinguishing mark of Strotz's treatment is the fact that each equation defines a sort of cosmos (perhaps "closed circuit" would be a better term) in which the only economic activities are (a) highway expenditures, (b) expenditures on the-production-of-everything-else (defined as bread for simplicity), and (c) the taking of trips on the road. In parables one and two these trips are regarded as pleasure trips; or at least to have no economic attribute other than the cost, d, of making a trip. In the third parable the trips become work trips, and the fact is acknowledged that highways are a link in the chain of production. "The main change .... is that we can no longer regard the total amount of resources available as a fixed quantity. Instead we must consider R.... to depend upon the number of trips made by various individuals." (21, p. 31)

In the fifth parable the possibility is entertained that a rental component should be added to the user toll supporting the highway expenditure to compensate for the contribution to total trip costs by land occupied along any route to the city center. This is a form of argument for a nonuser component in highway taxation, although surely it does not embody all of the reasons that can be adduced for such a component in other contexts.

The results of both these exploits are negative. In the case of the work trips (made for "bread-making" purposes) the optimum toll is the same as for pleasure trips in the first parable; i.e., the amount needed to equate price and marginal trip cost. In the fifth parable it is found that the optimal condition of highway support requires no contribution from special taxes on land. The reason for these results appears to lie in the fact that the process of optimizing utility requires taking partial derivatives and equating them to zero. By this process the mutual relationships that appear so binding in the original equation become unshackled. Although the rental theorem may perhaps be dismissed as trivial in any event, the thought lingers that in the case of the bread-winning work trips a different formulation might cause the mutuality to persist even in the differential form.

The Walters Article and Comments Thereon

The British economist, Walters (26), developed a model for optimum tolls or taxes based on the marginal social cost approach. The model assumes a road system not subject to change and is therefore less advanced than those of Mohring and Strotz. Among other devices for collecting the charges his calculations require, he suggests an urban gasoline tax of $0.33 per gallon.

During the summer of 1962 three economists at the Bureau of Public Roads were asked by this writer to comment on the Walters article. Because the replies received are germane to the congestion-toll issue, they are reproduced in part here, the deletions being either extraneous or concerned with points peculiar to the Walters article. (Comments were also received from C. M. Grubbs of the University of Colorado, but since Professor Grubbs was a participant in the panel discussion for which this paper was prepared, his comments are not given here.)

Comments by Sidney Goldstein. —

> Professor Walters is analogizing the highway situation to that of the private business where MC and MR must be equal at the best profit position; depending on the extent of competitiveness in the industry, however, MR (marginal revenue) and price will deviate accordingly. The rationale is that if one can arrive at net marginal social cost and set the price at this point one would have the most efficient social arrangement. Implicit in this is the assumption of perfect competition in the private sphere, for it is only in that area that MC = MR = P at its best profit point. Setting price at this marginal social cost would imply that each person using the highway would be paying his full share for his marginal addition to social cost or congestion cost.

This argument falls flat because one can never really obtain true social cost (many amenities are not accounted for and various psychological factors are not included in market price). In addition, only by assuming no future highway construction to relieve congestion is the example valid. But if demand for highways is regarded as a dynamic activity always being upgraded technologically and improved to meet growing demands upon it, then a static approach to taxing congestion on road A-B is merely a logical exercise. It will push traffic to road C or may even remain the same until taxation gets out of all reasonable bounds.

Highway and other public works economists are not in complete agreement on whether only marginal costs or average costs are the proper means of establishing price or whether private industry concepts apply to highways. The author acknowledges this but believes that Meyer, Peck, etc., have erroneous notions about marginal cost pricing.

Professor Walters on page 677 assumes that traffic is homogeneous, all drivers are the same, and all vehicles have the same costs and speed, etc. He agrees that this is wholly unrealistic, but pursues his model in terms of these assumptions as though these were not people with individual preferences but water moving through a conduit pipe.

It is known from experience that costs of vehicles, maintenance, etc., have been no deterrents to motor vehicular use. This is because there are extra-economic factors that are given no consideration, or there are economic factors that cannot be valued in terms of dollars.

The writer is fully in accord with Kanwit's remarks that the administrative proposals for taxing congestion present more problems than they solve and the rural-urban dichotomy as described by Walters is rather extreme.

Walters gives no recognition to the regressive nature of the tax as being most burdensome on those least able to afford it. It would thus aim at keeping lower income individuals out of the cities and city centers, and tend to aggravate an already poor situation.

The proposal for built-in compensations or an equalization mechanism to turn over taxes collected in urban areas (page 697) to those in the local areas is currently already accomplished in a more painless and hidden fashion through the present user taxes. The use of congestion taxes in urban areas might well accentuate the dispersal of communities and industry.

The empirical data presented by Professor Walters were found to be weak reeds, indeed, upon which to hang such an all-embracing proposal.

Walters appears to have given little consideration to the redistributional effects on urban and rural structures that could be put into motion by the congestion tax. If this scheme is effective, the capital loss in building investment could be quite significant. To counter any such tendencies, alternative transportation investments must be considered in order to retain the current centers. Walters does not discuss this aspect, however. Neither is there any discussion of "equity" or a more equitable arrangement for taxation, such as incremental costs associated with different size vehicles, etc., or taxation of real estate and businesses benefitted by highways. In fact, this is dismissed on page 697 with the following statement: "Generally, urban car users will be injured by these arrangements and the reduction in the density of traffic will have various other repercussions on property owners—and on the automobile industry. It would be both difficult and tedious to try, at this state, to trace all the reactions in the various classes of the community."

Comments by E. L. Kanwit. —

The writer would not presume to attempt to unravel Mr. Walters' econometrics. Basically, I disagree with the attempt to apply the economics of competition to the highway. The public highway which is free and open to all cannot be equated with a monopolistic mode of transportation operated for private profit.

... The current situation can hardly be divided neatly into "urban" and "rural" situations. The extent of variation among "urban areas" (for example, Boston and Oklahoma City); the complete and utter dependence of the suburb on the motor vehicle; the fact that commercial vehicles would immediately pass on higher transportation costs; the essentially regressive character of his tax proposal, are neatly ignored.

Even more important would be the catapult-like effect on existing economic geography should the theoretical economic notions actually be permitted to go into effect. The centrifugal tendencies of residence and employment are already the most dynamic factors in the changing structure of American cities; Walters' proposals would be the coup de grace to the downtown core.

Actually, with some 90 percent of entrants into the Manhattan CBD using public transportation, and more than 80 percent of Chicago's, how much is left to accomplish which high parking, congestion, and urban highway backlog haven't already achieved?

Presumably the purpose underlying the toll suggestions is to maintain and increase concentration of activity at the urban core. I doubt if a more self-defeating proposal—in the long run—could be devised.

The trouble with Walters' logic is the old ceteris paribus bugbear. He assumes that the principal result of raising prices will be to create a more desirable equilibrium in precisely the same context in the situs of activity. To some extent, in the short run, this would be achieved with gross injustice to those whose behavior had been planned on entirely different pricing. In the long run, the partial equilibrium created to the dissatisfaction and annoyance of millions would unchain a series of reactions which would be as revolutionary as those which unrestricted "automobility" has created.

Comments by John Rapp. —

Essentially, Walters is purporting a theory of equating highway prices with the marginal social cost involved in their existence. The basic intent is to tax congestion. In developing his geographical analysis, he relates private costs to density of traffic. This concept of highway finance, however, fails to be of much usefulness. It does not really construct a supply function which relates the cost of highways themselves to the amount of highway service. Had this been done, the unit cost curve would be likely to decline over a wide range. This renders the analysis useless and illogical. In several places the graphs are improperly labeled, sloppily constructed, and contain misstatements.

The entire analysis implicitly assumes that no new highway construction will take place. Marginal cost pricing, Walters says, is appropriate only for the efficient utilization of existing facilities. A partial solution to congestion, however, is the construction of new highways. In the absence of new construction, congestion would only be relocated. For this reason, serious doubts can be raised concerning the applicability of marginal cost pricing to highways. He even states that the costs of providing highways are irrelevant to the highway tax problem.

Walters completely denies that there should be any attempt to obtain highway payments from the general public and landowners. This completely contradicts his criterion of efficient resource allocation. It is quite clear at this point that Walters is not acquainted with the real problems of modern highway finance. He proceeds to deny that there is validity in the standard of tax neutrality in highway finance. To deny this is to open the door to total inequity in highway finance.

His mathematical exposition is similar to many econometric treatments of price theory. He adds the element of congestion and implicitly makes the judgment that the reduction of congestion is the sole aim of highway taxation. His final formulas (Eqs. 7 and 10) are incapable of solution—this he admits. Further, there is no way possible to even make a reasonable estimate of the necessary data. Hence, no practical purpose is served—neither is any theoretical validity obtained.

Equity is, apparently, of no concern to Walters. The discrimination between urban and rural tax rates, his disregard for possible adversities resulting from his recommendations, and his disinterest in nonusers all testify to his lack of desiring an equitable solution.

The Demand Function.--Walters did, however, make the significant point that it is very difficult to determine the demand function on any road.

That is to say, the data available enable one to identify the cost curve, but the demand curve remains unidentified. The demand parameters are, however, very important for estimating the effects of road improvement as well as for the more menial task of fixing efficiency tolls (26, p. 686).

Mohring (20, pp. 21-27) gets around this difficulty by estimating the marginal cost (or rather, the excess of marginal over average cost) for different values of the volume-capacity ratio. Then, for any street or street network having a volume-capacity ratio of, say, 0.7, 0.8, or 0.9, the corresponding estimated amount is stated as the optimum toll. There seems to be an element of error in this maneuver. Before the congestion toll is imposed the price is equal to the average congestion cost plus the user-tax cost, which may be assumed to be less than the congestion toll based on marginal cost. The demand, then, is fixed by this price and not by the marginal cost. If TC is the user-tax cost, the following expression may be written for the price:

$$P = AC + TC < MC$$

Imposition of a congestion toll would produce a reduction in demand, which would be associated with a new (presumably reduced) value of marginal cost. It would be at best a matter of experimentation, or trial and error, to determine the point where the tax imposed becomes equal to the calculated marginal cost increment. The user might experience some discomfort during this experimental period, but then, so does the guinea pig.

There is a possibility that valid demand functions could be developed from traffic assignment models, which Walters dismisses, perhaps too summarily, with the statement: "Unfortunately there is no way of eliciting the characteristics of the demand curves from the engineers' results." (26, p. 687) Because assignment models customarily contain functions expressing the inverse variation of trip frequency with trip cost, there would seem to be a chance, assuming that data confirm their validity, of conversion to the terms of an economic demand-cost function.

The Gown and the Salesbook

An interesting contribution to the congestion-toll debate was made in 1959 by a university professor testifying before the Congressional Joint Committee on Washington Metropolitan Problems (27). The testimony in itself was not a significant contribution to congestion-cost theory, although the witness presented exhibits of previous work done by him in this field. It was distinguished by the fact that the professor brought with him, and introduced to the Committee, a salesman for a corporation manufacturing an electronic device by means of which a vehicle passing a point may be identified, its travel within a delimited area thus measured and recorded on a central computer, and the owner billed monthly for the amount of congestion toll due.

The combination of academic expertise with high-pressure salesmanship is not unknown to the American scene, but is always of interest to observe. This episode should at least suggest that economic factors and influences are at work that are not comprehended in the congestion-toll models produced to date.

It is not intended in this paper to consider the various devices that have been developed or suggested for metering the motorist's congestion tax or toll obligation. Their adoption is contingent upon the somewhat doubtful public acceptance of congestion tolls as a substantial factor in road-user taxation. One must, however, be alert for future contingencies. If vehicle propulsion systems become so varied that the motor-fuel tax is no longer a viable instrument for allocating and collecting road-user taxes, mechanical or electronic devices may prove to be the most logical means of metering highway use. This is uncomfortable to contemplate, but it has to be put on the list of things to be considered.

IMPLICATIONS OF CONGESTION-COST THEORY

For a mathematical model, whether in economics or in any other science, to gain acceptance it must pass three tests: (1) The assumptions on which it is based must be accepted as valid; (2) the mathematics must be impeccable; and (3) inasmuch as every model is an abstraction from real life, and therefore much simpler than actual conditions, the model must embody the essential sources of variation that are encountered in the real situation. The layman would better leave the mathematics severely alone; and he is quite likely to get out of his depth in exploring the basic assumptions. His best approach to the consideration of the applicability of such a formulation is therefore to ask if it does represent real conditions to a respectable degree; for the layman actually exists in real life and may have as much or more experience in the particular aspect of it than the formulator of the model. Caution must be exercised in the criticism, however. One may say that the model covers only static or short-run conditions, only to find that the eager economist is incited by this criticism to fabricate an even more baffling model to cover the long range. The comments given here are made in the spirit of inquiry rather than opposition. The effort is to examine the implications and the import of this system of formulas in the light of actual situations and the necessities of action in the field of highway transportation.

The Formulations in Relation to Changes over Time

The first reaction of one accustomed to paying user taxes is that these equations call for a form of double taxation, or at least double payment of vehicular costs. The user realizes that he is incurring costs in the form of time delays, strains and discomforts, and perhaps running costs, when he travels in congested traffic. To be asked to pay again for his suffering seems a little too much. It is true that he is being taxed for the delays and discomforts he causes his fellow motorists, but they too are asked to pay. He asks why he should incur these congestion costs twice.

To this objection there are two principal rejoinders. The first is that the object of the tax or toll is to maximize benefits rather than to penalize the motorist. The second is that the marginal cost of congestion, or rather, the difference between marginal and average cost, is a measure of the optimum value of the tax, the proceeds of which will presumably be used either to build and maintain roads or for some general purpose beneficial to all, if not to the users in particular.

These answers are not entirely satisfactory, partly because there is a certain ambivalence among the stated objectives of the advocates of congestion tolls. Mohring

(15, 20) and Strotz (21) throughout their analyses appear to regard the congestion-toll theory as a rationale for the enactment of user taxes and as a guide for the fixing of their magnitude. Their fomulations tend toward the proposition that, under most circumstances, a user tax can be found such that it will both equate to marginal social costs (i.e., congestion costs) and exactly meet highway costs at the same time. Beckman (19, pp. 99-100) in dealing with the two-road problem states: "From the point of view of the community the tolls do not constitute costs but are available again for redistribution or use in road construction and maintenance." Others, however, seem to disregard the relation of congestion tolls to public outlays for highway provision, and look eagerly toward their use as a source of subsidy for other modes of urban transportation, such as rapid transit.

Another difficulty, which has been noted by Mohring (15, p. 80), is that charges pitched to the marginal costs of congestion would tend to be high when the provision of highway service is inadequate and low when it is adequate. Thus, at least in its simplest form, the congestion-toll theory does not seem to provide for the case of a freeway program to eliminate congestion. The dilemma, if it can be so described, can be stated in another form. If the charges are based on existing congestion, the revenues they bring in will dry up (a) if they are successful in diverting motor vehicle traffic to rapid transit, or (b) if an adequate freeway system is built. The more formal and complete treatments of Mohring and Strotz, which include capital outlays in the equations, seem to eliminate this difficulty. One may be skeptical as to whether they truly represent the case of an accelerated program for providing a freeway network.

The issue is confused somewhat by the circumstance that so much of the capital outlay for highways is financed out of current revenues. Thus the users of completed highways are continually supplying the revenues for the building of new ones. This situation, which causes no anguish either to the users, to highway administrators, or to user-tax administrators, is most vexatious to some economists (28, p. 11) who speak of one class of road users "subsidizing" another. If a city or metropolitan area did not have a freeway system and one is now being built out of Federal and State road-user tax revenues, it is quite easy to say that the future freeway users are subsidized by millions of users of other roads, both rural and urban. That the freeway system gives every evidence of solvency in terms of earnings compared with annual cost is no deterrent to the charge.

Mohring's demonstration of potential freeway benefits in the Twin Cities (20, pp. 51-52) is a case in point. They will pay out in a very few years, even if there is a 100 percent substitution of freeways for arterials. But during the building period, surely, because the charges are to be based on congestion costs rather than on anticipated savings, the luckless users of the arterial streets will be paying the bills—"subsidizing" the freeway users of years to come.

The toll-road situation is the one preferred for model making, being viewed as a closed-circuit operation in which the users pay directly for the service received and toll collections are used to retire the debt and maintain and operate the road. Public (as distinguished from revenue) bond issues served by user-tax proceeds are a substitute, but one frowned upon by those more inclined toward economic niceties than toward the actual saving of user-tax monies. Two grounds of objection are: (1) Quite often such bond issues are backed by the full faith and credit of the State and, even when buttressed only by pledged user-tax revenues, they command interest rates much lower than those of toll-supported revenue-bond issues; and (2) During the construction period interest and retirement charges are paid out of the general pool of user-tax funds (i.e., the earnings of other roads), any special financing for "interest during construction" being thus avoided. Even toll facilities are not immune from this evil, if such it be, for today's tolls are continually being used to finance (a) increases in the capacity of the toll road itself by the addition of lanes and other improvements, and (b) extensions of the toll-road or toll-crossing system over which the toll authority has jurisdiction (29, pp. 26-43).

It is customary to avoid these twists and turns of financing by the introduction of an annual-cost term (such as Mohring's rK), to serve as the equivalent of any form of financing whatever. The uncertainty about the "true" value of the interest rate (values ranging from zero to 20 percent per annum (30) have been cited) is perhaps sufficient to suggest that expressions of theoretical annual cost, although often useful, are an inadequate abstraction from the real life of public investment financing. Indeed, if annual-cost expressions can truly perform the role of substitution, the question of whether to finance a highway program by means of general obligation bonds, toll revenue bonds, or current revenues is of no consequence. But the question is of consequence; decisions about financing enter into the summation of costs and benefits involved in long-range highway programs.

A model that would take adequate account of all the significant variables in highway planning and financing would be very complex, but perhaps not beyond the resources of mathematical economics and automatic data processing. It would need to be a dynamic model, taking account of variations over time, if only to allow for the business of this year's road-user taxes financing highways to be used in subsequent years. Introduction of the time dimension, not used in any of the formulations yet produced, would take account of the growth of traffic and the increase over the years in the extent and capacity of the highway network. The model would also have to deal with the community, business and income effects of the decisions made regarding highway taxation and financing, some of which are discussed later herein. It is possible that such a dynamic model embodying macro- as well as micro-economic effects, would find marginal-cost pricing playing a less prominent role than in the static models now under consideration.

Urban Highway Costs

The cost of constructing, maintaining, and operating urban highways and streets is one of the principal factors in the economics of congestion tolls. Both Mohring (20) and Strotz (21) have recognized this fact in writing highway cost terms into their equations, although it is questioned whether a single term in an essentially static equation can fully represent the effect of expanding and improving highway networks over time. The question of whether current urban highway and street costs are such as to require special urban user surcharges is therefore pertinent.

An interesting sidelight on this question is cast by Mohring's calculation, previously discussed, of the reductions in motorists' variable costs (operating, accident, and time) that would result from substitution of freeways for arterial streets in the Twin Cities (20, pp. 51-52). The results show, in effect, that, if congestion tolls were imposed at rates sufficient to recapture the cost reductions or benefits derived from the substitution, the freeways could be paid for in less time than it would take to build them. In this there is a suggestion that much lower user tolls or taxes would amortize the investment at a rate more normally related to the useful life of the facility. And this brings up the question of whether present methods of financing major urban improvements approach this desirable norm.

Nationwide Comparisons of Expenditures and Travel.—One of the indictments sometimes brought against present-day urban highway financing is that highway expenditures in urban areas greatly exceed either (a) the user-tax revenues made available for highways in these areas, or (b) the user-tax revenues generated in these areas. To the first of these charges there is some substance because benefit assessments, property tax revenues, and local general funds still supply much of the revenue for local city streets. To the second charge there is little or no foundation. Neither is there any basis to the claim that urban motor vehicle travel is subsidized by rural travel.

Table 1 gives a comparison of expenditures and travel on rural and municipal roads and streets in 1961. The expenditure figures include all funds, Federal, State, and local, applied to highways in that year. Expenditures on all roads and streets were $10.8 billion, of which $7.1 billion or 65.1 percent was spent on rural roads and $3.8 billion or 34.9 percent was spent on municipal highways and streets. In contrast, the estimated travel on rural roads was 398 billion vehicle-miles, 54.0 percent of the total, and that on municipal highways and streets was 340 billion vehicle-

TABLE 1

COMPARISON OF DISTRIBUTION OF 1961 HIGHWAY EXPENDITURES ON RURAL ROADS AND MUNICIPAL ROADS AND STREETS[1], WITH CORRESPONDING DISTRIBUTIONS OF 1961 MOTOR VEHICLE TRAVEL[2]

Item	Rural	Urban	Total
Expenditures ($ million):			
Capital outlay	4,365	2,429	6,794
Percentage distribution	64.25	35.75	100.00
Other expenditures:			
Maintenance	1,905	842	2,747
Highway police and safety	192	159	351
Administration and research	344	175	519
Interest on highway debt	253	174	427
Subtotal	2,694	1,350	4,044
Percentage distribution	66.62	33.38	100.00
Total expenditures ($ million):	7,059	3,779	10,838
Percentage distribution	65.13	34.87	100.00
Vehicle-miles of travel (millions)	397,902	339,633	737,535
Percent distribution	53.95	46.05	100.00
Expenditures (¢ per veh-mi)	1.77	1.11	1.47

[1]Source: Table HF-2, Department of Commerce release BPR 63-2, January 13, 1963. State expenditures for highway police and safety, administration and research, and interest on highway debt prorated to State and local rural and urban roads in proportion to distribution of capital outlay and maintenance. Federal expenditures for administration and research estimated 60 percent rural and 40 percent urban.
[2]Source: Table VM-1, 1961, "Highway Statistics 1961," p. 25.

miles, or 46.0 percent. In terms of expenditures per vehicle-mile these 1961 totals amount to $0.0177 for rural roads and $0.0111 for municipal highways and streets. It is quite apparent that, if there is a "subsidy," it flows outward from the cities rather than inward from the rural areas.

Evidence of the Section 210 Study. — Table 2 consists of a series of comparisons made with the data on estimated highway needs that were collected as a part of the highway cost allocation study project conducted under the terms of Section 210 of the Highway Revenue Act of 1956. The data are given for all highway systems, including Interstate, other Federal-aid primary, Federal-aid secondary (State and local), other State highways, and other roads and streets. Each system group is divided into rural and urban components. The data are tabulated in terms of the cost, in cents per vehicle-mile, of a 16-year improvement program (1956-1972) based on the highway needs estimates made for all road and street systems as a part of this study. Thus the calculations for all systems are on a uniform basis, although there is an element of unreality in that only the Interstate System has been held to a program that would meet its estimated needs in the period 1956-1972. Maintenance and operation costs have been included in the calculations.

The first column of figures gives the average annual program costs. This form of expressing costs assumes a program financed out of current revenues, which is entirely the case for Federal funds and the prevailing situation for highway expenditures as a whole. The costs per vehicle-mile under the current-revenue program are expressed in terms of predicted 1964 travel, as that is the midyear of the projected 16-year improvement program. In the remaining three columns costs per vehicle-mile are expressed as annual ownership costs as of 1975, at 5 per-

TABLE 2

COSTS, IN CENTS PER VEHICLE-MILE OF TRAVEL, OF A 16-YEAR IMPROVEMENT PROGRAM[1] FOR ALL ROADS AND STREETS, 1956-1972

Highway System	Method of Cost Calculation			
	Average Annual Program Costs[2]	Annual Costs in 1975 at 5.0% Interest	Annual Costs in 1975 at 2.5% Interest	Annual Costs in 1975 at 0.0% Interest
Interstate:				
Rural	1.69	0.89	0.60	0.38
Urban	2.00	1.05	0.65	0.34
Total	1.81	0.95	0.62	0.36
Other Federal-aid primary:				
Rural	1.36	1.38	1.05	0.79
Urban	1.23	1.02	0.73	0.50
Total	1.32	1.27	0.95	0.70
Federal-aid secondary, State:				
Rural	1.72	2.04	1.62	1.28
Urban	1.13	0.94	0.68	0.47
Total	1.63	1.86	1.47	1.15
Federal-aid secondary, local:				
Rural	2.24	2.33	1.90	1.54
Urban	0.97	0.83	0.65	0.50
Total	1.98	2.02	1.64	1.33
Other State highways:				
Rural	2.77	3.53	2.76	2.12
Urban	1.06	1.05	0.76	0.53
Total	1.97	2.38	1.83	1.38
Other roads and streets:				
Rural	3.35	3.92	3.24	2.70
Urban	1.38	1.56	1.26	1.02
Total	1.97	2.30	1.88	1.54
Summary:				
All rural	1.91	1.84	1.44	1.12
All urban	1.41	1.26	0.95	0.70
All roads and streets	1.70	1.61	1.24	0.95

[1]Source: Calculations based on estimates of highway needs made as a part of the Highway Cost Allocation (Section 210) Study. Values are for roads and streets in the 48 States and the District of Columbia, exclusive of toll facilities.
[2]Based on predicted 1964 vehicle-miles.

cent, 2.5 percent, and 0.0 percent interest, respectively, the year 1975 being taken as a year when the highway improvements built during the 16-year program of 1956-72 have become fully operative.

Turning first to the current-revenue column it is found that for all roads and streets the program costs of rural roads are $0.0191 per vehicle-mile and those of urban highways and streets are $0.0141 per vehicle-mile, indicating something rather different from a subsidy of the urban users by the rural. The greater unit costs of rural roads persist on all systems except the Interstate. There the extraordinary outlays required for right-of-way and structures on urban freeways tip the balance and urban costs are $0.0200 against $0.0169 for rural costs.

In calculating annual costs the capital outlays are amortized, at a given rate of interest, over the estimated life of the investment. Inasmuch as right-of-way and structures are long-lived investments, their prominence in the urban program causes alterations in the rural-urban cost relationships. Where the interest rate is high a preponderance of long-lived investments tends to raise the relative cost per vehicle-mile. At a low rate of interest the reverse is true.[5] At 5 percent interest the same general relationships hold between rural and urban costs per vehicle-mile as in the current-revenue calculation. On the Interstate System the ratio of urban to rural costs remains about the same, being 1.18 in both cases. In this calculation the lower cost per vehicle-mile of the higher-order heavy-traffic systems becomes quite evident, except for a few "maverick" cases, all of them low urban costs.

The 2½ percent rate is perhaps more suitable for highway investments because (a) the tax exempt general obligation bonds of the States can be sold at rates of this order (a rate of 3 percent would be more closely representative of State general obligation bonds in the last few years), and (b) the net yield of Federal issues, which are subject to the Federal income tax, is of the same order. At 2½ percent the disparity between rural and urban cost per vehicle-mile on the Interstate System is materially reduced, the comparison here being $0.0065 against $0.0060. The calculation for the no-interest condition (amortization only) causes the situation on the Interstate System to reverse. For this calculation the rural costs are $0.0038 per vehicle-mile and the urban costs $0.0033.

The fact that the expression of these expenditures in terms of annual costs greatly reduces their magnitude in comparison with the program or current revenue costs is quite evident, particularly on the Interstate System, although the 5 percent rate causes expenditures on some of the lower systems to be higher on an annual cost basis than on the current revenue basis. Because the annual cost calculations without interest can hardly be accepted as ruling, it can be accepted as true that the cost of providing urban Interstate improvements and facilities of like order tends to be somewhat greater per mile of travel on them than the cost of providing rural facilities of the same order. A cost difference of 18 percent, or only 8 percent in the case of the 2.5 percent calculations, does not seem to produce the occasion for imposing extraordinary increased charges on urban users. This is the sort of differential that Federal, State, and local governments seem quite able to take in their stride.

The fact is, of course, that if the cost per mile of segments of a freeway were to be traced from its point of origin in the open country to its point of nearest approach to the central business district, the probable result would be an irregular but definitely upward gradient. In terms of cost per mile the slope would be rather steep. In cost per vehicle-mile the upward trend would be much milder, and in some cases the profile would be level, or the slope would reverse, depending on the extent of large outlays for right-of-way and the variation in traffic volumes. When one considers that it is the suburban resident whose commuting by auto is charged with causing

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[5] An article in the March 1962 issue of "National Tax Journal" contains the following footnote: "Irving Fisher noted long ago (in "The Theory of Interest," Ch. VII) that in societies where rates of interest were high there would be incentives to build wooden bridges rather than steel ones, and in general to substitute short-lived assets for longer-lived ones which serve the same purposes."

intolerable congestion, and whom it is hoped to lure to the rapid-transit cars, one is forced to conclude that these peak-hour commuters are subsidizing themselves.

Highway Expenditures and Earnings in Standard Metropolitan Statistical Areas. — When confronted by figures of this sort, critics of urban freeway and arterial expenditures have responded that the terms "urban" and "municipal" cover a wide range in size of place, and that the urban costs per vehicle-mile are heavily weighted by costs in small places having conditions very like those of the rural areas. It is quite true that the figures for urban places as a whole do include the expenditures of small cities. It is untrue, however, that this produces a large distortion of the costs per vehicle-mile or in any sense misrepresents the relation of urban highway costs to the contributions by urban motor-vehicle users. Tables 3, 4, and 5 compare the 1960 revenues and expenditures for highways of a group of 46 SMSA's (Standard Metropolitan Statistical Areas)[6] with the revenues generated by the vehicles and traffic within the area. The data represent the summarized results of a Bureau of Public Roads study, not yet published, in which the effort was made to obtain data of this sort from at least one urban area in each State. The selection of cities given here provides good geographical coverage as well as a wide range in population.

The data on highway income and expenditures were obtained from reports received by the Bureau of Public Roads in its annual urban highway finance studies (31, pp. 70-83). The vehicle-miles traveled in each SMSA in 1960 were estimated from traffic counts, information from transportation studies, and other available data. User-tax earnings, State, Federal and local, were estimated as follows: (1) Taxes based on motor-vehicle use, such as motor-fuel taxes and the Federal excises on tires, tubes, and rubber were estimated on the basis of average consumption factors applied to the vehicle-mile estimates; (2) Taxes based on ownership, such as State registration fees, were applied to motor vehicles registered in the area in 1960; (3) Tolls paid at crossings within the area were counted in full; (4) Toll-road earnings were estimated on the basis of the vehicle-miles traveled on toll roads within the area; and (5) Payments of the Federal manufacturers' excise tax on trucks, buses, and combinations, were also estimated on the vehicle-mile basis.

Table 3 lists the 1960 income for roads and streets of these 46 Standard Metropolitan Statistical Areas, divided into four population groups. Revenue income items are divided into (1) road-user imposts, Federal, State, and local (including tolls) and (2) other income, including property taxes and assessments and general fund appropriations. It is of interest that in only three SMSA's (Atlantic City, N. J.; Lewiston-Auburn, Me.; Wichita, Kans.) did the local nonuser income exceed the income from road-user imposts. In the smaller places user taxes and tolls provided 76.4 percent of the revenue income; in the places of 250,000 to 500,000 population, 75.4 percent; in the places of 500,000 to 1,000,000 population, and in the places over 1,000,000 population, 73.1 percent. For the entire group the percentage was 73.4. The fact that nearly 28 percent of the highway income of these 46 places came from local nonuser sources does, however, illustrate the persistence of the traditional methods of financing ordinary local roads and streets.

Expenditures in the 46 SMSA's are given in Table 4. Because nearly all of them contain land classed as rural (much of it suburban but some definitely rural and even wild land), capital outlays are divided into rural and urban portions as well as between State-administered highways and local roads and streets. In all four sizes of place the dominance of the State program, which includes Interstate and other Federal-aid projects, is evident. For the entire group of 46 SMSA's expenditures on State projects totaled $686 million out of total capital outlays of $935 million, or 73.4 percent. Maintenance, administration, and operation, including allied functions, such as traffic policing and control, parking, and street lighting, accounted for $476 million and

[6] A Standard Metropolitan Statistical Area, selected by the Census Bureau for convenience of reporting, consists of the counties containing the entire urbanized portion of a metropolitan area. The SMSA includes, of necessity, the rural portions, if any, of its constituent counties.

TABLE 3

ROAD AND STREET INCOME OF 46 SELECTED STANDARD METROPOLITAN STATISTICAL AREAS IN 1960
(In $1,000's)

Standard Metropolitan Statistical Areas by Population Group	From Imposts on Road Users					Other Revenue Income				Total Revenue Income	Investment Income and Borrowing	Total Income	Funds Drawn from (+) or Placed in (-) Reserves		Total Funds Available
	State Road-User and Federal Trust Fund Taxes	Local (includes parking fees)	Tolls, State Facilities	Tolls, Local Facilities	Total	Property Taxes and Assess-ments	General Fund Appro-priations	Miscel-laneous	Total						
Under 250,000:															
Atlantic City, N. J.	2,385	273	380	-	3,038	1	3,593	-	3,594	6,632	221	6,853	+	12	6,865
Bay City, Mich.	5,158	-	-	-	5,158	48	449	219	716	5,874	555	6,429	-	53	6,376
Cedar Rapids, Iowa	2,833	210	-	-	3,043	2,214	22	122	2,358	5,401	561	5,962	+	1	5,963
Charleston, S. C.	4,082	-	-	-	4,082	-	485	-	485	4,567	-	4,567	+	120	4,687
Eugene, Ore.	12,507	276	-	-	12,783	1,292	-	39	1,331	14,114	696	14,810	-	679	14,131
Fargo, N. D.	12,821	-	-	-	12,821	1,983	573	133	2,689	15,510	2,186	17,696	-	152	17,544
Fitchburg-Leominster, Mass.	306	1,012	-	-	1,318	-	269	198	467	1,785	7	1,792		-	1,792
Fort Wayne, Ind.	4,596	95	-	-	4,691	1,079	171	68	1,318	6,009	-	6,009	-	165	5,844
Great Falls, Mont.	3,517	137	-	-	3,654	1,627	-	-	1,627	5,281	181	5,462	-	116	5,346
Jackson, Miss.	3,906	137	-	-	4,043	2,761	848	301	3,910	7,953	2,313	10,266	-	585	9,681
Las Vegas, Nev.	4,367	197	-	-	4,564	635	424	139	1,198	5,762	460	6,222	-	49	6,173
Lewiston-Auburn, Maine	111	134	272	-	517	-	717	15	732	1,249	20	1,269	-	9	1,260
Lexington, Ky.	1,606	81	-	-	1,687	-	826	-	826	2,513	188	2,701	+	2	2,703
Little Rock-No. Little Rock, Ark.	19,151	188	-	-	19,339	1,084	943	157	2,184	21,523	-	21,523	+	993	22,516
Lynchburg, Va.	2,202	260	-	-	2,462	4	412	2	418	2,880	788	3,668		-	3,668
Macon, Ga.	1,824	174	-	-	1,998	502	492	10	1,005	3,003	-	3,006	+	20	3,023
Madison, Wisc.	9,999	360	-	-	10,359	2,196	2,463	206	4,865	15,224	1,486	16,710	-	72	16,638
Sioux Falls, S. D.	8,216	158	-	-	8,374	641	494	144	1,279	9,653	600	10,253	-	225	10,028
South Bend, Ind.	2,766	152	-	-	2,918	1,039	-	516	1,555	4,473	1,000	5,473	-	991	4,482
Springfield, Mo.	3,977	770	-	-	4,747	860	155	265	1,280	6,027	265	6,292	-	350	5,942
Waterbury, Conn.	4,346	91			4,437	4	1,960	222	2,186	6,623	25	6,648	+	301	6,949
Subtotal	110,676	4,705	652	-	116,033	17,970	15,297	2,756	36,023	152,056	11,552	163,606	-	1,997	161,611
Percent	72.79	3.09	0.43	-	76.31	11.82	10.06	1.81	23.69	100.00					
250,000 to 500,000:															
Albuquerque, N. M.	11,061	629	-	-	11,690	2,692	52	276	3,020	14,710	2,809	17,519	+	725	18,244
Charleston, W. Va.	2,642	257	-	-	2,899	363	1,023	-	1,386	4,285	-	4,285	+	125	4,410
Charlotte, N. C.	3,676	144	-	-	3,820	-	1,857	-	1,857	5,677	-	5,677	+	202	5,879
Jacksonville, Fla.	20,439	427	3,336	-	24,204	2,234	1,634	1,997	5,865	30,069	1,673	31,742	+	13,531	45,273
Nashville, Tenn.	18,250	1,401	-	-	19,651	1,813	85	198	2,096	21,747	654	22,401	+	106	22,507
Omaha, Nebr.	16,080	1,987	-	197	18,264	5,003	-	344	5,347	23,611	2,760	26,371	+	1,225	27,596
Salt Lake City, Utah	9,505	257	-	-	9,762	2,391	943	171	3,505	13,267	-	13,267	-	222	13,045
Tacoma, Wash.	9,836	-	-	-	9,836	1,451	1,157	259	2,867	12,703	-	12,703	+	1,026	13,729
Tulsa, Okla.	6,376	484	1,598	-	8,458	850	744	426	2,020	10,478	4,481	14,959	+	857	15,816
Wichita, Kans.	7,627	418	359	-	8,404	7,842	362	840	9,044	17,448	6,659	24,107	+	908	25,015
Wilmington, Del.	5,359	467	4,770	-	10,596	99	4,412	28	4,539	15,135	5,853	20,988	-	970	20,018
Subtotal	110,851	6,471	10,065	197	127,584	24,738	12,269	4,539	41,546	169,130	24,889	194,019	+	17,513	211,532
Percent	65.54	3.83	5.95	0.12	75.44	14.63	7.25	2.68	24.56	100.00					
500,000 to 1,000,000:															
Birmingham, Ala.	7,108	2,283	-	-	9,391	4,592	-	969	5,561	14,952	3,300	18,252	-	2,985	15,267
Columbus, Ohio	24,587	446	-	-	25,033	2,337	696	961	3,994	29,027	8,203	37,230	+	523	37,753
Denver, Colo.	17,130	-	643	-	17,773	4,441	2,580	752	7,773	25,546	47	25,593	-	120	25,473
Honolulu, Hawaii	12,090	4,368	-	-	16,458	3,493	85	474	4,052	20,510	-	20,510	-	993	19,517
New Orleans, La.	17,311	539	2,926	1,437	22,213	5,259	5,476	1,796	12,531	34,744	9,074	43,818	-	845	42,973
Phoenix, Ariz.	14,501	-	-	-	14,501	1,635	5,144	4,349	11,128	25,629	4,686	30,315	-	1,467	28,848
Providence, R. I.	27,140	1,390	718	-	29,248	12	10,104	222	10,338	39,586	4,368	43,954	-	118	43,836
Subtotal	119,867	9,026	4,287	1,437	134,617	21,769	24,085	9,523	55,377	189,994	29,678	219,672	-	6,005	213,667
Percent	63.09	4.75	2.25	0.76	70.85	11.46	12.68	5.01	29.15	100.00					
1,000,000 and over:															
Baltimore, Md.	40,512	4,602	5,558	351	51,023	865	13,016	442	14,323	65,346	4,840	70,186	+	345	70,531
Buffalo, N. Y.	21,943	781	4,637	-	27,361	5,069	18,223	1,277	24,569	51,930	12,774	64,704	+	2,219	66,923
Chicago, Ill.	193,293	39,080	18,426	2,208	253,007	30,443	5,928	2,741	39,112	292,119	83,073	375,192	-	8,127	367,065
Houston, Tex.	36,799	687	-	-	37,486	20,674	6,387	3,766	30,827	68,313	19,224	87,537	-	5,406	82,131
Los Angeles, Calif.	153,767	3,686	-	281	157,734	11,202	44,776	15,262	71,240	228,974	10,720	239,694	-	8,961	230,733
Minneapolis-St. Paul, Minn.	53,995	1,072	-	-	55,067	19,945	6,832	3,175	29,952	85,019	11,495	96,514	-	2,676	93,838
Philadelphia, Pa.	52,480	1,999	28,034	1,566	84,079	429	26,987	7,215	34,631	118,710	14,601	133,311	+	700	134,011
Subtotal	552,789	51,907	56,655	4,406	665,757	88,627	122,149	33,878	244,654	910,411	156,727	1,067,138	-	21,906	1,045,232
Percent	60.72	5.70	6.22	0.49	73.13	9.73	13.42	3.72	26.87	100.00					
Total, all SMSA's	894,183	72,109	71,659	6,040	1,043,991	153,104	173,800	50,696	377,600	1,421,591	222,846	1,644,437	-	12,395	1,632,042
Percent	62.90	5.07	5.04	0.43	73.44	10.77	12.22	3.57	27.56	100.00					

TABLE 4

ROAD AND STREET EXPENDITURES OF 46 SELECTED STANDARD METROPOLITAN STATISTICAL AREAS IN 1960

(In $1,000's)

Standard Metropolitan Statistical Areas by Population Groups	Capital Outlay: On State Administered Highways: Rural	Capital Outlay: On State Administered Highways: Urban	Capital Outlay: On State Administered Highways: Total	Capital Outlay: On Local Roads and Streets: Rural	Capital Outlay: On Local Roads and Streets: Urban	Capital Outlay: On Local Roads and Streets: Total	Total Capital Outlay	Maintenance, Administration, Operation, etc.[1]	Interest	Total Expenditures	Debt Retirement	Total Disbursements
Under 250,000:												
Atlantic City, N. J.	1,044	51	1,095	165	293	458	1,553	4,608	298	6,459	406	6,865
Bay City, Mich.	3,773	99	3,872	41	745	786	4,658	1,614	14	6,286	90	6,376
Cedar Rapids, Iowa	907	370	1,277	888	911	1,799	3,076	2,552	56	5,684	279	5,963
Charleston, S. C.	2,817	353	3,170	99	84	183	3,353	1,334	-	4,687	-	4,687
Eugene, Ore.	7,849	-	7,849	1,763	1,135	2,898	10,747	3,084	54	13,885	246	14,131
Fargo, N. D.	10,265	985	11,250	1,572	1,552	3,124	14,374	2,361	273	17,008	536	17,544
Fitchburg-Leominster, Mass.	99	-	99	46	206	252	351	1,289	12	1,652	140	1,792
Fort Wayne, Ind.	1,952	205	2,157	809	599	1,408	3,565	1,875	97	5,537	307	5,844
Great Falls, Mont.	2,834	70	2,904	42	241	283	3,187	1,443	241	4,871	475	5,346
Jackson, Miss.	2,287	478	2,765	505	1,033	1,538	4,303	2,598	295	7,196	2,485	9,681
Las Vegas, Nev.	3,011	24	3,035	180	853	1,033	4,068	1,830	41	5,939	234	6,173
Lewiston-Auburn, Maine	4	110	114	-	110	110	224	795	199	1,218	42	1,260
Lexington, Ky.	1,492	73	1,565	-	-	-	1,565	1,138	-	2,703	-	2,703
Little Rock-No. Little Rock, Ark.	4,739	12,698	17,437	99	1,530	1,629	19,066	2,964	141	22,171	345	22,516
Lynchburg, Va.	1,243	168	1,411	-	604	604	2,015	1,229	120	3,364	304	3,668
Macon, Ga.	1,559	-	1,559	345	135	480	2,039	915	24	2,978	45	3,023
Madison, Wisc.	6,127	166	6,293	2,006	3,129	5,135	11,428	3,914	227	15,569	1,069	16,638
Sioux Falls, S. D.	4,428	2,782	7,210	1,004	241	1,245	8,455	1,539	14	10,008	20	10,028
South Bend, Ind.	153	16	169	477	436	913	1,082	2,800	25	3,907	575	4,482
Springfield, Mo.	2,911	642	3,553	67	307	374	3,927	1,656	29	5,612	330	5,942
Waterbury, Conn.	3,216	-	3,216	104	245	349	3,565	3,089	103	6,757	192	6,949
Subtotal	62,710	19,290	82,000	10,212	14,389	24,601	106,601	44,627	2,263	153,491	8,120	161,611
Percent	40.85	12.57	53.42	6.65	9.38	16.03	69.45	29.07	1.48	100.00		
250,000 to 500,000:												
Albuquerque, N. M.	1,031	9,157	10,188	101	2,268	2,369	12,557	3,726	469	16,752	1,492	18,244
Charleston, W. Va.	655	-	655	-	37	37	692	3,426	116	4,234	176	4,410
Charlotte, N. C.	1,436	396	1,832	-	428	428	2,260	3,140	181	5,581	298	5,879
Jacksonville, Fla.	17,862	6,338	24,200	143	1,058	1,201	25,401	7,898	5,011	38,310	6,963	45,273
Nashville, Tenn.	7,465	8,694	16,159	626	1,126	1,752	17,911	3,454	276	21,641	866	22,507
Omaha, Nebr.	8,205	2,740	10,945	3,156	3,708	6,864	17,809	6,510	402	24,721	2,875	27,596
Salt Lake City, Utah	7,931	174	8,105	778	685	1,463	9,568	3,477	-	13,045	-	13,045
Tacoma, Wash.	2,044	4,629	6,673	-	2,795	2,795	9,468	3,736	179	13,383	346	13,729
Tulsa, Okla.	3,347	419	3,766	1,739	1,856	3,595	7,361	5,151	1,757	14,269	1,547	15,816
Wichita, Kans.	3,658	2,894	6,552	1,152	4,228	5,380	11,932	4,637	1,330	17,899	7,116	25,015
Wilmington, Del.	6,342	1,958	8,300	48	943	991	9,291	6,336	1,145	16,772	3,246	20,018
Subtotal	59,976	37,399	97,375	7,743	19,132	26,875	124,250	51,491	10,866	186,607	24,925	211,532
Percent	32.14	20.04	52.18	4.15	10.25	14.40	66.58	27.60	5.82	100.00		
500,000 to 1,000,000:												
Birmingham, Ala.	4,988	103	5,091	2,718	2,251	4,969	10,060	4,144	217	14,421	846	15,267
Columbus, Ohio	7,697	9,822	17,519	1,543	1,892	3,435	20,954	7,196	829	28,979	8,774	37,753
Denver, Colo.	5,920	5,033	10,953	1,625	1,677	3,302	14,255	10,438	325	25,018	455	25,473
Honolulu, Hawaii	2,877	4,584	7,461	-	3,334	3,334	10,795	7,801	475	19,071	446	19,517
New Orleans, La.	4,051	12,478	16,529	1,693	3,594	5,287	21,816	9,892	5,627	37,335	5,638	42,973
Phoenix, Ariz.	2,917	6,046	8,963	8,153	3,117	11,270	20,233	6,767	440	27,440	1,408	28,848
Providence, R. I.	3,197	20,518	23,715	459	4,372	4,831	28,546	12,793	459	41,798	2,038	43,836
Subtotal	31,647	58,584	90,231	16,191	20,237	36,428	126,659	59,031	8,372	194,062	19,605	213,667
Percent	16.31	30.19	46.50	8.34	10.43	18.77	65.27	30.42	4.31	100.00		
1,000,000 and over:												
Baltimore, Md.	10,812	37	10,849	4,146	15,761	19,907	30,756	27,208	4,245	62,209	8,322	70,531
Buffalo, N. Y.	10,100	9,193	19,293	4,346	6,806	11,152	30,445	22,304	3,719	56,468	10,455	66,923
Chicago, Ill.	46,414	120,089	166,503	8,573	26,159	34,732	201,235	101,616	31,450	334,301	32,764	367,065
Houston, Tex.	-	35,954	35,954	2,548	12,087	14,635	50,589	16,949	4,403	71,941	10,190	82,131
Los Angeles, Calif.	38,885	59,884	98,769	15,494	31,647	47,141	145,910	78,583	1,692	226,185	4,548	230,733
Minneapolis-St. Paul, Minn.	7,923	33,772	41,695	6,046	11,761	17,807	59,502	27,096	1,511	88,109	5,729	93,838
Philadelphia, Pa.	23,110	20,642	43,752	3,512	12,195	15,707	59,459	46,787	11,259	117,505	16,506	134,011
Subtotal	137,244	279,571	416,815	44,665	116,416	161,081	577,896	320,543	58,279	956,718	88,514	1,045,232
Percent	14.35	29.22	43.57	4.67	12.17	16.84	60.41	33.50	6.09	100.00		
Total all SMSA's	291,577	394,844	686,421	78,811	170,174	248,985	935,406	475,692	79,780	1,490,878	141,164	1,632,042
Percent	19.56	26.48	46.04	5.29	11.41	16.70	62.74	31.91	5.35	100.00		

[1]Includes parking, policing, and allied functions.

interest on highway debt for $80 million. Total expenditures, exclusive of debt retirement, were slightly less than $1.5 billion.

The estimated 1960 earnings from road-user taxes, tolls, and parking fees in these 46 SMSA's are set forth in Table 5. The estimates of vehicle-miles traveled within them total to nearly 122 billion. The total estimated earnings were $1,650 million.

By far the greatest block of revenues generated is that of State motor-fuel taxes and motor vehicle registration and other fees, which totaled to $1,001 million. Payments of tolls on State toll facilities amounted to nearly $22 million, bringing the total in State taxes, fees, and tolls to $1,072 million, or 65.0 percent of the total earnings. Federal motor-fuel and excise taxes generated ($499 million) were slightly less than one-half the State total. They do not include the 10 percent excise tax on automobiles, the proceeds of which do not accrue to the highway trust fund. The earnings of local taxes and tolls were $78 million, a small but significant contribution.

The last column in Table 5 gives the ratio of user earnings to expenditures in 1960. In 20 of the 46 SMSA's expenditures were greater than earnings; in 26 earnings exceeded expenditures. Ratios in the larger places exceed those in the smaller places. The ratio for the whole group is 1.11.

The outcome of this preliminary examination of earnings and expenditures in SMSA's is the finding that road-user taxes, fees, and tolls generated are of the same order of magnitude as expenditures. In a year of much greater construction activity expenditures in these SMSA's might well exceed earnings. This would be illusory, however, because the accelerated construction of long-lived facilities builds for the future, and such peaks are leveled out in the long run.

Comparison of Tables 3 and 5 reveals the fact that, although the earnings were $1,650 million, the amount of road-user taxes, fees, and tolls applied to roads and streets was only $1,044 million. The ratio of user earnings to user revenues applied is 1.58. Two inferences can be drawn from this showing. One is that the cities, and even the partly rural SMSA's, are not getting their share of user-tax revenues in relation to earnings, in comparison with the rural areas. The other is that, as long as substantial amounts of local nonuser revenues are used for local street purposes, user earnings can exceed expenditures only if user revenues applied are considerably less than earnings.

It is difficult to pass judgment on this situation. The practice of using local nonuser revenues, including benefit assessments, for at least a part of the cost of local roads and streets, although condemned by some students, retains popular acceptance as well as the approval of many who have studied the subject. The current trend is for the urban places to receive an increasing share of motor vehicle tax proceeds, chiefly through the Federal and State programs of improvement of urban Interstate highways and other urban connections of Federal-aid and State highways. For the urban places to receive an exact return of the user tax earnings attributable to them would be too restrictive a policy. It is better for both State and Federal governments to have some leeway for the exercise of judgment as to where the needs for highway improvement are greatest.

Imputed Costs. — Where highway-related costs such as expenses of traffic policing, street lighting, and storm sewers can be identified, they may be accepted as a part of urban street costs, although close analysis would reveal that householders, business establishments, and pedestrians have a large stake in these services. It is not uncommon, however, when interests hostile to highways or motor vehicles are at stake, for the highway tax bill to be inflated by items of cost that never appear on the books of account, never have to be paid to anybody by anyone (32, pp. 5-9).

Imputed interest has caused much controversy over the years, perhaps because of misunderstanding and lack of communication. Annual expenditures for capital outlay, interest, maintenance, and operation may be listed for a series of years, and when so listed they give a true account of costs for highways or any other activity, except for the fact that the story is seldom ended at any cutoff year. For analytical purposes it is advantageous to substitute annual cost calculations for lists of expenditures, in order to impart uniformity, order, and continuity to the series. It should

TABLE 5

ESTIMATED MOTOR-VEHICLE USER-TAX AND TOLL EARNINGS GENERATED BY TRAVEL AND VEHICLE OWNERSHIP IN 46 SELECTED STANDARD METROPOLITAN STATISTICAL AREAS IN 1960, AT 1960 TAX RATES AND TOLLS
(In $1,000's)

		Collecting Agencies								
		Federal Government: Excise	State Agencies[1]			Local Governments[1]				
Standard Metropolitan Statistical Area by Population Group	Vehicle-Miles of Travel Within the SMSA	Taxes of the Federal-Highway Trust Fund[2]	Motor Fuel and Vehicle Taxes and Fees	Tolls	Total State Taxes and Fees	Motor Fuel and Vehicle Taxes and Fees[3]	Tolls	Total Local Taxes and Fees	Total User Taxes on Highway Use in SMSA	Ratio of User Earnings to Expenditures
	(thousands)									
Under 250,000:										
Atlantic City, N. J.	1,175,000	4,690	7,102	380	7,482	273	-	273	12,445	1.93
Bay City, Mich.	425,000	1,751	3,354	-	3,354	-	-	-	5,105	0.81
Cedar Rapids, Iowa	501,680	2,125	4,988	-	4,988	210	-	210	7,323	1.29
Charleston, S. C.	715,000	3,103	5,332	-	5,332	-	-	-	8,435	1.80
Eugene, Ore.	643,400	2,597	6,456	-	6,456	276	-	276	9,329	0.67
Fargo, N. Dak.	451,962	1,962	3,835	-	3,835	-	-	-	5,797	0.34
Fitchburg-Leominster, Mass.	426,000	1,492	2,286	-	2,286	1,012	-	1,012	4,790	2.90
Fort Wayne, Ind.	581,960	2,399	5,072	-	5,072	95	-	95	7,566	1.37
Great Falls, Mont.	273,057	1,048	2,174	-	2,174	137	-	137	3,359	0.69
Jackson, Miss.	589,712	2,526	5,112	-	5,112	137	-	137	7,775	1.08
Las Vegas, Nev.	358,823	1,722	3,658	-	3,658	197	-	197	5,577	0.94
Lewiston-Auburn, Maine	174,125	622	1,650	272	1,922	134	-	134	2,678	2.20
Lexington, Ky.	432,700	1,832	3,666	-	3,666	81	-	81	5,579	2.06
Little Rock-No. Little Rock, Ark.	794,700	3,876	7,330	-	7,330	188	-	188	11,394	0.51
Lynchburg, Va.	423,912	1,837	3,220	-	3,220	260	-	260	5,317	1.58
Macon, Ga.	451,870	1,721	3,273	-	3,273	174	-	174	5,168	1.74
Madison, Wisc.	911,610	3,916	7,436	-	7,436	360	-	360	11,712	0.75
Sioux Falls, S. Dak.	340,451	1,435	3,027	-	3,027	158	-	158	4,620	0.46
South Bend, Ind.	570,090	2,301	4,888	-	4,888	152	-	152	7,341	1.88
Springfield, Mo.	659,096	2,505	2,962	-	2,962	770	-	770	6,237	1.11
Waterbury, Conn.	523,283	2,146	4,208	-	4,208	26	-	26	6,380	0.94
Subtotal	11,424,431	47,606	91,029	652	91,681	4,640	-	4,640	143,927	0.94
Percent		33.08	63.25	0.45	63.70	3.22	-	3.22	100.00	
250,000 to 500,000:										
Albuquerque, N. Mex.	827,424	3,531	7,109	-	7,109	629	-	629	11,269	0.67
Charleston, W. Va.	814,431	3,504	8,734	-	8,734	257	-	257	12,495	2.95
Charlotte, N. C.	675,129	2,741	6,462	-	6,462	144	-	144	9,347	1.67
Jacksonville, Fla.	1,807,115	7,297	15,715	3,338	19,053	427	-	427	26,777	0.70
Nashville, Tenn.	1,208,996	5,147	10,389	-	10,389	1,401	-	1,401	16,937	0.78
Omaha, Nebr.	1,842,338	7,585	14,988	-	14,988	1,987	197	2,184	24,757	1.00
Salt Lake City, Utah	1,155,000	4,929	8,908	-	8,908	257	-	257	14,094	1.08
Tacoma, Wash.	1,281,000	5,087	12,035	-	12,035	-	-	-	17,122	1.28
Tulsa, Okla.[4]	1,436,382	5,931	15,757	1,598	17,355	484	-	484	23,770	1.67
Wichita, Kans.	1,381,796	5,514	8,846	359	9,205	418	-	418	15,137	0.85
Wilmington, Del.	1,586,247	6,554	11,000	4,770	15,770	467	-	467	22,791	1.42
Subtotal	14,015,858	57,820	119,943	10,065	130,008	6,471	197	6,668	194,496	1.05
Percent		29.73	61.67	5.17	66.84	3.33	0.10	3.43	100.00	
500,000 to 1,000,000:										
Birmingham, Ala.	2,052,312	8,140	14,661	-	14,661	2,283	-	2,283	25,084	1.74
Columbus, Ohio	2,696,374	10,308	23,291	-	23,291	446	-	446	34,045	1.17
Denver, Colo.	3,500,000	14,354	26,939	643	27,582	-	-	-	41,936	1.68
Honolulu, Hawaii	1,123,090	4,544	8,903	-	8,903	4,368	-	4,368	17,815	0.93
New Orleans, La.	1,940,483	9,138	16,690	2,926	19,616	539	1,437	1,976	30,730	0.82
Phoenix, Ariz.	3,083,304	13,157	21,430	-	21,430	-	-	-	34,567	1.26
Providence, R. I.	3,401,100	11,997	27,150	718	27,868	1,390	-	1,390	41,255	0.99
Subtotal	17,796,663	71,638	139,064	4,287	143,351	9,026	1,437	10,463	225,452	1.16
Percent		31.78	61.68	1.90	63.58	4.00	0.64	4.64	100.00	
1,000,000 and over:										
Baltimore, Md.	5,965,707	24,796	48,698	5,558	54,256	4,602	351	4,953	84,005	1.35
Buffalo, N. Y.	3,417,680	13,638	31,416	4,637	36,053	781	-	781	50,472	0.89
Chicago, Ill.	19,210,133	76,656	135,788	18,426	154,214	39,080	2,208	41,288	272,158	0.81
Houston, Texas	4,265,000	17,958	36,935	-	36,935	687	-	687	55,580	0.77
Los Angeles, Calif.	27,808,000	117,625	264,876	-	264,876	3,686	281	3,967	386,468	1.71
Minneapolis-St. Paul, Minn.	5,500,000	22,557	42,210	-	42,210	1,072	-	1,072	65,839	0.75
Philadelphia, Pa.	12,313,914	48,908	90,797	28,034	118,831	1,999	1,613	3,612	171,351	1.46
Subtotal	78,480,434	322,138	650,720	56,655	707,375	51,907	4,453	56,360	1,085,873	1.13
Percent		29.67	59.92	5.22	65.14	4.78	0.41	5.19	100.00	
Total all SMSA's	121,717,386	499,202	1,000,756	71,659	1,072,415	72,044	6,087	78,131	1,649,748	1.11
Percent		30.26	60.66	4.34	65.00	4.37	0.37	4.74	100.00	

[1]Includes earnings from State motor-fuel taxes at estimated consumption rates per mile of travel, and registration, operator license, and other fees that were either recorded collections in each area, or computed on basis of vehicle ownership in that SMSA. Local highway-user imposts include the proceeds from motor-fuel, bus and wheel taxes, automobile and truck licenses, and other fees levied on highway users within those jurisdictions.
[2]Includes taxes on motor fuel, truck, bus, and trailer excise, tires, tubes, and tread rubber, and vehicle-use taxes. Does not include automobile excise, parts and accessories, and lubricating oil taxes, which are general fund revenues.
[3]Includes parking fees.
[4]Excludes Osage County.

not be forgotten that this is a substitution, an abstraction from reality that brings its own uncertainties, in the form of an assumed rate of interest and an assumed term of amortization.

A fact that is often disregarded is that when capital outlay is paid for out of current revenues the interest, at whatever rate, is prepaid. This can be demonstrated by pointing out that the taxpayer, in supplying say $1,000 for this purpose, is laying on the line an amount that, at 4 percent interest, will be worth $1,480 in 10 years, $3,245 in 30 years. At 7 percent its value will be $1,970 in 10 years. This means that the taxpayer should not be made to pay an interest charge on the money he has supplied for direct capital outlay. Conversely, it means that the taxpayer has a right to expect a return in benefits from the highway investment at least equal to the return he would receive from an alternative investment of the $1,000.

This point can be demonstrated by an exercise in which one imagines a State highway department in possession, on January 1, of $10,000,000 in user-tax proceeds available for use in highway construction. Wishing to have its transactions conform to the annual-cost canon, the department does not use the money in this way. Instead, on January 1, it borrows $10,000,000 on a 30-year annuity loan at 4 percent interest. At this rate the recovery factor is 0.0578301, so that the department is obligated to an annual debt-service charge of $578,301 for 30 years. To meet this obligation it invests the $10,000,000 of user-tax money, on January 1, in a 30-year annuity loan at 4 percent interest. This loan will yield an annual income of $578,301. Thus the transaction washes out. The end result of this ritual dance is as if the original $10,000,000 had been used directly for highway construction. The interest, in short, is prepaid.

Somewhat more subtle is the contention that the motorists should pay the equivalent of a rental on the present value of the land occupied by roads and streets, calculated presumably on the value base of the abutting land. In response to this one may inquire what would be the value of the land on Manhattan Island if there were no streets there. One may point out that most highway right-of-way has been paid for and become sunk costs many years ago; that right-of-way currently purchased is being paid for, chiefly out of user-tax proceeds; and that no institution, whether government or private firm, needs to earn a return on investments that have been amortized. The recital of these facts will not deter the advocates of such charges, but it serves to highlight the essential frivolity of the proposal.

Of equal inconsequence is the proposal that the road users should pay taxes on the value of the land and the highway improvements built upon it. For any ordinary road or street the value added to the tax base by the presence of roads giving access to land and improvements far outweights the imputed taxable value of the road itself. The case of modern freeways and other large-scale highway improvements is somewhat different in that extensive land acquisitions and demolitions may cause dislocations resulting, at least temporarily, in "loss of ratables."

There are, however, mitigating factors even in the case of freeways. For each parcel of land and improvements a price equal at least to its fair market value was paid. The impression seems to prevail that the money received in such transactions is squandered the next day at the races. It is more likely, however, that most—indeed, nearly all—of it is reinvested in new residential property or income-producing commercial and industrial property. It may not be in the immediate area; it may even be outside the jurisdiction in which the land was sold; but the money does not vanish into thin air. Furthermore, the reorganization of land uses attendant on major highway improvements, described by Garrison (33, p. 22) as "... the more efficient operation of vehicles, firms, and households, given better highway facilities," is almost certain to have a favorable effect on the tax base of the urban area as a whole (34). Specific hardship areas in the midst of general improvement can be cured by specific action. Tax equivalents are a remedy for this sort of dislocation, but they are applied where needed, and not to the whole body politic.

These items of imputed highway tax responsibility are frequently advanced as a means of equalizing the competitive position of alternative modes of transportation or, as in the case of the rapid-transit controversy, of finding funds with which to shore up the financial position of the competing mode. Railways and transit lines, being public utilities, can be relieved of onerous taxes, although Meyer et al (35, p. 267) question the desirability of doing so. As for subsidies for the support of public transit, there would be great advantages to giving them as broad a tax base as possible, rather than incurring enmity by taxing the highway users to subsidize the nonusers.

Summary. —The foregoing leads to the following conclusions about the relation of present-day highway financing to the problem of congestion tolls:

1. Highway expenditures per mile of travel are significantly greater in rural areas than in urban areas; in this sense the urban user may be said to "subsidize" the rural user.

2. System for system, costs, per mile of travel, of urban highways and streets are lower than rural highway costs. At the very top level there is an apparent reversal, in that extraordinary expenditures for right-of-way and structures cause the costs per vehicle-mile of urban expressways to exceed somewhat those of their rural counterparts. This disparity, being of the order of 8 to 18 percent, is not such as to indicate the necessity for revolutionary changes in urban highway financing.

3. Comparison of income, expenditures, and user-tax earnings of 24 individual urban areas (SMSA's) indicates that urban users are paying their way in generated user-tax proceeds. The cities, however, do not receive State road-user tax revenues in proportion to their earnings.

4. The shortage of State motor vehicle revenues is counterbalanced by the continued use of benefit assessments, ad valorem property taxes, and local general funds for the construction and maintenance of ordinary city streets, a practice having the sanction of tradition and (apparently) popular support.

5. There is little to be said in favor of imputed interest, rental, and tax costs that would inflate the highway tax burden far beyond the actual costs of owning and operating a highway system. There are more practicable and more equitable means of improving the competitive position of competing modes of transportation.

Some Notes on Urban Travel

It is a popular theme nowadays to dilate on the horrors of motor vehicle traffic congestion in cities and to paint the picture of a day when all traffic will grind to a halt. Because cases of severe congestion are more easily remembered than the more normal case of slow but steady traffic flow, these frightful images are generally well received. Wisecracks about the alleged hazards and delays of the Hollywood Freeway are always good for a laugh on television, whereas the greater hazards and delays of driving on the ordinary streets of that great city have not, apparently, engaged the attention of the mass media.

It seems likely that the terrors of urban traffic congestion have been somewhat exaggerated. For one thing, if urban driving were so unpleasant it would probably bring about its own cure out of the sheer revulsion of the motorists. It is quite plain that for the most part they do not mind it, or not very much. Why this should be so can be told by any experienced suburb-to-city commuter, either driver or rider. Stopping for a red light, although it annoys one and makes one long for a freeway, is not an unbearable experience. Severe traffic tie-ups occur only semioccasionally, can almost always be ascribed to a known cause, and can be endured with stoicism when they occur.

Patterns of Urban Travel. —It is well to review some of the characteristics of urban traffic that have a bearing on the problem of congestion and the congestion-toll proposals. One of the most important is the relation of trips to the central business district to all trips in the urban or metropolitan area. Smith (36, pp. 95-103) shows that even for transit trips the percentage to or from the downtown area is as low as 25 in larger cities like Chicago and Detroit. Smith's Table 21 (36, p. 95), based on origin-destination studies in 10 metropolitan areas, shows that the percentage of all person trips made to or from the CBD varies from 9.2 in Chicago to 23.5 in Charlotte,

N. C., and 34.8 percent in Washington, D. C., for which the delimited CBD is inordinately large in comparison with those of other cities. For auto trips the percentage varies from 3.5 in Chicago to 21.7 in Charlotte and 25.3 in Washington; for transit the variation extends from 25.1 percent in Detroit to 72.5 percent in Phoenix, Ariz.

In general, the more populous the metropolitan area, the smaller the proportion of trips beginning or ending in the downtown area. As the suburbs grow and the importance of subsidiary urban complexes increases, this trend will continue. Thus it is seen that the problem of congestion in the CBD is only a fraction of the urban transportation problem. All urban areas in this country are in reality auto-oriented, and the transportation planning for a great metropolitan area must recognize this fact.

Of perhaps greater pertinence to the question at issue here is the proportion of trips entering the CBD but having destinations elsewhere. Table 6, also taken from the Smith report (36, p. 101), gives the relevant percentages for six individual cities and for 67 cities, taken as a group, in which the Bureau of Public Roads was associated with origin-destination studies. For the 67 cities 55 percent of the vehicles entering the CBD were only passing through on their way to a destination elsewhere. Of the remaining cities, the lowest percentage, 51, is found in Kansas City, and the highest, 78 in New Orleans. These data serve to emphasize the fact that an adequate freeway network would deflect a substantial portion of the automobile traffic from the central business district, which should be skirted by an inner beltway.

The great problem of traffic service in the central business district is, of course, that of the peak-hour flow of commuters to and from work. Peaking characteristics are different on different modes of transportation. Vickrey (32, p. 12) states that commuter railways receive one-half their total traffic during the 15 peak hours of the week; that subways receive one-third their traffic during these hours; and that the percentage for expressway traffic to and from the central city is 18. Cummings (37) analyzed traffic on the six-lane Lodge-Ford expressway system in Detroit. In terms of the expected average ADT of 120,000 after 1967, he found that on the inbound lanes there will be 13 hr of the day during which three lanes are needed (over 3,000 in one direction). On the outbound lanes, because of sharper peaking, only 6 hr require three lanes. By Vickrey's standard, which Cummings deplores, the three peak hours will produce 25,140 vehicles or 21 percent of the daily traffic. (There are 6 hr when three lanes are required for both inbound and outbound traffic, and these account for 38 percent of the daily volume.)

The sharp peak-hour concentration of rapid-transit patronage restricts its use to situations where it can sustain a very heavy load during the morning and afternoon rush hours. A freeway system has the advantage of a broader traffic base. It can also accommodate bus transit, either as a part of the traffic stream or on separate controlled lanes if the prospective load factor warrants a high frequency of service.

These considerations and those previously discussed should suggest that the major problems of urban transportation are those of structure rather than of pricing. A well-designed expressway system culminating in an inner freeway loop will provide motorists the needed access to the central business district, protect that district from encroachment by traffic destined elsewhere, and relieve the arterial surface streets to serve a more local function with less congestion.

TABLE 6

WEEKDAY TRAFFIC PASSING THROUGH AND DESTINED FOR TYPICAL CENTRAL BUSINESS DISTRICTS[1]

City	Percent of Total Vehicles Entering CBD	
	Vehicles Passing Through	Vehicles Having Destinations in CBD
St. Louis, Mo.	62	38
Kansas City, Mo.	51	49
Charlotte, N. C.	66	34
New Orleans, La.	78	22
Philadelphia, Pa.	67	33
Nashville, Tenn.	75	25
Bur. Pub. Roads (67 cities)	55	45

[1]Sources: Compiled from origin-destination studies in each area, from data compiled by Bureau of Public Roads, published in Schmidt, R. E., and Campbell, M. Earl, "Highway Traffic Estimation," Eno Foundation for Highway Traffic Control, Saugatuck, Conn. (1956), and from Wilbur Smith and Associates, "Parking Study, Central Business District," New Orleans, Louisiana (1960). Data are for 24-hr periods except New Orleans, which are for 10 hr, 8:00 a.m. to 6:00 p.m. (Taken from Smith (36, p. 101).

In the great metropolitan areas the salvage or creation of rapid-transit systems may ease and simplify the freeway plan, reducing the number of lanes needed in corridors of tremendous peak load. To achieve such a structure requires coordination and balance, in which various disciplines unite to create a seemly product.

Self-Rationing Character of Urban Congestion. —The point has been made that present-day urban congestion is perhaps not intolerable because it is tolerated. Beckman (19, pp. 80-86) states the proposition that traffic tends to distribute itself in such wise that costs are equalized on alternative routes; and then proceeds to demonstrate, by means of the Pigou two-road theorem, that the equilibrium position does not produce the maximum benefit, which can only be achieved, according to the congestion-cost theorems, by marginal-cost pricing.

It is recognized by all that the pricing of any commodity or service tends to diminish the market for it. Thus, even at the present moderate levels of road-user taxes and tolls, some prospective users are priced out of the urban travel market, although perhaps more by the congestion costs than by the taxes themselves. One rather important item in the price of a trip to the CBD is often ignored—that of parking costs. In the office building district where the offices of the Bureau of Public Roads are situated the weekday price for all-day parking is around $1.50 to $2.00, with a monthly contract price of $25 or more. This is a deterrent, particularly to the commuter who drives alone. To a five-person carpool it is not an exorbitant charge; but car pooling in itself reduces congestion.

There is no doubt that the market for downtown parking space is confused by special situations and arrangements, such as free or low-priced curb parking, differentials in charges between public and private off-street parking facilities, free-parking-for-customers agreements, and free parking for individuals or groups in government establishments or private firms. Some of these arrangements are merely the absorption of the parking price in the charge for other services or the granting of fringe benefits (e.g., free parking space granted to an official or a group of workers can be regarded as a part of salary or wage because the space could otherwise be rented at the market). Problems of competition between public and private parking space can be resolved by suitable adjustment of public parking fees, both off-street and curb, and the restriction of curb parking to the space truly available for that use. The provision of downtown parking space adequate to the demand will reduce congestion by cutting down movement in search of space.

In the final result the influence of the "natural" forces of self-rationing, although producing a tolerable (or at least tolerated) situation, is not sufficient to produce the desired condition of free flow. Marginal-cost pricing based on congestion costs is urged as a means of bringing about this condition, either by a forced reduction of travel on a fixed system of arterial streets, with rapid transit receiving the commuters driven off the streets; or, alternatively, by using the proceeds of congestion tolls to construct a freeway system.

Perhaps much of the revulsion with which the congestion-toll proposal is greeted by motorists is due to the fact that it applies a market pricing mechanism to a set of costs that do not enter the market. Ordinarily the costs that determine market price in relation to demand are those of the enterpriser who manufactures the product or provides the service. But these costs are incurred by the customers, to themselves and to each other. The analogy is not quite good enough.

In particular, the value of time, the principal item of congestion costs, is so uncertain, so mercurial in character, that its use in building up the structure of marginal-congestion costs is questionable. It is true that the importance of time savings (as well as that of the even more elusive comfort and convenience element) in the demand for transportation improvements is so great that one is forced to deal with it in any sort of economic analysis, and to make dubious calculations of average unit values. The point should never be neglected, however, that time is of different unit value to different people and to the same person at different times and in different situations.

It will be recalled that in Mohring's derivation of the unit value of time as a function of speed by a refinement of the trade-off method (20, pp. 20-22), values

TABLE 7

ANALYSIS OF AN ASSUMED COMMUTER TRIP TO THE CENTRAL BUSINESS DISTRICT

Distance Traveled (mi)	Elapsed Time (min)		Average Speed	
	To End of Interval	During Interval	(mi/min)	(mph)
0.0	0.0			
		7.5	0.667	40.0
5.0	7.5			
		10.0	0.500	30.0
10.0	17.5			
		15.0	0.333	20.0
15.0	32.5			
		10.0	0.250	15.0
17.5	42.5			
		15.0	0.167	10.0
20.0	57.5			
Avg.	-	-	0.348	20.9

range from a slight negative at 20 mph to \$67.82 per hour at a desired speed of 70 mph. The average of \$2.80 was calculated on the basis of the normal distribution of free-moving vehicles on level tangent sections of high-speed two-lane highways, as given by the "Highway Capacity Manual" (16, p. 32). The average speed for this distribution is 48.5 mph. It is questionable whether the average unit values of time thus derived are applicable to the travel of commuters to and from the CBD in pursuit of their daily work trips.

This point may be made clearer by reference to Table 7, which gives the details, in distance, time, and speed of an imagined but perhaps fairly typical 20-mi commuter trip. During the first 5 mi the average speed is 40 mph; during the second 5 mi, 30; and during the third 5 mi, 20. During the next 2½-mi interval the average speed is 15 mph; and in the last 2½ mi it slows to 10 mph. The time for the trip is 57.5 min. If the construction of a freeway should enable this car to make the 20-mi trip at an average speed of 30 mph, the trip time would be 40 min, and the time savings would be 17.5 min. If time were valued at the AASHO rate of about \$0.025 per min, the savings would be \$0.44 per trip. The owner would be more than able to pay his share of the freeway cost under conventional Federal-State user-tax financing. But if he were told that he must pay Mohring's rates of \$0.17 to \$0.29 per mile (22, p. 17) for the last 2½ mi of his trip, he would regard the charge as grotesque. And indeed, these monumental tolls for the tag ends of suburb-to-city trips do seem to reflect a myopic view of the problems and purposes of highway transportation.

Progress in Relief of Urban Congestion. —Meyer, Kain, and Wohl (38, pp. 22-37) have called attention to the fact that the progressive development of freeway programs in the large cities, coupled with progress in routing and handling traffic through better traffic engineering and control, are beginning to show results in marked improvement of urban traffic flows, although volumes continue to increase. It is pertinent to quote directly:

> Excessive despair about urban transportation, however, may be more a reflection of a failure to realize anticipations or aspirations than of reality and also of a lag between effectuation of an improvement and its public realization. In several important respects, in fact, performance of urban transportation systems recently has held constant or improved, particularly in the last seven years when highway construction began to accelerate and the rate of growth in the automobile stock declined. For example, comparative travel time studies made in Washington, D. C., in 1947 and 1954 show virtually no change in peak-hour commuting time from the CBD despite a large increase in automobile travel and no large-scale highway construction. As a much greater proportion of Washington commuters are using private autos, and as travel times by auto have been better than those by public transit in Washington during any time period—prewar, wartime, or postwar—this means that the average level of performance as measured by commutation time in the Washington urban transportation system has probably improved.
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> A recent study on urban transportation reports that by utilizing advanced traffic techniques and controls, Baltimore has achieved during the last eight years a threefold increase in traffic volume on some streets and savings in travel time up to 33 percent.

TABLE 8

AVERAGE SPEEDS AND TRAVEL TIMES IN LOS ANGELES[1] METROPOLITAN AREA, 1957, 1960, AND 1962

Year	Avg. Speed (mph) Overall	Avg. Speed (mph) Range	Avg. Travel Time (min)	Regis. Veh. in Los Angeles County
1957	24	20-33	51	3,010,000
1960	26	19-42	46	3,350,000
1962	30.5	22-42	41	3,575,000[2]

[1]Source: "Peak-Hour Driving Study, Metropolitan Los Angeles." Automobile Club of Southern California, p. 2 (1962).
[2]Estimated.

These writers also discuss the situation in Los Angeles, and give data illustrating the improvement in trip travel times in that city. It is possible, however, to quote figures directly from a report prepared in 1962 by the Automobile Club of Southern California (39). Table 8 summarizes the results of measurements of trip time and average speeds over a large number of routes in 1957, 1960, and 1962. Average speeds rose from 24 to 26 to 30.5 mph; average travel times declined from 51 to 46 to 41 min. During this period motor vehicle registrations in Los Angeles County increased from 3.0 to 3.6 million.

A closer glimpse of the Los Angeles experience is afforded by Table 9, which gives a comparison of peak-hour travel times and average speeds in 1957, 1960, and 1962, on trips from Adams Boulevard and Figueroa Street to 16 different places in the Los Angeles area. For two of the places only 1962 data are given. Of the remaining 14, all but one show a decrease in travel time in 1962 from the 1957 value, and all but two show improvement in 1962 over 1960. For some routes the changes are small, but for others, such as the trips to Glendale, Long Beach, and Woodland Hills, the improvement is striking, probably reflecting the results of freeway openings.

Although the 1962 study concentrated on peak-hour travel, comparisons with trip characteristics of earlier years were more readily available for off-peak hours. Table 10 gives travel-time values for trips made from 7th and Broadway, Los Angeles, to 14 places during the period between 9:30 a.m. and 3:30 p.m. in the years 1936, 1957, and 1960. The progress over the years in reduction of travel time is quite evident. Reductions ranging from 20 to 50 percent between 1936 and 1960 were found on all these trips. Reductions between 1957 and 1960 were relatively small but occurred on all but two of the trips.

Table 11, taken from a 1962 report of the Chicago Motor Club (40, pp. 10-12 and Appendix Tables 9 and 10) shows that progress along the same line has been made in Chicago. The table contains a list of trip times measured before and after the opening of the Northwest Expressway on three arterial routes alternative to the expressway. There were significant reductions in travel time on all of these trips.

The sense of these findings is that, despite the widespread notion that urban traffic conditions are worsening, they are in reality improving with the progress of the Interstate System and other freeway programs. Improvements in traffic control without major capital outlays have also increased the capacity of arterial streets.

TABLE 9

PEAK-HOUR TRAVEL TIMES AND DRIVING SPEEDS IN METROPOLITAN LOS ANGELES,[1] 1957, 1960, AND 1962

From Adams Boulevard and Figueroa Street to--	Distance (mi)	Peak-Hour Travel Time (min) 1957	1960	1962	Peak-Hour Driving Speed (mph) 1957	1960	1962
Bellflower	18.5	-	-	48	-	-	23
Buena Park	21.9	52	46	46	27	31	31
Duarte	24.9	54	54	51	28	28	30
East Whitter	19.9	-	-	44	-	-	27
Glendale	12.5	36	38	23	20	19	31
La Habra	23.0	62	69	52	22	20	27
Long Beach	25.2	65	41	36	23	37	42
Pacific Palisades	22.1	54	54	48	22	22	25
Playa Del Rey	12.0	32	32	29	22	22	24
San Fernando	27.7	51	50	40	29	30	38
Van Nuys	21.3	-	-	50	-	-	26
Venice	11.7	29	29	29	22	22	22
West Covina	23.8	47	47	42	30	30	34
Whittier	22.6	58	58	54	23	23	25
Wilmington	17.1	34	27	26	33	42	40
Woodland Hills	27.5	72	47	45	22	33	35

[1]Source: "Peak-Hour Driving Study, Metropolitan Los Angeles." Automobile Club of Southern California, p. 7 (1962).

Research in Traffic Guidance and Control. —Although the prospects for improvement in urban traffic conditions are bright, constant vigilance and the steady advancement of research are necessary in order to avoid retrogression under the pressure of metropolitan growth and expansion. Two major problem areas command attention: (1) That of conserving the capacity of the freeways and protecting them from crippling overloads;

TABLE 10

OFF-PEAK[1] TRAVEL TIMES IN METROPOLITAN LOS ANGELES,[2] 1936, 1957, AND 1960

From 7th and Broadway, Los Angeles, to--	Travel Time (min)		
	1936	1957	1960
San Pedro	48	42	35
Wilmington	39	36	29
Bell	25	22	20
Downey	33	25	24
Norwalk	37	27	26
Hollywood	23	17	16
Universal City	32	20	16
Van Nuys	45	39	28
South Pasadena	26	15	14
Monterey Park	25	21	18
Pasadena	31	21	18
San Marino	30	22	22
Sierra Madre	40	34	34
El Monte	31	26	24

[1]Between 9:30 a.m. and 3:30 p.m.
[2]Source: "Peak-Hour Driving Study, Metropolitan Los Angeles." Automobile Club of Southern California, p. 12 (1962).

TABLE 11

SUMMARY OF AVERAGE TRAVEL TIMES DURING RUSH HOURS ON ALTERNATE ROUTES BEFORE AND AFTER OPENING OF NORTHWEST EXPRESSWAY IN CHICAGO

Trip	Average Travel Time (min)	
	Before	After
ROUTE 1		
From Lincoln and Cicero:		
To Lincoln and Peterson	7:35	6:40
To Hollywood and Sheridan	19:23	14:25
To Lake Shore and Ohio	33:08	24:15
From Lake Shore and Ohio:		
To Lake Shore and Sheridan	12:00	9:35
To Lincoln and Peterson	24:00	18:10
To Lincoln and Cicero	32:00	24:35
ROUTE 2		
From Foster and Cicero:		
To Lincoln and Foster	10:05	6:53
To Sheridan and Foster	17:15	11:50
To Lake Shore and Ohio	29:05	21:27
From Lake Shore and Ohio:		
To Lincoln and Foster	20:45	16:41
To Cicero and Foster	28:55	24:05
ROUTE 3		
From Elston and Cicero:		
To Elston and North	24:00	19:03
From Elston and North:		
To Cicero and Elston	36:50	16:45

and (2) that of increasing the capacity of arterial and feeder streets. The focal points are those of intersecting or merging traffic—the interchange ramps of the freeway and the grade intersections of city streets. The resources of electronic computers and other modern research tools are being currently applied in a vigorous campaign on three fronts, those of traffic surveillance, traffic simulation, and traffic control. An able treatment of this subject is given in a recent paper by Baker (41).

Two projects that have been in operation for several years combine traffic surveillance and the amassing of data on freeway performance with actual traffic control. One is the Detroit Freeway Television Surveillance Project, of which Baker states: "The 14 television cameras, monitors, traffic sensing, analog computer equipment, and display system give the operators full control of all six freeway lanes during both normal, peak-hour, and emergency situations. Ramp entrance control signs have now been installed to close ramps for short periods during peak traffic in order to relieve observed congestion on the freeway." (41, p. 3). The other project, in place of television, utilizes ultrasonic detectors to sense the volume of traffic and measure average speeds along a 5-mi section of the Congress Street Expressway in Chicago. In Toronto, six years of preliminary study and a pilot traffic control project have culminated in the recent installation of a large-scale electronic computer to be used in actual time traffic control.

On the 7½-mi, 12-lane Seattle Freeway a remote control system will be included as an integrally designed part of the highway. The plan for use of the surveillance control system to reverse flow in the four center lanes has eliminated the need for four additional lanes.

Numerous other important research projects involving simulation or surveillance have been completed or are now in progress. Among them may be mentioned a large-scale simulation covering 77 intersections in the District of Columbia designed to study various signal timing plans with the objective of minimizing total delay, and an application of simulation to the study of traffic on two-lane roadways undertaken at North Carolina State College.

Of broader import is the problem of insuring the protection of the metropolitan transport system as a whole from serious overloading. A single freeway can be protected by closing ramps, but how can the entire freeway-street network, or better, the freeway-street-transit complex, be protected? This is a problem in the total planning of the metropolitan area, its governmental organization and land uses as well as its transportation system. It is a problem that must command the services of architects, geographers, political scientists, and sociologists, as well as planners, engineers, and economists.

It is plain, as previously stated, that the major problems in urban highway transportation are structural rather than financial. The decisions—as, for example, the extent of sharing, by freeway and rapid transit, of the traffic within a corridor—must be made on other than fiscal grounds. In this situation the role of congestion tolls is problematical. It may be that the problem of financing could be eased somewhat by revenues derived from some form of municipal or metropolitan-area user taxation. On the other hand, the economic orthodoxy of marginal-cost pricing is no great selling point if ample financing is available through the use of Federal and State road-user taxes. Furthermore, with congestion tolls as with miracle drugs, it is necessary to be watchful of the side effects.

Income Effects

Beckman, McGuire, and Winston (19, p. 83), in discussing the meaning of consumers' surplus as a measure of user benefits, express the following admonition:

> All of this is not to say that the consumers' surplus would be easy to measure in practice, but rather that it is adequate from a conceptual point of view. However, mention should be made again of an implicit assumption on which its applicability rests, namely that there should be no effects on income which would render the costs saved at various levels of spending of unequal (per unit) value to the road users.

Questions of income effects, of the marginal utility of income, and the difference between money income and real income have always plagued the subject of welfare economics, tending to increase the uncertainty of whether individual satisfactions can be accumulated to mass totals of utility, benefits, consumers' surplus, or what not. Little (4, pp. 10-11) discusses some of these logical difficulties:

> There is a final necessary condition for achieving the maximum possible happiness, which is that the marginal unit of money must yield the same satisfaction to everyone. If this condition is not fulfilled, then happiness can be increased by taking money income away from one man and giving it to another. If we assume a law of diminishing marginal utility of income, this implies than an equalitarian distribution of income will yield the most satisfaction. But there is a trap here. Do we mean to assume that the marginal utility of money decreases as money income increases, or as real income increases?

It was noted earlier that Coase (7) objected to the income redistribution that would occur if the customers of decreasing-cost industries were subsidized at the expense of the customers of increasing-cost industries. In the case of congestion tolls the field is reversed, in that anticipated surpluses are coveted by some advocates (32, pp. 14-15) as subsidies to rapid transit lines. This prospective action is defended on the ground that the patrons of transit lines are, on the average, on a lower income level than motorists. This is probably true; but if a subsidy of rapid transit is in the interest of the general welfare, then the general tax base, resting on the wealth of the community, is a more appropriate source for the subsidy. This is also true if a State or Federal subsidy is contemplated.

In the great metropolitan areas where rapid transit lines exist or are thought feasible, the densest aggregations of people are found in the residential sections surrounding the central city and its major satellites. These close-in residents are rather well served by existing transit lines, whether surface or subway, although many of them group in car clubs and otherwise make use of automobile transportation. Although this group would benefit if fares were reduced, the impact of the scheme on commuters by auto would be that of a one-two punch: those undaunted by congestion tolls would pay the subsidy; the craven-hearted would pay the fare.

It is generally agreed that there is a wide variance in the unit values people place on time savings, or on comfort and convenience. Mohring's calculations (20, p. 20) found the standard deviation of the unit value of time to be of the same order of magnitude as the value itself. The effect of the toll, therefore—and this also is widely recognized—is to sort out the prospective users of the tollway, rejecting those to whom the trip is not worth the price. Although there are numerous reasons for a given person to be unwilling to pay a toll at a given time, there can be no doubt that income status is the principal one, particularly in the case of a toll to be paid daily.

In the ordinary case of a toll road, bridge, or tunnel a marked advantage is to be gained by paying the toll. In the case of congestion tolls, if imposed according to the theory underlying them, the toll would be highest on the streets where, and at the times when, the congestion is greatest. The objective is to eliminate the congestion by forcing those unable or unwilling to pay the toll off the streets and on to another transportation mode, presumably subsidized by those electing to pay the toll. In the somewhat unlovely parlance of the economists, the well-heeled motorists are to "bribe" their less fortunate brethen to leave them in untrammeled possession of the arterial streets.

It must be acknowledged at once that all trip costs—user taxes, running costs, time costs, etc.—are parts of a price that some will not or cannot pay, that in this world of wages and prices some will have more to go on than others. Even so, congestion tolls as proposed are a new and drastic increase in trip costs, aimed directly at the lower income groups among motorists. They are to be imposed in accordance with a theorem of welfare economics to which Beckman's quoted admonition and Little's strictures apply. They nullify the phrase "other things being equal," for other things are not equal when there are significant income effects.

Business Effects

The effect on various business interests of a proposed government action is a matter for delicate treatment. The decision to adopt or reject cannot hinge on whether one business group will gain or another lose. These facts are not immaterial, however. For one thing, the business gains and losses are a part of the complex of benefits and costs, whether or not they fit into the model. For another, the potential winners and losers hold cards in the game. It is a fact of economic life, of political economy, that those who have economic power exert it.

The Winners.—If one could accept the beguiling picture of a freeway system financed by congestion tolls on arterial streets, one would congratulate the motor vehicle user as the big winner. But this seems too easy, too much like winning the Irish sweepstakes, to be credible. A more likely winner in this unlikely game is public transit. Not necessarily existing transit, because a rapid transit system subsidized by congestion tolls would absorb at least part of the patronage of surface lines. Then there are the industries that would supply equipment and motive power to the transit lines. And there is the enterpriser who would equip each urban vehicle with the electronic device that would meter its congestion toll. There are indeed opportunities for maximization of benefits.

The Benefits of Toll Charges.—In most schemes to enact congestion charges the proposition of a system of urban toll facilities is offered as a "second best" solution, in view of the untested status of the electronic tax collector. Because urban toll collecting systems do exist—some of them highly solvent, others not doing so well—it is natural that extension of the practice, both in metropolitan areas where tolls are charged and in those where they are not found, should be regarded as a promising prospect. As a result of a successful campaign in this direction, one might look forward to the day when each great metropolitan area would be girdled by a not entirely invisible wall of toll charges. Such a situation would be reminiscent of the medieval charge called the "octroi" which was levied against visitors attempting to transport goods into a walled city for sale. There is, of course, Manhattan Island, a sort of moated grange to which it is difficult to find entrance without paying tribute to the benevolent but well-heeled bondholders of its encircling toll facilities.

Because the intent to collect tolls implies the construction of toll expressways, or at least crossing facilities, the motor vehicle user might be expected to greet the prospect with glee, were it not for the fact that he is expected to share his benefits rather generously with the investors in tax-exempt securities, who have proved themselves to be no amateurs at the benefit-maximizing game. Table 12, compiled from information in the McCallum report (29, pp. 35-42), gives a brief analysis of the financing of five of the most recent large toll-revenue enterprises, and compares revenue-bond financing with the estimated costs of general-obligation bond financing (limited-obligation in Maryland) at interest rates at which each of the States issued highway bonds in the same or a very recent year.

The contrasts are striking. In issuing State highway bonds it is seldom if ever necessary to have their value exceed the capital outlays to be financed. In each of the five cases described in Table 12 the par value of the bonds issued far exceeded project costs in right-of-way, construction, and related expenses. The ratios of bonds issued to project costs vary from 1.15 for the Northeastern Expressway in Maryland to 1.44 for the Chesapeake Bay Bridge and Tunnel Commission project in Virginia.

McCallum's comparisons deal with the total cost of financing to the date of final maturity. The ratio of financing cost (including interest, redemption, and other charges) to project cost varies from 2.15 for the Massachusetts Turnpike Extension to 3.48 for the Chesapeake Bay Project in Virginia. In contrast, the corresponding ratio for the estimated general- and limited-obligation bond financing varies from 1.28 to 1.57 in four of the five States. No comparison is available for Virginia, as that State has no history of State highway bond issues. For the other four projects the ratio of revenue-bond financing costs to the estimated costs of general- or limited-obligation bond financing varies from 1.59 to 1.79.

The most direct comparison is that between the net interest rates, inasmuch as the higher rate paid on revenue-bond issues represents the premium price paid to the

TABLE 12

COMPARISON OF RECENT TOLL-REVENUE BOND FINANCING WITH ESTIMATED GENERAL-OBLIGATION BOND ISSUES AT RATES OF SUCH ISSUES BY THE SAME STATES IN RECENT YEARS[1]

Item	Massachusetts Turnpike, Boston Extension	Kentucky Turnpike Authority	Delaware Turnpike and Northeastern Expressway		Chesapeake Bay Bridge and Tunnel Commission
			Delaware	Maryland	
Project costs	$152,000,000	$130,569,950	$23,957,250	$ 64,200,000	$139,200,000
Revenue bond issues:					
Year of issue	1962	1961	1962	1962	1960
Net interest cost or interest rate	4.48 and 5.00	4.86 and 4.928	4.1875	4.1875	5.61766
Par value of issues	180,000,000	157,000,000	28,000,000	74,000,000	200,000,000
Interest and other financing	146,863,000	169,091,631	27,474,000	72,419,000	283,760,794
Total cost of financing	326,863,000	326,091,631	55,474,000	146,419,000	483,760,794
Ratio of financing to project cost	2.15	2.50	2.32	2.28	3.48
Estimate of general-obligation bond financing at rates of State issues in same years	-	-	-	-[2]	-[3]
Interest rate, percent	3.10	3.60	3.20	3.50	-
Par value of issues	152,000,000	130,000,000	24,000,000	64,000,000	-
Interest	51,615,000	74,800,000	8,064,000	17,920,000	-
Total cost of financing	203,615,000	204,800,000	32,064,000	81,920,000	-
Ratio of financing to project cost	1.34	1.57	1.34	1.28	-
Ratio of revenue-bond financing cost to general-obligation bond financing cost	1.61	1.59	1.73	1.79	-

[1]Source: "Highway Bond Financing: An Analysis, 1950-1962." William R. McCallum, U. S. Department of Commerce, Bureau of Public Roads (1963).

[2]It has been the practice in recent years for the State of Maryland to issue limited-obligation highway bonds secured by road-user tax revenues.

[3]There is no history of State highway bond financing in Virginia to afford a basis of comparison.

investor for his risk in buying securities not backed by the full faith and credit of the State or the assurance of its sturdy user-tax revenue structure. In calculating the following ratios the arithmetic mean was used in the two cases where two rates of revenue-bond interest are shown:

Project	Ratio of Net Interest Rates, Revenue-Bond Issue to Estimated General- or Limited-Obligation Bond Issue
Massachusetts Turnpike Extension	1.53
Kentucky Turnpike Authority	1.36
Delaware Turnpike	1.31
Northeastern Expressway, Maryland	1.20

The relatively low value of the ratio in the Maryland case is attributable chiefly to the fact that a limited-obligation rather than a general-obligation bond issue is used in the comparison. If it were to be assumed that Virginia would be equally able to issue State highway bonds at 3.5 percent interest, the ratio for the Chesapeake Bay Bridge and Tunnel Commission financing would be 1.61. Such are the surcharges a State—and the user—pays for the privilege of floating toll-revenue securities.

The Losers.—The widespread adoption of congestion tolls in such magnitude as actually to discourage the use of motor vehicles in metropolitan areas would have an adverse effect on motor vehicle manufacturers, tire manufacturers, the petroleum industry, and the corresponding distributive businesses. Consideration of this point can lead to a variety of conclusions. People in the industry would naturally resist any attempt to limit the use of their products. The owners of automobiles and commercial vehicles would be resentful of imposts materially above those they are accustomed to paying. If the outcome were such as to cause a drastic curtailment of urban freeway programs, highway contractors and the suppliers of construction materials and equipment would be affected to some degree. The vast structure of employment in the highway-motor-vehicle industry would suffer a disturbance, the magnitude of which would depend on whether the anti-motor-vehicle distemper, now rather closely confined, became epidemic.

It has been held that the question of effects on the motor vehicle industry is not germane; that congestion tolls should be imposed because they are necessary in order for the motor vehicle to pay its due share of highway costs. If the charges were based on the public outlays required to defray the costs of the freeway program, they could be accepted calmly in the realization that the benefits would equal and probably exceed the costs. But the fact is that freeway programs are being financed at the present rates of Federal and State road-user taxes, and at the most, only moderate increases are in prospect. Congestion tolls are justified on the ground that marginal-cost pricing, based on time-delay and other costs incurred by the users, maximize benefits. In this context side effects, such as benefits or disbenefits to business and employment, may with reason be regarded as a part of the total benefit-cost equation.

On the other hand, it is possible to take a detached viewpoint and ask whether there are too many motor vehicles or whether their number is increasing too rapidly, whether too much time and money are being spent for motor vehicle transportation, whether considerations of frugality do not dictate seeking the least expensive forms of transportation from here to there. From this angle congestion tolls are advanced as a means of promoting the optimum utilization of resources in the realm of urban transportation.

This viewpoint can be generalized to an attitude on nationwide and worldwide affairs. Perhaps resources are being wasted; perhaps we are living too well; perhaps if we lived less well we could be of more assistance to the underdeveloped countries. In other words, if the American standard of living were to be lowered, perhaps standards could be raised elsewhere. The trouble with this notion is the simple fact that a regime of austerity at home is quite unlikely to yield a surplus for export abroad. Only by producing abundance for ourselves can abundance be helped to appear in other places.

These observations do not do away with the vexing question of whether too much is being spent on motor vehicle transportation and too little on some other things. The same question applies to the entire spectrum of goods and services in both public and private economies. In the particular field of urban transportation a proposed action, such as the creation of a system of congestion tolls, can only be justified if it improves the quality and increases the availability of transportation. A policy aimed at cutting down the use of motor vehicles in the urban area seems unlikely to accomplish either purpose.

Community Effects

The urban community is a far-spreading and complex entity, often embracing several counties as well as the central city. The nature of the governmental structure makes planning difficult and consistent decisions even harder to come by. The transportation and communication systems are the means by which the city's life and movement become effective in production, distribution, education, religion, recreation, social and family activity. Decisions made about its transportation system should be decisions of and for the whole community. They should not attempt to stop the clock. They should not attempt to pour the developing metropolis into a rigid and undeviating plan. They should be in harmony with the observed long-term trends of regional growth.

Congestion Tolls and the City Center. —The objective of preserving the best values of the city center—commercial, governmental, cultural, scientific—is one that, if conceived in realism and not in nostalgia or hysteria, commands almost unanimous acclaim. This objective will not be served by transportation charges that are coercive in character and go against the grain of the urban, suburban, and exurban residents. Motorists have choices that go beyond the question of whether or not they use their automobiles in driving to the central business district. They may be able to look elsewhere for employment opportunities and they certainly can look elsewhere for places to do their shopping and other family business. The persistent trend for more rapid growth, in business and employment, of the outer rings of metropolitan areas, in comparison with the slower growth (and sometimes decline) of the central city, has been observed and depicted in many studies. Meyer, Kain, and Wohl (38, pp. 1-15) discuss this trend and cite many of the reports that give evidence of its persistence.

It is quite unlikely that either the trend of urban residents to move to the suburbs or the trend of business and industry to seek outlying locations will be reversed by even the most strenuous efforts to block them. Indeed it is apparent that the best chance of preserving the commercial, governmental, and cultural values of the city center lies in keeping open and improving the channels of communication, both transit-oriented and highway-oriented, rather than in efforts to favor one against the other. This point was made by Goldstein, Kanwit, and Rapp in their comments on the Walters article (26) quoted earlier in this paper.

Moses (42, pp. 7-8), discusses the question of the effects of metropolitan development, in the following terms:

> The efficiency argument has a great deal of force and as an economist I accept it. However, city planners, municipal officials, and public administrators whose real concern is not traffic congestion and the inefficient use of highway capacity—viewed as a resource—but the economic future of our mature, central cities, should pause before accepting it.
>
> The assumption most often made in studies that deal with traffic problems is that people will shift to public transportation for the downtown work trip if the cost of automobile commuting is increased sufficiently. There is a third alternative. Substantial

> increases in the cost of downtown commuting could solve the traffic congestion problem by encouraging a faster movement of manufacturing and business establishments from the core area of the city to suburban areas, or even to the newer, less-well-developed portions of the country.
>
> In economists' language, all of us have been proceeding as if the demand for downtown trips is perfectly inelastic and choice restricted to the various means of getting there. This is incorrect. Transport costs are a significant factor in determining where within a metropolitan area economic growth will take place. If the cost of getting to the downtown area is greatly increased, there is a strong possibility that the core area's traffic problem will be solved by reducing the number of people who work there.
>
> Changes in price are not the only method by which diversion may be carried out. Investments that reduce travel times and the disutility of travel by the alternative modes might prove effective.

It is rather interesting that some of the advocates of congestion tolls cite them as a means of accomplishing the objective of moving business and employment out of the city center. Roth and Thomson (43), advocate what are, in effect, congestion tolls and some form of electronic device for their measurement and recording. In discussing the effects of such a congestion toll system the authors speak hopefully of "... a tendency for occupations associated with large road requirements to leave city centers and to make way for occupations requiring less .... "

Thinking Regionally. —The image created by the congestion-toll proposal is that of the beleaguered central city protecting itself from invasion by the residents of its outlying areas, the suburbs, and the surrounding countryside, by means of a system of charges becoming ever more mountainous as the inner citadel is approached. The unhappy analogy with a medieval walled town was previously cited. It is true that the outward movement of people and business has produced dislocations in the tax base and in the provision of services such that the commuter from the outer areas often seems to derive an unfair advantage. The multiplicity of local governments, often of two or more States, further complicates the situation. It is unlikely that the alpine system of mounting charges is the ideal remedy. The object is for the city center to attract, not repel, invaders.

It should be obvious that these difficulties are to be solved, if at all, by an approach to regional government, or at least regional action based on genuine regional planning. Beginnings have been made in a few metropolitan regions, of which the Metro experiment in the Miami area (44) is the best known. The problem is difficult in an interstate metropolitan region, such as the tri-State New York City area or the District of Columbia-Maryland-Virginia complex. The most progress, perhaps, has been made in the metropolitan transportation studies, past and current, in these great areas. The transportation studies point the way toward areawide solutions. Fortunately, Federal and State programs will provide most if not all of the funds for the needed freeways and major arterials. If more highway funds are needed, regional user taxes, preferably at moderate rates, are not unthinkable. They certainly would be preferable to, and probably more lucrative than, congestion tolls levied on the last few miles of the suburb-to-city trip. Solution of the governmental problems of metropolitan regional taxation (user or other) should not be beyond the reach of American ingenuity, even in an interstate area.

The role of public transit is a major element of the regional transportation plan, and should be solved integrally with the highway plan. If subsidies are needed, regional taxation again seems to be indicated, but in this instance not aimed at the motor vehicle user as such.

SUMMARY

1. In the first part of this report the elements of marginal-cost theory were presented and the views of a number of economists, including Little and Samuelson,

about the sanctity of the rule of marginal-cost pricing were discussed. In view of the skepticism of these experts and the cogency of the reasoning and evidence they presented, it was concluded that no planning official or public authority is obligated, in theory or in equity, to adopt marginal-cost pricing of a public service, and that schemes for this form of pricing should be subjected to the tests of popular acceptability, of soundness from the standpoint of public finance, of consistency with observed trends in the development of the affected area, and of conformity with the objectives of long-range regional plans.

2. The second section discussed the formulations of economists who have developed the theory by which the marginal cost of congestion determines the price at which user taxes or tolls are to be set. Particular attention was given to the work of Mohring and Strotz, whose models, contrary to the practice in earlier formulations, include highway costs as terms in the equations.

Acknowledging the reality of congestion costs, comments on Mohring's treatment stressed the basic incongruity, to motor vehicle users, of being taxed for the costs they cause themselves and each other. Strotz's formulations elicited the observation that, although the interdependence of highways with other economic activity was written into the model, the very form of the equations, designed for a simple optimization procedure, insured that the implicitness would disappear in the partial derivative.

3. In the third section the implications of congestion tolls were considered. It was first suggested that a proper model to represent highways and highway finance in a real world would be a dynamic one, hitched to the chariot of time, that would take note of this year's taxes building next year's highways, of the growth of traffic and the expansion of the highway plant, of long-range plans and programs, and of the effects over time of the decisions that might be made. And it was hinted that in such a model marginal-cost pricing would perhaps not play a crucial role.

4. Next the current status and characteristics of urban highway financing were reviewed. It was found that expenditures and annual costs per mile of travel are lower in urban than in rural areas, with the exception that urban freeways seem to cost somewhat more per vehicle-mile than their rural counterparts. It was further found that, although local nonuser taxes still make a substantial contribution to the support of ordinary city streets, Federal and State road-user tax revenues are dominant in urban highway finance, particularly in the construction of expressways and other major connections of Federal-aid and State highways. In the analysis of 1960 revenues, expenditures, and earnings of user taxes and tolls in 46 Standard Metropolitan Statistical Areas it was found that (a) earnings were far in excess of the user revenues applied to roads and streets in these urban places and (b) the aggregate user earnings in these 46 SMSA's exceeded the aggregate expenditures on roads and streets by 11 percent. From this review it was concluded that in view of the adequacy of present rural and urban highway financing, through a combination of Federal and State user revenues with local funds derived from both user and nonuser sources, congestion tolls are not needed as a supplementary source of urban highway revenues.

5. Some of the characteristics of urban travel were next examined, including (a) the surprisingly small proportions of all urban trips that are made to or from the downtown area; (b) the fact that a majority of trips entering the central business districts of metropolitan areas have destinations elsewhere, a situation that can be corrected by the provision of an inner beltway; (c) the characteristics of peak-hour traffic on both freeways and rapid-transit lines; (d) parking costs as an element in total trip costs; (e) an examination of time savings in relation to a typical commuter trip, leading to the inference that the levy of congestion tolls on the last few miles of a trip is no substitute for a user-tax-supported freeway; (f) the introduction of evidence showing the reduction of trip travel times and increase of average speeds resulting from the construction of expressways and the improvement of traffic control on arterial streets; and (g) a discussion of current research in traffic surveillance, simulation, and control on both freeways and arterial streets. This review led to the conclusion that the problems of urban transportation are mainly structural, demanding the cooperation of architects, engineers, sociologists, planners, and many others; and that the congestion-toll proposition has little to offer toward their solution.

6. Authorities were quoted to the effect that the validity of theorems involving the maximization of benefits is contingent upon the absence of adverse income effects—e.g., in Little's words "... that the marginal unit of money must yield the same satisfaction to everyone." Two kinds of income effect were pointed out: (1) The subsidy of transit users by motor vehicle users often advocated as a part of the congestion-toll proposition; and (2) the discrimination against low-income motor vehicle users inherent in congestion tolls.

7. Effects on business—favorable to rapid transit, to suppliers of rapid-transit equipment and power, to purveyors of electronic congestion-tax metering devices, and to investors in tax-exempt toll-revenue bonds; adverse to motor vehicle users, manufacturers, distributors, and suppliers—were cited as elements in the complex of benefits and costs that are not cared for in the congestion-toll formulations.

8. In discussing community effects the point was made that the imposition of congestion tolls, rather than conserving the central business district, might well produce the opposite effect by inducing motor vehicle commuters to seek employment elsewhere and causing downtown businesses to move to outlying and suburban locations. It was further urged that the problems of metropolitan regions, whether structural or financial, be attacked and solved on a regional basis.

In view of this series of adverse findings it is concluded that congestion tolls do not offer great promise as a means of improving the conditions of urban transportation.

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