The Place of Subsidies in an Optimum Transportation System

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In the free enterprise world of economic theory, four distinct grounds for socially desirable subsidies are generally enumerated: (a) economies of scale, (b) indivisibilities, (c) "second best" considerations, and (d) social considerations. Many students of transportation economics have presented arguments that would seem to justify general transportation subsidies or subsidies to particular components of transportation on grounds other than these four commonly accepted ones. Four of these arguments are presented.

This paper demonstrates through use of some simple mathematical models that these common and seemingly plausible arguments do not provide an economic foundation for a general policy of transportation subsidy; describes the basic economic conditions generally regarded as justifying subsidy; and summarizes the limited available evidence concerning the presence of these subsidy justifying characteristics in transportation activities.

•THE EFFECTS of highway improvements pervade the economy in a different manner than do, say, the effects of new steel mills. Perhaps for this reason, many noneconomists (particularly those engaged in the use or development of highways) tend to regard highway investments not only as quantitatively but also as qualitatively unique. Similarly, when dealing with a wide variety of problems, economists find it convenient to ignore the condition that the production and distribution of goods and services normally entail the employment of resources to overcome the friction of space. Perhaps for this reason, the opinion seems common among economists that different tools of analysis and different standards of valuation are required to deal with problems—the economics of transportation and of international trade, in particular—in which space must necessarily play a central role.

One upshot of this putative uniqueness of the role of transportation is a wide variety of special economic arguments purporting to show why various types of transportation or transportation in general is deserving of subsidy. Two matters should be clarified at the outset: what a "subsidy" is and what a "special economic argument" for subsidy is.

Dictionaries define "subsidy" along the lines of "a payment out of general tax revenues to support an activity deemed advantageous to the public." This definition is too narrow. The label "subsidy" has been attached to a wide variety of situations in which no direct payment from tax revenues is involved. For example, some argue that apple growers subsidize bee keepers because no payment is made for the nectar bees convert into honey. Some claim that non-user contributions to highway trust funds would constitute subsidies to highway users; others maintain that paying for highway improvements entirely through user taxes subsidizes the many non-users who benefit from these improvements. Inasmuch as the license fee a private passenger vehicle operator pays is independent of the number of miles he drives, it can be contended that the 3,000-mile per year driver subsidizes his 30,000-mile per year counterpart.

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Some of the special arguments discussed here are arguments for subsidies in the narrow dictionary sense; that is, arguments for payments out of general tax revenues. Others are arguments for subsidies in a broader sense of the term, subsidies that involve payments from one specific population group to another rather than from general tax revenues.

In the last analysis, payment of a subsidy of either variety is justified and justifiable only on grounds of social desirability; that is, on grounds that its payment is deemed a good thing. Some subsidies are justified largely or entirely on humanitarian, equity, or national defense grounds. Unemployment compensation is paid because most feel that it is not nice to let people starve. Many argue that public transportation subsidies are necessary to enable people who cannot afford cars or are unable to drive to get to and from work. The basic argument for veterans' benefits seems to be that the services rendered by veterans are deemed to have been of higher value to society than the price initially paid for them. The American merchant marine (among a great many other activities) has successfully petitioned for subsidy on grounds that ships are needed in time of war.

Whether a subsidy is justified on humanitarian, equity, or defense grounds is a matter for politicians, not economists, to decide. About all an economist acting in his role as economist can do is put the costs involved in perspective. He can, for example, point out the number of nuclear submarines that could be provided with the funds presently spent on merchant marine subsidies.

In addition to humanitarian, equity, or defense justifications, however, proponents frequently claim purely economic justifications for the subsidies they favor. That is, they claim, in effect, that the market value of the subsidy's anticipated benefits will exceed its dollar costs. Although most economists have rather jaundiced views about subsidies, they do typically agree that a subsidy to an activity would have a benefit-cost ratio of greater than one under certain conditions. The argument runs about as follows: It would be economically desirable to increase the output of a commodity if the cost of the additional resources required to do so is less than the price consumers would be willing to pay for these additional units. More succinctly, it would be economically desirable (economically efficient, to employ the commonly-used term) to increase the output of any commodity as long as its additional, incremental, or marginal production costs are less than its market price. Expanding output would be economically efficient in the sense that doing so would enable making at least one person in the economy better off, without at the same time making any one else worse off.

Also, the key here is not average production costs; it is, rather, additional, incremental, or marginal production costs. The key to achieving economic efficiency is to set marginal cost equal to price even if doing so requires operating at a loss and hence requires a subsidy. A "marginal cost equals price" output policy would require operating at a loss if the production process in question was characterized by economies of scale, by a decline in average production costs with an increase in output. Under such circumstances, marginal production costs would necessarily be less than average production costs.

The economic efficiency argument for subsidy is a perfectly general one. If the existence of unexploited scale economies (or some other possibilities) is proved in any line of economic activity, most economists will agree that a subsidy is justified in principle. However, the economic efficiency argument is rarely adduced by petitioners for public doles. Much more common are arguments purporting to show why the petitioning activity is more or less unique in providing economic benefits that would be lost in the absence of a subsidy. A number of such special arguments for transportation subsidies—arguments that do not fall under the general "economic efficiency" heading—have been put forth. Four of the most common of these special arguments are really not sound. An analysis of these is followed by a presentation of the limited available information on the extent to which it may be possible to justify transportation subsidies on general economic efficiency grounds.

The four common special subsidy arguments discussed are those for (a) urban mass transportation subsidies that rest on the alleged superior efficiency of these modes of travel; (b) highway subsidies that rest on the existence of "non-user benefits," particu-

larly benefits to the owners of land near improved highways; (c) subsidies to transportation and public utilities, which are common in the economics profession although perhaps not outside it (Hotelling paradox); and (d) private passenger vehicle operators' willingness to subsidize existing or improved mass transit facilities inasmuch as a shift from private to public conveyances would reduce highway congestion and thereby benefit the remaining highway users.

As an example of efficiency arguments for mass transportation subsidies (1 p. 116),

> The automobile is already obsolete as the primary means of transportation and communication within our major metropolitan areas—based on current auto sales and the glut of city streets which in themselves already occupy one third of our central business districts (such as in Los Angeles). How much more of our most valuable land can we sacrifice to such necessary but unproductive uses? A new, more efficient, less costly and less space-consuming means of mass transport must be brought into operation. If we continue with the hopelessly inefficient system of transport, we will move toward the point of the "immovable glut" and to increase in private as well as public costs of transport.

Or (2, p. 53),

> If transportation modes were selected on the basis of sound economic decisions, then the whole problem of urban transportation could be much [more?] objectively approached and analyzed by traffic engineers, traffic companies, and others.
>
> People don't behave according to sound economic decisions in the selection of transportation modes. There are conveniences and psychological values that cause many people to use automobiles when it can be simply demonstrated that such usages are [not?] most economical.

These arguments seem to boil down to the contention that socially undesirable waste is entailed in using a high dollar cost transport system when one involving lower dollar costs could be substituted. Although this argument is really quite silly, the frequency with which it is made and the apparent discomfort of private transportation proponents on hearing it make it desirable to spend some time attacking it. Its silliness can perhaps be most easily seen by applying the same line of reasoning to a different problem.

A recent Bureau of Labor Statistics study (3) determined the amount required to provide a "modest but adequate" living for a hypothetical four-person family "according to standards prevailing in large cities in the United States in recent years." The food and beverage component of this budget ranged between $1,514 and $1,889 a year. If the most "efficient" diet is defined as that entailing the lowest dollar outlay, the Bureau of Labor Statistics' conception of a "modest but adequate" diet entails gross inefficiency. Stigler and others (4, 5) have shown that about $100 a year would suffice to provide a balanced diet (one containing neither too much nor too little protein, carbohydrates, vitamins, etc.) for a 160-lb man of average metabolism and activity. Yet even though they cost more, few bemoan the preference for steak, french fries, and asparagus instead of the primary constituents of an efficient diet—wheat flour, evaporated milk, spinach, cabbage, and dried navy beans. If the Spartan "efficiency" concept is deemed applicable to transportation, consistency would seem to demand that it also be applied to diets and other consumption activities. After all, why berate people for letting "conveniences and psychological values" interfere with "sound economic decisions in the selection of transportation modes" when the same condemnation is not applied to their dietary preferences?

Restricting attention to land values, the "non-user benefits" argument for highway subsidies seems to say the following: land values have been shown to increase in the vicinity of improved highways, sometimes by dramatic amounts. Because benefited landowners need not use the improved highways involved to reap their benefits, a class of non-user beneficiaries clearly exists. To measure total highway benefits, it is therefore necessary to add benefits received by landowners to those received by highway

"efficiency" or "benefit-maximizing" tax should be in the case under discussion depends, of course, on the value motor vehicle occupants place on their travel time. If this time is valued at $1.55 an hour as suggested by the American Association of State Highway Officials (8, p. 126), the tax for the trip ought to be about $0.26 at a traffic level of 700 vehicles per hour. Assuming an average gasoline consumption rate of 15 mi per gallon, a gasoline tax of about $0.0775 per gallon would be required. At $5.00 an hour, on the other hand, the required tax would be $0.25 per gallon.

Thus, putting the costs of highway congestion into proper perspective reduces the apparent conflict between the long-run and short-run maximization of highway benefits. Of course, nothing has yet been said about the relationship between "benefit-maximizing" or "efficient" highway-user taxes on the one hand, and the total cost of providing highways on the other. Unfortunately, no general statements can be made on this subject. However, if a severe but plausible condition holds, it can be demonstrated that an "optimum" highway system would require benefit-maximizing tolls that would just suffice to cover total highway costs. An optimum highway system is one that would maximize the present value of net highway-derived benefits. Establishing such an optimum highway system would require two steps: (a) charging benefit-maximizing tolls that force each individual driver to take fully into account the costs that his trips impose on other drivers; and (b) increasing capital expenditures on highways to the point where, for the corresponding optimum traffic level, the annual congestion cost savings provided by an increment in capital expenditures just equals the annual capital charge on that increment.

The condition under which a highway system that is optimum in this sense would generate tolls just sufficient to cover its capital and maintenance costs is, simply enough, that there be neither economies nor diseconomies of scale in highway construction, maintenance, and use. That is, an optimum highway system would just pay for itself if (a) the cost of building and maintaining one four-lane highway is the same as that of two two-lane highways having equivalent characteristics; and (b) the time and money costs incurred by each individual driver would not change if both the traffic on a highway and its capital and maintenance costs were increased by the same proportion. If economies of scale exist in highway construction, maintenance, or use, maximizing the net highway benefits would require highway subsidies. But these are, after all, the basic conditions under which an economist would agree that a subsidy would be warranted to any line of economic activity.

Just as with the "efficiency" argument which was given such short shrift, the final special subsidy argument also relates to the benefits of mass transportation subsidies. As an example (9, p. 62) of the "bribery" argument for subsidy,

> To make people pay what it costs is self-defeating for the reason that one of the broad social justifications of a new investment in rapid transit facilities is to reduce the urban traffic dilemma by inducing people to give up the use of private motor vehicles or to remain on public transportation if they are becoming discouraged by poor service.

This and similar "bribery" propositions say, in effect, that anything that reduces the number of automobile trips taken on the roads connecting here and there will reduce congestion on these roads, thereby benefiting the remaining auto drivers. In particular, the substitution of trips by subway or bus for trips by auto will be encouraged by improvements in existing subway or bus service or by the introduction of new service if none is presently available. Because they benefit from the resulting reduction in congestion, the remaining auto travelers ought to be willing to pay part of the costs of improving public transportation service. That is, they ought to be willing to subsidize, to bribe people to shift from auto trips to subway or bus trips.

As with the "efficiency" argument for subsidies, it is instructive to attempt to generalize the bribery argument. The consumers of a commodity are not the only beneficiaries of a reduction in its price. Those who consume substitute products also benefit. For example, a reduction in the price of apples will cause some people to substitute apples for oranges in their diets. Such substitutions benefit orange consumers because they serve to reduce the demand for and hence the price of oranges.

This suggests a couple of intriguing possibilities. For example, it would be possible

for a representative group of orange consumers to use some of the money they presently spend for oranges to subsidize apple producers. This would lower apple prices and would induce orange consumers to shift to apples. Alternatively, they could use some of this money to bribe present orange consumers to shift to apples. Clearly, either alternative would serve to lower the price of oranges. Would it not therefore be in the interest of orange consumers to follow one or another of these alternatives?

Perhaps not surprisingly, the answer is "No." To see why, it is useful to consider the bribery proposition in somewhat greater detail. Once more, if some orange consumers bribed other orange consumers to shift to apples, the remaining orange consumers would benefit. In addition, by substituting apples for oranges, the bribed consumers would increase the demand for and hence the price of apples. Apple producers therefore ought also to be willing to contribute part of the necessary bribe. Orange producers and apple consumers, however, would clearly oppose the substitution of apples for oranges. The former would suffer a reduction in the prices they received; the latter, an increase in the prices they pay. Both groups ought therefore to be willing to contribute counterbribes to discourage the shift.

Clearly, these two groups of potential subsidy payments tend to cancel each other out. Indeed, they would precisely cancel each other if the markets for oranges and apples are competitive. More exactly, if both orange and apple markets are in competitive equilibrium, the dollar gains to orange consumers and apple producers resulting from a small shift from orange to apple consumption would be precisely offset by equal dollar losses to orange producers and apple consumers.

At least some of the same considerations apply to the markets for auto and public transit trips. Although congestion would be reduced if auto drivers bribed (either directly or by contributing to an improvement in public transportation service) some of their number to shift to public conveyances, those who presently use public conveyances would likely suffer from such shifts. The public conveyances would become more crowded. The number and duration of stops might increase. Present users of public conveyances would therefore likely be willing to offer counterbribes to keep such shifts from taking place. The possibility exists, then, that these two sets of bribes would also cancel each other out.

However, there is at least one peculiarity of the public-private transportation case that makes it seem intuitively plausible that the orange-apple analogy might not apply. Even if the conveyance on which he travels is publicly owned, the individual must himself supply a valuable asset—his time—if he makes a trip. Individuals do differ substantially in the values they place on their time. That the occupant of one vehicle values his time at $50 an hour and the occupant of another at $0.10 might well seem to open the way to mutually beneficial and socially desirable bribes, even if both private and public transportation are "competitive."

As it turns out, however, this peculiarity is not a vital one. Just as argued in the case of the Hotelling paradox, if a highway, or more generally, a transportation system is of optimum size (that is, if it is designed to maximize long-run net benefits) and if there are no economies of scale in either construction or use of the system, the toll system that would maximize benefits would be one that required each member of each user class to pay exactly the costs his trips impose on others. In particular, under such circumstances, it would not be desirable from the viewpoint of either society or auto drivers to have each auto driver pay more than the cost he imposes on other travelers in order to encourage still more people to travel by bus or subway.

Again, the logic supporting these contentions is not overly complicated. However, time does not permit developing it here. The argument, however, can be made intuitively more plausible by putting it in a broader context. Individual tastes in various commodities—furniture, clothing, housing, and autos, for example—do differ. This being the case, if no cost penalty is involved, society as a whole would seem better off if a variety of choices was available in these product groups than if alternatives were few in number. The more alternatives available, the more likely it is that each consumer will be able to find a combination of specifications that conforms closely to his tastes. So, too, with transportation routes. Tastes do differ. Most importantly, the rates at which individuals would be willing to exchange dollars for time do vary con-

siderably. Thus, again, if no cost penality is involved, the availability of routes possessing a wide variety of toll and time combinations would clearly give each traveler a better chance of finding a personally optimum travel mode than if no choice was available. However, the fact that tastes differ does not in itself justify subsidizing either a particular product or those who buy it.

In nothing said so far has it been proved or even contended that transportation subsidies are undesirable. Rather, plausible reasons have been offered for the contention that, if transportation subsidies are to be proven economically desirable, essentially the same arguments must be used as those which would provide economic justification for a subsidy to any other line of economic activity. In conclusion a brief summary of the small amount of information available on the extent to which transportation activities possess these general subsidy-justifying characteristics is offered.

Once more, economic efficiency requires setting price equal to marginal cost. If scale economies exist, marginal costs will be less than average costs. If marginal costs are less than average costs, setting prices equal to marginal costs would require operating at a loss and hence would require a subsidy. In discussing empirical evidence of scale economies in transportation, it is useful to distinguish between the long-run costs of providing transportation capacity and the short-run costs of utilizing that capacity. As for the long-run problem, there seems to be no information on whether scale economies exist in the construction of such special rights-of-way as railroad and subway tracks. The only study providing information on scale economies in highway construction appears to be an unpublished analysis by a University of London economist, Michael Beesley, of optimum investment timing on Great Britain's only superhighway, the London-Birmingham Motorway. He is reported to have concluded that increasing the size of the road in question by 50 percent from four to six lanes would have increased its capital cost by only about 35 percent. Without seeing the study, why this should be the case can only be speculated on. Economies of scale may exist in the construction of roadways, interchanges, and bridges. In addition, scale economies in the provision of rights-of-way quite probably exist. A 50 percent increase in the number of lanes would presumably increase the amount of land required for this purpose by almost exactly 50 percent. However, the land required for medians and shoulders increases little, if at all, with increases in road width.

Economies of scale in highway use also appear to exist, although perhaps only for relatively small traffic flows. The "Highway Capacity Manual" (8, pp. 38, 46-47) indicates that the "practical capacities" of straight, level, two- and four-lane roads with 12-ft lanes are 450 and 1,000 vehicles per lane per hour, respectively. Above four lanes, however, scale economies in highway use seem to disappear. A six-lane highway is also regarded as having a "practical capacity" of 1,000 vehicles per lane per hour and, probably due to the effects of increased weaving from lane to lane, the capacity of an eight-lane highway seems to be somewhat less than 1,000 vehicles per lane.

In brief, there is some evidence that economies of scale exist in the construction of highways or at least in the construction of limited-access highways. Economies of scale also appear to exist in highway use. However, these latter economies appear to end well below the levels at which urban traffic arteries are used. If scale economies in highway construction and use do exist, they presumably apply with equal force to all highway users—public or private; truck, bus, or auto.

In addition, there is at least one factor that suggests economies of scale to be greater in public than in private transportation. Although there may be no scale economies in the costs to a transit company of providing bus or subway trips, there do definitely appear to be scale economies from the standpoint of the individual user. The time costs to users of public transportation facilities are really of two sorts: time en route and waiting (or walking) time at one or both ends and perhaps in the middle of the trip. Once a rider is aboard a bus or subway car, an increase in the number of passengers very likely increases his time en route by increasing both the number and duration of stops. At the same time, however, an increase in the demand for trips on a route can also be expected to result in increased service frequency, and therefore reduced waiting time. For example, if service is scheduled on a route every 15 min, and if

an individual rider does not know the schedule, he can expect on the average to wait 7½ min for his bus to come. If service is increased to a 10-min interval, his expected wait is cut to 5 min. Furthermore, as density increases still further, skip stop or express service may become possible, thereby actually reducing time in transit.

Another possible subsidy-justifying attribute of economic activity is indivisibilities. It is common in economic theory to assume that changes can be made in very small steps; that the cost of producing an additional unit of a commodity differs by only a very small amount from the cost of producing the unit that preceded it. In the real world, however, this assumption is frequently inapplicable. Choices often have to be made on an all-or-nothing basis. Such choices definitely exist in transportation. Either a road is built from here to there or it is not. If a subway is to be built, it must necessarily have at least two tracks.

All-or-nothing choices are of particular importance in dealing with urban mass transit facilities. As the "efficiency" proponents of these facilities are so fond of pointing out, a single subway track can carry as many passengers as 12 or 24 or 32 or some other such large number of highway lanes. If the choice is between no subway at all or a subway so large that it does not generate sufficient efficiency tolls to cover its capital costs, benefit maximization may dictate the latter alternative. That is, benefit maximization may dictate subsidy even though true economies of scale are not present.

Having recognized this possibility, however, it is perhaps worth pointing out that transportation facilities are by no means as lumpy as commonly supposed. Although engineering standards generally call for 12-ft lanes, there is no divine law saying that the capacity of a highway can be expanded only by adding 24-ft increments to its width. Capacity also depends on the widths of lanes, and on signal, sight distance, and gradient characteristics. At least in planning a highway, improvements in these characteristics can be made in quite small steps. Similarly, once two rails have been laid, it is by no means essential to duplicate them completely if the capacity of a rail or subway line is to be increased. By improving signaling and control devices and by installing sidings, capacity can be increased in small increments.

All that has been said so far has implicitly assumed that it is possible to talk about the demand for trips per time period without specifying the time period involved; that is, once a transportation network and benefit-maximizing tolls for its use are established, the demand for trips will be the same regardless of the hour of day or day of week being considered. Such is, of course, anything but the case. Trips per hour on transportation facilities vary considerably through the day. Indeed, there is considerable reason to argue that the financial crisis currently besetting most urban mass transportation systems stems not so much from the loss of patrons per se but rather from the loss of off-peak patrons. The demand for service during morning and afternoon rush hours appears to have declined little, if at all, on many transit systems. The reduction in demand has primarily entailed a shift from public to private transportation by former off-peak riders.

The costs of providing peak and off-peak service differ considerably. Public transit systems must acquire vehicles and the crews to man them only to have them remain idle for all but a few hours a day. It seems only reasonable to regard the costs of these idle facilities and men as costs attributable exclusively to the provision of peak load capacity.

Similarly, from the long-run point of view, highway construction requirements would almost certainly be considerably smaller than at present if traffic was distributed evenly throughout the day. It might well have been possible, for example, to have constructed Lake Shore Drive in Chicago as a six- or even four-lane facility had it not been necessary to provide for morning and afternoon rush hour traffic. It therefore seems quite reasonable to regard the costs of the additional two (or four) lanes as costs attributable to these peak load periods.

Looked at from the short-run viewpoint, the costs an individual driver imposes on the remaining drivers clearly depend on how many other drivers there are. The more drivers, the greater these costs are. Indeed, the difference between the private and the social costs of a trip approaches infinity as traffic on a highway approaches the "capacity" level.

As already argued, each component of an optimum transportation system would just pay for itself if the system entailed no scale economies and if marginal cost prices were actually charged. The validity of this contention is in no way affected by the fact that the demand for transportation varies through the day. All this characteristic implies is that an optimum pricing system for transportation services would entail tolls that vary with time of day. The greater the demand for the service, the greater these optimum tolls would be.

This point deserves emphasis. An optimum pricing system for urban transportation facilities would entail prices that vary directly with the demand for the services provided by the system. Such a toll system would almost certainly serve to diminish peak traffic loads. In the short-run, high peak-hour tolls would likely serve to shift to off-peak hours many of whatever non-work trips presently take place during peak hours. Furthermore, high peak-hour tolls would likely provide a considerably greater incentive than presently exists for employers to stagger work hours.

Once more, varying tolls on urban transportation facilities through the day would seem highly desirable. Various systems for doing this have been proposed. These range from highly complex mechanical and electronic systems to variable taxes on parking facilities in highly congested areas. All these proposals present substantial—perhaps insuperable—financial, legal, or political obstacles. The possibility must therefore be faced that it may not prove feasible to establish marginal cost prices for some or all forms of metropolitan transportation.

Economists are generally in agreement that, if it is impossible to establish marginal cost prices in one line of economic activity, it no longer follows that marginal cost prices are desirable in all other lines of economic activity. In particular, if it proves impossible to establish marginal cost pricing procedures for the use of highways by private vehicles, it may well prove desirable to provide public transportation subsidies even if no scale economies are involved in these facilities. Unfortunately, the cost and demand data necessary to determine whether subsidies would be desirable under such circumstances are not presently available.

To summarize, whether a particular activity or group is worthy of subsidy is, in the last analysis, a matter for politicians, not economists, to decide. Subsidies may be deemed desirable for humanitarian, equity, or national defense reasons. In discussing arguments for subsidy based on such considerations, about all an economist can do is attempt to supply some perspective on the costs involved.

However, many advocates allege purely economic justifications for the subsidies they favor. Economists do not deny that subsidies can, under certain circumstances, be justified on purely economic grounds. However, subsidy justifications that an economist would accept on such grounds are rarely advanced by subsidy proponents. Rather, they typically adduce one or another special argument as to why the benefits of a subsidy to their favored activity or group would exceed its costs. After discussion of four of the most common special economic justifications for subsidies to transportation activities, they were found to be without merit as special justifications. This paper has concluded with a brief discussion of the extent to which the general economic justifications for subsidy apply to transportation activities. The basic conclusion to be drawn is that there is really not enough information on the subject at present to make any firm statements at all.

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