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Efficiency of Transit Subsidies to the Elderly

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This paper proposes a method of evaluation to measure the user benefits of transit subsidies to the elderly. Included are methods to evaluate transit fare reductions, human service agency transportation systems, and user-side subsidies. For each program the ratio of user benefits to subsidy costs is estimated at a variety of price elasticities and discount rates. Some external benefits may accrue to nonusers of subsidized transportation; measurement of direct user benefits is only one part of an evaluation plan for such programs. The paper concludes that evaluations of transit subsidy programs for the elderly have not focused on measurement of user benefits and suggests the data requirement for such evaluations.

The increased amount of attention being paid to the transportation needs of the elderly has resulted in a number of federal, state, and local transportation subsidies to this segment of our population. Although these subsidies are certainly proper from an income distribution perspective since there is a disproportionate incidence of poverty in the elderly population, little analysis has been performed in measuring the efficiency of these programs.

In general, direct cash transfers or income supplements are more efficient means of income transfer than a system of subsidies and rebates for specific goods. However, where a significant amount of external benefits is caused by consumption of specific goods, subsidies may be superior to direct cash grants. For example, low-cost or free medical assistance to low-income individuals has been justified by policymakers who state that, if consumption decisions were left to the free choice of individuals, the use of medical services from a societal perspective would be less than optimal. Public policy has looked favorably on these subsidy programs possibly due to donor preference. Public expenditures on Medicaid and food stamps, the two largest consumer subsidy programs, are considerable and these subsidies typically represent a significant portion of the purchasing power of low-income persons.

While the external benefit argument for transit subsidies in general is quite compelling in light of uninternalized cost of automobile travel, particularly in cities during rush hours, arguments on behalf of such transit subsidies, particularly directed toward the elderly, have not been discussed in the literature on the subject.

Except in rare cases, for each $1.00 spent on a subsidy, the intended beneficiary actually benefits by some amount less than $1.00. That is, a person could be made equally well off with a $1.00 subsidy on a particular item as he or she would be with a direct cash grant less than $1.00. Although some might claim that each $1.00 spent on subsidy provides $1.00 in benefits, consider the extreme example of issuing free $20 gilded pens to low-income persons. Surely they would not benefit by the full $20 cost of the item. The welfare loss of such programs, measured as the difference between the cost of the subsidy and user benefits, is in addition to administrative and participation costs, which are frequently nontrivial.

This paper is intended to analyze the efficiency of various transit subsidies as income transfer devices for the elderly. As such, the welfare loss will be estimated for each program. No inference will be made concerning the external benefits of such programs. The reader can determine whether the benefits that accrue to nonparticipants exceed the calculated welfare loss. The implications of this research for transit subsidy policy are also discussed.

The types of programs to be analyzed include reduced-fare programs on urban transit systems, provision of demand-responsive transportation service by human service agencies, and user-side subsidies.

THEORY OF CONSUMER DEMAND

Program efficiency can be measured by analyzing the factors that influence consumer choices. The simple model shown in Figure 1 illustrates this. The model assumes that all income is spent either on transportation or nontransportation. In Figure 1, the vertical axis is the amount of income spent on nontransportation and the horizontal axis is the number of trips. The curves represent consumer indifference curves. On every point on each curve, the consumer is equally well off. Indifference curves farther away from the origin are

Figure 1. Consumer demand model.

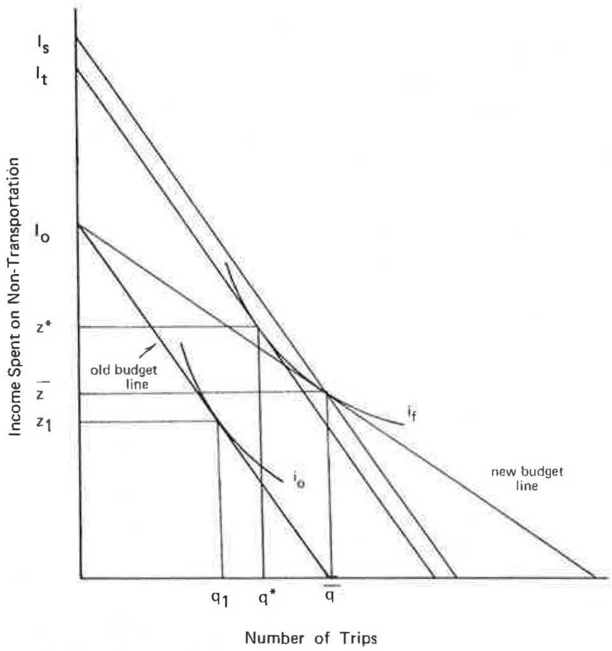
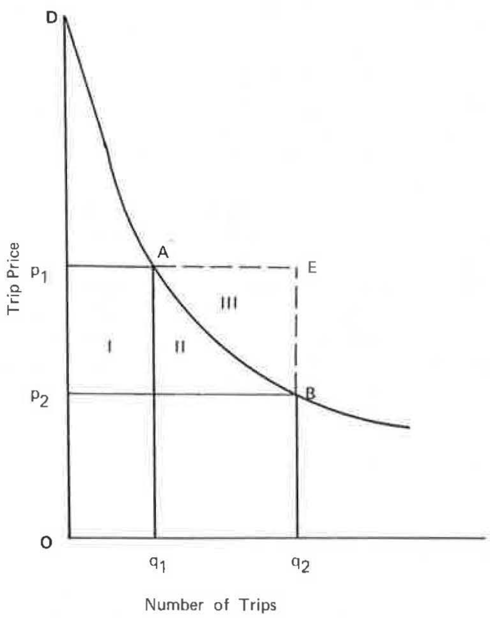


Figure 2. Consumer surplus model.



preferred to those close to the origin.

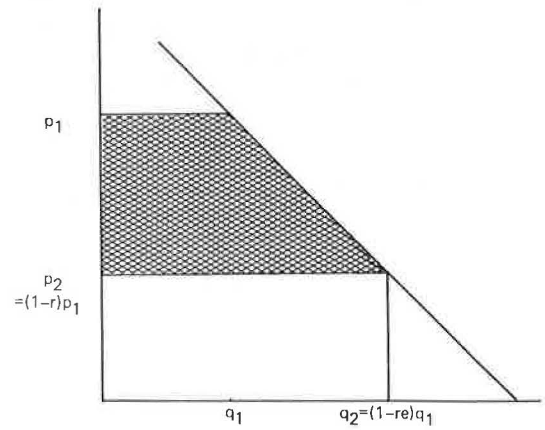
The consumer spends income on transportation and nontransportation in such a way that his or her utility or welfare is maximized subject to a budget constraint. If the consumer has an income of I_o, the budget line is represented by

$$z = I_o - pq \qquad (1)$$

where

z = income spent on nontransportation,
I_o = total income,
p = trip price, and
q = quantity of trips taken.

Figure 3. Simplified consumer surplus model.



The figure shows the budget line without the subsidy (old budget line). Before the subsidy the consumer purchases q_1 trips and spends z_1 on nontransportation. A transportation subsidy alters the slope of the budget line (the price of transportation). The new budget line is shown in the figure. The consumer is placed on a higher indifference curve (i_f) and consumes $\bar{q}$ trips. The cost of this subsidy (assuming no scale economies or diseconomies and efficient prices) is $I_s - I_o$. (I_s is the intercept of a line parallel to the initial budget line through the point of consumption after the subsidy.) It can be seen that a lower amount of money ($I_s - I_t$) could have been spent on direct income transfer and placed the consumer on the same indifference curve (i_f). If a person were given a cash grant equal to the cost of the subsidy, q^* trips would have been taken and more money would have been spent on nontransportation ($z^* > \bar{z}$).

The program efficiency is defined as

$$e = (I_t - I_o)/(I_s - I_o) \qquad (2)$$

Simply stated, the efficiency is defined as the ratio of program benefits to the consumer to program costs.

This method has been successfully applied to evaluating housing programs by Aaron and Von Furstenberg (1) and DeSalvo (2). However, it is quite difficult to work with this formulation in light of the fact that transportation costs typically represent a low portion of the income of elderly persons. In Figure 1, z_1, z^*, and $\bar{z}$ would be very close to I_o. Additionally, transportation markets are not priced efficiently; thus subsidy costs are not likely to be precisely the change in price times the number of units consumed as it would be for housing, which typically exhibits no scale economies or diseconomies.

A simpler formulation of the model will be satisfactory since the percentage of income spent on transportation is small and a subsidy no matter how large is unlikely to radically influence the purchasing power and lifestyle of the individual.

A consumer surplus model (3), as illustrated in Figure 2, will be used in the analyses of this paper. The figure shows a demand curve for transportation. At high prices few trips are taken. The demand curve represents how the individual values his or her trips. At the initial (unsubsidized) price (p_1), the consumer pays p_1Aq_1O for the trips but thinks they are worth $ODAq_1$. The triangle Dp_1A represents the excess value of the trips over this cost. This is the consumer's surplus. At a subsidized price (p_2) this excess value over consumer's cost is the triangle Dp_2B. The change in consumer's surplus between the two prices is the sum of areas I and II. The cost of a subsidy program is generally the product of the price reduction ($p_1 - p_2$) and the quantity of trips taken at the subsidized price (q_2). The triangle AEB represents the welfare loss of the program. In this formulation, the efficiency is the ratio

$$e = (I + II)/(I + II + III) \quad (3)$$

Areas I + II may be looked on as the net increase in value to society of a subsidy program and I + II + III represents the cost of such a program.

EXAMPLES OF SUBSIDY EFFICIENCY

Program Type I: Reduced-Fare Transit Subsidies

This type of subsidy is perhaps the most ubiquitous in the United States due to the requirement that recipients of allocated federal transit funds provide fares to the elderly during off-peak times that are no greater than half the fare for nonelderly peak passengers. In this narrative, only the case of fixed-route urban transit systems is considered. Price reductions on demand-responsive systems are treated in the next section.

A simple demand relationship was used to estimate program benefits. Caruolo (4) has suggested that the average shrinkage ratio (the ratio of percentage passenger increase to percent fare reduction) for a number of cities that have instituted reduced fare programs is -0.56 with a standard deviation of 0.20. It should be noted that, for small values of price change, the shrinkage ratio is nearly equal to the price elasticity of demand.

The demand model is of the form

$$q_2 = q_1 - req_1 \quad (4)$$

where

q_2 = quantity of trips taken after the fare reduction,
r = percent fare reduction,
e = shrinkage ratio, and
q_1 = initial number of trips taken.

This type of demand curve is both easy to work with analytically and assumes a linear increase in trip making with price decrease. Figure 3 illustrates this model.

The benefits (B) to the user of a fare reduction are measured by the shaded area in Figure 3. This can be expressed as

$$B = p_1 q_1 [1 - (re/2)] r \quad (5)$$

The program costs are not merely the product of cost reduction and trips consumed at the lower price. During off-peak hours on urban transit service, there is typically significant excess capacity, which costs no more to produce once the transit vehicle is operated (5). This has also been suggested by Millar (6) using data on the Pennsylvania free transit program for senior citizens. The actual cost (C) to a transit operator of off-peak fare discount is the revenue lost from patrons who formerly rode for a full fare and ride for a discount once the fare reduction is instituted. In Figure 3 this is represented by

$$C = p_1 q_1 - p_2 q_2 \quad (6)$$

From previously established relationships between p_1 and p_2 and q_1 and q_2, the cost is

$$C = p_1 q_1 (r + re - r^2 e) \quad (7)$$

From these two relationships the efficiency (user benefits divided by costs) can be computed as a function of price elasticity for transit (e) and discount factor (r). The table below shows sample values of efficiencies for ranges of each variable. The values of e used were Caruolo's estimate plus or minus one standard deviation.

Price	Fare Reduction			
Elasticity	25 Percent	50 Percent	75 Percent	100 Percent
-0.36	1.43	1.32	1.25	1.18
-0.56	1.85	1.58	1.41	1.28
-0.76	2.55	1.92	1.59	1.38

The entries in the table make some intuitive sense. As the discount rate increases, the individual takes more trips but these trips have less value. As the price elasticity increases, a given percentage reduction will cause more trips to be taken.

From this table it is shown that the 50 percent elderly off-peak fare reduction mandated by the Urban Mass Transportation Administration (UMTA) for grantees of formula funds is efficient because its ratio of user benefits to program costs exceeds one. A complete fare elimination for the elderly would provide benefits to the elderly of \$0.72/\$1.00 lost in revenue due to the fare reduction if a moderate price elasticity is assumed. This is not to deny that a number of benefits of such programs may accrue to the nonelderly.

It is not apparent from this simple model whether or not reduced transit fares for the elderly are efficient during the peak hours. If reduced fares during peak hours cause more passenger congestion and increase the requirement for bus service, then it is not appropriate to assess the program cost by measuring the revenue lost from elderly persons who paid full fare prior to the initiation of the program. It is not likely, however, that extensions of the half-fare privilege to peak hours would increase transit costs, particularly in small- and medium-sized transit operations. Although it is theoretically possible that reduced peak-hour fares could cause extra costs, the preference of elderly for off-peak travel would practically preclude such an occurrence. The fact that many small- and medium-sized properties do indeed have reduced elderly fares at all times (7) is some evidence that the elderly peak-hour riding is not considered sufficiently significant to increase peak-hour transit costs.

Program Type II: Demand-Responsive Transportation Systems

The second program type to be considered is the extension of discounts to the elderly on demand-responsive transportation systems. Generally, this includes both discounts on taxi services and special purpose human service agency transportation systems.

Throughout the country, private and public human service agencies provide transportation to elderly persons. More often than not, the price is far below its cost and very frequently it is offered without a direct charge to the user. These transportation systems can be divided into two categories: (a) transportation service provided by an agency as an adjunct to human service programs, such as transportation to senior citizen centers for congregate feeding, and (b) transportation of elderly persons not related to the agency's primary mission. An example of (b) would be an agency providing transportation to elderly persons for any trip purpose. This analysis will focus on category (b), since evaluation of the transportation component of (a) should be performed along with an evaluation of the overall program. That is, it is probably imprudent to evaluate transportation to and from elderly social programs independently of the social programs themselves.

Measurement of the user benefits of such programs can be done in a manner similar to that of the reduced-fare transit program discussed previously. The user-benefit equation, Equation 5, is used. To estimate the user benefits, a value of the price elasticity of demand is required. Little published research has been done on estimating price elasticities of such transportation, particularly by the elderly. In general, demand-responsive transportation systems are more price elastic than fixed-route systems. Kirby (8) estimated a -1 elasticity for taxis for the general population, but Lerman and Wilson (9) used data from Roos (10) to estimate a price elasticity of -1.1 for dial-a-ride systems by the general public. Mouchahoir (11) estimated an elasticity value between -0.6 and -0.76 for dial-a-ride systems.

Each of these estimates was based on small numbers of observations and not subject to rigid tests since at the time of fare changes many of the dial-a-ride systems were encountering steady growth or changes in service quality.

The primary determinant of price elasticity, however, is likely to be the quality and availability of alternative transportation modes. Since many of the demand-responsive transportation systems observed were the only form of transit in their service territory, the observations of estimates of elasticities were a lower bound on what would be expected for human service transportation systems.

Cost estimates were performed by multiplying the price reduction of the trip by the number of trips taken. The estimated program cost is represented by

$$C = p_1 q_1 r(1 - er) \quad (8)$$

Although it has been suggested that there are scale economies up to a point in providing such transportation (12), indicating that additional trips can be produced at a lower unit cost, this does not alter the analysis. These scale economies exist because the current method of production of human service agency transportation, characterized by a number of small units providing service, is inherently inefficient. If human service agencies were to coordinate these transportation resources, as has been frequently proposed, the service would probably be of a sufficient size that these economies would not exist.

The following table gives the ratio of user benefits to costs for a range of price reductions and price elasticities of travel demands for demand-responsive service. The most likely estimate of efficiency for most service agency transportation is around 75 percent, which reflects a moderate price elasticity and a 100 percent price discount. External benefits (those that accrue to nonusers) are in addition to these estimates.

Price Elasticity	Price Reduction 25 Percent	50 Percent	75 Percent	100 Percent
-0.50	0.94	0.90	0.86	0.83
-1.0	0.90	0.83	0.79	0.75
-1.5	0.86	0.79	0.74	0.70

The table yields the not surprising result that the higher the subsidy rate and the higher the price elasticity of demand, the less efficient the program. The relationship between price elasticity and efficiency is actually quite ironic. A program that intends to increase trip making by the elderly will be more effective if the price elasticity is higher. However, higher price elasticity implies less efficiency since a price decrease encourages the taking of more trips valued below their cost by a person with high elasticity than one with low elasticity.

Program Type III: User-Side Subsidy

An increasingly popular form of transportation subsidy of the elderly is the user-side subsidy, which stimulates transportation demand by increasing the purchasing power of the recipient rather than reducing the production cost of the transportation supplier. The most broad-based of these is the Transportation Remuneration Incentive Program (TRIP) operated by the West Virginia Department of Welfare. The Urban Mass Transportation Administration (UMTA) has, however, sponsored demonstration projects of this concept in Danville, Illinois, and Montgomery, Alabama. TRIP permits low-income elderly and low-income disabled persons to purchase books of transportation tickets valued at \$8.00 for a price ranging between \$1.00 and \$5.00, depending on household income. These tickets can be used in lieu of cash payment for taxi, bus, and rail carrier in the state.

The principal advantages of a user-side subsidy are the ability to vary the subsidy rate with income and the ability to limit the amount of support given to any individual. By varying the subsidy rate, more program money can be spent on lower income individuals, where it presumably will do the most good, thus making this program superior to a provider subsidy from a distributive point of view.

Conceptual evaluations of program efficiency can be done by using the procedures developed in the last two sections.

For programs located in areas where taxis are the only form of public transportation, the efficiency discussion of the previous section applies. However, if a user is permitted to allocate his subsidy between taxi and conventional bus modes, the efficiency discussion becomes slightly more complex. Let us denote by t the percent of subsidy allocated to transit modes in a user-side subsidy program. The benefits of a choice program would be

$$B = p_1 q_1 r\Big(\{t[1 - (re_b/2)]\} + (1 - t)[1 - (re_t/2)]\Big) \quad (9)$$

where

e_b = bus price elasticity, and
e_t = price elasticity of demand-responsive systems.

The costs of such a program are

$$C = p_1 q_1 \{t(r + re_b - r^2 e_b) + (1 - t)[r(1 - e_t r)]\} \quad (10)$$

Thus computing program efficiency is a function of four variables and not very amenable to display in simple charts. However, if we use a medium value of bus and taxi price elasticities (-0.56 and -1.0, respectively), Table 1 shows how efficiency varies with subsidy rate and percent of subsidy spent on bus contrasted with taxis.

Preliminary results of TRIP (13) indicate that throughout the state 33 percent of subsidy payments were made to providers of fixed-route and scheduled service and 67 percent were made to providers of demand-responsive service. The average price reduction of 67.5 percent indicates that the program is providing benefits to the user slightly in excess of program costs.

Table 1. Efficiency of user-side subsidies.

Bonus Value on Transit	Price Reduction			
	25 Percent	50 Percent	75 Percent	100 Percent
0 percent	0.90	0.83	0.79	0.75
25 percent	1.14	1.02	0.94	0.88
50 percent	1.38	1.21	1.10	1.02
75 percent	1.61	1.40	1.26	1.15
100 percent	1.85	1.58	1.41	1.28

The simplicity of the transportation demand model used in this paper precludes an evaluation of whether or not increasing the subsidy rate to lower income persons increases or decreases the program efficiency. To determine this one would have to know how price elasticity varies with income.

CONCLUSIONS

Planners and administrators need to recognize that transportation subsidies to the elderly though beneficial from an income distribution point of view do have efficiency consequences. To date, most analyses of programs designed to improve the mobility of the elderly have focused on effectiveness and have typically measured such things as cost per trip taken. Analysts should attempt to measure the effect of their programs on economic efficiency. Specifically the following questions should be answered:

1. What is the price elasticity of demand for various types of service?
2. How do the elasticity measures vary with income?

The benefits measured in each of the foregoing analyses represent only those benefits that accrue to the persons receiving the subsidy. External benefits to providing transportation subsidies to the elderly may accrue to those who are not subsidized. Such externalities might include:

1. Reduced reliance on friends and neighbors for transportation,
2. Lower welfare costs due to increased mobility of elderly, and
3. Less reliance on institutional care.

Administrators must ask themselves if the value of these external benefits exceeds the efficiency loss of subsidy programs. That is, before a subsidy program is initiated, the alternative choice of a direct income transfer should be explored and evaluated. If the proposed program is intended to be an income redistribution device, the welfare loss discussed in this paper, particularly in demand-responsive transportation facilities, is ample evidence that more efficient ways of income transfer exist. In general, people will spend additional income on goods they desire, not those desired by public administrators.

Furthermore, the program administrative and compliance costs must be considered. Some subsidies can be inordinately costly not only to public agencies (in terms of administration) but also to intended beneficiaries (in terms of cost of registration for the program). The value of external benefits must exceed not only the welfare loss discussed in this paper but also the administrative and compliance costs.

Some public implications are that reduced fares on existing transit services would be a far more efficient means of providing transportation to the nonhandicapped elderly. Reduced or free fares on demand-responsive or special-purpose transportation systems should be well evaluated prior to their implementation due to both their high cost per passenger carried and the high price elasticity of demand for these services.

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