Redistributive Effects of Public Transit: Framework and Case Study

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Study of the redistributive effects of public policy, i.e., who pays and who benefits, is often lacking in economic analysis. This paper stresses the importance of including a redistributive focus and presents a procedure for analyzing redistributive effects in public transit. The main redistributive effect studied is due to varying profitabilities of transit lines. Ceteris paribus, the users of profitable lines subsidize the users of unprofitable lines. To measure this effect requires that the costs and revenues of the transit system be allocated to the individual lines. The means of accomplishing this allocation are considered. The results can then be correlated with socioeconomic data of the users of each line. Along with this, variables that seem important in explaining the variance in line profitability can be tested. This framework is applied in a case study of the Chicago transit system.

The study of redistributive effects should be a part of any analysis of public policy. These effects are concerned with who pays for a particular program and who benefits. An obvious example of redistribution is the tax system. Taxes are collected by the government and in turn are spent on various public programs. However, those persons who pay taxes are generally not those who receive the benefits of the expenditure of their tax dollars. Thus, income may be redistributed from some identifiable groups to other identifiable groups.

A number of studies of these effects have already been undertaken; they generally deal with total government tax and expenditure figures, broken down by income class (5, 14). However, few attempts have been made to determine the redistributive effects of a single component of government activity; exceptions (1) include public higher education, water resource development, and the farm program. It is likely that any public program has redistributive effects. While this is the objective of a few programs (e.g., social security and welfare), most other programs are not specifically designed for redistribution. Nevertheless, these programs have distributional impacts.

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There are a number of reasons for studying redistributive effects. As Booms and Halldorson (2) suggest, these effects

> are an important determinant of the quality of life for many people in our society. The allocation of public burdens and benefits is a major point of conflict in our society. It is obviously advantageous to know something about the factors influencing the distribution of public outcomes.

Also, Hansen and Weisbrod (6) note that

> a knowledge of the magnitude and distribution of subsidies or direct benefits provided through . . . any public program is important for what it suggests concerning appropriate pricing, tax and expenditure policies.

In the past, economic analysis has tended to concentrate solely on the efficiency of a project, i.e., the degree of success of an activity in producing outputs that are more valuable than the resources used in production. Most of these studies have completely ignored equity (i.e., distributive) effects. In this regard, Weisbrod (15) states:

> To date, valuation of distributional effects of public expenditure programs has eluded economists. . . . It is the exceptional . . . analysis that considers them explicitly. Indeed, according to a recent survey of the literature [11] . . . , it almost seems wrong to consider distributional effects.

Decision makers, however, tend to base their choices on equity considerations as well as efficiency criteria. In theory, integrating distributional gains and losses with efficiency benefits and costs into a single grand efficiency measure would be optimal. However, this is not possible unless weights for different groups' benefits and costs can be devised. Even if equity effects cannot be quantified, it is still important to consider them along with efficiency results. To that end, this study is concerned with the issue of equity, rather than the issue of efficiency, in what is often a government program (public transit). A framework is presented to identify which groups receive the benefits of this public program and which groups pay the associated costs, i.e., the redistributive effects of public transit. Then this framework is applied in a case study of the redistributive effects of the Chicago rapid transit system.

A FRAMEWORK FOR ANALYSIS

Redistributive effects can occur between users and nonusers, particularly if a transit system runs a deficit. In addition, distributional effects are evident between users. Five specific user effects can be identified (12). One of these is due to fare reductions available to certain groups (13). Three other effects are caused by the interplay of the fare structure with uneven use patterns: peak versus off-peak redistribution, long-haul versus short-haul redistribution, and peak direction versus backhaul redistribution. A final effect is due to the differing costs and revenues of each transit line. This paper concentrates on the latter user effect.

The following procedure is proposed to determine the redistributive effects due to the differing costs and revenues of each line. First, the costs of the transit system must be determined and assigned to the users. To do this requires that the costs of operating each line under consideration be determined. This involves examining the various cost categories inherent in providing transit service and examining the allocation of these costs, by suitable bases, to the various line segments. Then, the revenues for each line should be obtained and matched with the costs for each section. This gives a measure of the redistribution involved between lines. Finally, to determine what identifiable groups of people are involved in redistribution, socioeconomic data such as the income levels and racial composition of the users of each line are necessary. In addition, the variables that seem important in explaining why the costs and revenues vary by line can be investigated.

Before the allocation of transit costs and revenues is undertaken, the relationships between these amounts and total benefits and costs need to be specified. With demand given, a transit company incurs the costs of setting up and operating a system and thus provides a level of service (Figure 1). From this service, users obtain direct benefits, and all people experience certain external benefits (e.g., reduced pollution and road congestion) and external costs (e.g., noise) from the existence of the system. Because of the nature of externalities, they cannot be recovered by the transit firm. Only some of the direct user benefits can be recovered from the market for transportation services. Because people will pay for a service only if it is worth no less than the price, their total direct benefits will reflect the sum of the price paid for the service (i.e., user cost, which becomes transit revenue) plus any consumers' surplus that is reaped. The transit firm is only interested in the amount of its costs and revenues. From a wider point of view (such as the community's), the value of external benefits and costs and consumers' surplus (8) should be considered in addition to the transit firm's costs and revenues. Because of the difficulty involved in putting a value on externalities and consumers' surplus, only direct costs and revenues can be considered. Therefore, the research must focus on the transit firm's perspective as expressed in its accounts. Nonetheless, to the extent that the users of the system contribute to costs and revenues, their focus will be included as well.

The demand for transit service (and lack of private supply) provides the rationale for an authority to set up and operate a system. Although this study is concerned with demand only as it directly affects costs and revenues, a brief word relating these concepts is appropriate. Lang and Soberman (7) suggest that rush-hour transit capacity requirements are obtained from peak demand and the car space per person that is allowed. In turn, this rush-hour capacity dictates equipment, work force, and energy needs. These factors largely determine operating costs (since provision for peak service will cover much of the capacity in labor, capital, and other factors needed to meet off-peak demand) and therefore unit costs as well. Unit costs, to the extent that they are reflected in fare levels, affect transit demand. Thus, the chain of cause and effect actually comes full circle.

Cost Allocation

The first step in determining redistributive effects is the measurement and allocation of the costs of transit operations to individual lines. Relevant cost allocation literature includes Lang and Soberman (7) and Morlok (9, 10). Although cost allocation is a fairly straightforward and mechanical procedure, care must be exercised.

A general principle in (variable) cost allocation is to express costs as a function of the output measure that reflects the reasons for incurring the cost. Depending on the cost category, an appropriate basis might be car-kilometers (for costs that vary with usage such as vehicle repair costs), track-kilometers (for costs that are time based and related to the length of track, e.g., some station and signal costs), or scheduled payroll hours (for costs that are labor related, e.g., cost of operators and ticket agents). This method of cost allocation is distinguished from three other methods. One method common in transportation planning literature expresses all operating costs as constant per car-kilometer. This method is quite crude, since only some costs are a function of car-kilometers. A second possibility is a cross-sectional regression analysis of the cost data of various transit systems. The difficulty with this approach is the small number of systems in existence. Also, this overlooks the peculiarities inherent in a particular transit firm's operating and accounting procedure. The third method uses the results of a time-series regression analysis of system costs. The lack of long time-series data, the small range of the variables, and the difficulty in applying this to a detailed examination of a system make this approach infeasible.

Additional cost-related considerations include the allocation of fixed costs, the distinction between the true and average cost curves, and the problem of measuring quality of service. Although it is reasonable to allocate variable costs as a function of the appropriate output measure, fixed costs (e.g., management and capital) cannot easily be handled in this manner. These fixed costs depend largely on the size of the transit firm's operation. Thus, Lang and Soberman (7) suggest that they might best be allocated as a fixed percentage of operating costs, inasmuch as fixed costs provide the base from which all operating costs develop. If this line of reasoning is followed, operating costs (in aggregate or broken down by line) would be increased by a percentage sufficient to account for an annualized amount of fixed costs. This assumes that fixed costs accrue to each line on the same basis as total operating costs. However, application of this procedure will not affect the relative costs of the lines (vis-à-vis each other). Because of this fact and the somewhat arbitrary nature of fixed-cost allocation, not considering these costs would not significantly affect a study of user redistributive effects.

When the variable costs of transit are allocated as a function of an output measure, it is desirable to know the true cost curve over the range of all outputs. The true cost curve in general will not coincide with the average cost curve because of economies of scale in provision of transit. Unfortunately, only total or average cost data are available. Thus, it must be assumed that costs vary linearly with the appropriate output measure. This limitation must be kept in mind, for it necessarily introduces some bias in any cost prediction or allocation that is made. A similar limitation relates to the quality of service on the system. This aspect will differ markedly throughout the system; for example, new equipment will require less maintenance than old. Because of the data available and the inability to quantify quality differences, service quality must be assumed to be uniform throughout the system.

Revenue Allocation

The allocation of system cost to each line must be matched with an allocation of system revenue. Three possible approaches for accomplishing this are considered: by originating revenue, by incremental revenue, and by adjusted originating revenue.

The first approach to revenue allocation is simply to note the amount collected on each line (originating revenue). The main advantage in using these data is that they are readily available. The disadvantage of this approach is that it fails to account properly for those trips that travel over more than one line if patrons pay their total fare (including transfer charges) when they start their trip. Regardless of where the trip is taken on the system, all of the fare paid is attributed to the originating line. Thus, if a trip begins on line 1 and ends on line 2, no revenue will be reported for line 2. This would be mitigated, of course, to the extent that trips taken are round trips. For example, as a complement to the above trip, the return trip begins on line 2 and ends on line 1. The originating revenue for this return trip will be credited to line 2. Depending on what the originating fare is on each line, there may be objections to the way the revenue is split between the two lines, but at least each line is credited with revenue. Another bias occurs if a trip is taken on more than two lines; if this is the case, no revenue will be recorded for the middle lines.

A second way of dealing with revenue allocation is through an incremental approach. The term incremental refers to the costs or revenues of the entire system that are due to the existence of a particular line. To obtain the incremental cost and incremental revenue of a line, one would determine what system costs would be saved and what system revenues would be lost if that unit were to cease operations. In effect, the entire system with the line is being compared to the remaining system without the line. One apparent advantage of this method is that this type of analysis can be used for efficiency-oriented decision making (such as whether a line should be shut down or what scope of operation should be undertaken by comparing the incremental cost and revenue of the line at each scope).

The incremental cost of a line is composed of all operating costs that can be saved if the line is shut down (this assumes a sufficient time span). It is probable that most management costs and capital depreciation will not be saved and therefore should not be included. Estimating incremental revenue depends on determining what percentage of riders of a line would use alternate modes if the line were discontinued and what percentage would continue to use the transit system by riding a different line. Unless these percentages can be obtained, the incremental approach is not feasible. Another disadvantage of this approach is that it is only applicable to those lines whose shutdown would not radically affect other lines.

A third approach, which can be applied to analyzing one segment of a bimodal operation (e.g., analyzing the rail portion of a rail and bus transit system), is to obtain adjusted (originating) revenue. This procedure is based on the fact that the costs and revenues of a line ultimately are derived from the passengers who use the line. This is so whether they originate on that line or a different line. To reflect this fact and to consider all lines on an equal basis require that the revenue for passengers who originate on another line be added to originating revenue to obtain adjusted revenue. For example, if only the rail system is being analyzed, revenue for those passengers who arrive at a particular rail line by bus will be input (at the rail fare times the number of bus originators) and added to originating rail line revenue. This will throw off the apparent profitability of rail vis-à-vis bus, but if a study is solely interested in rail travel, then only the relative profitability of rail lines is of interest. This approach more truly represents the ridership differences between the rail lines.

Of course, inputing all of the bus revenue for those who arrive by bus as if they originated on the rail system will certainly overstate the amount of revenue that should be transferred from bus to rail. That is, some revenue should theoretically be left with the bus. The result of this allocation is a bias; those rail lines with a higher percentage of bus arrivers will seem relatively more profitable than those with a lower percentage. However, in a practical sense, there are no available criteria for determining how much revenue to leave with the bus and how much to attribute to rail. In the case study below, this bias does not appear to be significant (and is certainly less than the bias that would occur if the adjustment for bus originators was omitted entirely) inasmuch as the costs and revenues obtained seem consistent with other measures of profitability (e.g., load factor). A remaining bias with this approach, as with the first approach, occurs when a trip is taken on more than one line. This cannot be corrected or accounted for, because of the vast combinations of possible trips and the difficulty in designing criteria to allocate revenue (and cost) over each trip.

Cost-Revenue Ratios and Redistribution

After the costs and revenues have been allocated by line, these amounts must be combined, and the specific groups involved in redistribution should be identified. Along with this, the factors that seem important in causing the ratios to vary can be determined.

Two ways of combining costs and revenues are considered. First, line revenue can be subtracted from line cost and expressed in per capita terms for comparison purposes. Obviously, the results of this method depend vitally on the number of users. This direct dependence on number of users can be avoided by using another approach that considers the number of passengers only as they are reflected in the relative magnitudes of costs and revenues of a line. This second method is to combine costs and revenues into a cost-revenue (C-R) ratio. With respect to an individual line, the lower the ratio is, the more profitable the line is.

Both methods, per capita differences and ratios, will illustrate the same outcome. However, the ratio is less sensitive to the number of users. Another reason that the use of a ratio is preferred is the similarity between C-R ratios and cost-benefit ratios, which are used extensively in economic decision making. Because the focus of this study is the differences between the lines, the C-R ratios should be normalized to reflect the relative ratios between the lines. That is, the overall system C-R ratio should be adjusted to 1.00 so that only user redistribution is measured. Dividing all the line figures by the amount necessary to obtain an overall ratio of 1 will normalize the figures, i.e., solely reflect the differences between the lines.

Given the costs (and capacity) of each line, the higher the revenue is, the more profitable the line will be. This reflects the importance of filling capacity to give the line a low C-R ratio. A measure relating capacity to revenue is the load factor of each line, which is the average number of passengers per car measured at an appropriate point for a suitable time period (e.g., 24 hours). The line load factor should correlate strongly and inversely with the C-R ratio; specifically, the greater the line load factor is, the lower the ratio will be.

Before considering why the ratios vary as they do, two points should be clarified. First, what is the relationship between the ratios and redistribution? Second, what is the link between the ratios of each line and the users of that line? The cost-revenue ratios tell which lines are profitable and which lines are money losers. For example, assume that there are two lines in a system: A and B. The overall system is breaking even, but line A is profitable (has a C-R ratio less than 1) and line B is not (has a C-R ratio greater than 1). As the system is set up, the surplus of line A subsidizes the deficit of line B. Apparently, there is a redistribution of income from line A to line B. But, in fact, redistribution is not really between lines; it is a phenomenon taking place between users of a line. To be strictly correct in identifying who is subsidized and who is providing this subsidy requires that the identity and circumstances of the users of each line be determined. With this information, judgments concerning both the outcomes of redistribution and corresponding policy decisions can be made.

Given the cost-revenue ratios by line, two questions emerge. First, can the direction of redistribution be correlated with any socioeconomic characteristics of the users? Second, why do the ratios vary between the lines (i.e., what causes this variance)? To answer these questions, appropriate hypotheses can be formulated and tested through the use of linear regression, where the cost-revenue ratio is the dependent variable. The independent variables will fall into five broad categories: geographic and physical attributes, price variables, competition-measuring variables, policy variables, and socioeconomic variables. Within each category, variables that may be important should be considered, and the direction of their effect should be hypothesized. (The specific variables tested in each category will depend on data availability and the peculiarities of the system being analyzed.) Then, this hypothesis can be statistically tested, either singly against the C-R ratios or in combination with other variables.

CASE STUDY

The above framework was applied to the Chicago transit system. Publicly operated transit in the Chicago area is provided by the Chicago Transit Authority (CTA) through both surface (bus) and rapid transit (rail) operations. For simplicity, only rail lines of the CTA were considered, and these were broken into units suitable for analysis. The time period used was calendar year 1972. A more detailed description of the case study is given elsewhere (12).

To undertake the cost allocation, CTA financial reports and supporting data were analyzed in detail. The main document used was the Operating Location Cost Report, which breaks down 11 variable cost categories into three portions: surface, rapid, and common-to-system costs. The rail costs are further divided among four lines; but for a more meaningful result, it was necessary to break these four major lines into 10 distinct segments. Where necessary, finer details of these costs were consulted to improve the accuracy of the allocation.

The amount of each cost category that was allocated to the rapid system was determined, and this was in turn allocated to the 10 lines on the basis of the most appropriate output measure, as described above. The results of these calculations are given in Table 1 and the first column of Table 2. Capital and management costs are not included, for the reasons suggested above.

To begin the revenue allocation, originating revenue by line was obtained from CTA records. As mentioned above, this should be adjusted by imputing revenue for those who arrive by bus to each line. CTA data on bus originators were used to adjust the revenue of each rail line (the adjustment factor ranged from 0 to 233 percent of originating revenue). This will more accurately measure ridership differences between the lines. However, the bias that occurs when a trip is taken on more than one line remains. The extent of this bias was determined by obtaining the percentage of trips that are taken on only one line. The higher this percentage is, the less the possible bias is. The percentage of riders who use only the originating line is as follows:

Line	Percent	Line	Percent
Evanston	58.8	Ryan	88.6
Skokie	10.8	Congress	83.5
North	82.5	Douglas	86.6
South	89.2	Milwaukee	89.5
Lake	89.7	Ravenswood	74.8

Seven of the lines have figures in the range of 80 to 90 percent, and an eighth is just slightly less. It is reasonable to suspect that most of the trips taken on these lines go to the central business district and return home on the same line. Many of the remaining trips involve only two lines, and, under a round trip assumption, revenue will be credited to each line.

Any substantial bias, therefore, would come from two suburban lines: Evanston and Skokie (the percentage of trips taken only on the two lines is 60 and 10 respectively). Trips on these two lines that are taken on other lines will include a portion on the North line. Because many of these trips terminate in the CBD as well, under a round trip assumption revenue would be recorded in a suburban line (Evanston or Skokie) and the North line for each round trip. However, the originating fare is much higher in each suburb than on the North line, while the portion of the total trip is significantly shorter in time and distance in each suburb than it is on the North line. To this extent, the revenues for Evanston and Skokie are apt to be overstated relative to costs. For the same reasons, the other lines have revenues somewhat understated, although the main understated line is North.

The results of the cost and revenue allocation, and their combination into a ratio, are given in Table 2. In analyzing these results, it is highly likely that the figures for Evanston and Skokie do run in the direction indicated (Skokie being profitable, Evanston being a money loser). This inference is lent support by the following CTA statement (4): "Expansion to follow population

Figure 1. Relationship between transit costs and benefits.

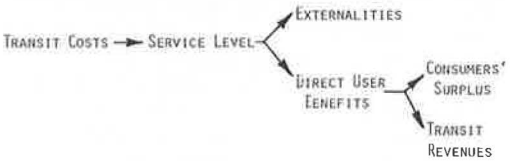

Table 1. Cost allocation for CTA rail rapid transit (1972).

Category	Amount (dollars)	Basis of Allocation
Trainmen	14 912 000	Scheduled payroll-hours
Agents, janitors, yardmen	15 832 000	Scheduled payroll-hours
Station operation	1 893 000	Car-kilometers
General office, utility, and traffic planning	2 753 000	Car-kilometers
Instruction, security	927 000	Car-kilometers
Shops and equipment	11 759 000	Car-kilometers
Engineering	6 407 000	Car-kilometers, track-kilometers
Electrical	4 741 000	Car-kilometers, track-kilometers
Power	3 970 000	Car-kilometers, track-kilometers
Snow and refuse removal	231 000	Track-kilometers
Provision for injuries and damages	634 000	Car-kilometers
Total	64 060 000	

Table 2. Results of cost and revenue allocation.

Line	Cost of Operation (dollars)	Adjusted Originating Revenue (dollars)	C/R	Normalized C/R
Evanston	2 977 000	2 460 000	1.21	1.32
Skokie	619 000	832 000	0.74	0.81
North	12 349 000	15 213 000	0.81	0.89
South	10 836 000	10 893 000	0.99	1.09
Ravenswood	5 536 000	4 774 000	1.16	1.27
Lake	6 189 000	5 889 000	1.05	1.15
Ryan	7 431 000	11 089 000	0.67	0.73
Congress	5 232 000	4 528 000	1.16	1.26
Douglas	4 667 000	5 314 000	0.88	0.96
Milwaukee	8 224 000	9 078 000	0.91	0.99
Total	64 060 000	70 071 000	0.91	1.00

Table 3. Results of simple linear regressions of cost-revenue ratios on listed variables.

Variable	Units	Hypothesized Direction	Regression Coefficient	Standard Error
Geographic				
North dummy	0, 1	?	+0.017 8	0.136 5
West dummy	0, 1	?	+0.109 7	0.144 0
South dummy	0, 1	?	-0.171 8	0.159 7
Expressway dummy	0, 1	?	-0.074 3	0.146 8
New line dummy	0, 1	-	-0.288 6[a]	0.108 7
Price				
Extra fare dummy	0, 1	+	+0.149 6	0.129 1
Average price	Cents/km	+	+0.129 4	0.172 6
Competitive				
Commuter railroad	Percentage of stations having this alternative	+	+0.002 5	0.002 4
Another CTA line	Percentage of stations having this alternative	+	+0.002 3	0.003 4
Policy				
24-hour agents	Percentage of stations	?	-0.002 2[b]	0.001 3
Stations per 1.6 km		?	+0.253 6[c]	0.085 4
Headway	Min	?	+0.069 2	0.076 4
New car dummy	0, 1	-	-0.056 7	0.135 2
Socioeconomic				
Density	Population/2.59 km^2	-	+0.000 001	0.000 011
Automobiles per capita		+	-0.080 3	0.804 5
User income	Dollars	?	-0.000 02	0.000 03
White income	Dollars	?	-0.000 03	0.000 04
Black income	Dollars	?	-0.000 03	0.000 02
Black users	Percentage	?	-0.002 6	0.003 1
Employed users	Percentage	-	-0.309 3	1.102 1

Note: 1 km = 0.6 mile; 1 km^2 = 0.4 mile^2.

[a]95% confidence level. [b]80% confidence level. [c]98% confidence level.

growth could not be accomplished 'from the fare-box' with the significant . . . exception of the Skokie Swift." Additional support for the contention appeared in mid-1973, when the CTA proposed closing a number of stations on the Evanston line. Although this proposal was later abandoned, the Evanston City Council Transportation Committee at the time felt that the closures had the objective of restructuring the Evanston service to an operation similar to Skokie's. Lending additional weight to the results is the fact that many Evanston patrons are within walking distance of the Chicago and Northwestern commuter railroad, alternatives that Skokie patrons do not have.

However, the results of a study by Wohl (16) seem at odds with these results. Wohl reported that during the first 2 years of operation of the Skokie Swift (1964-65) the total costs, including interest on capital outlays, exceeded revenue by $485 000 or about 14 cents per trip. It is evident that in this study certain capital expenditures involved in setting up the Skokie service were included in the cost figures for these 2 years (e.g., line rehabilitation and parking lot construction). However, these capital items have a significantly greater life span than 2 years; thus, this procedure will overstate expenses. Additionally, one should question the full inclusion of one-time expenses (promotion and data survey costs). The correct amount to report will depend on the capital items considered (for example, does the purchase price of already owned equipment become an obligation of the Skokie line?), the capital recovery method and interest rate used, and the treatment of one-time expenses. In any case, Wohl's cost data are overstated. In fact, the publication from which the data on the Skokie line were obtained directly contradicts Wohl's results (3): "Skokie Swift has proven that fares collected could meet all the costs of operation."

As another check on the C-R ratios, the correlation between the load factor (obtained from CTA data at the maximum load point of each line for a 24-hour period in both directions) and the ratios was calculated. In confirmation of the hypothesis above, the simple correlation coefficient was -0.84. Thus, the C-R ratios are reasonably accurate.

The final step in the case study is to determine whether particular groups that are involved in redistribution can be identified and to determine what variables are significant in explaining the variance in the ratios. Many factors interact in determining the C-R ratios of the lines. Because of the small number of observations and degrees of freedom (10 lines), it is difficult to sort out all the influencing factors. For this reason, the statistical technique used seeks simply those variables that correlate best with the ratios. Thus for the most part, the analysis is limited to simple linear regression using a t-test as a measure of significance.

There are five categories of variables considered. The first category, geographical and physical attributes, contains variables that measure possible political favoring of different city areas, differences in geographic terrains, differences of costs and revenues owing to the type of right-of-way (e.g., location of line in the median of an expressway), and "newness" of lines. The second category, price, is difficult to represent because the base price of an originating trip was the same on all lines (with some minor exceptions). To work around this, variables accounting for the extra fare on some lines and average trip price were tested. The third category reflects the availability of competing services (for simplicity, the price of competing services was not considered). The nearness of commuter lines or other CTA lines to each line was measured. Fourth, variables were tested whose values are significantly determined by CTA policy decisions: percentage of stations with 24-hour agents, stations per 1.6 km (1 mile), train headway, and newness of cars. The final category of variables considered is socioeconomic influences. These include density around the lines, automobiles per capita around the lines, user income, race of users, and percentage employed living near a line.

The results of simple linear regression of the above variables on the C-R ratios are given in Table 3, along with the hypothesized directions for each variable. The most significant single variable explaining the ratios is stations per 1.6 km (1 mile). The positive correlation suggests that more stations mean less net revenue (a lower C-R ratio); thus, a faster train seems preferred to more access, or costs are lower with fewer stations. A number of variables that would be expected to be significant were not (e.g., density and automobiles per capita) because of the interaction of other variables, the small sample size, and incomplete specification, among other reasons.

The lack of significance of the race and income variables suggests that no identifiable redistribution by income or race is taking place. Nevertheless, a simple redistribution does occur between users of each line. Skokie, North, and Ryan users are subsidizing Evanston, Ravenswood, Lake, and Congress users, but the users of other lines are not involved in redistribution.

CONCLUSION

A framework for analyzing the redistributive effect due to the differing costs and revenues of transit lines was presented. This consists of an allocation of system costs to each line or segment. This is complemented by an allocation of system revenue to each line. The resulting costs and revenues can be combined and statistically tested to determine what variables are important in causing these figures to vary and whether identifiable groups are involved in redistribution.

A case study using the Chicago rail rapid transit system was presented to illustrate use of the framework. The most important single variable explaining the variance of costs and revenues is stations per 1.6 km (1 mile). Surprisingly, variables measuring density and automobiles per capita tested insignificant. Similarly, no conclusions on the direction of redistribution between identifiable groups could be made. This lack of significant results is probably due to small sample size, data limitations, and the compound influence of many variables. The resulting redistribution is simply from users of the profitable lines to users of the unprofitable lines.

This suggests that the redistributive framework presented may be most fruitfully applied to an area smaller than Chicago, where the number of lines, trip possibilities, influencing variables, and resulting data needs will be much less. In addition, other forms of redistribution need to be investigated, both among users (e.g., reduced fare policies, peak versus off-peak policies, long-haul versus short-haul pricing) and between users and nonusers (e.g., financing of a transit system deficit).

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