IMPACTS OF SUBSIDIES ON THE COSTS OF URBAN PUBLIC TRANSPORT

By John Pucher, Anders Markstedt and Ira Hirschman*

INTRODUCTION

Since 1965 subsidies to urban public transport (here called “transit”) have increased rapidly throughout the world. In a study of transit finance in fifteen countries, Bly, Webster and Pounds (1980) reported large increases from 1965 to 1976 in the absolute amount of subsidies as well as in the percentage of costs covered by them. The growth of subsidies has been particularly striking in the United States. Though only $88 million in 1965 and $518 million in 1970, the combined capital and operating subsidy to transit exceeded $7.8 billion in 1980 (Pucher, 1980 and 1982). Passenger fares covered less than 42% of transit operating costs in the U.S. in 1980 (against 99% in 1965 and 86% in 1970) and did not contribute at all toward financing capital costs (Pucher, 1982).

Transit subsidies have long been controversial. For example, Meyer, Kain and Wohl (1965) rejected most arguments for subsidies, and therefore argued against proposed subsidy programmes in the U.S. In spite of early opposition, transit subsidies have burgeoned. The number of critics has grown as the results have been observed. Recent studies of subsidy impacts conclude that direct benefits to transit riders have been small relative to the increase in subsidy, and that the alleged environmental and secondary economic benefits are negligible or non-existent (Altshuler et al., 1981; Meyer and Gomez-Ibanez, 1981; Hilton, 1974; Hamer, 1976; Webber, 1976). Some critics—including former transit advocates—complain that subsidies have simply inflated costs instead of providing more, better, or cheaper service for transit riders (Altshuler et al., 1981; U.S. House of Representatives, 1981b; Bonnell, 1981). There is strong pressure in the Reagan Administration and in Congress to curtail the programme or at least to revise it so that subsidies would be more effective. (Executive Office of the President, 1981; U.S. General Accounting Office, 1979 and 1981).

This article examines the extent to which subsidies have worsened the productivity and cost problems of transit in the United States. It reviews nationwide aggregate trends in subsidies and then compares them with changes in productivity and cost

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TABLE 1


<table>
<thead>
<tr>
<th>Type of Subsidy</th>
<th>1970</th>
<th>1975</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating subsidies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federal</td>
<td>0 (0%)</td>
<td>408 (21%)</td>
<td>1,324 (30%)</td>
</tr>
<tr>
<td>State</td>
<td>30 (9%)</td>
<td>549 (29%)</td>
<td>992 (23%)</td>
</tr>
<tr>
<td>Local</td>
<td>288 (91%)</td>
<td>944 (50%)</td>
<td>2,062 (47%)</td>
</tr>
<tr>
<td>Total operating subsidy</td>
<td>318 (100%)</td>
<td>1,901 (100%)</td>
<td>4,378 (100%)</td>
</tr>
<tr>
<td><strong>Capital subsidies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federal</td>
<td>133 (67%)</td>
<td>1,287 (80%)</td>
<td>2,787 (81%)</td>
</tr>
<tr>
<td>State and local</td>
<td>67 (33%)</td>
<td>322 (20%)</td>
<td>647 (19%)</td>
</tr>
<tr>
<td>Total capital subsidy</td>
<td>200 (100%)</td>
<td>1,609 (100%)</td>
<td>3,434 (100%)</td>
</tr>
<tr>
<td><strong>Operating and capital subsidies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federal</td>
<td>133 (26%)</td>
<td>1,695 (48%)</td>
<td>4,111 (53%)</td>
</tr>
<tr>
<td>State and local</td>
<td>385 (74%)</td>
<td>1,815 (52%)</td>
<td>3,701 (47%)</td>
</tr>
<tr>
<td>Total subsidy</td>
<td>518 (100%)</td>
<td>3,510 (100%)</td>
<td>7,812 (100%)</td>
</tr>
</tbody>
</table>

Sources: Calculated on the basis of data in American Public Transit Association (1981a), Pucher (1980), Urban Mass Transportation Administration (1981a), and supplemental statistics collected by the author directly from the 26 largest transit systems in the U.S. Commuter rail as well as rapid transit, streetcars, trolley buses, and motor buses are included in these statistics. The capital subsidy amounts do not include the special Congressional appropriations for the Washington subway system.

*The state and local portion of capital subsidy financing was estimated on the basis of statutory matching rates for different segments of the transit capital programme.

*The overall Federal matching rate for capital subsidies in 1980 exceeded 80% because of the 85% matching rate on Interstate Transfer funds.

indices. Next, multiple regression analysis on a pooled cross-section sample of 77 transit systems in 1979 and 135 systems in 1980 isolates the separate impacts of subsidies on costs, controlling for various other factors affecting costs. Recommendations are made for revisions in the subsidy programme that would encourage more efficient use of subsidy funds.

TRENDS IN SUBSIDIES

Subsidies to mass transit in the United States have increased rapidly since 1965. The total capital subsidy from all government levels then was $76 million, and the total operating subsidy only $14 million (Pucher, 1980). By 1970 the capital subsidy was $200 million, and the operating subsidy $318 million. Table 1 shows that from 1970 to 1980 subsidies increased more than 15-fold, exceeding $7.8 billion in 1980. Another striking trend evident in the table is the increased Federal role in transit finance. Federal assistance rose from $133 million in 1970 to $4.1 billion in 1980, from 26% to
53% of the total subsidy. State subsidies also increased substantially, but their relative importance has fallen since 1975.

Metropolitan regionwide taxes earmarked for transit have become increasingly widespread. Virtually no large city had adopted this financing mechanism by 1970. By 1980, however, 15 of the 26 largest U.S. metropolitan areas relied primarily on earmarked transit taxes for the local share of subsidy financing (Pucher, 1980). Of 101 cities surveyed in 1980 by the U.S. Conference of Mayors, 46 already had either state or local taxes dedicated for transit, and 21 had plans for implementing such taxes by 1982 (Gortmaker, 1981).

The natural results of these trends are as follows. First, capital projects are undertaken giving benefits that fall far short of total costs yet exceed local costs. Similarly, urban areas receiving relatively generous Federal operating assistance (50% in many cases) have initiated or maintained highly unprofitable routes and types of services that local officials would not have supported on their own. These effects have been compounded by the adoption of earmarked state and local taxes. Most of these arrangements rely on revenue-elastic sales taxes or income taxes. Especially during inflationary periods, they automatically yield growing tax revenues even if statutory rates remain constant. These dedicated funds have reduced local transit authorities' incentives to eliminate highly unprofitable services, to bargain for moderate settlements in wages and fringe benefits, and to increase productivity. Finally, no Federal or local subsidy programme has made funding contingent on performance standards, cost control, ridership gains, or the achievement of social, environmental, and economic goals. Few states have begun to tie subsidy payment to performance indicators. Even these have set aside only a small fraction of the state subsidy to do this.

The very design of transit subsidy programmes in the U.S. may, therefore, encourage inefficient use of subsidy funds. Subsequent sections of this article examine the extent to which they have encouraged escalation of costs.

TRENDS IN PRODUCTIVITY AND COSTS

Transit costs have increased rapidly over the past three decades, and productivity has fallen. But the rate of change has not been uniform throughout: costs have increased and productivity has fallen much faster when subsidy growth has been greatest. As Table 2 shows, the average annual rate of growth in operating cost per vehicle mile (in constant, inflation-adjusted dollars) was only 1.4% per year from 1950 to 1965. In contrast, cost per mile increased by an average of 4.1% per year during the rapid subsidy growth from 1965 to 1980, three times as fast. From 1965 to 1980, productivity—as measured by vehicle miles of service per transit employee—fell by 19%, from 13,800 miles per employee to only 11,200 (see Table 2). Miles per employee had increased by 10% over the 15-year period before.

These trends have not been the same for all portions of the industry. We could not obtain mode-by-mode breakdowns of trends over the entire 30-year period, but Table 3 disaggregates the transit operating and financial statistics for the crucial decade of the 1970s, when subsidies increased 15-fold in current dollars. Increases in operating expenses were larger for bus and commuter rail services than for rail rapid transit.


### Table 2


<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating cost per vehicle mile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual dollars</td>
<td>0.46</td>
<td>0.56</td>
<td>0.64</td>
<td>0.72</td>
<td>1.06</td>
<td>1.89</td>
<td>3.11</td>
</tr>
<tr>
<td>1980 constant dollars</td>
<td>1.38</td>
<td>1.56</td>
<td>1.65</td>
<td>1.71</td>
<td>2.07</td>
<td>2.63</td>
<td>3.11</td>
</tr>
<tr>
<td>Average annual rate of growth in</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>operating cost per mile (% per year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted for inflation</td>
<td>4.0</td>
<td>2.7</td>
<td>2.4</td>
<td>8.0</td>
<td>12.3</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>Adjusted for inflation</td>
<td>2.5</td>
<td>1.1</td>
<td>0.7</td>
<td>4.0</td>
<td>5.0</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Vehicle miles per employee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per year (thousands)</td>
<td>12.5</td>
<td>12.4</td>
<td>13.7</td>
<td>13.8</td>
<td>13.6</td>
<td>12.5</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Source: Calculated on the basis of transit data in American Public Transit Association (1981a) and dollar deflation indices in the *Statistical Abstract of the U.S.* (Washington: U.S. Census Bureau, 1982). Only bus, rail rapid transit, trolley coach, and streetcar services are included in this table; commuter rail is excluded.

*Expressed in current dollars for each year, unadjusted for inflation.*

*Expressed in constant, inflation-adjusted dollars.*

*Calculated by fitting an exponential curve.*

*For 1980 APTA reported 4,600 part-time workers and 184,700 full-time workers. For calculating the miles per employee in 1980, each part-time worker was counted as half a full-time worker; this yielded a figure of 187,000 full-time workers.*

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Between 1970 and 1980, total operating costs increased by 287% for bus and streetcar service, by 228% for commuter rail service, and by 138% for rail rapid transit. These figures do not control for inflation or for changes in service. Inflation-adjusted operating costs per vehicle mile also increased considerably: by 73% for bus and streetcar and by 29% for rail rapid transit. Because of declining load factors, real cost escalation is slightly greater on a per-passenger basis: 75% for bus and streetcar, 74% for commuter rail, and 36% for rapid transit.

Perhaps the most striking of these operating and financial trends is the sharply increased unprofitability of bus and streetcar services relative to rail rapid transit and commuter rail. In 1970, bus services in aggregate in the U.S. covered all their operating costs from passenger fares, whereas rapid transit and commuter rail fares covered less than two-thirds of costs. By 1980, however, bus services covered only 39%, less than either of the other modes. This reversal stems both from the faster increase in bus costs—as noted above—and from the much slower increase in bus fares than in fares on the other modes. Between 1970 and 1980 average bus fares rose by only 33%, whereas rapid transit fares rose by 108%, and commuter rail fares by 139%. Thus the increase in operating subsidy was 62¢ per bus rider and 37¢ per rapid transit passenger. For commuter rail passengers it was even larger ($1.24), because of the greater average length of commuter rail trips.

The sudden escalation of operating deficits in bus service was due to two factors.
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**Table 3**  
*Trends in U.S. Transit Operations and Finances for Different Modes, 1970–1980*  
(Statistics in millions, except for ratios)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Bus and Streetcar</th>
<th>Rail Rapid Transit</th>
<th>Commuter Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating expense ($)**</td>
<td>1,303</td>
<td>2,500</td>
<td>5,049</td>
</tr>
<tr>
<td>Operating revenue ($)</td>
<td>1,323</td>
<td>1,483</td>
<td>1,957</td>
</tr>
<tr>
<td>Operating deficit ($)</td>
<td>-20</td>
<td>1,017</td>
<td>3,092</td>
</tr>
<tr>
<td>Operating revenue/operating expense</td>
<td>1.02</td>
<td>0.59</td>
<td>0.39</td>
</tr>
<tr>
<td>Vehicle miles</td>
<td>1,476</td>
<td>1,567</td>
<td>1,710</td>
</tr>
<tr>
<td>Cost per vehicle mile ($)</td>
<td>0.88</td>
<td>1.60</td>
<td>2.95</td>
</tr>
<tr>
<td>Revenue passengersb</td>
<td>4,358</td>
<td>4,245</td>
<td>4,926</td>
</tr>
<tr>
<td>Cost per passenger ($)</td>
<td>0.30</td>
<td>0.59</td>
<td>1.02</td>
</tr>
<tr>
<td>Average fare ($)</td>
<td>0.30</td>
<td>0.35</td>
<td>0.40</td>
</tr>
<tr>
<td>Operating subsidy per passenger ($)</td>
<td>0.00</td>
<td>0.24</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Sources: Calculated on the basis of data in American Public Transit Association (1981a), Pucher (1980), and supplemental statistics collected by the author directly from individual multi-modal transit systems.

*Excluding depreciation.

b Also defined as linked passenger trips.

c Average fare was calculated as the ratio of passenger revenue divided by revenue passengers, excluding transfer passengers.

First, Federal operating subsidies per rider were much larger for all-bus systems in low-density urban areas than for multi-modal systems in dense urban areas. Because the allocation formula for Federal operating subsidies is based primarily on population and population density, and not on ridership, transit-oriented cities with rail systems received substantially less subsidy than if the formula had distributed funds in proportion to ridership (Urban Mass Transportation Administration, 1976). Also, most rail rapid transit service is in older, declining urban areas, where the state and local governments have had the most severe budget crises. In those areas smaller Federal, state and local government operating subsidies led to larger fare increases and less service than on bus routes elsewhere. Second, bus transit is more labour-intensive than rail transit, so bus transit is more exposed to increasing labour costs and declining labour productivity, and has less opportunity to eliminate personnel through automation.

Capital costs increased rapidly for all transit modes. The price of a new standard-size bus rose five-fold from 1970 to 1980, from $33,000 to $153,000 (Urban Mass Transportation Administration, 1982b). Rail vehicle costs increased about three-fold over this period, though there were differences by size of vehicle. The price of smaller rapid transit cars, such as those used by the Chicago Transit Authority,
rose from $150,000 to almost $500,000. The price of larger cars, such as those used on San Francisco's BART system and the Washington Metro, rose from $300,000 to $825,000 (Urban Mass Transportation Administration, 1982b). Construction costs for new rapid transit systems have also increased. The new Washington subway, for example, cost $90 million per mile to build, almost equal to the $89 million per mile for the new Atlanta subway (U.S. House of Representatives, 1981a; Metropolitan Atlanta Rapid Transit Authority, 1981). The current extension to Boston's subway is costing even more—$150 million per mile (U.S. House of Representatives, 1981b). In contrast, San Francisco's rapid transit system, built in the late 1960s, cost $23 million per mile (Metropolitan Transportation Commission, 1980). From 1965 to 1980, rail transit accounted for 76% of the nation's total cumulative capital subsidy to transit, but for only 27% of all transit ridership. Rail transit requires much more capital subsidy per passenger than bus. Indeed, the capital subsidy per rail passenger trip has been nine times larger than the capital subsidy per bus trip (Urban Mass Transportation Administration, 1981a).

The question remains, however, whether increased subsidies have actually encouraged increased costs, and thus whether the design of the subsidy programme is responsible for its own ineffectiveness. As was evident from Tables 1 through 3, transit cost increases in the U.S. have indeed been correlated with subsidy growth. During periods of little or no subsidy (from 1950 to 1965) productivity increases and cost increases were small. In contrast, productivity declined and cost increases were large during periods of rapid subsidy growth (from 1965 to 1980). These trends are consistent with the hypothesised adverse impact of the subsidy programme on costs. Moreover, the bivariate regressions of Bly, Webster and Pounds (1980) reinforce this impression. Examining changes in subsidies and costs from 1965 to 1976, they estimated that, for every additional one per cent of operating costs covered by subsidy, real unit costs rose by 0.4 to 0.6 per cent. Thus, for their time-series sample of 59 transit systems in seven countries—and national aggregate data from 15 countries—only about half of the real increase in subsidy was translated into lower fares or additional service.

Factors beyond the control of the transit industry may have contributed to cost escalation. In the econometric analysis which follows, a cross-section multiple regression model is used to isolate the impacts of subsidies on costs by controlling for other important cost determinants. Three different subsidy variables are employed to determine the effects of earmarked transit taxes and subsidy grants from higher levels of government.

**MULTIPLE REGRESSION ANALYSIS**

Past econometric analysis has focused almost exclusively on bus operating costs, primarily to assess the extent of scale economies or diseconomies (Lee and Steedman, 1970; Wabe and Coles, 1975; Nelson, 1972; Miller, 1970; Mohring, 1972). Except for the investigations of Bly, Webster and Pounds (1980) and Barnum and Gleason (1979), the effect of subsidies on costs has been neglected. The analysis here is also limited to bus costs, because the few rail transit systems in the U.S. yield few data. The impacts of subsidies are explicitly incorporated in the regression model.
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TABLE 4

Percentage Distribution of Transit Systems Included in the Regression Sample

<table>
<thead>
<tr>
<th>Bus Fleet Size</th>
<th>%</th>
<th>Percent Federal Subsidy</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100</td>
<td>49</td>
<td>Less than 25%</td>
<td>15</td>
</tr>
<tr>
<td>100-499</td>
<td>33</td>
<td>25%-44%</td>
<td>25</td>
</tr>
<tr>
<td>500 or more</td>
<td>17</td>
<td>45% or more</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Per Hour</th>
<th></th>
<th>Percent State Subsidy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $20</td>
<td>21</td>
<td>Less than 10%</td>
<td>53</td>
</tr>
<tr>
<td>$20-$29</td>
<td>58</td>
<td>10%-24%</td>
<td>15</td>
</tr>
<tr>
<td>$30 or more</td>
<td>22</td>
<td>25% or more</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revenue/Cost Ratio</th>
<th>Percent of State and Local Subsidy Dedicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.25</td>
<td>Less than 25%</td>
</tr>
<tr>
<td>0.25-0.49</td>
<td>25%-49%</td>
</tr>
<tr>
<td>0.50-0.74</td>
<td>50%-74%</td>
</tr>
<tr>
<td>0.75 or more</td>
<td>75% or more</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Management</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>56</td>
</tr>
<tr>
<td>Private</td>
<td>44</td>
</tr>
</tbody>
</table>

Sample selection

The data base for the regression consisted of a pooled cross-section sample of 77 transit systems in 1979 and 135 systems in 1980. The systems were selected primarily because data were available for them. They included virtually all sizes and types of systems, types of urban areas, geographic locations, cost and service levels, fare policies, and, perhaps most important, institutional structures and subsidy financing arrangements. The percentage distribution of the sample along seven key dimensions is shown in Table 4. All the 40 largest transit systems in the U.S. were included in the data set. This greater proportional representation of the larger systems was felt to be justified because they account for 85% of total bus ridership in the U.S., and thus have far greater importance to the transit industry than the 1,014 smaller systems.

The necessary transit data were assembled from four sources: (1) mandatory financial and operating reports submitted by all Federally-subsidised systems to the Urban Mass Transportation Administration (1981b and 1982a); (2) voluntary financial and operating reports filed by member systems with the American Public Transit Association (1980 and 1981a); (3) annual reports published by most of the systems; and (4) supplemental, unpublished information obtained by the authors from all the systems. Use of this range of sources permitted cross-checking of statistical values and helped us to identify and revise inaccurate figures.

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Theoretical considerations

Operating cost per bus hour was chosen as the dependent variable in the regression analysis, instead of cost per bus mile, in order to minimise the impact of travel speed, which varies according to differences between cities in layout, density and traffic conditions—factors beyond the control of transit operators. Average speed of a bus system is also affected by routing decisions. For example, a system would appear to have lower costs per mile simply as a result of expanding express suburban service and curtailing local inner-city service. Using cost per hour alleviates these two problems. Vehicle hour statistics could not be obtained at the nationwide, aggregate level, but they were available for the individual systems included in the disaggregate econometric analysis which follows.

A number of factors were hypothesised to influence bus operating costs. These included the size and age of the bus fleet, the base hourly wage rate of bus drivers, transit worker productivity, type of management, and key aspects of the transit subsidy programme. In particular, it was expected that costs would be affected by the level of Federal operating subsidy, the level of state operating subsidy, and the proportion of state and local operating subsidies that was derived from taxes dedicated exclusively for transit. In addition, a dummy variable for the sample year was included to capture the effects of inflation and other cost increases from 1979 to 1980 that could not be explained by changes in the eight explanatory variables. The model was formally specified as follows:

\[ \text{COSTPH} = f(\text{FLTAGE}, \text{FLTSIZE}, \text{WAGE}, \text{PRODUCT}, \text{MANAGE}, \text{FEDSUB}, \text{STSUB}, \text{DEDSUB}, \text{YEAR}). \]

Definitions and descriptive statistics for each of the variables are contained in Table 5.

The relationships between bus operating costs and several of the explanatory variables are rather obvious. A transit system using old vehicles will probably experience more equipment failure and require greater maintenance expenditures than systems with new buses. Higher worker productivity—as measured by hours of bus service per employee—will lead to lower per-hour operating costs.\(^1\) In contrast, higher hourly wage rates for bus drivers clearly lead to higher operating costs.\(^2\)

The other variables require more consideration. The relation between unit costs and fleet size—an indicator of scale economies or diseconomies—is somewhat controversial. Most previous econometric studies, however, find either constant or slightly increasing unit costs as size system increases (Lee and Steedman, 1970; Wabe and Coles, 1975; Nelson, 1972; Miller, 1970). In the present study, informal examination of the data led to an expectation of diseconomies of scale, and thus a positive relation

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\(^1\) Bus hours of service per employee reflect the combined effects of worker performance, management effectiveness, and the quality of the capital stock.

\(^2\) The hourly wage of bus drivers is not the only factor affecting a system's labour expenses. Fringe benefits, overtime arrangements, use of part-time workers, and non-driver wages are also important. Unfortunately, reliable data on these other factors were unavailable.
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Definition</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSTPH</td>
<td>Operating costs (nets of depreciation and taxes) per bus hour of service ($)</td>
<td>25.94</td>
<td>7.83</td>
</tr>
<tr>
<td>FLTAGE</td>
<td>Average age of buses in fleet (years)</td>
<td>8.72</td>
<td>3.18</td>
</tr>
<tr>
<td>FLTSIZE</td>
<td>Number of buses in fleet (natural logarithm)</td>
<td>4.89</td>
<td>1.30</td>
</tr>
<tr>
<td>WAGE</td>
<td>Base hourly wage of bus drivers ($)</td>
<td>7.46</td>
<td>1.34</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>Bus hours of service per full-time equivalent transit employee (000)</td>
<td>1.06</td>
<td>0.22</td>
</tr>
<tr>
<td>FEDSUB</td>
<td>Federal operating subsidies per bus hour of service ($)</td>
<td>6.19</td>
<td>2.34</td>
</tr>
<tr>
<td>STSUB</td>
<td>State operating subsidies per bus hour of service ($)</td>
<td>2.84</td>
<td>3.69</td>
</tr>
<tr>
<td>DEDSUB</td>
<td>Dummy variable for dedicated state and local transit taxes (−1 if earmarked taxes accounted for 50% or more of state and local subsidies, 0 otherwise)</td>
<td>0.37</td>
<td>0.48</td>
</tr>
<tr>
<td>EARNINGS</td>
<td>Average monthly earnings of public employees in each metropolitan area ($)</td>
<td>1190.63</td>
<td>245.83</td>
</tr>
<tr>
<td>MODESPLT</td>
<td>Percentage of work trips in each urban area made by mass transit</td>
<td>6.05</td>
<td>6.02</td>
</tr>
<tr>
<td>PEAKING</td>
<td>Ratio of peak-hour buses in service to off-peak, mid-day buses in service</td>
<td>1.92</td>
<td>0.65</td>
</tr>
<tr>
<td>MANAGE</td>
<td>Dummy variable for private contract management (1 if private management, 0 otherwise)</td>
<td>0.44</td>
<td>0.50</td>
</tr>
<tr>
<td>RESWAGE</td>
<td>Adjusted transit wage variable (residuals from the regression of wage on FEDSUB, STSUB, DEDSUB, MANAGE, FLTAGE, and FLTSIZE)</td>
<td>0.00</td>
<td>0.80</td>
</tr>
<tr>
<td>RESPRODUCT</td>
<td>Adjusted productivity variable (residuals from the regression of PRODUCT on FEDSUB, STSUB, DEDSUB, MANAGE, FLTAGE, and FLTSIZE)</td>
<td>0.00</td>
<td>0.20</td>
</tr>
<tr>
<td>YEAR</td>
<td>Dummy variable for year of observation (1 if 1980, 0 if 1979)</td>
<td>0.64</td>
<td>0.48</td>
</tr>
</tbody>
</table>
between cost per bus-hour and number of vehicles. The form of the relation was found to be non-linear, with the rate of increase in unit costs declining as fleet size increased. Consequently, the variable for fleet size was logarithmically transformed.

Of greatest interest in the model are the management and subsidy variables. It was hypothesised that privately managed systems would be more efficiency-oriented than publicly managed systems, and that private management facilitates lower costs. Federal subsidy per hour and state subsidy per hour were included to capture the cost impacts of subsidies from higher levels of government. Both were expected to encourage higher costs, but differently. The Federal operating subsidy programme is structured as a matching grant, requiring a dollar of state or local subsidy for every dollar of Federal subsidy, up to a specified maximum total Federal contribution that is different for each metropolitan area. State transit subsidies do not usually entail explicit matching provisions; they therefore represent simple lump-sum grants. Public finance economists have long argued that matching grants from higher levels of government stimulate local government spending to a greater degree than non-matching grants (Wilde, 1968; Oates, 1972; Gramlich and Galper, 1973). Because matching grants reduce the relative cost of the subsidised item, subsidy programmes of this type have positive income and price effects on local government spending. Empirical research in this area clearly demonstrates that matching grants lead to greater public expenditures than lump-sum grants (Inman, 1979).

Federal operating subsidies also differ from state subsidies because the maximum amount received by each area is determined by a formula based on population and population density, not according to a transit-related measure such as ridership, vehicle hours of service, or passenger revenues. So most low-density cities with little transit service receive the full 50% Federal match. In contrast, denser, transit-oriented urban areas receive a smaller proportion of their funding from Federal subsidies, because their total subsidy requirements are more than double the maximum Federal subsidy determined under the formula for their urban areas. Systems with high proportions of Federal aid are more likely to initiate costly and unprofitable services, because less of the cost is borne locally. Moreover, in spite of its statutory matching requirement, the Federal subsidy is likely to have the effect of a lump-sum grant for large systems in transit-oriented cities that have reached their Federal subsidy limit. At the margin, additional state and local subsidies attract no additional Federal subsidy for these systems. Thus the Federal subsidy probably acts as a matching grant only for systems in lower-density cities. Both by its matching effect and because of its higher proportion of the total subsidy, Federal subsidy encourages more cost escalation in lower-density cities.

Finally, local transit officials may be more politically accountable to state officials than to Federal officials for the way in which subsidies are spent. Local taxpayers share more directly and to a greater extent in the burden of state taxes channelled to transit subsidies; the link is much weaker for Federal taxes.

Each of these considerations suggests that Federal subsidies have a worse effect on transit costs than state subsidies. The Federal and state subsidy variables were included in the model to test this.

The third subsidy variable was the proportion of state and local subsidy funds derived from taxes dedicated for transit. This was included to test the notion, argued earlier, that they have reduced the incentive for cost control and improvement in
productivity by local transit authorities. Because most of the sampled transit systems had dedicated either very high or very low proportions of their state and local funding, this variable was specified as a 0–1 dummy variable, denoting systems above and below the 50% level.

The relationships between costs and subsidies described by the formal model abstract from the complexities of transit finance and management. Many political and institutional factors affect costs—and the degree to which costs are subsidised—but they could not be incorporated. For example, a transit system’s cost and subsidy levels are obviously affected by its organisational structure and the quality and motivation of its personnel; by the physical layout and climate of the city; by the fiscal capacity of the city and its propensity for public expenditures; and by the relative priorities given to numerous alternative objectives for transit. Cost and subsidy levels are also affected by the degree of political opposition to either higher fares or increased taxes for subsidies, and by the social and economic consequences of strikes. Barnum and Gleason (1979) argue that wages will be higher where union strength is great, and where the political costs of higher transit fares exceed the political costs of higher taxes for subsidies. They were unable (as we are) to test this theory, because it is difficult to find quantifiable proxies for these explanatory variables.

A less abstract but more complex depiction of the relationship between subsidy and cost would also reflect the joint determination of service levels, fares, subsidies and costs. It might be argued, for example, that higher unit costs result in larger operating deficits and thus create the need for more subsidies. Increased costs and deficits may also motivate local and state officials to set aside earmarked revenue sources for transit. Higher costs, therefore, may be the cause as well as the result of increased subsidies.

Again, subsidies probably affect costs indirectly through their impact on fares and services. It was noted earlier, for instance, that Federal matching formulas may cause higher costs by encouraging more expensive types of service. The indirect cost impact of subsidies through fares may take several forms. Higher subsidies make lower average fares possible. Concern of transit patrons for higher costs is almost certainly less than it would be if they were forced to pay a high proportion of cost increases through higher fares. Though taxpayers must bear the burden of those costs not borne by riders, political opposition to higher taxes may be less than to higher fares. The tax burden from financing subsidies is both more dispersed and less visible. Transit taxes for example, are often hidden within general-purpose tax structures. Moreover, Federal operating subsidies enable each urban area to shift elsewhere much of the tax burden of subsidising low fares.

In addition, the increasing availability of subsidies during the 1970s resulted in fare structures that exacerbated the cost problems of transit (Kirby, 1982; Wachs, 1981). Subsidies have permitted transit authorities to maintain or reinstate politically popular but inefficient flat fares instead of peak/off-peak and distance-based fares. This has encouraged riders to use transit at times of the day and over distances which have the highest marginal costs per trip.

It was impossible to estimate a comprehensive, multi-equation model incorporating all these interrelationships and institutional factors. Data limitations and insuperable statistical problems dictated the narrower, more focused approach described earlier. Despite this, the model produced interesting and useful empirical results.
Regression results

The first version of the estimated equation for per-hour operating costs is reported in Table 6. As expected, the coefficient for fleet size is positive and statistically significant, indicating diseconomies of scale. The coefficient for fleet age is also positive, but it is small and statistically insignificant. This unexpectedly weak effect of fleet age is probably attributable to the recent introduction of the new, so-called “advanced-design”, buses, which have experienced frequent breakdowns, high maintenance costs, and dramatic reductions in energy efficiency. The increase in costs from these new buses apparently offsets the hypothesised positive relation between fleet age and operating costs.

The estimated effect of transit wage rates on costs is positive and significant, whereas the impact of worker productivity is negative and significant. For every additional dollar in the base hourly wage of bus drivers, overall per-hour costs were $1.90 higher. This large coefficient reflects not only the direct effect of the base hourly wage on regular wage payments to drivers, but also the indirect effects of this key wage rate on overtime payments, premium payments (for split shifts and night work), and fringe benefits for drivers—as well as wage and salary payments to transit personnel other than drivers. The estimated effect of worker productivity was also in the expected direction: for every 10% decrease in worker productivity, per-hour costs were 6% higher.

Of greatest interest for this analysis, however, are the estimates for the management and subsidy variables. The coefficient for management—which is only significant at the 0.14 level—indicates that private management is associated with per-hour costs that are 82¢ lower. The coefficient for the dedicated subsidy variable is statistically
significant at the 0.02 level, and indicates that systems with more than half their state and local funding dedicated had costs that were $1.48 higher than systems with little or no dedicated funding. The regression reported in Table 6 also provides evidence of the particularly large increase in cost from Federal operating subsidies. Not only is the Federal subsidy coefficient statistically more significant than the state subsidy coefficient (0.02 against 0.11), but Federal subsidy is also estimated to have a greater impact on per-hour costs (29¢ against 13¢).

The results support the hypothesis that Federal subsidies and dedicated state and local subsidies are cost-inflationary. Moreover, distortions arising from the original model specification were suspected of masking the full impacts of subsidies on costs. Subsequent refinements in the model specifications dramatically improved the performance of these, as well as of several other explanatory variables.

In particular, one obvious problem with the equation as specified in Table 6 is the likely multicollinearity between the wage and productivity variables and each of the remaining explanatory variables. Indeed, it might be expected that subsidies affect costs through their impacts on transit wages and worker productivity, presumably by encouraging higher wages and lower productivity. Likewise, private management, fleet size, and fleet age may affect costs through their impacts on wages and/or productivity. The presence of all eight of these variables in the same equation may result in the wage and productivity variables siphoning off some of the effects on unit costs of the other explanatory variables, thereby causing excessive standard errors for these variables and $t$-statistics that are too small.

To examine these effects, separate structural equations were estimated for wage rates and worker productivity. In both equations the Federal, state, and dedicated subsidy variables are included as explanatory variables. Additional variables which were thought to influence hourly transit wages, and thus were included in that regression equation, were the average monthly earnings for public employees in each metropolitan area and the transit modal split for work trips in each area. Both variables were expected to have a positive influence on wage levels. Higher transit modal splits were assumed to increase the local bargaining power of transit unions. Average earnings of public employees were viewed as a benchmark against which transit workers in each area gauged the fairness of their own wages. As is shown by the regression results reported in Table 7, both modal split and earnings of public employees do indeed have highly significant impacts on transit wages. It is more germane to the present discussion, however, that all three subsidy variables also have positive effects on wage rates. Of these three, the dedicated and state subsidy variables have the most statistically significant coefficients (at the 0.001 and 0.002 levels,

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3Some multicollinearity among the three subsidy variables might also have been expected. For example, large Federal subsidies may evoke large state subsidies, because state subsidies can be used together with local subsidies to match Federal funds. Alternatively, it may be that Federal subsidies are instead substituted for state subsidies—a countervailing, inverse relation which would offset positive correlation. Multicollinearity between tax earmarking and the other two subsidy variables was also suspected, because state and local tax earmarking may encourage higher absolute levels of state and local subsidies. Yet the estimated correlation coefficients among the three subsidy variables were quite low, suggesting that the multicollinearity was not serious. The correlation values were as follows: +0.04 between DEDSUB and STSUB; +0.11 between DEDSUB and FEDSUB; and +0.21 between STSUB and FEDSUB.
TABLE 7

Multiple Regression of Transit Hourly Wage Rate

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAGE</td>
<td>EARNINGS</td>
<td>0.002</td>
<td>7.36</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>MODESPLT</td>
<td>0.089</td>
<td>7.54</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEDSUB</td>
<td>0.060</td>
<td>1.92</td>
<td>0.0566</td>
</tr>
<tr>
<td></td>
<td>STSUB</td>
<td>0.060</td>
<td>3.13</td>
<td>0.0020</td>
</tr>
<tr>
<td></td>
<td>DEDSUB</td>
<td>0.524</td>
<td>3.51</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>YEAR</td>
<td>-0.225</td>
<td>-1.50</td>
<td>0.1348</td>
</tr>
<tr>
<td></td>
<td>INTERCEPT</td>
<td>3.494</td>
<td>8.96</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Overall equation statistics:
- $R^2 = 0.52$
- $F$-statistic = 36.86
- Std. Dev. = 0.95
- $n = 212$

respectively), whereas the Federal subsidy variable is only significant at the 0.06 level. Nevertheless, the Federal coefficient is as large as the state coefficient (both 6¢ per hour).

The regression equation for the worker productivity variable is presented in Table 8. In addition to the three subsidy variables, the equation covers type of management, degree of service peaking, fleet size and fleet age. Private management probably enhances productivity, whereas sharp differences in supply of service between time periods almost certainly detract from worker productivity by leaving much of the labour force idle during off-peak periods. It was also expected that fleet size and fleet age might affect productivity, though in the case of fleet age it was not clear what the direction of the net effect would be.

Table 8 shows that the private management and peaking variables have the expected effects on productivity, and both variables are statistically significant (at the 0.01 and 0.001 levels, respectively). The Federal and state subsidy variables both have the expected adverse impact on productivity, but Federal subsidy has three times as much impact and is also much more statistically significant (at the 0.01 level vs. the 0.23 level). The dedicated subsidy variable is estimated to have an unexpected positive effect on productivity. The coefficient has virtually no statistical significance, however, and it is so small that the degree of impact is negligible.

The fleet size variable was estimated to have a significantly adverse effect on productivity, as might be expected if bus operations are subject to diseconomies of scale. The fleet age variable has a positive coefficient, but it is very small and statistically insignificant. As in the aggregate cost equation, this result probably arises from the confounding effects of the advanced-design buses.

Overall, the equations in Tables 7 and 8 indicate that both wage rates and worker productivity are indeed significantly a function of the subsidy variables. Thus, it is quite likely that if the direct effect of subsidies on costs were combined with their indirect effects on costs—through the wage rate and productivity variables—the total
effect would be considerably greater than is shown in Table 6. Moreover, because wage rates and productivity are also affected by type of management and fleet size, the total impact of each of these two variables on costs would also be greater than their direct effects.

In an attempt to capture these total effects, the overall cost equation was re-estimated with modified versions of the wage and productivity variables. In particular, the estimated impacts of subsidies, management, fleet size, and fleet age were removed from the wage and productivity variables so that their transformations would include only that portion of the variation in wage rates and productivity that was not explained by variation in the other six explanatory variables. The procedure involved separately regressing wage rates and productivity on the six other variables, and using the residuals from these regressions as instrumental variables for wage rates and productivity in the overall cost equation (\textit{RESWAGE} and \textit{RESPRODUCT}, respectively). By construction, these instrumental variables are uncorrelated with the other six explanatory variables.

The results of the re-estimated cost equation are given in Table 9. With multicollinearity removed through the procedure described above, the impacts of subsidies, private management, and fleet size emerge dramatically. The estimated coefficients for these variables are not only much larger, but are much more statistically significant as well. A dollar of Federal subsidy is associated with hourly costs that are 62¢ higher, whereas a dollar of state subsidy is associated with costs that are 34¢ higher. Thus, state subsidies are still estimated to be only about half as cost-inflationary as Federal subsidies. Moreover, systems with more than half their state and local subsidies earmarked for transit had costs that were $2.38 per hour higher—when we controlled other factors affecting costs.
Table 9
Multiple Regression of Operating Costs per Bus Hour

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSTPH</td>
<td>RESPRODUCT</td>
<td>-15.065</td>
<td>-11.29</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>RESWAGE</td>
<td>1.896</td>
<td>5.78</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FLTAGE</td>
<td>0.062</td>
<td>0.74</td>
<td>0.4575</td>
</tr>
<tr>
<td></td>
<td>FLTFSIZE</td>
<td>3.675</td>
<td>17.06</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEDSUB</td>
<td>0.619</td>
<td>5.16</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>STSUB</td>
<td>0.338</td>
<td>4.55</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>DEEDSUB</td>
<td>2.377</td>
<td>4.08</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>MANAGE</td>
<td>-1.722</td>
<td>-3.12</td>
<td>0.0021</td>
</tr>
<tr>
<td></td>
<td>YEAR</td>
<td>3.068</td>
<td>5.50</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>INTERCEPT</td>
<td>0.553</td>
<td>0.35</td>
<td>0.7270</td>
</tr>
</tbody>
</table>

Overall equation statistics:
\[ R^2 = 0.77 \]
\[ F\text{-statistic} = 76.57 \]
\[ \text{Std. Dev.} = 3.81 \]
\[ n = 212 \]

The estimated effect of management also increases; after multicollinearity has been removed, private management is associated with costs per hour that are $1.72 less than for publicly managed systems. An increase in the estimated effect of fleet size suggests significantly larger diseconomies of scale than were evident from Table 6. The coefficient indicates, for example, that as fleet size increases from 100 to 500, hourly costs increase by 23% (other things being equal). Finally, the coefficient for fleet age increases slightly from its value in Table 6, but it remains statistically insignificant.

As a final refinement of the analysis, the same model was estimated separately for two subsets of the sample—those systems receiving the maximum 50% of their operating subsidy from the Federal government, and those receiving less than 50%. The purpose of this disaggregation was to test the hypothesis that a dollar of Federal subsidy has a more cost-inflationary impact in low-density, auto-oriented areas, where the Federal subsidy covers a higher percentage of that deficit and has the full stimulative effect of a matching grant—in contrast to transit-oriented areas, where the Federal subsidy covers a lower percentage of the deficit and has the less stimulative effect of a lump-sum grant. Table 10 shows that the disaggregate regression results support this hypothesis. The Federal subsidy coefficient for the high-match sample is more than twice as large as for the low-match sample, and the high-match coefficient is more statistically significant. A dollar of Federal subsidy is associated with costs

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4Because of the peculiar timing of Federal grants to each area and the idiosyncratic accounting procedures used by each transit system to apportion subsidies over time, some systems receiving the maximum Federal match reported slightly less than a 50% Federal match. Thus, in disaggregating the sample, 45% was used as the cutoff point instead of 50%
## Table 10

**Multiple Regressions of Per-Hour Operating Costs for Two Subsamples of Bus Systems**

### Equation A: Systems With Full Federal Match

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSTPH</td>
<td>RESPRODUCT</td>
<td>-8.084</td>
<td>-7.90</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>RESWAGE</td>
<td>0.998</td>
<td>4.15</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FLTAGE</td>
<td>0.078</td>
<td>1.48</td>
<td>0.1408</td>
</tr>
<tr>
<td></td>
<td>FLT.SIZE</td>
<td>2.081</td>
<td>10.88</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEDSUB</td>
<td>1.707</td>
<td>15.21</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>STS.SUB</td>
<td>0.040</td>
<td>0.53</td>
<td>0.5991</td>
</tr>
<tr>
<td></td>
<td>DEDSUB</td>
<td>-0.652</td>
<td>-1.51</td>
<td>0.1341</td>
</tr>
<tr>
<td></td>
<td>MANAGE</td>
<td>-0.414</td>
<td>-1.14</td>
<td>0.2559</td>
</tr>
<tr>
<td></td>
<td>YEAR</td>
<td>1.258</td>
<td>3.32</td>
<td>0.0012</td>
</tr>
<tr>
<td></td>
<td>INTERCEPT</td>
<td>0.678</td>
<td>0.57</td>
<td>0.5690</td>
</tr>
</tbody>
</table>

*Overall equation statistics:*

- $R^2 = 0.83$
- $F$-statistic = 66.31
- Std. Dev. = 1.99
- $n = 128$

### Equation B: Systems With Less Than Full Federal Match

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSTPH</td>
<td>RESPRODUCT</td>
<td>-18.913</td>
<td>-6.51</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>RESWAGE</td>
<td>2.682</td>
<td>4.12</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FLTAGE</td>
<td>0.054</td>
<td>0.29</td>
<td>0.7751</td>
</tr>
<tr>
<td></td>
<td>FLT.SIZE</td>
<td>3.782</td>
<td>10.80</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEDSUB</td>
<td>0.653</td>
<td>2.96</td>
<td>0.0041</td>
</tr>
<tr>
<td></td>
<td>STS.SUB</td>
<td>0.179</td>
<td>1.58</td>
<td>0.1194</td>
</tr>
<tr>
<td></td>
<td>DEDSUB</td>
<td>2.594</td>
<td>2.33</td>
<td>0.0227</td>
</tr>
<tr>
<td></td>
<td>MANAGE</td>
<td>-2.152</td>
<td>-1.85</td>
<td>0.0687</td>
</tr>
<tr>
<td></td>
<td>YEAR</td>
<td>3.929</td>
<td>3.54</td>
<td>0.0007</td>
</tr>
<tr>
<td></td>
<td>INTERCEPT</td>
<td>1.851</td>
<td>0.63</td>
<td>0.5313</td>
</tr>
</tbody>
</table>

*Overall equation statistics:*

- $R^2 = 0.78$
- $F$-statistic = 28.56
- Std. Dev. = 4.67
- $n = 84$
that are $1.71 higher in the high-match sample, but only 65¢ higher in the low-match sample. Clearly, aggregation of both groups of systems into the same sample conceals much of the differential impact of Federal and state subsidies. Indeed, the two disaggregate Federal subsidy coefficients in Table 10 are both larger than the aggregate Federal coefficient in Table 9. Conversely, the two disaggregate state subsidy coefficients are both smaller than the aggregate state coefficient.

The values of other variable coefficients in the model also vary somewhat between the two subsamples. Diseconomies of scale, for example, appear to be more pronounced in the low-match sample, which contains most of the largest transit systems. In addition, private management is estimated to have a more beneficial impact on costs in the low-match sample. A more surprising result is the opposite signs of the dedicated subsidy coefficient in the two equations. The expected positive effect on costs is found for the low-match subsample, but the dedicated coefficient is actually negative for the high-match subsample, though it is not statistically significant. It is difficult to explain this result. It seems unlikely that tax earmarking has the estimated beneficial impact. Moreover, examination of the correlation matrix suggested that the anomalous result may have been produced by collinearity between the management and dedicated subsidy variables.

The main purpose of the disaggregation was to test the differential effects of Federal subsidies in high-match and in low-match cities. The results conform well to expectations. They also highlight the extraordinarily adverse cost impact of Federal subsidies overall. Even in the low-match sample, cost escalation associated with Federal subsidy dissipates about two-thirds of that subsidy. In high-match cities, Federal subsidy is associated with cost increases so large that they fully consume not only the Federal subsidy itself, but 70% more than the Federal subsidy.

One final note on the regression results: pooling of the 1979 and 1980 datasets assumes that the same structural equation is appropriate for both years, and that the coefficients for the explanatory variables are approximately the same. To test the validity of pooling the data, separate sets of equations were estimated for each year. With the exception of the intercept term, which of course was different, the variable coefficients were virtually the same for the separate 1979 and 1980 regressions.

Limitations

As with any regression analysis, the results reported here must be interpreted with caution. It was noted earlier, for example, that costs and subsidies are jointly determined, as higher costs elicit more subsidies, which in turn induce higher costs. However, the multi-national time-series study by Bly, Webster and Pounds (1980) experimented with a number of different time-lag structures in their regressions and found that cost increases tended to follow subsidy increases, thus supporting the main hypothesis being examined here. Nevertheless, it seems likely that the reverse effect of costs on subsidies also occurs at least to some extent. Indeed, as suggested earlier, costs, subsidies, service levels and fares are all somewhat interdependent. The endogeneity of the subsidy and cost variables, in particular, may result in some positive simultaneous-equations bias to the subsidy coefficients (arising from the correlation of the subsidy variable with the error term in the cost equation).

To deal with these interrelationships, a two-stage least squares simultaneous equations model was attempted. Six separate but interdependent equations were
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estimated for service levels, costs, fares and subsidies (Federal, state, and percentage dedicated). Because of data limitations, however, no satisfactory instrumental variables could be estimated in the first stage that would permit statistically meaningful results in the second stage of the procedure.\(^5\)

Another potential statistical problem was error in specification. For example, a number of non-quantifiable political and institutional factors, such as union power, could not be incorporated in the regression model. Assuming that costs varied directly with transit union strength and that union strength and subsidy levels were also positively correlated, the estimated subsidy coefficient would be upwardly biased. However, the presence of both worker productivity and wage variables in the regression model mitigates this problem. Much of the impact of transit unions on costs is through their ability to influence wage rates and work rules governing productivity. Consequently, these two variables already capture a large part of the effect of labour unions on costs. The only direct cost impacts of labour unions not controlled for in the model would be those arising from their ability to increase fringe benefits and premium payments for overtime, night work, and split shifts. Thus the bias due to the omission of a union power variable is probably unimportant.

The several potential sources of statistical error do not appear to be so serious as to overturn the main finding. After controlling for other important variables affecting costs, we find that subsidies are very significantly correlated with higher costs per unit. This does not prove that subsidies cause higher costs, but it is certainly consistent with that hypothesis.

SUMMARY AND POLICY IMPLICATIONS

The preceding analysis suggests that transit subsidies have probably exacerbated increases in costs. During periods when subsidies have increased most, productivity has declined and costs have grown most rapidly. Moreover, when cost differences between bus systems were examined by multiple regression, it was found that costs were much higher for those systems that relied on large Federal and state subsidies and dedicated state and local transit taxes.

These results suggest that transit operations should be monitored more carefully and that subsidies should be related explicitly to output. Because most transit subsidy programmes in the United States simply cover costs—whatever they happen to be—without regard to any index of achievement of goals, there is not much incentive to use subsidies efficiently. Shifting the subsidy burden to the Federal government and earmarking state and local taxes for transit have compounded the problem. Federal and state subsidy programmes fail to reward efficient systems and penalise inefficient ones. Instead, distribution formulas—especially at the Federal level—arise from political

\(^5\)As usual with two-stage least squares, the first stage required regressing each of the endogenous variables in the model on all the exogenous variables in the six-equation system. These regressions produce instrumental variables, which are substituted for the endogenous variables in the second stage of the procedure. Unfortunately, these estimated instrumental variables were very poorly correlated with their respective endogenous variables, and thus were inadequate substitutes.
bargains and have little relationship either to the transport needs of individual urban areas or to the performance of individual systems.

To survive, the transit subsidy programme must be improved. There are several ways to improve it. One approach would be to alter Federal and state subsidy formulas to reward those systems that raise productivity, attract new riders, or enhance the quality of their service. This would tie the level of subsidy directly to the level of output, and, at the very least, would discourage unwarranted cost escalation. A limited version of this approach was implemented in Pennsylvania in 1978 (Miller, 1980). Approximately a tenth of the state's operating subsidy is now set aside for a bonus fund used to reward transit systems that achieve relatively slow growth in costs, increased ridership and fare revenue per hour of service, and some state-determined standard for the revenue/expense ratio. The more criteria are satisfied, the larger is the subsidy bonus.

Another strategy would be to equalise Federal matching rates for the capital and operating subsidy programmes to eliminate the present bias toward capital investment. This uniform rate might be set low to increase the proportion of costs directly relevant to state and local decision makers. In addition, both subsidy programmes could be made open-ended to equalise the Federal proportion of the local transit subsidy in all metropolitan areas. The Federal government could then adjust the single matching rate to reflect the total amount of the Federal transit budget in any given year. These proposed changes would certainly simplify the current programme, with its range of matching rates, complicated allocation formulas, and politically motivated distortions. In combination, the modifications would in effect create a Federal transit block grant. A subsidy system along these lines was recently endorsed by the Committee on Transportation and Public Works of the U.S. House of Representatives (1982), but was not adopted by the Congress as a whole.

Transit subsidies will probably diminish, or grow much less rapidly, than in recent years. Failure to improve productivity will almost certainly lead to service cutbacks, fare increases and ridership losses. Changes in the transit programme such as those discussed above would help to alleviate the impact of retrenchment. Whether these changes take the form of deregulation and reorganisation of the industry, or simply of a restructuring of the subsidy programme, the room for improvement is vast. Adaptation to curtailed subsidy may be difficult, but it probably represents a unique opportunity to implement a more rational and more effective urban transport policy.

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