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16. Abstract

Trends in cost, revenues, subsidies, and performance indicators were examined to determine the effect of subsidies on financial and performance aspects of the Texas transit industry. Regression analysis was used to identify influential factors on costs. Positive significant relationships were found for non-subsidy variables; city size, fleet size, public management and labor costs. State capital assistance had a slightly greater influence on costs for large systems than Federal or Local aid. Local capital assistance was more influential than other subsidies on small systems' costs. Operating subsidy was associated with higher costs per mile, higher costs per passenger, and higher costs per hour.

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IMPLEMENTATION STATEMENT

This report is an analysis of financial components of transit operations in Texas. A review of historical costs, revenues, subsidies, and performance measures, and a quantitative assessment of some effects of subsidy on costs is presented. The purpose of this report is to advance the existing knowledge concerning these financial components; to assist SDHPT in establishing criteria for and executing control of the expenditure of State money to support transit in Texas; and to provide transit operators with information to better evaluate their systems relative to the industry statewide.

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I. Introduction

The need to operate public transit in an economical, efficient, and effective manner is more critical now than ever in the industry's history. The likelihood of significantly reduced levels of operating assistance at the Federal level, and subsequent pressure on State and local resources, underscore the importance of cost control. However, control of rising costs is not the only issue confronting today's transit industry. The perception of a growing financial crisis is accompanied by concerns about deteriorating transit infrastructure, lagging productivity, and unreliable equipment. The need to assess the condition of the Texas transit industry with respect to such concerns prompted this study of historical trends of Texas' systems.

Study Objectives

Officials of the State of Texas need a sharper focus on the role and financial requirements of transit, to tailor policies that promote the efficient expenditure of its transportation revenues. A primary objective of this study is to analyze subsidies distributed to transit systems to illuminate: (1) the role of the State in providing capital and/or operating assistance; (2) the resources being used by regional transit authorities; and (3) the continuing requirements that transit systems have on local budgets.

To evaluate the wisdom of utilizing subsidies to operate transit systems, measures of benefits or effectiveness need to be described, documented, and analyzed. Further, relationships among revenues, costs, subsidies, and transit systems' performances are examined in this report.

Finally, the analysis also incorporates a historical examination of transit policy.

Related Studies

A wide range of key issues in transit finance and transit performance have been explored. To establish groundwork for model development, review in this section is limited to studies that directly pertain to the effects of public assistance on cost and performance.

Research by Cervero at Berkeley (1982) specifically addresses intergovernmental responsibilities for financing public transit services. Using 17 California transit properties from 1971 to 1981, Cervero analyzed historical effects of transit subsidies on fiscal and operating performance. From the time-series analysis Cervero concluded that operating subsidies exerted a negative influence on performance. These operating subsidies (primarily at the local level) seemed to have a more direct impact on costs than productivity or ridership levels.

In California, the performance effects of local aid were about twice as great as the effects from federal aid. Furthermore, performance effects of state aid were determined to be largely inconsequential. Specifically, the analysis yielded the following information:

1) For the 17 California systems examined, a one dollar increase in the amount of assistance per passenger increased the cost of operations by over $5.50 per hour. (This increase in cost was in large part due to inflation.)

2) Vehicle miles per employee declined in response to increases in local aid.

3) All other things being equal, a totally subsidized operation in California could be expected to carry at least 200 fewer passengers per vehicle annually than a comparable nonsubsidized one.

Cervero's conclusion was that reducing federal and state aid appears more justified than reducing local aid, considering the subsidy impact perspective. His findings "reinforce(d) the perception that user responsibilities should expand and government involvement should shrink."

In another study in New York (Barbour and Zerillo, 1981), a performance audit by the State Department of Transportation produced an understanding of some differences between subsidized public systems and privately owned bus systems.* The review revealed that private operators generally provided transit service more efficiently. Public systems did achieve greater effectiveness in passenger volume. Yet, despite their low passenger carrying levels, the private systems in New York reported higher revenue to cost ratios than did public systems. This result was attributed to the enactment of belt tightening strategies by private transit operators. Barbour and Zerrillo concluded:

> The review of public and private bus operators revealed that there were differences in performance, as suspected. Admittedly, the private operators often operate with fewer bureaucratic constraints, but the usually more cost-effective performance of the private operators provides a target for performance improvement of public operators (p. 27).

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*A 1979 State legislative mandate required certification of the economy, efficiency, and effectiveness of transit operations that participate in the New York State Operating Assistance Program.

A study by Barnum and Gleason (1979) produced a model to identify relationships between subsidies and performance. Their findings are simply stated:

- Subsidies increased ridership per capita.
- Subsidies increased expenses per vehicle hour by nine percent over what they would have been if no subsidies had been provided.
- Subsidies had minor and generally insignificant effects on six efficiency indicators, but a significantly favorable impact on the effectiveness measure, ridership per capita.

Other studies have dealt specifically with the relationship between subsidy and cost. One such study was conducted at the Institute for Defense Analysis (Nelson, 1973). Using 1968 data for 40 bus systems, Nelson developed a cost function that included the proportion of the fleet purchased with capital subsidies as one of the independent variables. The conclusion was that level of capital subsidy had no statistically significant influence on the cost of transit operation.

The impact of subsidy on driver wages and premium pay was examined by Stern and others (Stern, *et al.*, 1977) using sample data from 1965 through 1973. The ratio of operating revenues to operating expenses was used as a proxy for subsidies, assuming that the difference between revenues and expenses is the amount of subsidy received. In short, it was found that driver's wages and premiums were not significantly affected by subsidies. Barnum (1977) also found no statistically significant relationships between subsidy level and wage rate, nor any differences between public and private systems for these variables.

Contrary findings have recently been reported. Specifically, a cross sectional analysis of 212 systems in 1979 and 1980 revealed four significant findings (Pucher, 1982):

1. An additional dollar of Federal operating subsidy per hour was associated with operating costs that were $.62 per hour of operation higher. In contrast, an additional dollar of state operating subsidy was associated with a $.34 increase in operating costs.

2. Earmarking taxes for transit appears to have an adverse impact on costs. Bus systems with more than half of their state and local operating subsidies committed to transit from dedicated sources had operating costs that were $2.38 per operating hour higher than for systems with little or no dedicated funds.

3. Private contract management of transit systems was associated with significantly lower operating costs - $1.72 per hour lower than systems that were publicly managed.

4. Furthermore, subsidies were found to be associated with significantly higher wages and lower productivity. Private management was associated with considerably higher productivity.

In the same study Pucher performed a time-trend analysis of 34 systems from 1970 to 1979. His most important finding was that public ownership, public management, transit tax dedication, and high subsidy ratios all were associated with substantially larger increases in per hour operating costs.

The studies cited suggest variables that are important to consider when analyzing the relationships among subsidy, financial, and performance data. Although no consensus of results was found in the literature, performance and cost ratios were examined with similar categorical variables: labor costs, type of ownership, type of management, type of financing, and sources of subsidy. In the next chapter, salient dimensions of the Texas transit industry with regard to such variables are examined. Chapter III presents statistical analyses used to clarify the financial/performance relationship for Texas transit systems. The summary chapter includes a discussion of the implications of the findings for future policy decisions.

II. Texas Transit Cost, Revenue, Subsidy and Performance

This chapter documents recent trends in the financial components and operational performance of transit systems in Texas. In general, financial trends in transit systems in Texas have coincided with those of the nation. Specifically, in the last decade costs have escalated; ridership levels have risen only slightly; revenues have not kept pace; and much of the necessary increases in subsidy have been dissipated by the resulting net losses.

Income and Expenses

Table 1 provides a summary of transit industry trends in the United States. These data indicate a 153 percent increase in costs during the past decade, a 57 percent increase in revenues, and an overall increase of seven percent in linked passenger trips. All modes of transit are

Table 1. U.S. Transit Industry Trends in Operating Expense, Revenue, and Linked Passenger Trips

Year	Operating Expense (millions)	Operating Revenue (millions)	Passenger Trips (millions)
1970	$1996	$1707	5932
1972	2242	1729	5253
1974	3239	1940	5606
1976	3885	2161	5673
1978	4563	2381	6292
1980	$5049	$2674	6346

Source: American Public Transit Association, Transit Fact Book 75, 76, 77, 78; Pucher, "Transit Financing Trends," Transportation Research Record No.759 (1980).

represented in this U.S. industry table.

A similar trend has occurred in the Texas transit industry, as shown in Table 2. Although data from several systems is missing from early

Table 2. Texas Transit Industry Trends in Operating Expense, Revenue, and Total Passengers

Year	Operating Expenses (millions)	Operating Revenues (millions)	Total Passengers (millions)
1974	$44.1[a]	$32.1[a]	117
1976	60.3[b]	35.6[b]	122
1978	93.9	44.1	136
1980	$147.4	$57.3	152

Source: <u>Texas Transit Operations (Statistics and Analysis)</u>, Texas State Department of Highways and Public Transportation, 1974, 1976, 1978, 1980.

[a]excludes data from Laredo, Brownsville, and Harlingen
[b]excludes data from Brownsville, and Harlingen

years, the absence of these data does not substantially alter the totals for 1974 and 1976. Texas systems evidenced an even greater increase in costs than the nation as a whole. Operating costs increased 234 percent over the six year period, while operating revenue rose by 79 percent. Additionally, patronage on Texas buses increased more - 30 percent compared to the industry total gain of seven percent.

Previous TTI studies (Womack and Burke, 1979; 1981) have examined costs and revenue relationships extensively. Data collected from 16 Texas transit systems for 1973 through 1977 are shown in Figure 1 to illustrate the effect of inflation on total operating costs. As indicated by the solid line, the real cost of providing transit increased over the five year period from 35.3 million dollars to 43.6 million, or 24 percent. Each year the costs of operating transit seemed to skyrocket. However, as illustrated by the dotted line in Figure 1, much of this escalation was due simply to the effect of inflation.

The cost study also revealed that operational, administrative and maintenance costs all escalated from 1973 to 1977, in real terms. However, maintenance costs increased at a higher rate of 34 percent. The average administrative cost for a Texas transit system grew by over 27 percent. And average operational costs for all systems increased over 21 percent.

Figure 2 illustrates the revenue trend for the same five year period.* The net decrease, in real terms, from 1973 to 1977 was 25.4 percent. The apparently gradual decrease in revenues each year, represented by the dotted line, was obviously more dramatic in constant dollars, represented by the solid line. Revenue reductions were attributed primarily to the unchanged fare structures and slow growth in revenue passengers.

More recent data indicate that fare structures in Texas are beginning to change. In 1977-1979, only two of the 14 systems had fare increases. One increase was a nickel (to $.50) and one was a dime (to $.40). In 1980, six systems increased their base fares. The price to ride the bus in 1980 ranged from $.25 in Abilene to $.60 in Dallas and Fort Worth.

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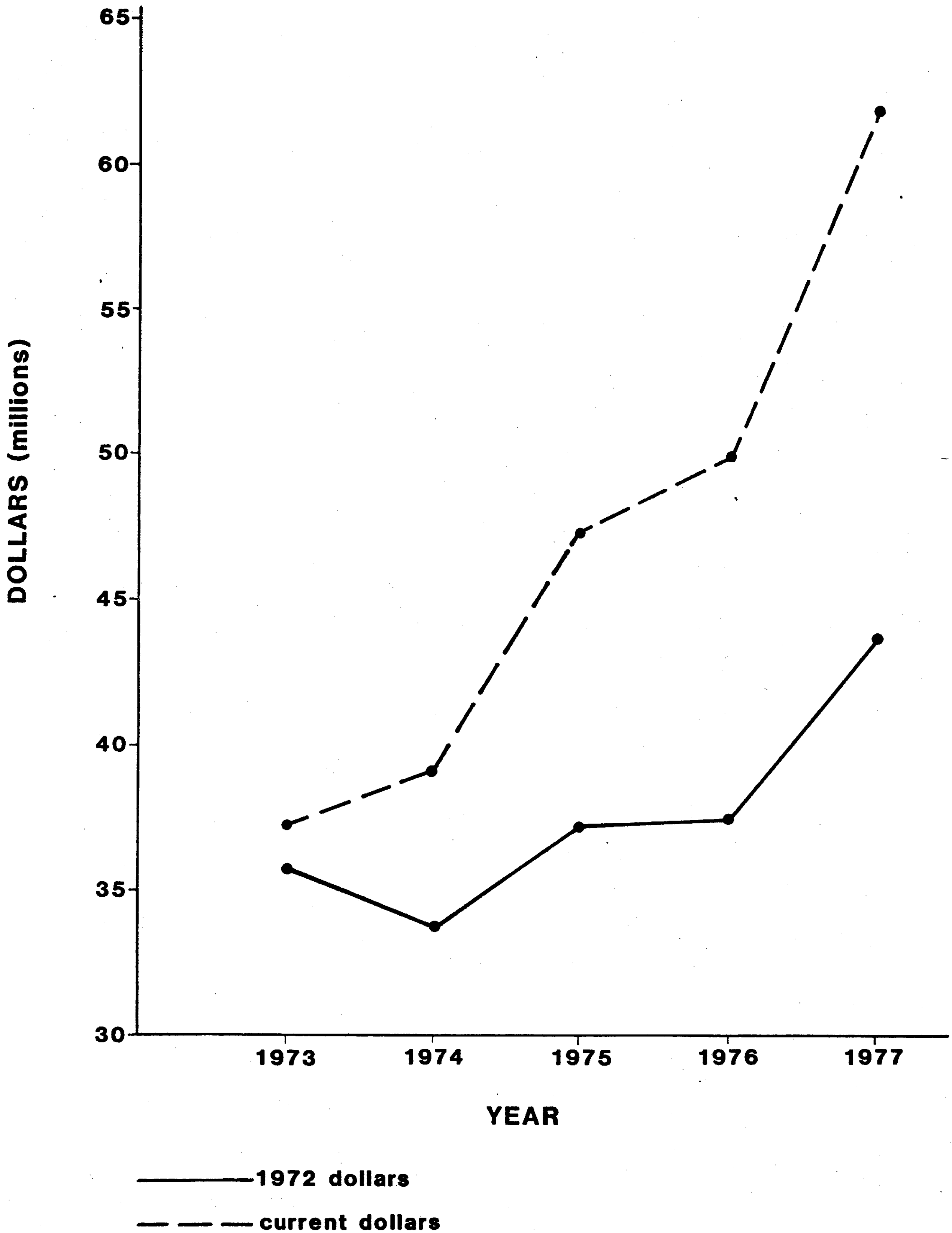
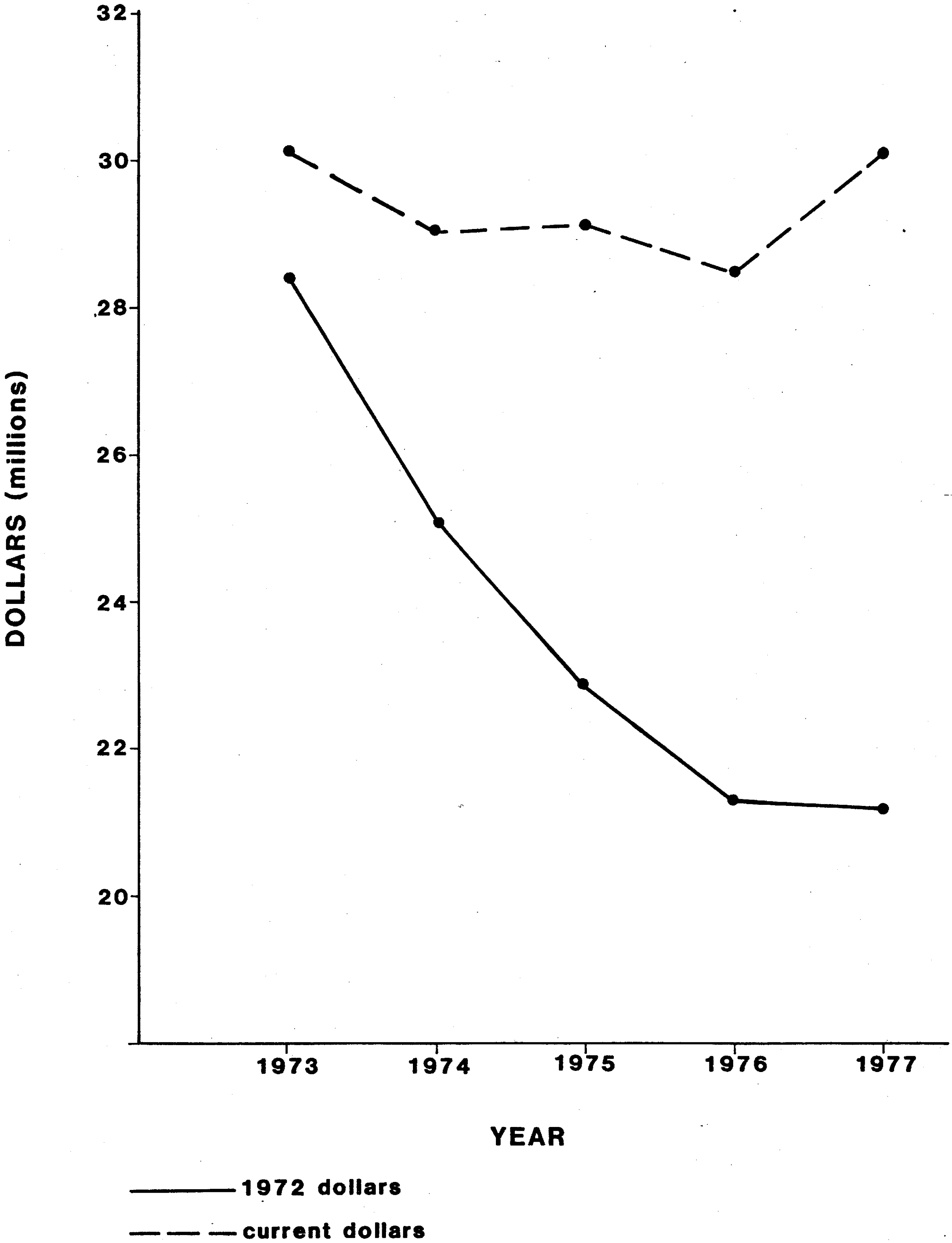
* These data are not the same as the data presented in Table 2 due to the use of a smaller number of bus systems and Total Revenue rather than Operating Revenue.

Figure 1. Total Annual Cost for Texas Transit, 1973-1977



Source: Womack, Katie. "Cost, Revenue, and Subsidies in Texas Transit," paper presented at the 9th Annual Public Transportation Conference, Austin, 1981.

Figure 2. Total Annual Revenue for Texas Transit, 1973-1977



Source: Womack, Katie. "Cost, Revenue, and Subsidies in Texas Transit," paper presented at the 9th Annual Public Transportation Conference, Austin, 1981.

Financial Assistance

The purpose of federal government financial assistance to transit is stated in Section Two of the National Mass Transportation Act of 1974. According to the Act, subsidies are to:

> enable many mass transportation systems to continue to provide vital service, to halt the continued increase in its cost to the user, and to allow urban areas time to revitalize their operations.

Thus, subsidies have become the major method used by governments to keep transit in business in the Unites States. In fact, it has been stated that the only reason the transit industry, as a whole, has been able to avoid financial collapse, has been because all levels of government have subsidized it (Barnum and Gleason, 1979).

During the previous decade, financial assistance to transit grew faster then any other type of government expenditure in the United States. Table 3 shows this tremendous growth from 1970 to 1980 for each type of assistance from each level of government. Subsidies totaled over $7.8 billion in 1980, which is an increase of more than 15-fold over the decade. As Pucher points out, a "striking trend evident in the table is the increased Federal role in transit finance" (1982, p.3). Federal subsidy grew from 26 percent to 53 percent of total subsidy and increased from $133 million in 1970 to $4.1 billion in 1980. Although State subsidies also increased substantially, their relative importance since 1975 has become less, due to the accelerated growth in Federal subsidy.

The subsidy program has obviously kept transit viable. It has also served to strengthen and revitalize systems as a direct result of capital expenditures. The capital grant program was initiated in 1964. Federal funding for capital grants climbed from $174 million in 1965 to $2.9

Table 3. Transit Assistance in the United States, 1970-1980
(Amounts in millions of dollars, percentages in parentheses)

Type of Assistance	YEAR 1970	1975	1980
Operating Assistance			
Federal	$ 0 (0%)	$ 408 (21%)	$ 1,324 (30%)
State	30 (9)	549 (29)	992 (23)
Local	288 (91)	944 (50)	2,062 (47)
Total	318 (100)	1,901 (100)	4,378 (100)
Capital Assistance			
Federal	133 (67)	1,287 (80)	2,787 (81)[b]
State and Local[a]	67 (33)	322 (20)	647 (19)
Total	200 (100)	1,609 (100)	3,434 (100)
Operating and Capital Assistance			
Federal	133 (26)	1,695 (48)	4,111 (53)
State and Local	385 (74)	1,815 (52)	3,701 (47)
Total	$ 518 (100)	$3,510 (100)	$7,802 (100)

SOURCE: Pucher, John. Redesigning Federal Transit subsidies to Control Costs and to Increase the Effectiveness of the Transit Program. USDOT, 1982, p. 4.

[a]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 program.

[b]The overall Federal matching rate for capital subsidies in 1980 exceeded 80% due to the 85% matching rate on Interstate Transfer funds.

billion in 1981 and totaled $2.6 billion in 1982 (see Figure 3). State and local governments provided at least $.6 billion in additional funds to meet the 20 percent local matching requirements.

The State of Texas is involved only in the capital grant program. In 1975 a Public Transportation Fund was established by an Act of the 64th Legislature, and Senate Bill 762 authorized appropriation of $31 million for public transportation purposes. An additional $30 million was appropriated for fiscal years 1978 and 1979 by the 65th Legislature. A total of $25 million for fiscal years 1980 and 1981 was appropriated by the 66th Legislature (SDHPT, 1982).

Of the $86 million appropriated through fiscal year 1981, less than one million dollars has been used for administration of the Public Transportation Fund. Commitments of the Fund as of the end of fiscal year 1980 totaled $41,821,785 (SDHPT, 1980).

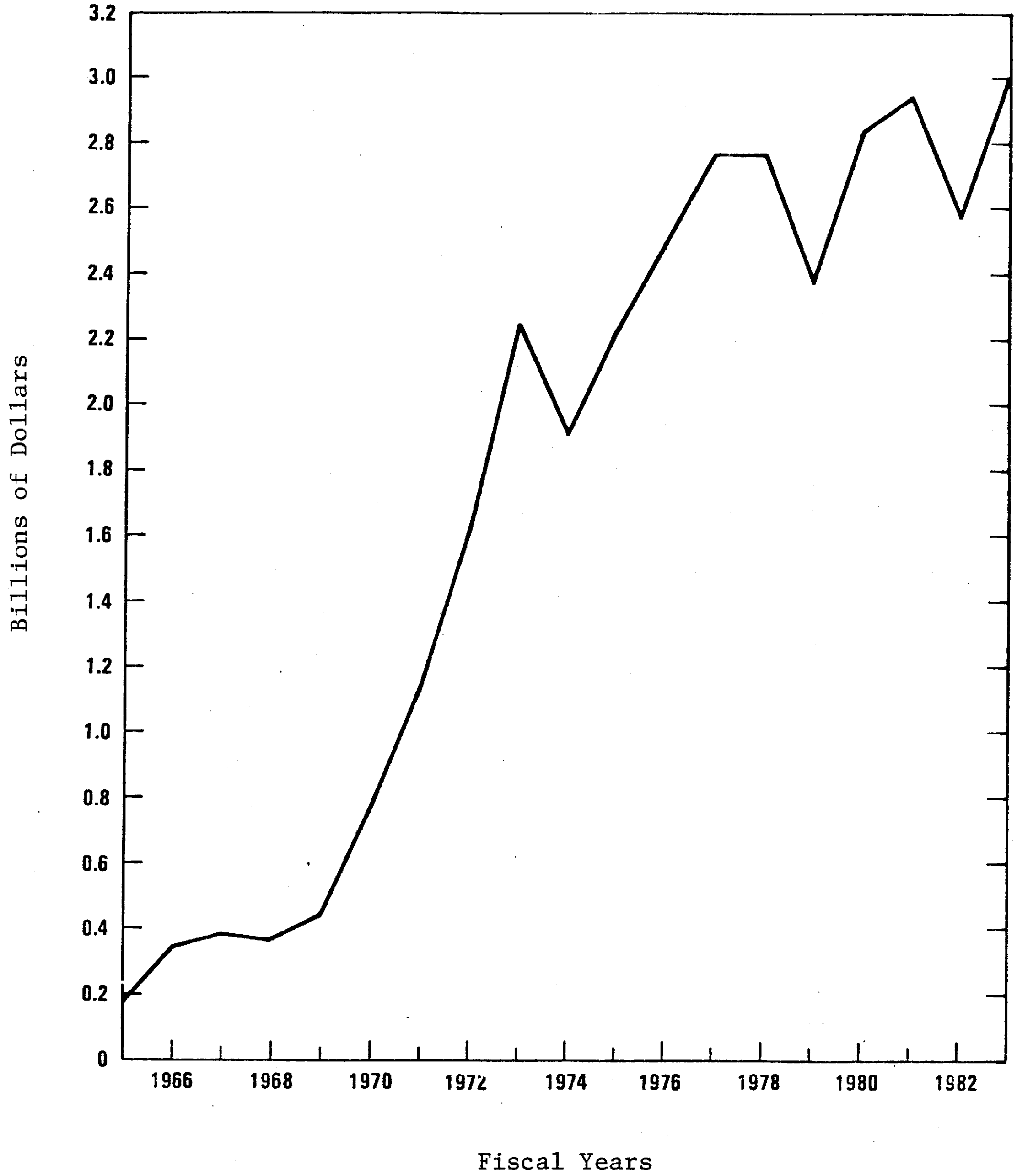
The State Public Transportation Fund grants are administered through two programs:

Formula Program - 60% of the annual funds are available for urbanized areas with populations in excess of 200,000.

Discretionary Program - 40% of the annual funds are available for all other areas of the State.

Uncommitted funds in either program after 1 1/2 years are placed into a secondary discretionary program which is then available to all areas in Texas (SDHPT, 1979). Most of the fund has been utilized by large urban areas. Table 4 shows the allocation of capital grants to Texas systems for the period 1976 - 1980.

Figure 3. Total Federal Funding for Public Transit Capital Grants, 1965-1983



Source: Public Works Infrastructure: Policy Considerations for the 1980's. Congressional Budget Office, Washington, D.C., 1983.

Table 4. Capital Assistance to Texas Transit[a], 1976-1980
(in thousands of dollars)

Source	Large Systems[b]	Small systems[c]	TOTAL
Federal	$208,859	$21,440	$230,300
State	38,338	3,484	41,822
Local	22,664	1,876	24,540
TOTAL	$269,861	$26,800	$296,661

Source: Plans for Public Transportation in Texas, 1978 and 1980, SDHPT

[a]Sections 3 and 5 Capital only
[b]Large systems are in cities of 200,000 population or more, and include Houston, Dallas, San Antonio, El Paso, Fort Worth, Austin, and Corpus Christi.
[c]Small systems are in cities of less than 200,000 population, and include Abilene, Amarillo, Beaumont, Brownsville, Galveston, Laredo, Lubbock, Port Arthur, San Angelo, Waco, and Wichita Falls.

Federal assistance is available to meet operating expenses that are not recovered by systems. These operating grants are provided on a 50 percent matching basis with local funds. No operating subsidy is provided at the state level in Texas.

Operating assistance data for the period 1977-1980 are presented in Table 5. The data confirms several points. First and most apparent is that aid for operations has risen sharply each year, increasing 213 percent overall. It is also clear from the table that the local share of operating assistance has become more important over time. In 1977, local operating

Table 5. Operating Assistance to Texas Systems, 1977-1980
(in thousands of dollars)

Source	1977	1978	YEAR 1979	1980	Total
Federal	$13,732	$22,085	$12,555	$24,961	$73,333
Local	15,081	27,702	53,934	65,119	161,836
TOTAL	$28,813	$49,788	$66,489	$90,080	$235,169

Source: Texas Transit Operations (Statistics and Analysis), Texas State Department of Highways and Public Transportation, 1978, 1980.

assistance accounted for 52 percent of the total assistance provided. By 1980 this percentage increased to 72. The greater local proportion can be attributed primarily to the establishment of Houston and San Antonio's regional taxing authorities.

Performance Ratios

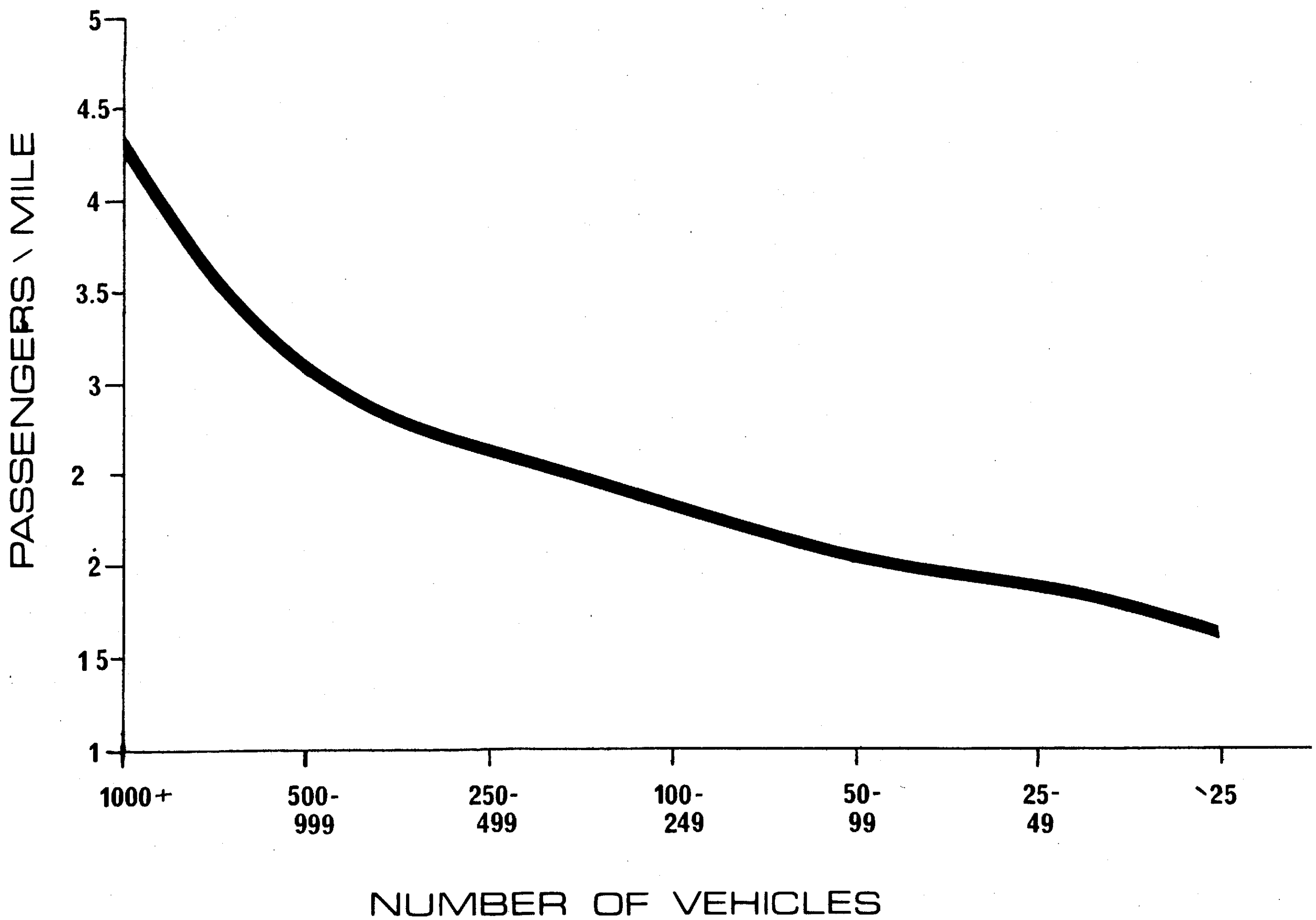
A starting point for reviewing transit's performance is data which has been published by the Urban Mass Transportation Administration (UMTA) in their Section 15 report. Thirteen of the 18 Texas transit systems had data included in the First Annual Report of the Section 15 report (1981). These data can be viewed as a subset to the industry as a whole.

The number of passengers per vehicle mile is one of the most common effectiveness indicators used in the transit industry. During the fiscal year ending June, 1979, the number of passengers per vehicle mile for Texas was 1.9. This compares with a national average of 3.4--slightly less than twice the rate. Only eight Texas systems had data in the Section 15 report for this indicator. The ratio of passengers to vehicle miles is on the average higher in larger systems. The graph on the following page aptly illustrates the direct relationship between size of the transit system and passengers per vehicle mile. One would expect this type relationship since larger systems normally serve greater numbers of people that are more densely concentrated into fewer miles. Because Texas cities served by transit are less dense and more of them are in the small range, the state average passenger per vehicle mile ratio is expected to be lower than the national average.

A more meaningful statistic is the number of passengers per revenue mile. This indicator is calculated by dividing the total annual ridership by the total annual revenue miles, which essentially means taking out miles added to the meter for deadhead going to the garage or the start of a route. A high passenger per revenue mile ratio indicates good utilization of the service. The same principle holds for this indicator as the more general passengers per mile ratio in that there is a direct relationship between system size and passengers per revenue mile. The national average for systems comparable to those found in Texas is approximately 30,000 passengers per revenue mile. Texas systems average 18,000 passengers per revenue mile per year.

A look at trends of efficiency indicators for Texas systems gives some evidence of the relationship between subsidy and performance. According to Passenger Transport (1981), "two consistent trends in transit since World War II were reversed during the 1970s: transit ridership stopped declining, and the cost of carrying a single transit passenger stopped growing and stabilized." This trend was only partially true in Texas. Ridership did increase, but the cost per passenger did not stop growing. For example, ridership for the three largest systems in Texas was at an

Figure 4. Relationship Between U.S. Transit System Size and Passengers Per Vehicle Mile (1978)



Source: U.S. Department of Transportation. "First Annual Report, Section 15, Reporting System," November 1981.

average of 85.7 million passengers in 1974 and 115.8 million in 1980, an increase over time of 35 percent. During the same time period, cost per passenger rose from $.39 to $.98, which is a 151 percent increase.

For medium sized systems the gains in ridership were not so pronounced (four percent). Consequently, these four systems had the largest increase of the three size categories in cost per passenger from 1974 to 1980. The cost per passenger increased 175 percent, from $.36 to $.99.

The smallest systems in Texas gained the most riders during the major portion of the 1970s. By increasing the number of passengers 129 percent from 1974 to 1980, their cost per passenger slowed relative to larger systems. An increase from $.45 to $.94 represents a 109 percent change.

Two other often used efficiency indicators are cost per vehicle mile and cost per vehicle hour. Data for each of these measures is provided in Table 6. These data suggest that there are no economies of scale with respect transit operations in Texas. In fact, the largest system, Houston, had a strong upward influence within the A-system category. For example, in 1980, Houston's cost per vehicle mile was $3.51, and cost per hour was $45.07. Conversely, a small system such as Amarillo cost $.92 per mile and $13.80 per hour to operate in 1980.

Table 6. Operating Cost Per Vehicle Mile and Per Vehicle Hour for Texas Transit Systems By Size and Year

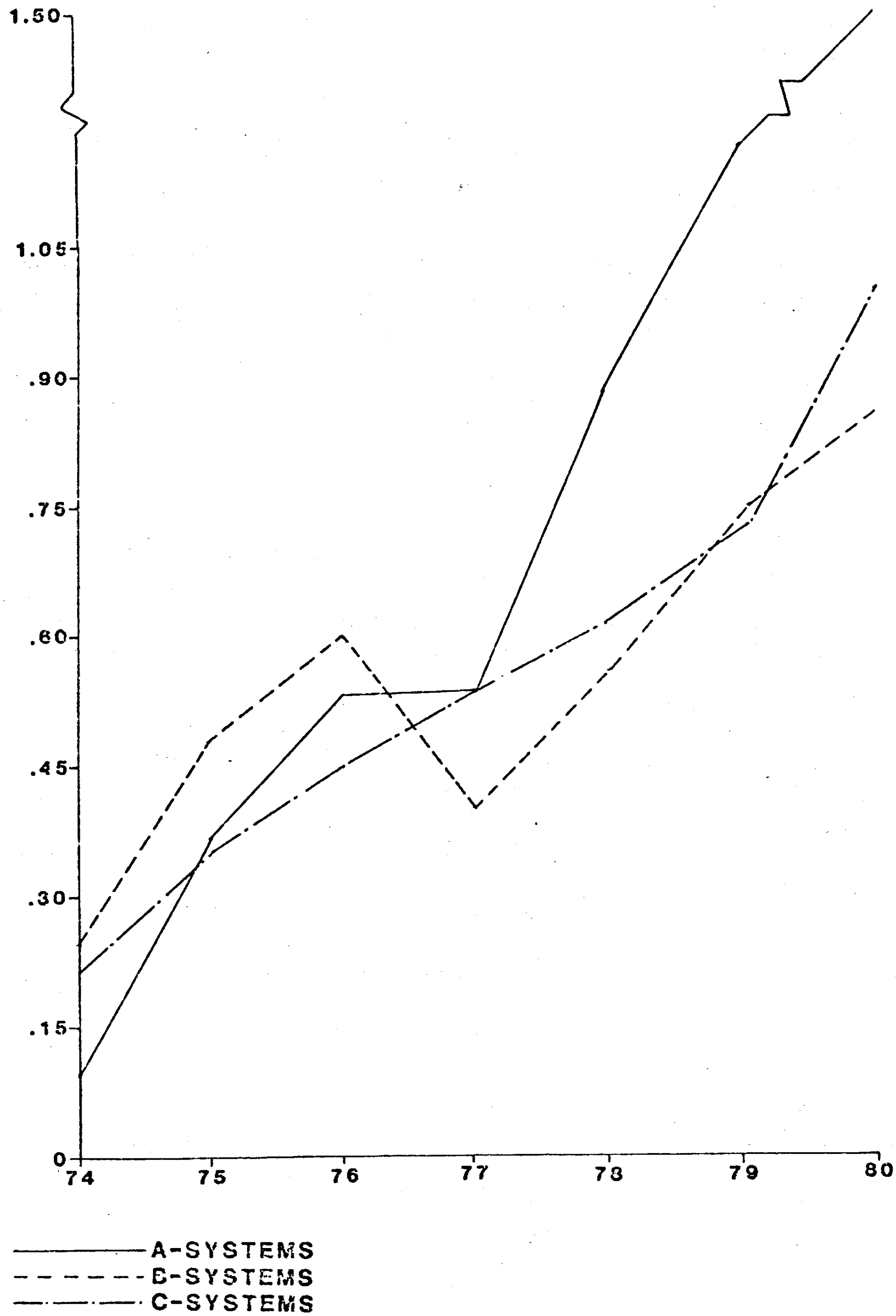
Year	Operating Cost Per Vehicle Mile			System Size	Operating Cost Per Vehicle Hour		
	A*	B*	C*		A	B	C
1975	$1.16	$ .85	$ .76		NA**	NA	NA
1976	1.33	.91	.86		NA	NA	NA
1977	1.42	1.04	.92		$20.45	$14.40	$10.86
1978	1.64	1.28	1.01		$21.88	$15.55	$12.13
1979	2.01	1.55	1.23		25.30	19.82	14.55
1980	2.44	1.77	1.56		32.54	23.28	18.88

Source: Texas Transit Operations (Statistics and Analysis), State Department of Highways and Public Transportation, 1975, 1976 1977, 1978, 1979, 1980

* A Systems (Large) include Houston, Dallas, and San Antonio
B Systems (Medium) include Austin, Corpus Christi, El Paso, and Fort Worth
C Systems (Small) include Abilene, Amarillo, Beaumont, Brownsville, Galveston, Laredo, Lubbock, San Angelo, Waco, and Wichita Falls
** Not available

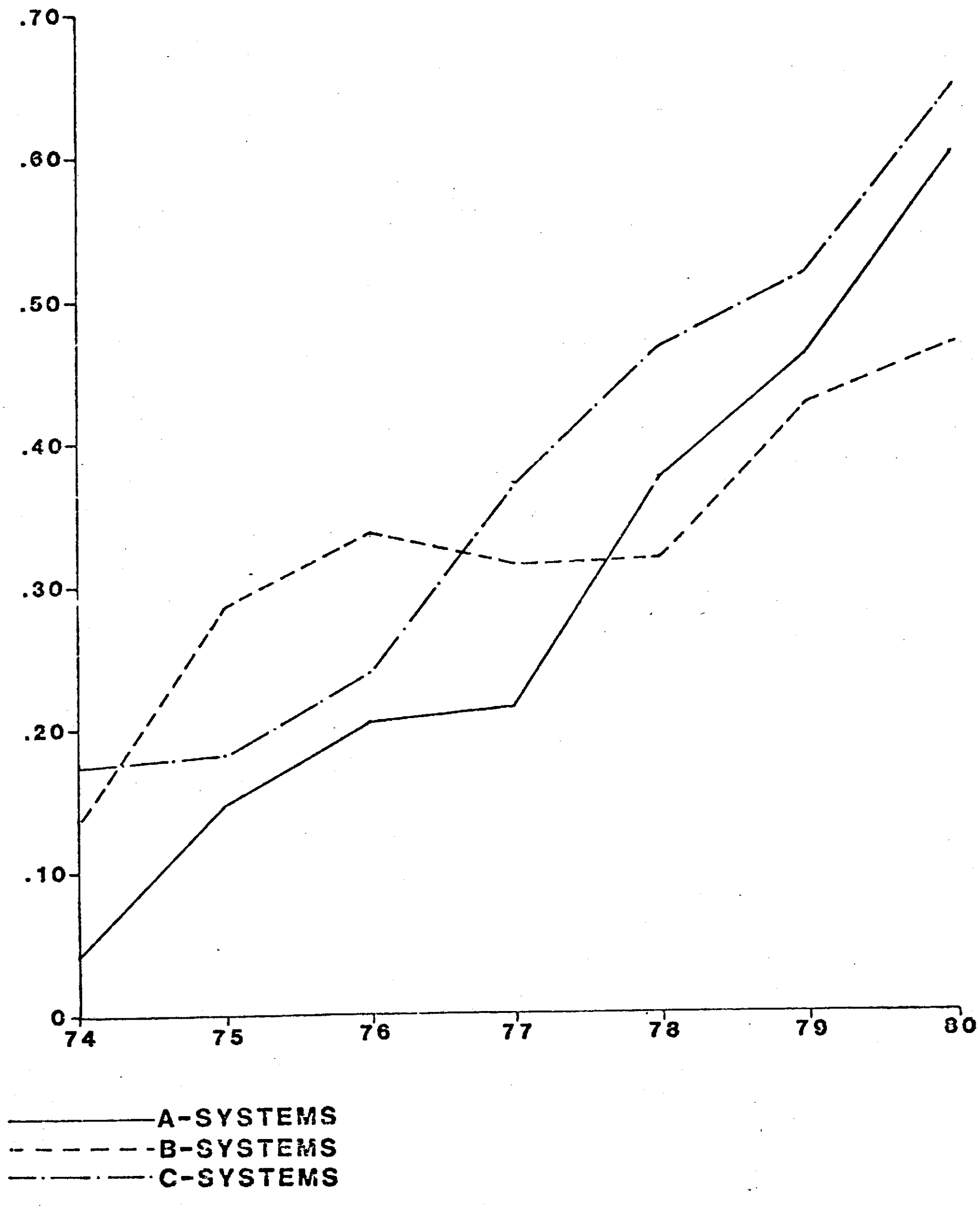
The difference between operating costs and operating revenues gives a measurement for public expense, or subsidy. Six year trends for public expenses are shown in Figures 5, 6, and 7. Figure 5 illustrates that medium and small systems' subsidy per mile increased by 240 and 376 percent, respectively, from 1974 to 1980. Although the graph does not really highlight the differential, large systems had a dramatic increase in subsidy per mile--1,400 percent.

Figure 5. Public Expense Per Vehicle Mile for Small, Medium, and Large Texas Systems, 1974-1980



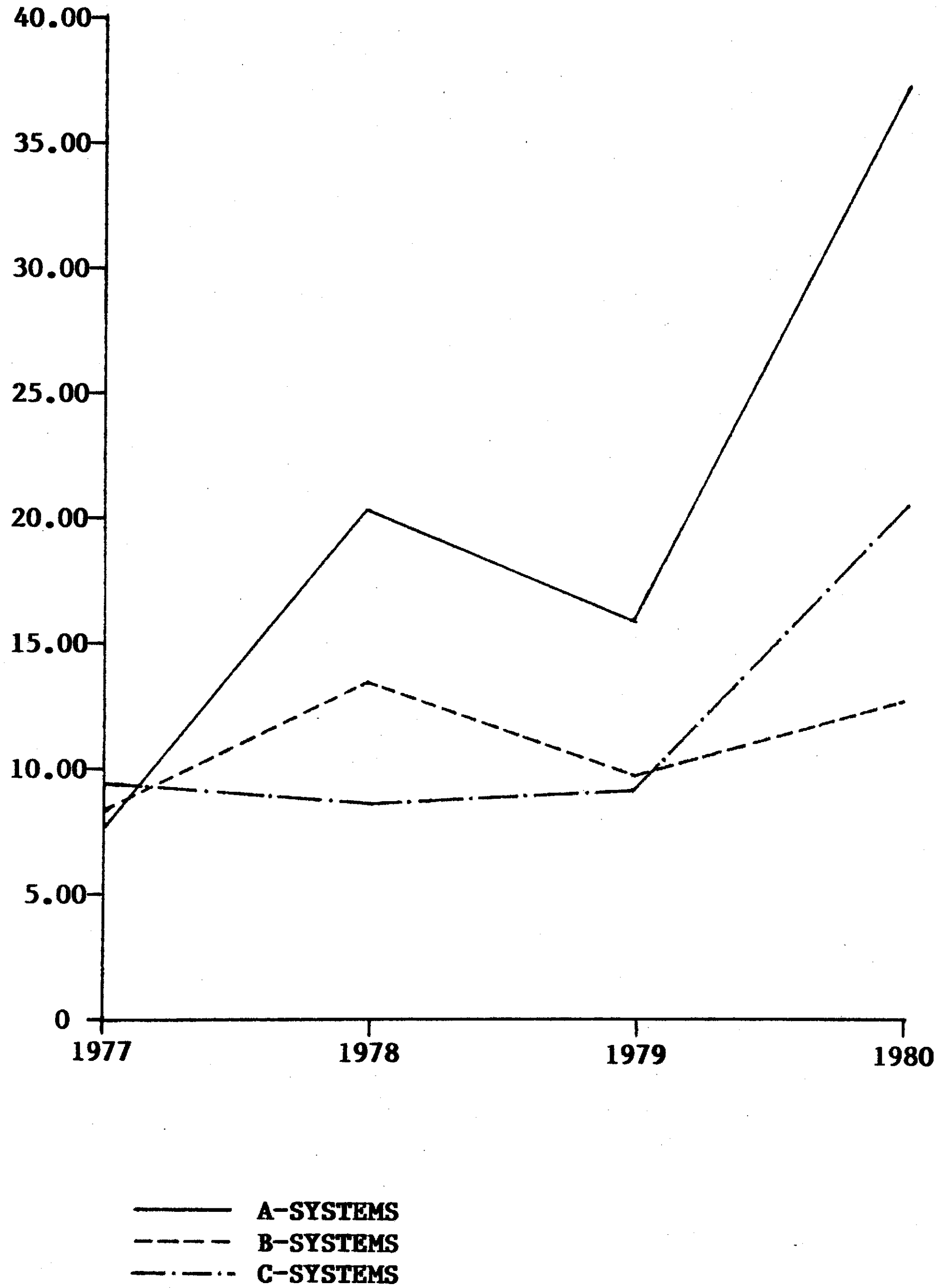
Source: Texas State Department of Highways and Public Transportation data reported in Texas Transit Operations (Statistics and Analysis, 1974-1980.

Figure 6. Public Expense Per Passenger for Small, Medium, and Large Texas Systems, 1974-1980



Source: Texas State Department of Highways and Public Transportation data reported in Texas Transit Operations (Statistics and Analysis, 1974-1980.

Figure 7. Public Expense Per Hour for Small, Medium, and Large Texas Systems, 1977-1980



Source: Texas State Department of Highways and Public Transportation data reported in Texas Transit Operations (Statistics and Analysis, 1977-1980.

A similar pattern is seen in Figure 6 for public expense per passenger. The graph illustrates 241 and 273 percent increases for medium and small systems, and a 1,363 percent subsidy per passenger increases for large systems.

Figure 7 shows very little difference in subsidy costs per hour for the three system sizes in 1977. Note, however, that in 1977 subsidy costs were inversely related to size. Through time, the ratio differences became very great and, in particular, large systems' public expense per hour increased substantially. The percentage changes over the four year period were 124, 66, and 396 for small, medium, and large systems, respectively.

<u>Summary</u>

During the period 1974 to 1980, the cost to operate transit in Texas increased by 234 percent. Approximately 47 percent of this cost escalation can be attributed to inflation. Operating revenue increased during the same period by 78.5 percent. Without inflation that increase would have been roughly 50 percent.

Bus systems gained riders during the six year period. However, the subsidy cost for each rider increased as well, because fares did not. Furthermore, transit operation increasingly became less efficient, costing more per passenger, per mile, and per hour than ever before.

What factors have contributed to this scenario? Can it be assumed that public assistance programs have caused these adverse effects? Hypotheses are tested in the following chapter that test the impact of subsidies on transit operations.

III. Statistical Analysis of Subsidy Impact

With the use of statistical techniques, impacts of subsidies can be measured. Regression analysis is a useful tool for isolating separate impacts of a variety of factors. One problem, however, that should be mentioned at the outset is the likelihood of simultaneity of relationships. In other words, there are explanatory variables that are determinants of the dependent variable and are functions of the dependent variable as well. Cause and effect are oftentimes not distinguishable. Least squares analysis can be used to study the strength of a relationship between variables having an apparent cause-effect relationship.

Review of Other Models

Analyses of some of the hypothesized impacts of subsidy can be found in previous research. In Pucher's work (1982), a number of factors were hypothesized to influence bus operating costs: 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 program. Pucher looked at a pooled sample of 77 transit systems in 1979 and 135 systems in 1980. His sample was biased toward large systems. All of the 40 largest transit systems in the United States were included in the data set.

Pucher found positive and significant coefficients for fleet size, wage rates, public management, dedicated state and local subsidies, and Federal operating subsidy. In other words, these variables were all significantly associated with costs.

A second regression study by Barnum and Gleason (1979) focused more on the employee (productivity) variables affected by subsidy. These variables included driver's wages, premium pay, driver hours per vehicle hour, nondriver's pay per vehicle hour, nondriver's pay per nondriver hour, and fringes per employee hour. They also examined one effectiveness ratio, annual rides per capita, with respect to subsidy source (Federal State, or Local), use (Capital or Operating), and control of funds (dedicated or nondedicated).

Barnum and Gleason did not find strong statistical influences of subsidy on the efficiency (productivity) variables they tested. They did find evidence that subsidies have generated real benefits for riders.

The results of these two analytical studies are limited for explaining transit events in Texas. In the first study, even though 49 percent of Pucher's sample of 212 systems were small operations (fleet sizes of less than 100), the inclusion of all 40 of the largest systems in the nation means that the diseconomies of scale, the generally higher costs of very large systems, would probably unduly influence cost related variable impacts upward.

Barnum's analysis was performed using sample data from years that were prior to those of large subsidy payments. Furthermore, their sample of 55 systems was not random, included only two Texas systems, and was not presented as representative of the industry.

Variables and Hypotheses

The purpose of the analysis is to determine the influence of subsidy on transit cost and performance. Several factors are tested for their impact on cost ratios based on evidence found in previous research and discussed in other sections of this report.

The dependent variables proposed to be influenced by subsidies are: cost per hour, cost per mile, and cost per passenger. Additionally, it is hypothesized that not only are total costs affected, but also component functions of total operational costs may be influenced differently by subsidy allocations. Therefore, operating costs, maintenance costs, and administrative costs, are each examined as dependent variables.

The independent variables considered influential for costs and cost ratios included the following:

Age of bus fleet (AGEBUS)
Size of bus fleet (FTSIZE)
City Size (SIZE)
Labor Cost (LABOR)
Type of Management (MGMT)
Type of Jurisdiction (OWNER)
Operating Subsidy per Hour (OSPHY)
Federal Capital Assistance (CAPFED)
State Capital Assistance (CAPST)
Local Capital Assistance (CAPLOC)
Total Capital Assistance per Hour
Total Subsidy per Passenger (TSPP)

"Age of bus fleet" refers simply to the average age of all the buses owned by a property in 1978 and in 1980. These ages ranged from one and three for the Beaumont fleet in 1978 and 1980, respectively, to the oldest fleets which were 10 to 12 years old in Abilene and San Angelo. The El Paso system experienced the most dramatic rejuvenation of its fleet. In 1978 the fleet age averaged 15.5 years. Retirement of old buses and new bus purchases in the interim lowered that age to three by 1980.

"Size of bus fleet" refers to the average number of total buses owned by a property for each of the four years considered. In 1980, fleet size ranged from nine in San Angelo to 590 in Houston.

The sixteen systems are classified according to "city" size using SDHPT's categories. Large cities are of greater than 500,000 population (Houston, Dallas, and San Antonio); medium cities are 200,000 to 500,000 population (Ft. Worth, El Paso, Austin, and Corpus Christi); and small cities are below 200,000 population (Lubbock, Amarillo, Beaumont, Wichita Falls, Waco, Abilene, Laredo, San Angelo, and Brownsville). In several cases where data points were too scarce due to the very limited number of larger systems, large and medium categories were combined to create one division -- greater and less than 200,000 population.

"Labor" costs include all employee costs. This consists of driver's salaries and wages, fringe benefits, and nondriver's salaries and fringes.

There are basically two types of "management" of transit -- public and private. Sometimes a system is supervised by a Board of Trustees, as is the case with three systems in Texas. However, these systems are classified as publicly managed. Public management means the transit system is operated by the city; private management is by contract with a transit management firm. In 1977 there were eight systems that were privately managed. The Houston system was changed to a regional authority in 1979 and became city operated. El Paso took over the management of its system in 1980.

"Type of jurisdiction" is a designation for the transit property as either 1) under city government, or 2) as an authority or district. This variable proved to be of little explanatory value due to the relationship between systems within taxing authority districts and system size. A Two-Way Analysis of Variance between number of employees and type of jurisdiction did reveal a positive correlation between the two variables.

Therefore, the independent variable, type of jurisdiction, was removed from consideration in the analysis.

"Operating subsidy per hour" is tested as an explanatory variable in the equations and is defined as the deficit that is recovered by public expenditure for each operating hour.

Federal, State, and Local Capital Assistance are funds that have been approved for expenditure by the systems. The variables are entered in the equations usually in terms of their dollar amounts. A ratio of "capital subsidy per hour" was also obtained by dividing the sum of Federal, State, and Local capital assistance by the total number of bus hours for a given system.

"Total subsidy per passenger" is operating and capital assistance combined and divided by total ridership.

Per hour ratios are considered more suitable for comparison analysis because factors such as speed and route configuration that are beyond the control of transit operators can be minimized. Therefore, "cost per hour" is the principal dependent variable emphasized in this analysis.

Data Collection for Analysis of Texas Systems

The data set used for this analysis includes transit systems in operation in Texas for the four years, 1977-1980. Data for Galveston is excluded due to missing information during a period of litigation involvement in Galveston. Port Arthur is not included in the analysis because it began operations in May 1979. The sixteen systems that comprised the data set are all urban systems that are publicly owned.

Most of the data are from the State Department of Highways and Public Transportation as reported by the individual transit systems (See Appendix). The cost function (operations, maintenance, and administration) data are directly from the systems.

Because of the time span selected and the statistical records of the SDHPT, there is very little missing data. Occurrences of missing data are primarily in the specific cost variables that were collected by survey directly from the system. In those cases where data were missing for a given observation, that observation was deleted from the regression equation. No attempt was made to estimate missing values.

Regression Analysis - General Model

As stated previously, a number of variables were hypothesized to influence transit operating costs. A formal model was specified as follows:

$$CPH = f(AGEBUS, FTSIZE, LABOR, CAPFED, CAPST, CAPLOC)$$

This equation states that cost per hour is a function of the age of the bus fleet, the size of the bus fleet, labor costs, and three forms of subsidy - Federal, State, and Local capital subsidies. Table 7 presents the results of the multiple regression equation for cost per hour.

This equation was for one year only of data (1978). None of the independent variables showed any significant effect on cost per hour, using .1 as the level for significance (or α = .05 for a two-tailed test).

Table 7. Multiple Regression for Transit Cost Per Hour

Dependent Variable	Independent Variable	Coefficient	t-statistic	Significance Level
	intercept	8.199	1.707	.1864
Cost Per Hour	AGEBUS	0.509	1.096	.3530
	FTSIZE	0.125	0.631	.5729
	LABOR	-0.002	-0.283	.7958
	CAPFED	0.005	0.379	.7299
	CAPST	0.543	1.028	.3794
	CAPLOC	-1.095	-1.113	.3468

The absence of significant effects was a result of the large number of variables in the model and the small number of data points. However, the R^2 for this model adjusted for the number of coefficients in the model is .1329 and the unadjusted R^2 is .7110. The difference emphasizes the fact that there is not enough data to fit this many coefficients using multiple regression. Furthermore, the variance inflation factors indicate a high degree of multicollinearity between FTSIZE and LABOR, and between CAPFED, CAPST, and CAPLOC. The effect of this multicollinearity is to increase the mean squared error. The solution to this problem is to analyze the effect of independent variables individually on the dependent variable, cost per hour (CPH). This approach removes the multicollinearity problem by not using multiple regression, and it increases the precision (decreases the standard error) of the coefficients by fitting only one coefficient for the same number of data points. In a further effort to improve the precision of the coefficients, data for all four years of this study were studied through multiple regression. The extra data did not help the analysis because the multicollinearities were too strong. The results are similar to Table 7 and are not presented.*

Simultaneous Regression - Cost Per Hour

The next step was to analyze the influencing variables on cost per hour using simultaneous regression and to analyze each variable using simple linear regression. Simultaneous regression is a method of fitting several simple regression lines at once so the slopes and intercepts may be compared.

The first series of models included management as a classification or control variable. It was predicted that a difference in operating costs would be found for privately and publicly managed systems, when observing bus age, fleet size, and three sources of capital subsidy. Previous research indicated that publicly managed systems would have significantly higher costs. The results can be summarized as follows:

1. The age of the bus fleet did not affect operating costs per hour differently for privately and publicly managed systems. There was a $.44 per year decrease with $23.71 base price, i.e.,

   CPH = $23.71 - $.44 * AGEBUS

2. Fleet size in both management systems had a positive relationship to cost per hour, $.02 per bus with $14.19 base price, i.e.,

   CPH = $14.19 + $.02 * FTSIZE

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*For an excellent discussion of the problems created by multicollinearity, see Hocking (1976).

3. Federal, State, and Local capital subsidy had a positive relationship to cost per hour for city managed systems.

The words "base price" are used in place of "Intercept" to suggest the interpretation of this parameter. State and Local capital subsidies were more influential on cost per hour when type of management was considered. With a base cost of $15.35, for every $1,000 of Federal subsidy, cost per hour increases $.30 for city managed systems.

$$CPH\ (Public) = \$15.35 + \$.30 * CAPFED/1000$$

A $2.35 increase per hour is predicted for each $1000 of State capital assistance (base cost of $15.49),

$$CPH\ (Public) = \$15.49 + \$2.35 * CAPST/1000$$

and $2.80 increases accompanied $1000 of Local capital assistance (base cost of $15.80).

$$CPH\ (Public) = \$15.80 + \$2.80 * CAPLOC/1000$$

The relationship of operating subsidy per hour was also tested with management, jurisdiction, and size as control variables. The equations relating cost per hour to operating subsidy per hour are:

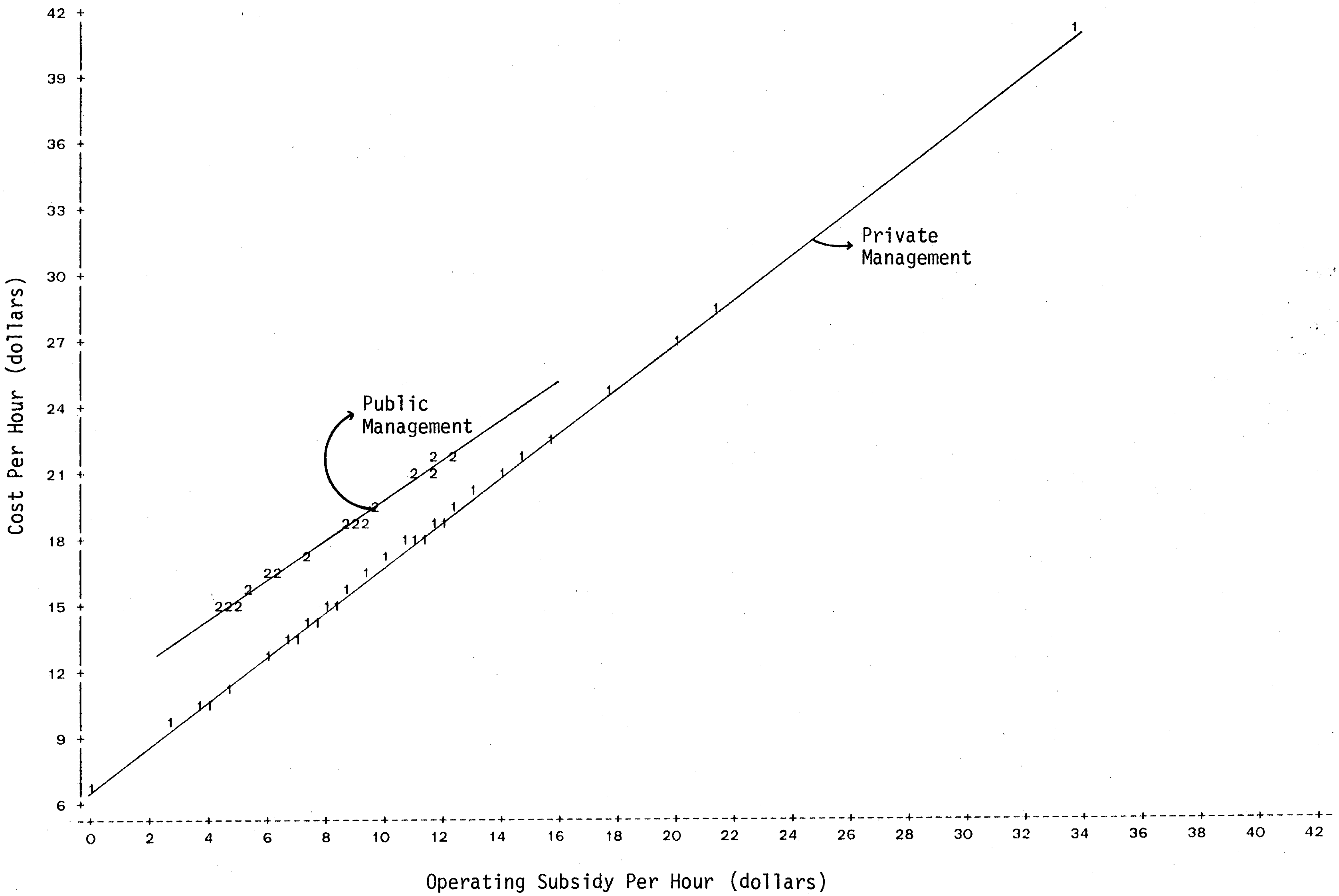
$$CPH = \$10.92 + \$.89\ OSPHY \text{ for Public}$$

and

$$CPH = \$6.60 + \$1.00\ OSPHY \text{ for Private}$$

Figure 8 shows that cost per hour as related to operating subsidy increases about the same for both privately and publicly managed systems. However, publicly managed operations have significantly higher costs. Note that the slopes in Figure 8 are almost the same, but the intercept for publicly managed operations is significantly larger. This is compatible with findings of other studies mentioned previously.

Figure 8. Operating Subsidy Influence on Cost Per Hour by Type of Management



A model was tested for operating subsidy's relationship to cost per hour with a comparison for the three system sizes. The data are plotted in Figure 9 and the equations are:

CPH (Small) = \$7.61 + \$.75 * OSPHY

CPH (Medium) = \$10.62 + \$.91 * OSPHY

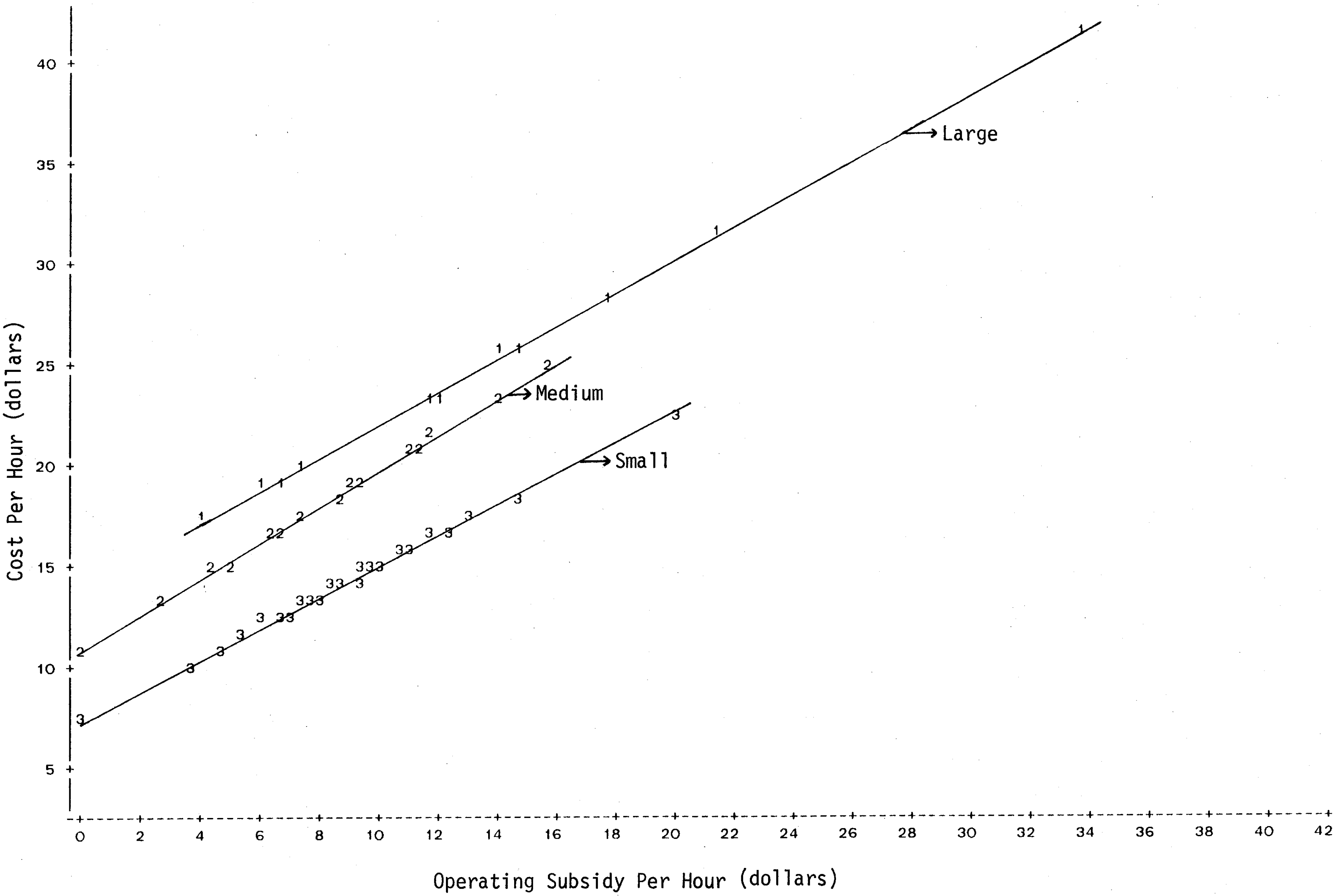
CPH (Large) = \$13.86 + \$.84 * OSPHY

The slopes of these three lines are not significantly different, although their intercept points are significantly different. The intercepts for the medium and large systems are not statistically different, but as a pair are different from the intercept for the small systems. This is basically confirmation that operating subsidy correlates similarly for systems of all sizes, but average cost per hour goes up as systems get larger. In this graph, at about $17 an hour of subsidy, the average predicted cost per hour for medium and large systems is about the same, $27. The small systems had a smaller predicted average cost per hour, $20 at about $17 an hour subsidy.

<u>Simple Linear Regression - Cost Per Hour</u>

When simple linear regression was used to analyze the separate independent variable models, the importance of size distinctions was undeniable. Fleet size and labor were two variables that were signficantly related to cost per hour in the analysis that considered no controls. Analysis of the residuals prevented any firm conclusion from these findings due to strong influences of several systems, specifically characterized as

Figure 9. Operating Subsidy Influence on Cost Per Hour
by Size of System



very large or very small systems.* The residuals for large and medium for a simple linear regression are large and positive whereas those for the small systems are large and negative. Therefore, the equations for individual independent variables were tested with size included as a comparison variable.

The results for these regressions are given in Tables 8 and 9. It was necessary to classify the systems as either large or small in order to have sufficient numbers of data points in each group (See "city" definition p. 32).

From these two tables it is evident that cost per hour as related to each independent variable is significantly greater than zero. Using .1 as the significance level, there are significant values for all variables except labor in large systems. Variables for the age and size of the fleet for small systems are not significant. Significant effects of labor and capital subsidy on small systems' cost per hour are shown.

Taking each of the equations separately and beginning with bus age, an unexpected negative relationship with cost per hour was found in the large systems. Figure 10 shows the results. For each year of bus age, the predicted value for cost per hour decreases by $1.23. The same relationship was reported by Pucher (1982). This negative effect of fleet age is most likely attributable to the acquisition of new "advance-design" buses by the large systems in the State, particularly the Houston property.

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*The residual analysis included studentized residual plots, Cook's D, and Hat diagonal lists for determination of outlier and influence behavior. (SAS Institute Inc: PROC REG) The pattern of residuals indicated that large and medium sized systems behave as a distinctly different population from small systems.

Table 8. Relationship of Cost Per Hour and Independent Variables for Large Systems

Variables	Intercept	Ho/t/=0	Significance	Slope	Ho/t/=0	Significance	N	R^2
AGEBUS	32.047	6.153	.0001	-1.2285	.634	.0766	14	.2383
FTSIZE	15.911	8.941	.0001	.0222	3.761	.0009	28	.3524
LABOR	15.488	8.944	.0001	.0003	1.473	.1749*	11	.1942
CAPFED	18.998	12.052	.0001	.0003	2.494	.0196	27	.1992
CAPST	18.764	13.359	.0001	.0018	3.341	.0026	27	.3087
CAPLOC	19.464	17.143	.0001	.0016	4.438	.0002	27	.4406

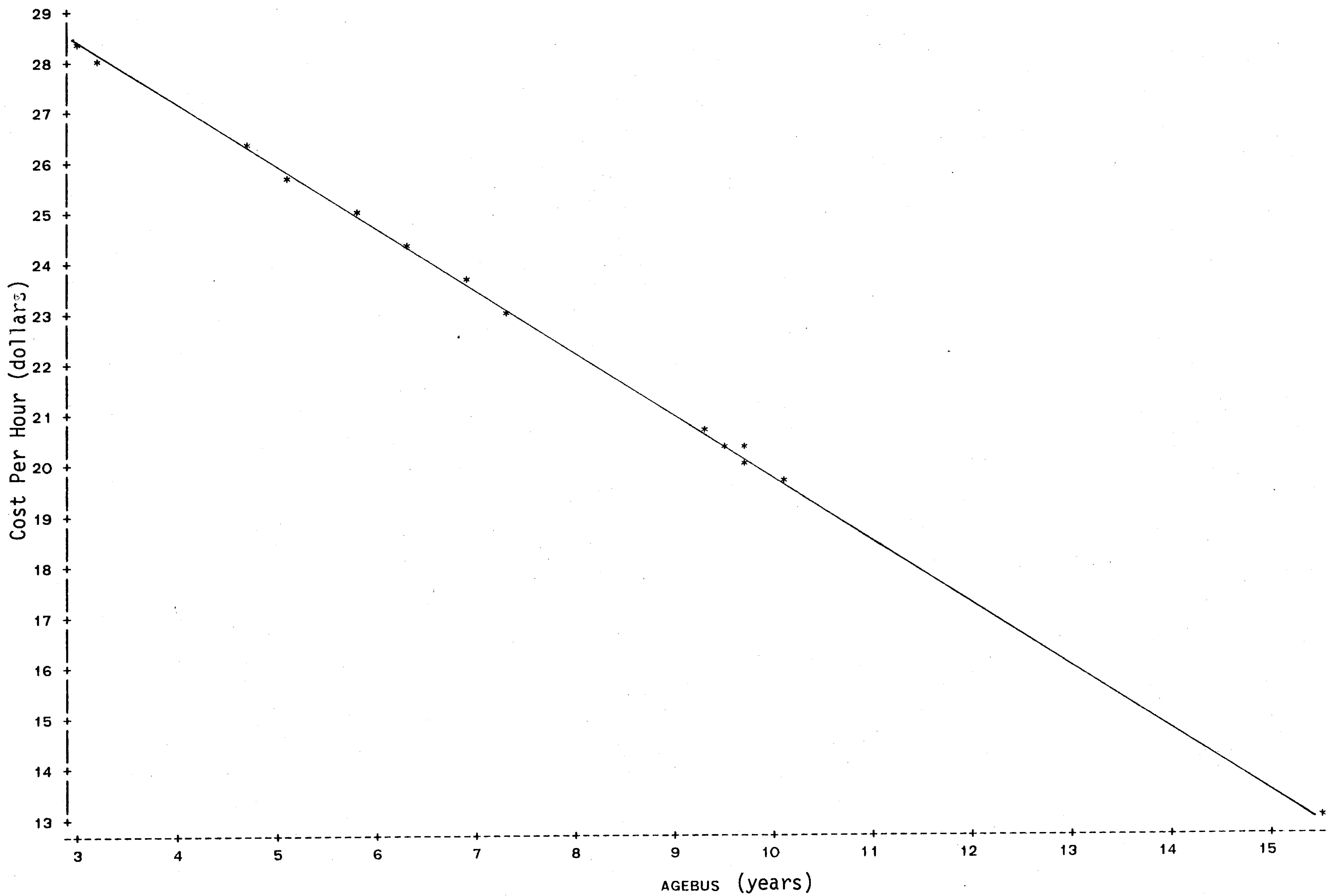
*not significant

Table 9. Relationship of Cost Per Hour and Independent Variables for Small Systems

Variables	Intercept	Ho/t/=0	Significance	Slope	Ho/t/=0	Significance	N	R^2
AGEBUS	14.079	5.653	.0001	.1254	.417	.6823*	18	.0107
FTSIZE	13.304	10.385	.0001	.0387	.708	.4835*	36	.0145
LABOR	10.225	13.660	.0001	.0053	2.602	.0209	15	.3260
CAPFED	13.635	24.921	.0001	.0009	1.732	.0926	35	.0834
CAPST	13.635	24.929	.0001	.0058	1.735	.0921	35	.0836
CAPLOC	13.635	24.900	.0001	.0107	1.725	.0939	35	.0877

*not significant

Figure 10. Relationship Between Bus Age and Cost Per Hour of Large Systems



Ironically, the "advance-design" buses had an adverse cost impact because of frequent breakdowns, high maintenance costs, and dramatically reduced energy efficiency. Hence \$1.23 over estimates the decrease in cost per hour. The regression equation with Houston is:

$$\underset{}{CPH} = \underset{(6.153)}{32.047} - \underset{(.634)}{1.2285}\ AGEBUS$$

but without Houston is:

$$\underset{}{CPH} = \underset{(5.602)}{24.252} - \underset{(-.941)}{.46988}\ AGEBUS$$

The slope is significant at a = .0766 with Houston but is significant at only a = .3690 without Houston. Thus without Houston, the decrease in cost per hour is a statistically nonsignificant \$.47 per year bus age of the fleet. This relationship was not found among small systems, where such acquisitions did not occur.

Cost per hour was highly correlated with the size of the fleet in large systems but not in small systems. Again, the Houston system was very influential in moving the relationship line upward (See Figure 11). On the graph for small systems (Figure 12), the line represents a very small (and insignificant) increase in cost associated with increases in fleet size.

The analysis to determine the effects of labor costs on total cost per hour was hampered by several missing data points. The presence of high labor costs in the State's large cities in the same equation with lower labor costs of medium systems resulted in a high degree of variation. This produced an insignificant association with the dependent variable. The plots are shown in Figure 13.

Figure 11. Relationship Between Fleet Size and Cost Per Hour for Large Systems

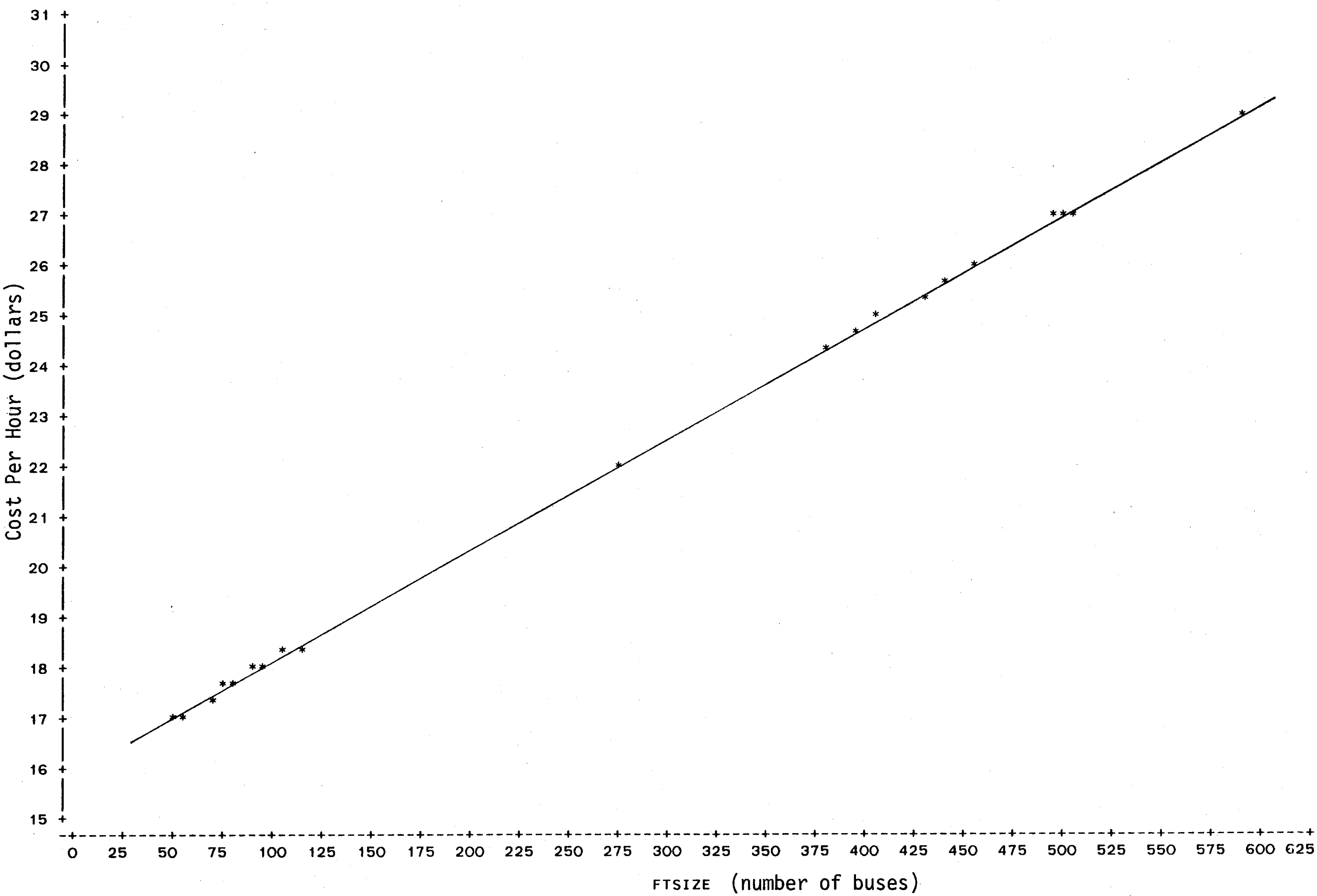


Figure 12. Relationship Between Fleet Size and Cost Per Hour for Small Systems

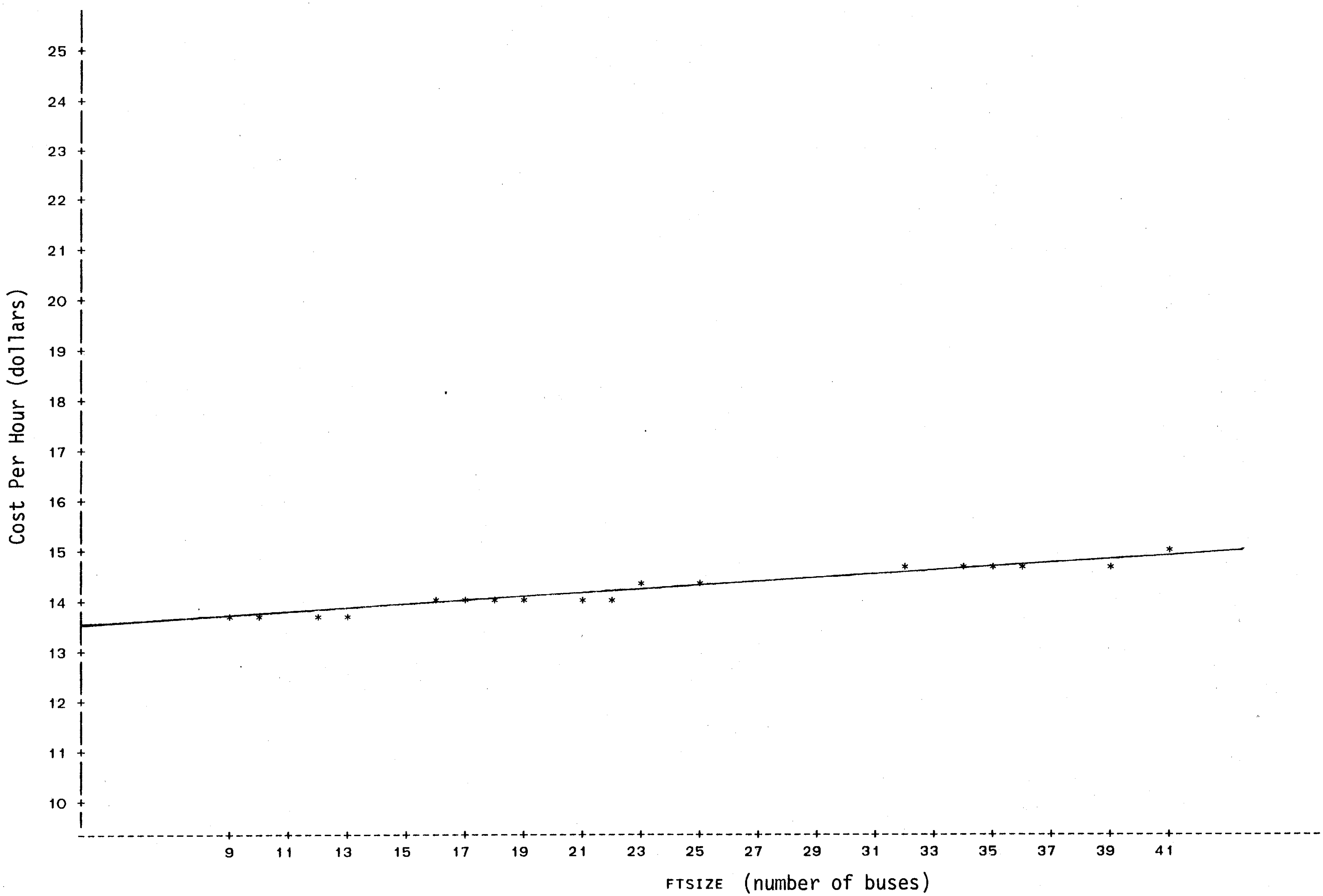
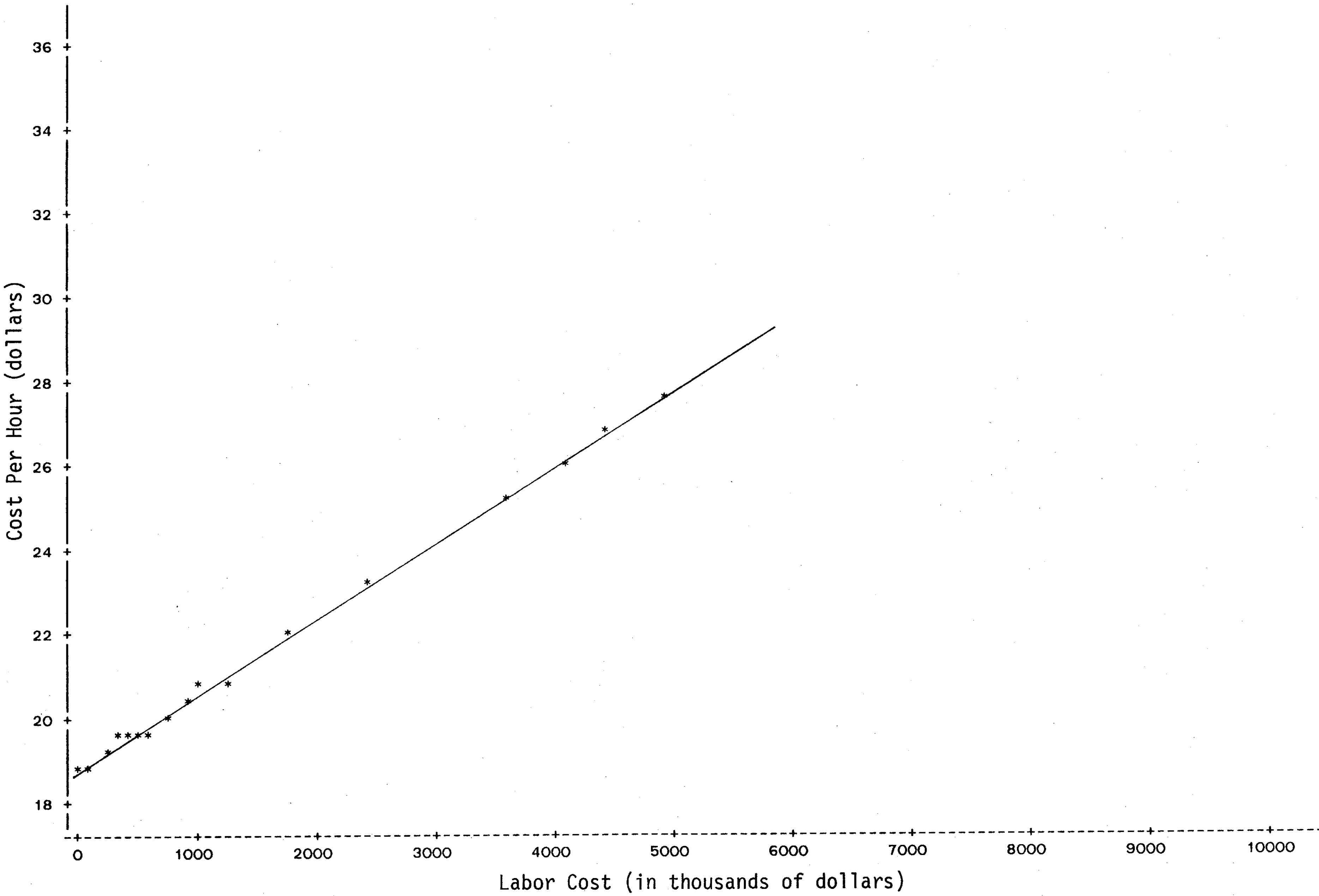


Figure 13. Relationship Between Labor Costs and Cost Per Hour for Large Systems



Labor cost was an influential variable for small systems. In fact, for each additional dollar spent on labor, cost per hour rose $0.53. The graph in Figure 14 illustrates this relationship.

All three sources of capital assistance were found to be significantly associated with higher cost per hour in both large and small systems. The relationship was stronger for larger systems. As indicated by the data in Table 8, $1000 of Federal capital assistance (CAPFED) was associated with $.30 higher costs per hour for large transit operations. State and Local capital grants were related to $1.80 and $1.60 increases in costs per hour. For small systems the cost relationships of Federal, State, and Local aid increased differently at each level of government. At the Federal level, $1000 of capital assistance resulted in a predicted average cost per hour that was $.90 higher. The same amount of State subsidy was associated with $.58 higher costs; and Local capital subsidy was associated with $1.10 higher costs per hour for small systems.

Subsidy Effects on Cost Functions

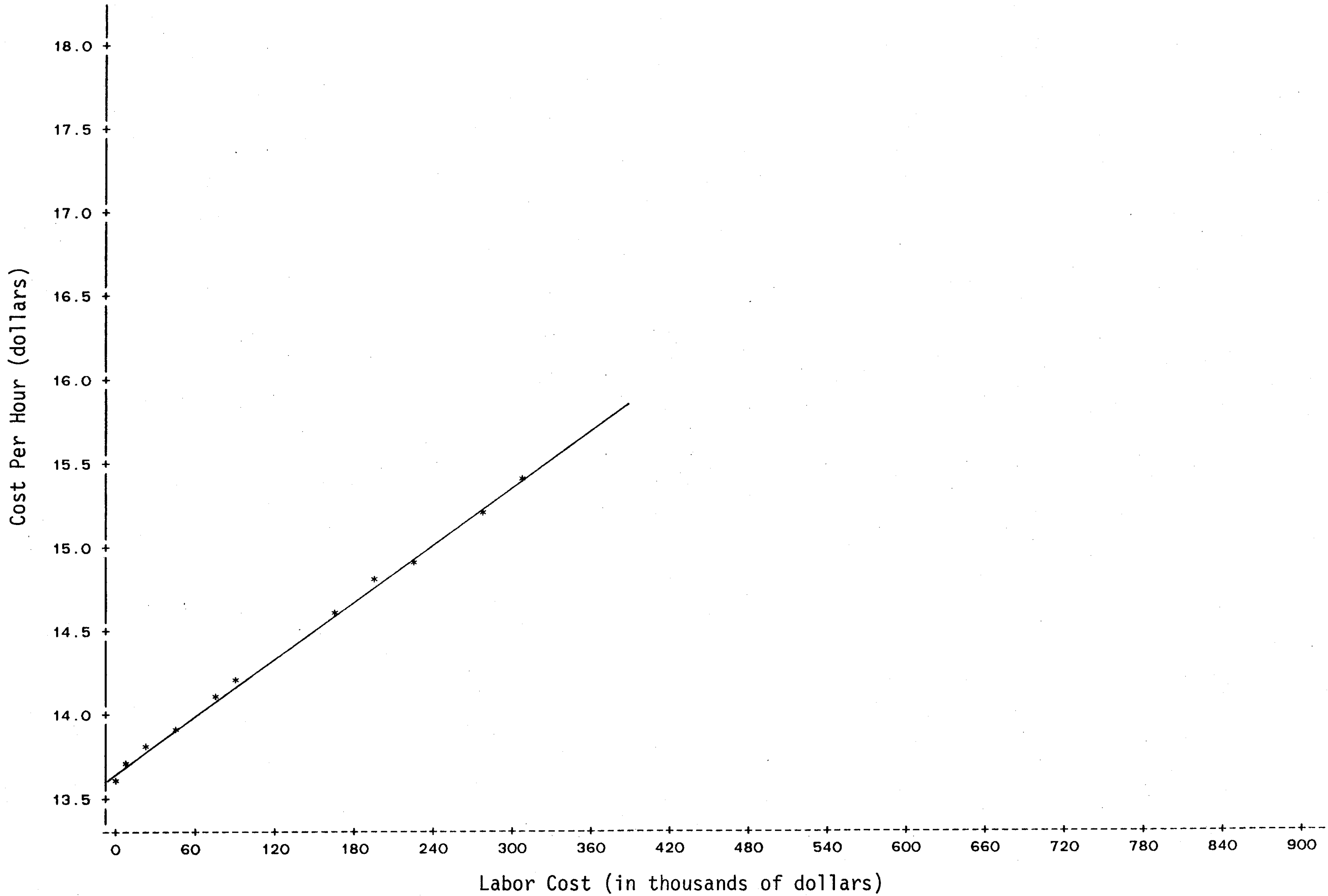
Equations were developed to determine the relationship of different types and sources of government expenditures on specific cost functions of transit operations. The following models were tested:

Cost Function (i.e., Operations or Maintenance or Administration)=
f(Total Subsidy Per Passenger)

Cost Function = f(Federal, State, Local Capital Subsidy Per Hour)

Cost Function = f(Operating Subsidy Per Hour)

Figure 14. Relationship Between Labor Costs and Cost Per Hour for Small Systems



The most sensitive cost function variable to subsidy was administrative costs. These costs were the only type that were significantly related to subsidy per passenger. The effect was downward. For every nickel of subsidy per passenger, yearly administrative costs were trimmed $20 in 1977 and 1978.

There was little or no difference in the simultaneous effect of Local, State, and Federal capital subsidy per hour on administration, maintenance, or operations (excluding depreciation) costs. Individual effects of the capital subsidy types were found only for administration, and these effects disappeared after controlling for size. Likewise, no simultaneous effects of total capital subsidy was discovered when controlling for size.

The effect of operating subsidy per hour on each cost function was tested for large and small systems. A fit was not possible, principally because of the extreme variability within each cost category for both system sizes.

Regression for Other Performance Ratios

As mentioned previously, cost per hour is the primary dependent variable of interest. However, cost per passenger and cost per mile were also examined. Cost per passenger was studied using the same hypothetical considerations as cost per hour. Specifically, it was proposed that cost per passenger is related to bus fleet age, bus fleet size, labor costs, and Federal, State, and Local capital subsidies. Tables 10 and 11 present the results of the simple regression equations for cost per passenger.

Tables 10 and 11 indicate that cost per passenger as it relates to the six independent variables is significantly greater than zero. However, if plotted, all the lines would be basically flat, because of the small

Table 10. Relationship of Cost Per Passenger and Independent Variables for Large Systems

Variables	Intercept	Ho/t/=0	Signif-icance	Slope	Ho/t/=0	Signifi-cance	N	R^2
AGEBUS	1.1100	5.843	.0001	-.03402	-1.471	.1671	14	.1527
FTSIZE	.7805	9.000	.0001	.00001	.045	.9644	28	.0001
LABOR	.7055	7.585	.0001	-.00001	-.857	.4163	11	.0755
CAPFED	.7650	11.240	.0001	.00000	.610	.5472	27	.0147
CAPST	.7497	11.690	.0001	.00003	1.133	.2678	27	.0489
CAPLOC	.7490	13.630	.0001	.00003	1.977	.0592	27	.1006

Table 11. Relationship of Cost Per Passenger and Independent Variables for Small Systems

Variables	Intercept	Ho/t/=0	Signif-icance	Slope	Ho/t/=0	Signifi-cance	N	R^2
AGEBUS	.6770	3.221	.0053	.0186	.732	.4745	18	.0324
FTSIZE	.8985	7.541	.0001	-.0057	-1.115	.2725	36	.0353
LABOR	.7494	6.022	.0001	-.0002	-.657	.5280	16	.0299
CAPFED	.7793	14.457	.0001	-.0000	-.595	.5557	35	.0106
CAPST	.7793	14.459	.0001	-.0002	-.595	.5561	35	.0106
CAPLOC	.7794	14.452	.0001	-.0004	-.598	.5541	35	.0107

slopes. The one exception is Local capital subsidy (CAPLOC) for large systems, which is associated with a $.03 increase in cost per passenger for each $1000 Local capital funds allocated.

Using simple linear regression, it was determined that cost per passenger increases as operating subsidy increases. A comparison of the three system sizes for this correlation revealed that the magnitude of the increases, and the base cost averages among the three system sizes are not significantly different (See Figure 15). The slopes and intercepts for the three regressions are not statistically significantly different at = .1. In other words, costs per passenger begin and increase in essentially the same pattern as operating subsidies increase. The cost per passenger has a base rate of $.33 and increases by $.04 for every dollar of operating subsidy per hour contributed. This was not the case for the effects of operating subsidy on cost per mile.

Figure 16 does indicate a higher operating cost per mile related to higher operating subsidy per hour. Another way of looking at this relationship is that a small system with the same costs per mile as a large system will require more operating subsidy per hour than the large system.

Statistical Analysis Summary

A sizeable number of regression equations were used to investigate factors that effect cost and performance. It was necessary to analyze these factors individually due to the small number of transit systems in the study (16), and the large number of proposed influencing variables.

It was found, not surprisingly, that most variables were related to higher operating costs. The only negative associations were for age of the bus fleet as related to cost per hour, and administrative costs as related

Figure 15. Operating Subsidy Influence on Cost Per Passenger by Size of System

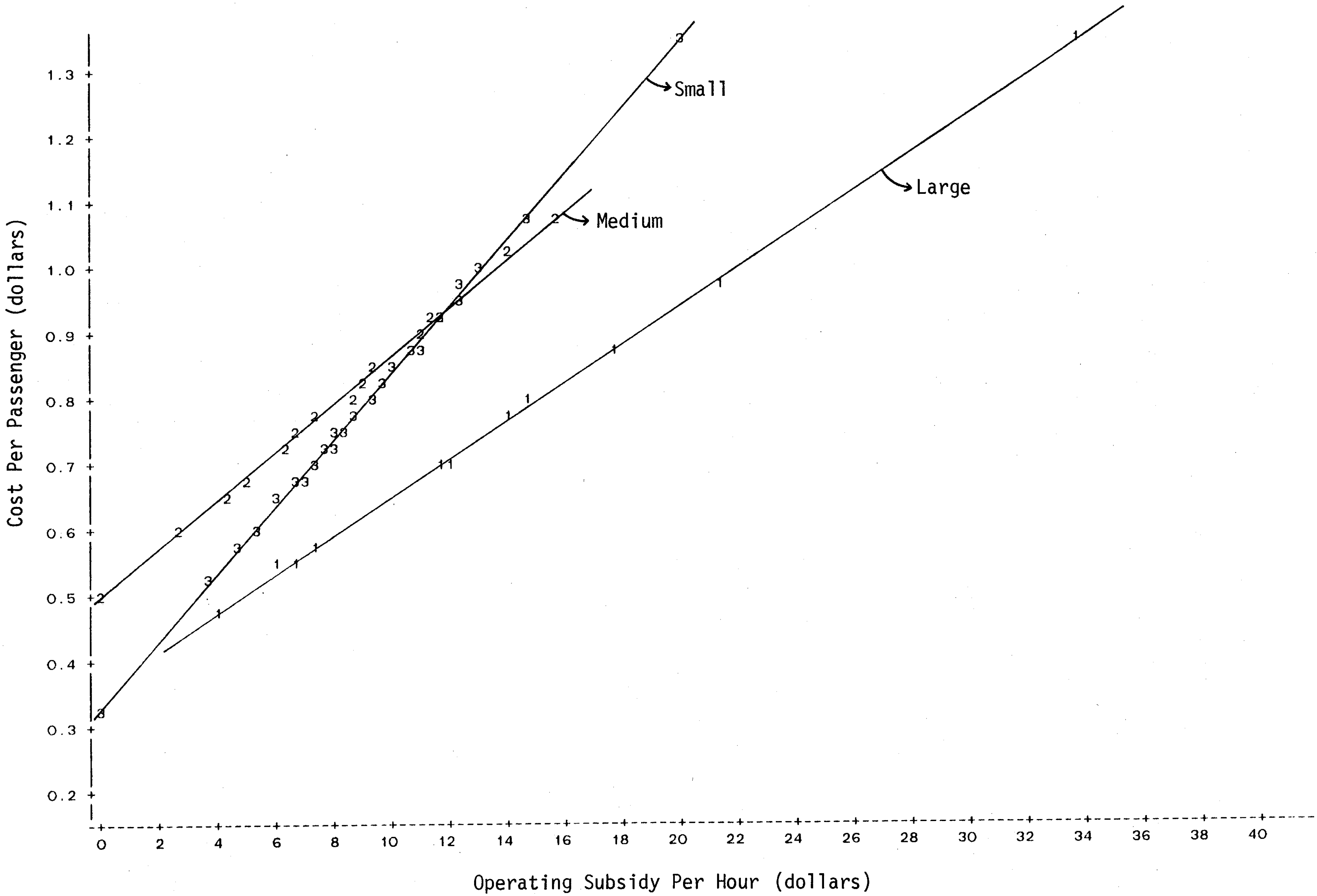
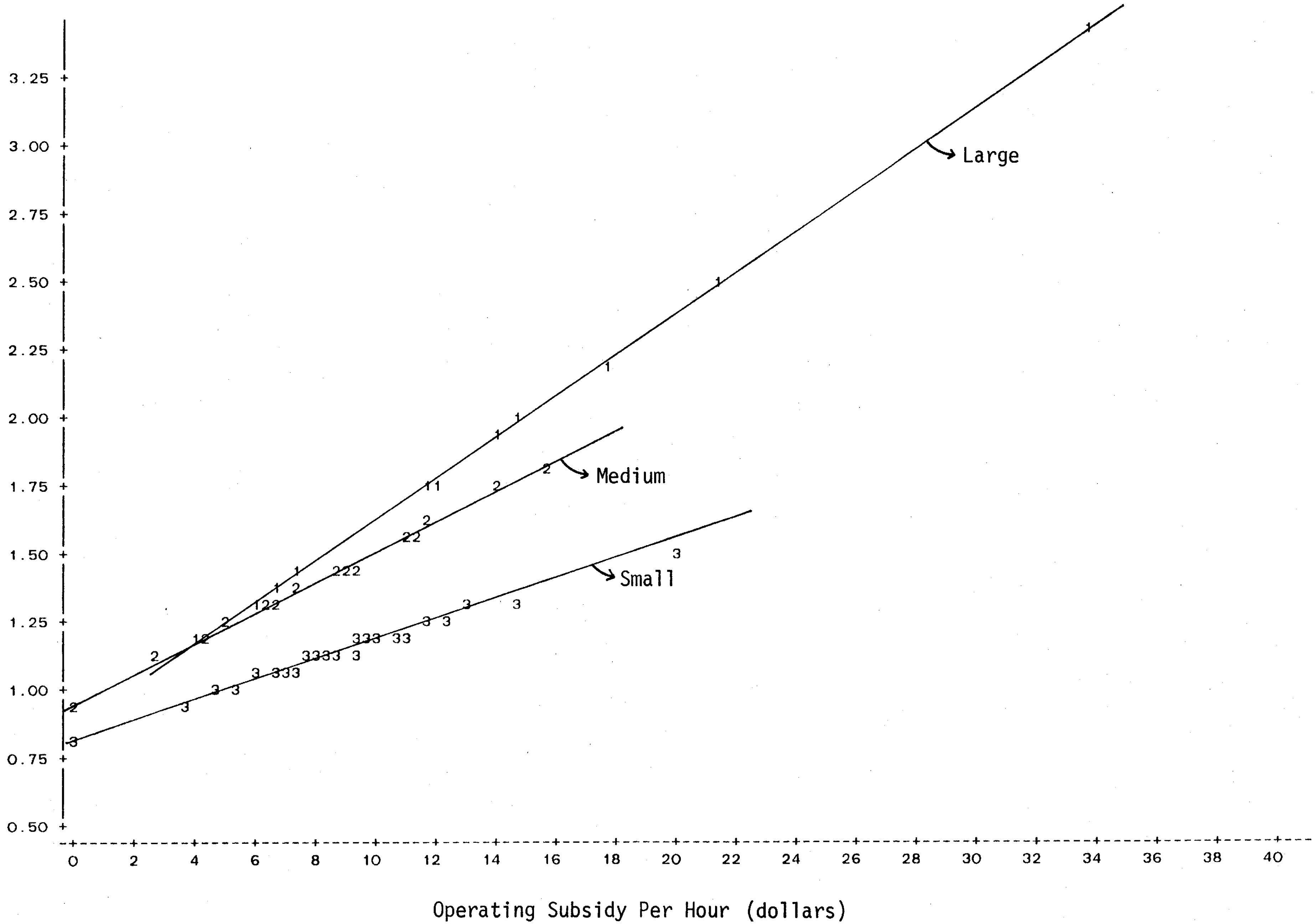


Figure 16. Operating Subsidy Influence on Cost Per Mile by Size of System



to subsidy. Probably the "advance-design" buses acquired by large systems during the study period had an adverse effect on cost performance ratios due to the initial mechanical problems that had to be solved. Although the reasons were not determined for the negative influence of subsidies on administrative costs, a model that tests for this relationship and also compares management type may prove revealing, with a larger data set.

Non-subsidy factors that were related to higher costs included city size, fleet size, management, and labor. City size was a key variable for analysis of this data set. Due to large differences in the data of large and small systems and the small total N analyzed, equations that did not control for size were not meaningful. Basically, small systems cost less (per unit) than larger systems; however, they require more operating subsidy than large systems on a per hour basis. Relatedly, larger fleets are also correlated with higher costs.

Furthermore, publicly managed systems have higher costs per hour than privately managed systems in Texas. These city managed systems' costs are influenced by Federal, State, and Local capital subsidy. Grants of $1000 were related to cost per hour increases of $.30, $2.35, and $2.80, respectively.

As expected, subsidy variables were positively related to costs. Analysis of capital subsidy influences by level of government revealed that State assistance had a slightly greater influence on costs for large systems than did Federal or Local aid. Local capital assistance was more influential than were other Capital subsidies on small systems' costs.

Operating subsidy was positively associated with higher costs per mile, higher costs per passenger, and higher costs per hour. The strength of this association was fairly consistent for each size system and for both types of management.

IV. Summary and Conclusions

The purpose of this study was to examine relationships among costs, revenues, financial assistance, and performance for the Texas transit industry. An evaluation of historical trends revealed that:

1. From 1974 to 1980, the cost (in current dollars) to operate transit in Texas increased by 234 percent.
2. From 1974 to 1980, operating revenue (in current dollars) increased 78.5 percent.
3. Ridership increased 30 percent from 1974 to 1980.
4. From 1975 to 1980, the State spent $41.8 million on transit capital.
5. In the four year period from 1977 through 1980, transit operations in Texas received over $235 million in operating assistance.

Regression analysis revealed that higher operating costs are significantly related to several factors: city size, size of the bus fleet, public management, subsidy, and high labor costs (in small systems).

Operating subsidy has the general effect of higher costs for all the dependent variables tested. Regression equations produced linear slopes that were not significantly different for control variables, system size and management type.

A general model was specified that included the three sources of capital assistance available to Texas transit systems. The model stated that cost per hour is a function of bus fleet age, fleet size, labor costs, and Federal, State, and Local capital assistance. This model did not reveal any significant relationships, but simple linear regression analysis on the individual variables was performed. This simple linear regression, controlling for city size, produced more significant results.

All three sources of capital assistance were associated with higher cost per hour for large and small systems. Capital assistance at the Federal level was associated with $.30 higher costs per hour for large transit operations. State and Local capital subsidies were related to $1.80 and $1.60 increases in costs per hour. Federal capital subsidy to small systems were related to $.90 higher costs per hour. State capital subsidy to small systems were related to $.58 higher costs per hour. And costs per hour rose $1.07 in small systems for every $1000 of Local capital assistance.

The relationship of the two types and three sources of subsidy to operational, maintenance, and administrative costs was investigated. Data limitations prevented any firm conclusions, although a negative effect of subsidy on administrative costs was indicated.

Caution was used throughout the analysis to avoid causal inferences. The results of the regression analysis did not necessarily prove that independent variables caused changes in the dependent variables. Therefore, specific policy changes based on the direct relationships between efficiency and subsidy reported herein may or may not produce the desired effect.

It should be pointed out that several widely held beliefs concerning the effects of subsidy in the transit industry were not substantiated for the operations in Texas. One such assumption is that the higher the costs, the larger the subsidies received; therefore, the current subsidy program rewards those systems that have the highest costs. This is not clearly the case in Texas. From the evidence presented in Figures 9 and 16, small systems with lower costs were given more subsidies relative to larger systems.

Furthermore, it is commonly concluded that current Federal and State transit programs have promoted inefficiencies by creating a bias toward expensive capital investment. The acquisition of new buses that had a negative effect on efficiency ratios may be considered an example of this conclusion. However, effects created by the inefficient buses should be studied over a longer period of time to fully account for this anomaly.

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APPENDIX

Data for Texas Transit Systems

System	Operating Cost Per Hour 1977	1978	1979	1980	Operating Cost Per Mile 1977	1978	1979	1980	Operating Cost Per Passenger 1977	1978	1979	1980
1. Abilene	$10.67	$11.65	$14.00	$22.48	$ .65	$ .76	$ .84	$1.31	$ .71	$ .83	$1.03	$1.29
2. Amarillo	13.53	12.57	13.99	13.80	.78	.89	.96	.92	1.04	1.21	1.21	1.05
3. Austin	16.83	15.80	19.00	21.95	1.09	1.28	1.58	1.79	.51	.61	.78	.91
4. Beaumont	12.05	12.33	14.01	17.33	1.08	1.18	1.33	1.65	.49	.53	.57	.68
5. Brownsville	8.93	9.60	14.97	19.64	.52	.85	1.65	2.07	.44	.52	.80	.87
6. Corpus Christi	18.27	20.38	24.60	27.85	1.15	1.50	1.80	2.01	.87	1.06	1.33	1.47
7. Dallas	19.83	18.97	23.45	29.46	1.34	1.40	1.71	2.13	.54	.59	.68	.86
8. El Paso	6.25	9.23	15.85	19.81	.72	1.02	1.23	1.41	.31	.47	.61	.65
9. Ft. Worth	16.24	16.78	19.83	23.51	1.21	1.34	1.58	1.89	.73	.79	.84	.94
10. Houston	21.71	28.02	30.55	45.07	1.59	2.15	2.76	3.51	.65	.84	1.01	1.38
11. Laredo	13.24	12.92	13.20	14.86	1.47	1.41	1.51	1.66	.40	.37	.34	.39
12. Lubbock	11.29	13.02	16.08	19.55	.78	1.01	1.23	1.41	.33	.43	.51	.53
13. San Angelo	9.96	10.33	13.28	18.02	.73	.75	.96	1.35	.70	.72	.84	1.05
14. San Antonio	19.82	18.65	21.89	23.09	1.32	1.38	1.57	1.67	.46	.67	.68	.70
15. Waco	16.01	14.22	18.04	18.65	1.20	1.15	1.44	1.52	.84	.98	1.15	1.14
16. Wichita Falls	10.77	12.94	13.79	17.03	.78	.93	1.00	1.22	.77	1.05	1.01	1.16

APPENDIX

Data for Texas Transit Systems

System	Base Fare 1977	Base Fare 1978	Base Fare 1979	Base Fare 1980	Fleet Size 1977	Fleet Size 1978	Fleet Size 1979	Fleet Size 1980	Avg. Age of Bus Fleet, 1978	Avg. Age of Bus Fleet, 1980
1. Abilene	$.25	$.25	$.25	$.25	12	12	12	12	10.00 yrs.	12.00 yrs.
2. Amarillo	.30	.40	.40	.40	36	35	34	32	6.07	4.63
3. Austin	.35	.35	.35	.40	68	75	80	81	4.72	5.11
4. Beaumont	.30	.30	.30	.30	25	25	25	25	1.00	3.00
5. Brownsville	.25	-	-	.35	13	17	18	22	8.65	5.25
6. Corpus Christi	.25	.25	.25	.35	49	50	50	54	9.66	6.85
7. Dallas	.40	.40	.40	.60	406	439	457	504	9.25	10.08
8. El Paso	.35	.35	.35	.35	89	89	89	95	15.48	3.02
9. Ft. Worth	.40	.40	.40	.60	106	106	106	113	6.29	7.28
10. Houston	.40	.40	.40	.40	429	500	495	590	5.77	3.20
11. Laredo	.35	.35	.35	.35	18	19	19	23	10.68	9.03
12. Lubbock	.45	.50	.50	.50	39	39	41	41	7.18	7.18
13. San Angelo	.30	.30	.30	.30	10	10	9	9	10.00	12.00
14. San Antonio	.25	.25	.25	.40	277	382	397	441	9.47	9.72
15. Waco	.40	.40	.40	.50	16	16	18	21	7.91	7.14
16. Wichita Falls	.35	-	-	-	16	17	17	17	8.00	10.00

APPENDIX

Data for Texas Transit Systems

System	Operating Subsidy Per Hour				Total Subsidy Per Passenger			
	1977	1978	1979	1980	1977	1978	1979	1980
1. Abilene	$ 7.75	$ 9.33	$12.18	$19.95	$ .52	$ .67	$ .90	$1.15
2. Amarillo	8.32	8.38	9.38	8.55	1.02	1.05	.88	.73
3. Austin	10.85	11.38	14.09	15.50	.33	.79	.58	.64
4. Beaumont	6.87	7.41	8.56	11.73	.91	.32	.35	.70
5. Brownsville	-	3.72	7.26	10.87	-	.52	.40	1.54
6. Corpus Christi	8.52	9.15	11.09	11.73	.47	.51	.62	1.13
7. Dallas	6.68	6.01	7.42	11.77	.19	.34	.25	.68
8. El Paso	.10	2.70	6.59	9.41	.26	.99	.25	.31
9. Ft. Worth	4.47	4.89	6.35	7.46	.29	.24	.30	.30
10. Houston	11.86	17.77	21.37	33.69	.35	.88	.74	1.95
11. Laredo	6.04	5.40	5.44	4.67	.18	.22	.16	.58
12. Lubbock	7.34	7.93	10.75	13.02	.45	.26	.34	1.32
13. San Angelo	6.69	7.60	10.09	14.76	.47	.53	.64	.86
14. San Antonio	4.11	11.56	14.79	14.12	.10	.77	.56	.80
15. Waco	9.77	9.19	12.42	11.82	.51	.68	.86	1.31
16. Wichita Falls	4.81	7.54	8.04	10.86	.35	.61	.59	.74