Dedicated Funding and Urban Transit Performance: Some Empirical Evidence

A MURP Professional Paper

In Partial Fulfillment of the Master of Urban and Regional Planning Degree Requirements
The Hubert H. Humphrey Institute of Public Affairs
The University of Minnesota

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February 22, 2006

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INTRODUCTION

In early 2005, the Metropolitan Council of the Twin Cities, the regional metropolitan planning organization (MPO) and operator of regional transit service for the Minneapolis-St. Paul metropolitan region, announced that it would be facing a $60 million operating shortfall over the upcoming legislative biennium. By the middle of February, when the State of Minnesota releases the first of its two annual budget forecasts, the figure had grown to $66 million. Of course, this event was not unique. Public transit agencies across the country were grappling with budgetary problems, owing largely to rising costs of fuel and employee health benefits. In the Twin Cities, these conditions were exacerbated by lower-than-expected receipts from the state motor vehicle sales tax (MVST), a major source of funding for regional transit operations.

During a special legislative session in July 2005, the state legislature resolved the shortfall by agreeing to appropriate an additional $40 million in general revenues to avert a potential crisis. The new revenue, along with a package of modest fare increases and service reductions, resolved the agency's immediate operational issues. This particular event, while significant due to the unusually large amount of the deficit, was nothing new for urban transit. In the Twin Cities, fiscal crises for the transit system have become commonplace in recent years, evidenced by repeated rounds of service reductions and fare increases between 2002 and 2005, as managers struggle to contain ever-increasing costs while minimizing impacts to riders. This same situation has played out in many other U.S. cities, leading bureaucrats and public officials to seek long-term solutions to the string of short-term problems transit agencies face.

In Minnesota, as elsewhere, public transit systems have inextricably linked their fortunes to those of highway interests, thus making for a more effective lobbying coalition in search of additional funding. While a number of new transportation funding proposals were advanced at the state level during the 2005 legislative session, among the more common elements was a proposed half-cent sales tax to be levied within the core seven counties of the Twin Cities region to support the transit system. Much of the funding would be directed toward major transit capital projects, though a substantial amount would also likely be dedicated for increased service levels. The proposal was not acted on during the 2005 session, but will likely return in future years as transportation issues remain high on the legislative agenda. Before any actions are taken though, a number of important questions about the effects of a major, new dedicated funding source for transit need to be answered regarding its potential effects on the efficiency and performance of transit operations.

This paper seeks to address some of these questions by investigating the links between dedicated funding sources (of which sales taxes tend to be the most common) and transit performance. Using a panel data sample of 23 U.S. public transit agencies observed over an eight-year period (1996-2003), this study will develop a model to relate the effects of dedicated funding sources to various operational outcomes. Application of the model will allow for estimates of the effects of dedicated funding on operating efficiency (as measured in terms of cost per revenue hour and operator wage rates) and service levels. Also, the model will allow estimation of a time-series equation describing the longer-term determinants of transit demand.

The following sections will review previous studies of the effects of transit subsidies on operational performance to develop some hypotheses about the effects of dedicated funding. Then, a description of the model specification and the data set will be provided. The results of the analysis will be discussed with attention to developing some generalizable conclusions regarding the effects of dedicated funding. Finally, a set of policy recommendations based on the findings of the analysis and some concluding remarks will be offered.

USE OF DEDICATED TAXES

Local and state dedicated taxes have played an increasingly important role in financing urban transit operations and capital improvements in U.S. cities since the decline of federal operating assistance during the 1980s and ultimately the abandonment of federal operating assistance for urban areas with populations under 200,000. Brown (2005) notes that the choice of finance mechanism tends to vary by region of the U.S., with smaller, northeastern states favoring state-level mechanisms, and urban areas in the South and West tending more toward local-option taxes. The most popular of these is the local-option sales tax, which generated more than $2.3 billion for transit operations in 2001 (Brown 2005). Local-option sales taxes are often levied on all of the counties of a metropolitan region, or some smaller subset of counties[1]. In some states, such as California, individual counties are empowered to levy sales taxes to fund transit. In some larger counties, such as Los Angeles County, these taxes can generate hundreds of millions of dollars per year for transit. California also maintains a statewide, quarter-cent

[1] One example of this is Atlanta, where suburban Cobb County opted out of the initial agreement to form a regional transit authority for the (then) five-county metropolitan area.

sales tax for transit assistance that is distributed to the state's urban regions through the Transportation Development Act, initiated in 1972. This source now provides upward of $1 billion per year for the state's public transit operators.

THEORY OF DEDICATED TAXES

In order to hypothesize about the effects of dedicated taxes, it is first useful to get a sense for how they might affect consumers and government agencies. Buchanan (1963) provides a review of these issues and puts forth a general theory about dedicated (earmarked) taxes based on considerations of political economy. Buchanan defines earmarking as: "The practice of designating or dedicating specific revenues to the financing of specific services." This practice is also typically accompanied by granting independent, but restricted taxation powers. Corollaries are seen in modern urban transit systems, where authority is often granted to regional bodies by state agencies to levy taxes, often dedicated at their source, to finance ongoing operations and capital improvements.

Buchanan posits that, contrary to prior budgetary theory, dedicated taxes may (under certain circumstances) be a "desirable feature of a fiscal structure", somewhat mimicking the behavior of private markets. Dedicated taxes could represent an element of "private" decision-making by individuals, as opposed to voting on aggregate outlays for "bundles" of services. In this sense, general fund budgeting is analogous to the concept of "tie-in" sales, where a consumer might need to buy some of a less-preferred (tie-in) good in order to receive the desired quantity of a preferred good. Dedicating funding could, in some sense, relate to the ability of private markets to adjust quantities.

Furthermore, total budgetary expenditures at equilibrium allocation will be determined by the elasticity of demand of each good in the bundle. Thus, some services (for example, education) can raise overall expenditure levels under general fund financing, since they are favored in general budget allocations. Buchanan argues that segregating accounts into groups of commonly-financed services may be "efficient" from the perspective of the voter-taxpayer-beneficiary. This practice could encompass special-purpose governments, including transit authorities, and the practice of tax dedication.

One shortcoming of this theory, as identified by Buchanan, is the absence of assumptions about decision-making costs (e.g., vote-trading). As it applies to urban transit, this is an important assumption. What a transit authority and those responsible for its oversight do once money is "in hand" is as important as the decision to adopt a dedicated financing mechanism in the first place. In many regions of the U.S., the decision to adopt a dedicated revenue source, such as a sales tax, has gone hand-in-hand with plans to build large, expensive, downtown-oriented rail systems, even in highly decentralized urban regions such as Los Angeles and Atlanta (Altshuler and Luberoff 2003). The sales taxes that support such systems typically are not allowed to expire, since governing boards responsible for disposing of such funds each have members eager to secure benefits for their jurisdiction. Thus, it is more often the case that projects of questionable merit are approved in exchange for commitments to other, favored future projects. The next section provides evidence regarding the hypothesized and empirically-tested effects of subsidies and dedicated taxes.

HYPOTHESIZED EFFECTS OF DEDICATED TAXES

While the merits of having dedicated revenue streams for certain public services have been demonstrated by Buchanan and others, there is some question as to whether it is an appropriate choice for urban transit. There are several factors involved with dedicated revenue sources that tend to interfere with incentives toward efficient operations.

For example, in his study of Boston's MBTA system, Gomez-Ibanez (1996) floats the idea of using a dedicated revenue stream (a regional sales tax) to fund the MBTA in an effort to get the agency to live within a budget[2]. However, Gomez-Ibanez entertains skepticism about whether such a constraint could be effective, citing the deteriorating economic condition of the transit industry, along with exogenous factors such as rising incomes and decentralization that have generally been unfavorable to transit use. These insights hint at other potential problems that may be associated with dedicated funding streams, namely volatility of revenue streams and "passive sponsorship" on the part of transit authorities.

Most sources of dedicated funding, including sales, income and property taxes, yield revenues that mirror regional economic performance to some extent. Some sources, such as a regional sales tax, tend to be highly sensitive to economic conditions and can have much greater volatility than income or property taxes, which tend to be more stable[3]. Volatility in funding levels for transportation is generally an undesirable

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[2] Such a tax was enacted at the state level in Massachusetts just four years after the publication of that particular study.

[3] Savage (2004) explains how economic downturns can have a compounded negative effect on transit authorities by affecting both employment (and hence demand), while simultaneously reducing consumer spending (and hence tax receipts). Wachs (2003) advances a similar argument in regards to the vulnerability of sales taxes to recession.

characteristic. With respect to highway funding, shortfalls can mean delays in previously programmed construction projects. Transit is more vulnerable to year-to-year cash flows, leading agencies to make difficult and unpopular decisions to raise fares and/or cut service during periods of lower-than-projected revenues. A rather extreme example is provided by the Santa Clara Valley Transportation Authority (VTA), which serves the San Jose, California metropolitan region. San Jose, an important center for the information and communications technology industry which helped to fuel the economic growth of the late 1990s, experienced the height of the economic boom, followed by its deepest depression within a period of two years. From 2001 to 2003, unemployment jumped from 1.6 percent (the lowest among major metropolitan areas) to 8.6 percent (Bureau of Labor Statistics 2006). This increase had a dramatically negative impact on the VTA's sales tax receipts (Table 1).

Table 1: Tax Receipts for Santa Clara VTA, 1999-2003

Fiscal Year	Sales Tax Revenues (dollars)	Increase / Decrease (percent)
1999	143,711,721	3.8
2000	166,764,390	16.0
2001	183,540,308	10.1
2002	144,217,679	-21.4
2003	132,632,378	-8.0
2004	138,917,173	4.7

Source: Santa Clara Valley Transportation Authority (2005)

As the table indicates, sales tax receipts increased by double-digits during 2000 and 2001, then plummeted in 2002 and 2003, leading to drastic service cutbacks.

While the San Jose example may be exceptional in some respects, it illustrates an important characteristic of dedicated funding sources, especially sales taxes. In faster-growing regions with vibrant economies revenues tend to rise quickly, even if demand for services does not follow. While incomes tend to be negatively correlated with transit use, declines in ridership will not likely be accompanied by reductions in service when dedicated funds are available. Transit agencies spend available funds because they believe they are carrying out their mandate (Rubin and Moore 1996). Conversely, in periods of slower growth, revenues tend to fall short. If the shortfall is large enough, as in the Twin Cities in 2005, public agencies will appeal to higher levels of government to cover the shortfall with other sources of tax revenue. In either case, the trend tends to be toward larger deficits and more heavily subsidized service.

The other major source of inefficiency from dedicated funding sources stems from "passive sponsorship" of public transit systems (Anderson 1983). Passive sponsorship results when a sponsor (a state or local government) provides funding without specifying a set of results to be achieved with a limited allocation of funds. Anderson (1983) demonstrates that when a sponsor is passive in bargaining with the service provider, the provider (or transit manager) will make an "all-or-nothing" demand for subsidy dollars, resulting in a case where the subsidy plus operating revenues will be more than the minimum cost necessary to provide a fixed level of output. In the case of a dedicated funding stream the sponsor is essentially absent, resulting in no negotiations regarding level of output or other goals. In this situation, costs might be expected to rise due to higher labor or other unit costs. Alternatively, the provider can simply provide more service or more costly service (extensions to low-density suburban areas or new rail systems). Taylor (1991) provides evidence from the San Francisco Bay Area showing how the per capita distribution of state Transportation Development Act (TDA) funds to the region's transit authorities results in inefficiency (and inequity). His argument follows that since funds are allocated to suburban providers on the basis of factors generally unrelated to demand, these funds end up supporting lightly patronized, but heavily subsidized suburban services.

Related to the issue of passive sponsorship is that of public rent-seeking. Since the transit industry is highly regulated and local transit authorities face little or no effective competition in the provision of services, input suppliers such as unionized labor groups have incentives to extract economic rents from transit authorities in the form of higher wages and benefits. Some public officials, who may count these interests among their constituents, may be indifferent to or even encourage such practice as a means of maximizing their base of support.

EMPIRICAL EVIDENCE FROM PRIOR RESEARCH

The extent of inefficiency caused by rent-seeking and ever-increasing subsidies has been the subject of a great deal of research interest. For example, Winston and Shirley (1998) report that as much as 75 percent of federal transit spending is consumed by transit operators and suppliers of capital, while just 25 percent is used to lower fares and maintain service. Bly and Oldfield (1986), using a set of data from 16 European countries over the years 1970 to 1982, estimate that 62 percent of increased subsidy dollars are consumed by higher costs per vehicle-kilometer (with 34 percent coming in form of higher wages). Lave (1991) reports that operating expenses per vehicle hour (exclusive of depreciation) for large U.S. bus operators increased from $18.84 to $40.18 in constant 1985 dollars over the period 1964-1985. Pickrell (1985) attempted to decompose the growth in U.S. transit subsidies using a "comparative static" model and found that rising unit operating costs accounted for 60 percent of the increase, 9 percent financed expanded service, 14 percent was used to lower fares, and another 7.5 percent related to declining demand (fare reductions and service increases that would have held ridership at previous levels). Gomez-Ibanez (1996) attempted to recreate Pickrell's analysis using time series data for the MBTA. These findings indicate that a much lower share of subsidy increases were absorbed in higher unit costs (7.6 percent), while most of the increase went toward service increases, fare reductions, inflation, and capital depreciation. Karlaftis and McCarthy (1998) studied the effects of subsidies on operating performance using panel data for 18 Indiana transit agencies and found mixed effects relating to the size of the firm.

Few studies have specifically tried to test for the influence of dedicated funding on cost and performance. Pucher, Markstedt, and Hirschman (1983) used cross-sectional data for U.S. firms in 1979 and 1980 to study the effects of subsidy on cost and productivity. Their estimated equations included a dummy variable for transit systems that received 50 percent or more of their state and local subsidy from dedicated taxes[4]. Results indicated that transit systems with greater than 50 percent of their state and local subsidy coming from dedicated sources had operating costs that were $1.48 higher per revenue hour, on average. Cervero (1984) used panel data for 17 California transit systems for the period 1974 to 1981 to study the effects of subsidies from different levels of government with an emphasis on the effects of local subsidies, which were drawn from dedicated sources (local sales taxes). The results indicated that local sources had twice the impact of federal sources in decreasing productivity. Also, cost per passenger was $4 higher for systems that were entirely dependent on local support. Finally, Pickrell (1985)

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[4] The choice to use a dummy variable for the effect of dedicated taxes was made because the authors noted that most of the dedicated tax shares of subsidy were either very high or very low.

estimated a cost model which showed that nearly 20 percent of increases in operating assistance financed by dedicated sources are absorbed in higher unit costs. Roughly half of this increase was attributed to rising wages, with a lesser portion coming from higher fuel costs.

In terms of methodological approach to the influences of subsidy and dedicated taxes, most of the studies cited previously use least squares regression as the primary analytical instrument. These studies use a mix of cross-sectional, time series, and panel data to conduct analyses, leaving open some questions about the comparability of results, due to the possibility of firm-specific effects in the samples. A more complex issue raise by these studies is the nature of the relationship between subsidy and cost. While indicating that dedicated taxes and other subsidies have a generally degrading effect on transit performance and efficiency, some researchers question the reliability of their results in light of the possibility of simultaneity and joint determination in subsidy effects. Pucher, Markstedt, and Hirschman (1983) and Pickrell (1985) both hint at the fact that fares, ridership, cost, and service levels might be jointly determined, and ought to be modeled as such. Karlaftis and McCarthy (1998) use Granger causality tests to check for joint determination between subsidy and performance, finding evidence of endogeneity for small systems on two of three different performance measures. These findings suggest that a more complex modeling approach might be required to untangle the effects of dedicated taxes from other factors that could potentially influence costs and other outcomes, such as service levels.

DATA AND METHODOLOGICAL APPROACH

Data

The data compiled for this analysis represent a panel of 23 large U.S. bus transit systems measured over an eight-year period (1996 through 2003). The grouping of systems for the analysis is based on Karlaftis and McCarthy (2002), who designated six size groupings of public transit systems using cluster analysis. The resultant clusters can more readily be used for statistical analysis without attendant problems of bias due to system size and operating environment. The panel data employed here represents the second largest of the six groups, excluding the five largest systems, which comprise a single group by themselves.

The National Transit Database (NTD) collects a wide variety of financial and operational data on public transit systems. All systems receiving federal funds are required to report such data, unless given a waiver. Data are available on operating and capital costs, though certain expenses are excluded from measurement, such as depreciation and amortization expenses[5]. Cost and revenue data cover several years and therefore are inflated to equivalent 2003 dollars using the CPI-U price index as an estimate of general inflation. Transit use is measured in unlinked boardings, an important distinction since this reported figure is often considerably higher than the true number of transit *trips*, which may include one or more transfer.

Operator wage data, unavailable prior to 2002, are estimated by dividing vehicle operations expenses by the number of work hours recorded for vehicle operations. An average fare is calculated for each system by dividing revenues by annual boardings. System-wide service frequency, a quality of service measure, is calculated by dividing

[5] Publicly-available data sets can be found online for the period 1996 to 2004 at www.ntdprogram.com.

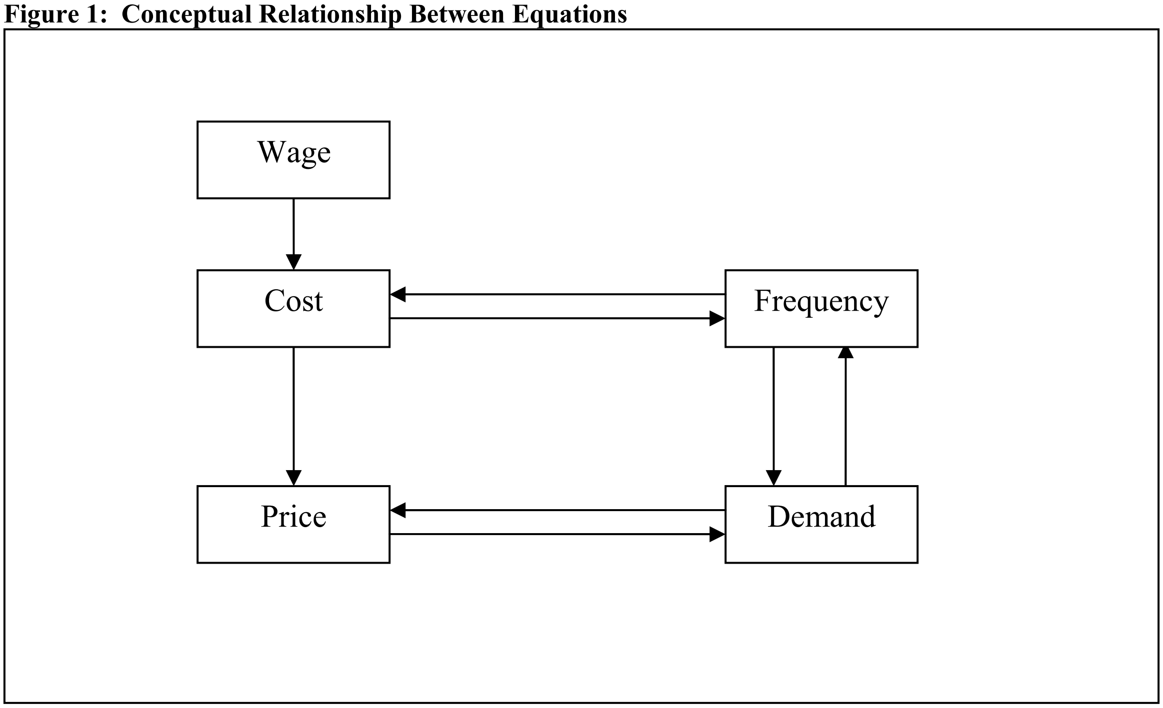
total revenue miles by route miles. Revenue data were perhaps the most difficult to compute. Since revenue data are only available by transit system (prior to 2002), all revenue is lumped together, including all modes that a system operates. To get around this problem, estimates of bus revenue were made by specifying OLS regressions of revenue on ridership by mode (excluding vanpool and demand-responsive systems). These regressions used the 46 observations available for 2002 and 2003, the years for which revenue data by mode were collected. The fit of this equation was generally quite good ($R^2 \approx 0.95$). The estimates provided by this equation were applied to data for 1996 through 2001 to obtain bus revenue estimates.

Some supplementary data was collected to capture socio-economic factors that might vary from region to region. Per capita income data was collected from Bureau of Economic Analysis (2006). Unemployment data by region came from the Bureau of Labor Statistics (2006). Vehicle ownership figures were estimated from census data (U.S. Census Bureau 2006a), along with 2001 through 2003 estimates provided by the American Community Survey (U.S. Census Bureau 2006b). The U.S. Statistical Abstract (U.S. Census Bureau 2006c) also provided data on fuel prices and levels of unionization by state.

Specification and Estimation

Using these combined data sets, a system of five equations was estimated in order to capture the simultaneity effects described previously. The modeling approach is based on Anderson (1983), who used two-stage least squares (2SLS) to estimate a similar set of equations to determine the effects of subsidy and public ownership on public transit costs. Anderson's approach encompassed the basic supply and demand factors influencing transit service levels and cost. In order to avoid the problem of correlation between regressors and disturbances encountered with endogenous variables in equation systems, the use of 2SLS allows for unbiased and consistent parameter estimates. The five equations represent operator wages, cost (operating cost per revenue hour), price (average fare), frequency (revenue miles per route mile), and demand (annual boardings). Four of the five equations involve an endogenous dependent variable, while the wage equation is considered to be entirely exogenously determined. The relationships between the endogenous variables in the system can be described with a simple, conceptual diagram (Figure 1). In all equations except the demand equation, dedicated taxes are specified as a continuous, exogenous variable defined as the share of operating cost covered by state and local dedicated taxes.

Figure 1: Conceptual Relationship Between Equations



The system of equations is estimated using three-stage least squares (3SLS), a system estimation method that accounts for disturbance term correlation between equations. Since 3SLS takes this additional information into account, it provides more consistent and efficient parameter estimates than single-equation estimation methods (Washington et al. 2003). Use of 3SLS also allows for the assumption that public transit managers make decisions about fares, subsidies and service levels simultaneously, rather than sequentially, as would be implied by the use of single-equation methods. The system of equations can be specified as follows:

1) $Y_C = \boldsymbol{\alpha}_{Ci} + \boldsymbol{\beta}_C\mathbf{Z}_C + \boldsymbol{\theta}_C\mathbf{X}_C + \lambda_C Y_W + \tau_C Y_F + t_C + \varepsilon_C$ (Cost)

2) $Y_W = \boldsymbol{\alpha}_{Wi} + \boldsymbol{\beta}_W\mathbf{Z}_W + t_W + \varepsilon_W$ (Wage)

3) $Y_P = \boldsymbol{\alpha}_{Pi} + \boldsymbol{\beta}_P\mathbf{Z}_P + \lambda_P Y_D + \tau_P Y_C + t_P + \varepsilon_P$ (Price)

4) $Y_F = \boldsymbol{\alpha}_{Fi} + \boldsymbol{\beta}_F\mathbf{X}_F + \lambda_F Y_D + \tau_F Y_C + t_F + \varepsilon_F$ (Frequency)

5) $Y_D = \boldsymbol{\alpha}_{Di} + \boldsymbol{\beta}_D\mathbf{Z}_D + \boldsymbol{\theta}_D\mathbf{X}_D + \lambda_D Y_P + t_D + \varepsilon_D$ (Demand)

where:

$\boldsymbol{\alpha}_i$ is a vector of firm-specific effects, $\mathbf{Z}$ is a vector of exogenous variables, $\mathbf{X}$ is vector of transit system and service characteristics, t is a time trend variable (taking on the value 1,2,…n for each year), $\boldsymbol{\beta}$ and $\boldsymbol{\theta}$ are vectors of estimable parameters, λ and τ are estimable scalars, and ε_i is a classical disturbance term.

The firm-specific dummies are intended to capture any residual effects stemming from unusual, idiosyncratic characteristics of transit agencies or their service areas. Dummies for Boston, San Francisco, and Baltimore are included in several equations due to their bus operations being part of a large, multiservice transit system. This effect might be thought to influence either their operations or demand characteristics. Including dummies for Honolulu and San Antonio in the price (fare) equation reflect these agencies' noticeably lower average fares. The frequency equation contains several firm-specific dummies intended to capture the larger or smaller than average service areas in places such as Detroit, New Orleans, Denver, and Chicago[6]. The time trend variable (t) is included to capture any longer-term, secular trends in demand, costs, fare, or service levels. Exogenous variables in the equation system cover a variety of factors, such as socioeconomic and urban form characteristics, prices, and labor market conditions. Again, the level of dedicated taxes supporting a transit system is considered exogenous, since is not within the conscious control of the transit agency itself.

Hypotheses

The dedicated tax variable is included in each equation to test its effects on transit system operation and performance. Based on the theoretical and empirical considerations described in prior sections, one might expect the level of dedicated funding to have the following effects:

- Inflationary effect on operator wages, as well as other non-labor cost components, leading to higher unit costs in operations.
- A depressing effect on average fare levels, as the additional subsidy dollars provided are used to hold down fares.
- An increase in service levels, as measured by the frequency of service variable.

RESULTS

Table 2 provides some operating and service characteristics for the 23 transit agencies included in the analysis, based on the most recent year's data (2003). Data is provided on the share of operating costs covered by dedicated state and local taxes

[6] For purposes of comparison the model was re-estimated using two alternate specifications. One specification involved the use of no firm-specific dummies, while the other involved a full fixed effects specification, including dummies for each firm in the sample. Results of these estimates are produced in appendices following the "References" section of the paper.

(agencies are listed in descending order), along with some indicators of cost, demand intensity (as measured by boardings per revenue hour), and service levels. Interestingly enough, the two agencies with the highest shares of dedicated state and local dedicated taxes also have the highest and lowest operating costs of all the agencies listed ($151.16 and $57.18, respectively). However, four of the five agencies with the highest cost per boarding also receive more than half of their operating dollars from dedicated taxes[7].

Table 2: Share of Operating Costs from Dedicated Taxes and Selected Performance Measures, 2003

Transit Agency	Dedicated Tax Share	Cost per Boarding*	Cost per Revenue Hour*	Boardings per Revenue Hour	Revenue Hours
San Antonio	72.3%	1.98	57.18	28.8	1,362,400
San Jose	70.3%	5.37	151.16	28.1	1,413,700
Cleveland	69.4%	3.32	94.73	28.5	1,710,600
Houston	66.5%	3.25	94.99	29.2	2,624,500
Oakland (AC Transit)	66.2%	3.95	120.08	30.4	2,048,400
Seattle (King County)	64.7%	4.14	111.34	26.9	2,641,800
Denver	62.6%	3.24	84.84	26.2	2,562,800
Portland	62.0%	2.58	91.03	35.3	1,882,900
Baltimore (MTA)	60.6%	2.49	112.17	45.0	1,870,700
Salt Lake City (UTA)	59.4%	4.06	89.34	22.0	938,200
Atlanta	57.5%	2.45	83.76	34.1	2,069,800
Chicago (Pace Suburban)	56.4%	3.53	75.35	21.3	1,451,300
Boston	55.5%	2.02	102.76	50.9	2,337,400
New Orleans	51.5%	1.78	107.47	60.4	772,400
Orange County	47.8%	2.31	85.39	37.0	1,759,100
Minneapolis-St. Paul	47.4%	3.17	99.27	31.3	2,278,000
Detroit (D-DOT)	33.4%	4.54	106.68	23.5	1,607,700
Pittsburgh	28.8%	3.51	96.64	27.5	2,179,400
San Francisco (MUNI)	20.5%	1.84	108.42	58.9	1,542,200
Miami-Dade County	20.0%	3.32	91.78	27.6	2,336,200
Milwaukee	12.7%	2.03	83.60	41.3	1,384,400
St. Louis	0.4%	3.50	99.65	28.5	1,074,200
Honolulu	0.0%	1.73	88.67	51.2	1,349,600

* Costs are reported in dollars
Source: National Transit Database, author's calculations

[7] Cost per boarding is hybrid measure of performance, combining cost and demand characteristics. Thus, some transit systems with high demand can also have low to moderate costs per boarding. In this sample, the systems with high costs per boarding tend also to have low demand intensity.

In terms of service levels, the three systems with the greatest amount of bus service also rely heavily on dedicated tax sources, receiving more than 60 percent of their operating budget from such sources.

These preliminary findings are further substantiated by the estimated model coefficients shown in Appendix A. As hypothesized, the variable representing the share of operating costs supported by dedicated tax sources has highly significant, positive effects on service frequency and weaker, yet still significant, effects on unit costs (cost per revenue hours) and fare levels.

The effects on operator wages are less clear, though. The parameter estimate for dedicated taxes in the wage equation is small but significant (at the $p < 0.05$ level) and has the wrong sign. There does not appear to be any good explanation for this finding other than the possible omission of relevant variables or some other form of specification error.[8]

The issue of practical significance can be fairly considered in this context. While dedicated taxes do appear to influence costs and service levels (and to a lesser extent, wages), their effect is relatively small. In order to illustrate, consider again the case of the Metropolitan Council in the Twin Cities. Table 2 indicates that the Council receives just under half of its funds (47.4 percent) from dedicated state and local taxes[9]. Assume that a region-wide general sales tax were adopted as the primary funding source, replacing the vehicle sales tax, and that this new sales tax represented 71.1 percent of the Council's bus operating costs (a 50 percent increase). Using the coefficient estimates from Table 3 to obtain the mean response, unit costs would increase by 0.0 to 0.9 percent,

[8] The relatively low overall fit of this equation might argue in favor the former.
[9] Recall from the introduction that the Metropolitan Council receives dedicated funds from a share of the state's motor vehicle sales tax.

or \$0.00 to \$0.94 per revenue hour[10]. Assuming service levels were held constant at 2003 levels, annual operating expenses would increase by up to a maximum of \$2.15 million per year. Additionally, service levels would increase by an estimated 0.25 to 1.25 percent over 2003 levels.

Other potentially useful information can be obtained from the model results, as well. Costs appear to decline as speeds increase, consistent with most research results. Costs also appear to decline with increases in frequency, providing tentative evidence of economies of density in operations. Wage rates appear to be most influenced by local income levels and unionization rates. Fares are shown to increase with overall levels of use, possibly an indication of transit agencies taking advantage of price-inelastic demand for certain types of service. Service frequency seems to be primarily a function of demand levels, operating cost, speeds, and system size. Demand is found to be sensitive to service levels and quality, and rises with urbanized area population and the number of carless households. Also, demand for transit is found to be price inelastic, with elasticity estimates of between 0.0 and -0.19.[11] Demand is *not* found to be sensitive to changes in fuel prices. This finding tends to contradict previous studies that have estimated cross-price demand elasticities for transit.[12]

Finally, the results of the model used in the preceding analysis can be compared to the results of the alternative specifications (in Appendices B and C). The results referred to previously can be term the "preferred" specification. The model with no firm-

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[10] These estimates provide a 95 percent confidence interval for the estimates from Table 3.
[11] In estimating the price elasticity of demand, the (short-run) elasticity was specified as the change in demand with respect to an increase in the average fare as a percent of the median per capital income. This specification has been used elsewhere (Shirley and Winston 1998), and provided a convenient alternative, since previous attempts to estimate fare and income elasticities separately produced inconsistent results.
[12] For a review of some prior estimates of cross-price demand elasticities, refer to Oum, Waters, and Yong (1992).

specific dummies shows generally similar results, although there is no statistically significant effect of dedicated taxes on fares and the statistical fit of the equations is poorer, especially for the fare equation. The fixed effects specification yields dramatically different results, indicating that dedicated taxes have no statistically detectable effects on fares, costs, or service levels. The results of this estimation are questionable, however. The high statistical fit for all five equations is marred by the fact that several theoretically important variables appear as either statistically insignificant or generally of the wrong expected sign. This finding may be evidence of collinearity between the original predictors and the firm-specific dummies, or may simply represent the loss of efficiency due to the need to estimate a large number of parameters in the equation system. The preferred specification was favored over this specification due to the lack of statistical problems and the overall satisfactory fit, while being flexible enough to account for the most pronounced system-specific effects in the sample.

CONCLUSION

The preceding analysis has attempted to answer the question of how and to what extent the presence of dedicated tax sources influence urban transit operations and performance. Using a panel data set of public transit agencies of similar size and a simultaneous equation system approach to account for the joint determination of several key policy variables, the hypothesized effects were largely confirmed. As dedicated state and local tax sources cover an increasing share of operating costs, unit costs and wages tend to rise, service levels (as measured by frequency) expand, though fares appear to be unaffected. While these observed effects were shown to be statistically significant, their practical implications were in fact quite small and unlikely to change the overall operations and management strategy of a public transit firm. Estimates showed that unit cost increases from a significant increase in the use of dedicated tax sources would likely be on the order of zero to one percent, and that increases in service levels of the same magnitude could also result. Effects on fares were negative and marginally significant.

Some caveats are probably appropriate for the empirical results provided here. First, this analysis focused only on the effects of dedicated taxes on transit operations, and then, only on *bus* transit operations. It would be desirable to estimate the influence of these tax sources on capital spending as well, particularly since dedicated taxes (sales taxes especially) are often geared toward capital improvements to transit systems. Many of the systems studied here have already built or are planning to build new rail systems, often at considerable cost. The Metropolitan Council recently joined this group, though operations began after the period covered by the data reported here. Extending the analysis presented here to cover system-wide performance and cost measures, including all modes, would be desirable. Dedicated revenue streams are often intended to cover all of a transit agency's operations. Likewise, the performance of one mode may influence the performance of another mode, such as the conversion of a productive bus route to a rail line. Additionally, it would be desirable to have better data on wages so that more accurate comparisons across systems can be made. Transit systems that make fairly extensive use of private carriers are not required to report some data as completely as directly-operated systems, making inferences based on comparisons of these systems somewhat tentative.

As a matter of policy, it is difficult to recommend more widespread use of dedicated taxation to support public transit systems. While their effects on the cost and performance of bus systems have been shown here to be minimal, they raise a number of other questions regarding fairness and equity that have not to date been adequately resolved. Regarding equity, Taylor (1991) has shown that state-level dedicated taxes in California intended to support local transit systems have led to a redirection of scarce subsidy dollars away from central cities, where they arguably produce the greatest amount of benefit, to thinner, suburban markets where they simply help to sustain otherwise unproductive routes. Also, reflecting on a previous (now defunct) long-range transportation plan developed by the Los Angeles County Metropolitan Transportation Authority, Moore et al. (1999) report elements of the plan that would have shifted over $450 million in dedicated sales tax revenue from bus capital and operations to construction of LACMTA's regional rail system. Both of these cases are emblematic of the difficulty of ensuring that subsidy dollars promote useful social objectives in light of the political turf wars that often accompany dedicated tax sources.

With respect to efficiency, there are also reasons for concern. Gomez-Ibanez (1996) notes the issue of the declining economic state of the transit industry, which has been fed by the continued securing of public sources of financial support to maintain services at unsustainably high levels. Unlike highway systems, which also make use of dedicated tax sources, public transit systems cannot claim a large and growing base of users to sustain the system at current levels. Many time-series studies of aggregate transit use indicate that long-term trends, such as rising incomes and continued decentralization, will not likely favor increasing transit use in the future (Pickrell 1985; Gomez-Ibanez

1996; Kain and Liu 1999). It is difficult then, to defend policies that promote higher levels of investment by essentially locking in year-to-year increases, when there few prospects for improving the system's productivity.

Furthermore, many transit agencies will continue to face rising costs in the foreseeable future. Rising health care and other benefit costs, along with steadily increasing fuel costs, will eventually catch up with them. These pressures will likely force difficult choices for public agencies such as the Metropolitan Council, such as further fare increases, service reductions, or changes in the way services are provided. It seems imperative that responsible public bodies ("sponsors"), in dealing with these issues, be given the maximum amount of flexibility and authority to make the necessary changes. This means being given the ability to adjust year-to-year spending levels to provide the appropriate amount and mix of services.

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APPENDIX A: Regression Results—3SLS Estimates of Equation System Parameters

	Cost			Wage			Price			Frequency			Demand		
Variable	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.
Costs															
Operating Cost per Revenue Hour							0.048	0.111		-0.013	0.045				
Operators' Wage Rate	-0.316	0.080	***												
Operating Taxes per Revenue Hour	0.062	0.011	***												
Fringe Benefits per Revenue Hour	0.563	0.031	***												
Prices															
Average Fare/Income (x 10^6)													-0.090	0.049	*
Gasoline Price (in cents)													0.018	0.053	
Service Levels															
Average Frequency	-0.106	0.024	***										0.373	0.041	***
Annual Revenue Hours													0.903	0.050	***
Average Speed	-0.103	0.068								1.091	0.117	***			
Travel Demand															
Passenger Boardings							0.121	0.040	***	0.717	0.047	***			
Average Trip Distance							0.291	0.059	***						
Transit System Descriptors															
Fleet Size	-0.085	0.026	***												
Peak-to-Base Ratio	-0.059	0.038								-0.023	0.039				
Total Route Miles										-0.792	0.030	***			
Sociodemographic Variables															
Per Capita Income				0.545	0.066	***	-0.237	0.107	**						
UZA Population													0.133	0.039	***
UZA Density										0.061	0.030	**	-0.040	0.041	
Percent of Workers Unionized				0.046	0.018	**									
Percent Zero-Car Households													0.184	0.041	***
Percent Unemployment				0.125	0.024	***							-0.046	0.035	
Firm-Specific Dummies															
Detroit (DDOT)										0.045	0.040				
Honolulu							-0.635	0.070	***	-0.273	0.054	***	0.313	0.068	***
Boston	-0.003	0.037		0.131	0.038	***	-0.286	0.070	***				0.006	0.068	
Baltimore	0.056	0.035		0.035	0.034								0.079	0.053	
San Francisco (MUNI)	-0.130	0.045	***	-0.072	0.044		-0.213	0.084	**	-0.334	0.065	***	0.279	0.106	***
New Orleans										-0.275	0.046	***			
Chicago (Pace Suburban)										-0.071	0.048				
Denver										0.004	0.035				
San Antonio							-0.660	0.079	***						
Time Trend	-0.008	0.003	***	-0.003	0.003		0.002	0.005		0.010	0.004	***	-0.008	0.006	
Dedicated Tax Variable	0.009	0.005	*	-0.013	0.005	**	-0.019	0.010	*	0.015	0.005	***			
Constant	0.909	0.743		-3.133	0.664	***	3.977	1.068	***	-0.778	1.084		-0.282	0.935	
Adjusted R^2	0.77			0.57			0.61			0.91			0.78		
N = 184															

Notes: All variables transformed using natural logs except for dummy variables
* indicates significance at $p < 0.10$ level
** indicates significance at $p < 0.05$ level
*** indicates significance at $p < 0.01$ level

APPENDIX B: Regression Results—3SLS Estimation Without Firm-Specific Dummies

	Cost			**Wage**			**Price**			**Frequency**			**Demand**		
Variable	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.
<u>Costs</u>															
Operating Cost per Revenue Hour							0.818	0.130	***	0.036	0.045				
Operators' Wage Rate	-0.194	0.098	**												
Operating Taxes per Revenue Hour	0.063	0.011	***												
Fringe Benefits per Revenue Hour	0.565	0.032	***												
<u>Prices</u>															
Average Fare/Income (x 10^6)													-0.130	0.026	***
Gasoline Price (in cents)													0.013	0.035	
<u>Service Levels</u>															
Average Frequency	-0.127	0.024	***										0.370	0.039	***
Annual Revenue Hours													0.964	0.046	***
Average Speed	-0.101	0.062								0.954	0.100	***			
<u>Travel Demand</u>															
Passenger Boardings							0.096	0.060		0.746	0.052	***			
Average Trip Distance							0.333	0.070	***						
<u>Transit System Descriptors</u>															
Fleet Size	-0.054	0.025	**												
Peak-to-Base Ratio	-0.053	0.035								-0.017	0.039				
Total Route Miles										-0.723	0.029	***			
<u>Sociodemographic Variables</u>															
Per Capita Income				0.508	0.052	***	-0.531	0.133	***						
UZA Population													0.042	0.022	*
UZA Density										-0.038	0.031		0.037	0.035	
Percent of Workers Unionized				0.056	0.019	***									
Percent of Zero-Car Households													0.117	0.024	***
Percent Unemployment				0.126	0.025	***							-0.023	0.024	
Time Trend	-0.007	0.003	**	-0.002	0.004		-0.001	0.008		0.007	0.005		-0.010	0.006	*
Dedicated Tax Variable	0.012	0.005	**	-0.017	0.005	***	0.017	0.012		0.030	0.008	***			
Constant	2.295	0.664	***	-2.769	0.533	***	3.780	1.192	***	-0.955	1.176		-0.054	0.790	
Adjusted R^2	0.77			0.52			0.22			0.85			0.74		
N = 184															

<u>Notes</u>: All variables transformed using natural logs except for dummy variables
* indicates significance at $p < 0.10$ level
** indicates signficance at $p < 0.05$ level
*** indicates signficance at $p < 0.01$ level

APPENDIX C: Regression Results—3SLS Estimation with Fixed Effects

	Cost			Wage			Price			Frequency			Demand		
Variable	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.	Coefficient	SE	Sig.
Costs															
Operating Cost per Revenue Hour							-0.426	0.164	***	-0.623	0.086	***			
Operators' Wage Rate	-0.134	0.083													
Operating Taxes per Revenue Hour	0.042	0.009	***												
Fringe Benefits per Revenue Hour	0.302	0.035	***												
Prices															
Average Fare/Income (x 10^6)													-0.334	0.034	***
Gasoline Price (in cents)													-0.042	0.016	**
Service Levels															
Average Frequency	-0.041	0.019	**										0.000	0.020	
Annual Revenue Hours													0.537	0.052	***
Average Speed	0.109	0.069								0.633	0.072	***			
Travel Demand															
Passenger Boardings							-0.988	0.136	***	0.419	0.064	***			
Average Trip Distance							-0.087	0.081							
Transit System Descriptors															
Fleet Size	-0.194	0.032	***												
Peak-to-Base Ratio	-0.002	0.024								0.069	0.024	***			
Total Route Miles										-0.913	0.017	***			
Sociodemographic Variables															
Per Capita Income				-0.059	0.175		0.515	0.154	***						
UZA Population													0.241	0.116	**
UZA Density										0.277	0.096	***	-0.033	0.103	
Percent of Workers Unionized				-0.206	0.091	**									
Percent Zero-Car Households													0.038	0.032	
Percent Unemployment				0.106	0.027	***							-0.034	0.014	**
Firm-Specific Dummies															
Pittsburgh	0.006	0.024		0.007	0.036		0.432	0.054	***	0.102	0.042	**	0.208	0.044	***
Twin Cities	0.075	0.028	***	0.066	0.039	*	0.488	0.061	***	-0.063	0.033	*	0.214	0.044	***
Atlanta	-0.119	0.020	***	-0.224	0.095	**	0.287	0.059	***	0.023	0.056		0.127	0.088	
Denver	0.039	0.025		-0.229	0.074	***	0.035	0.055		-0.092	0.042	**	0.063	0.056	
Miami (MDTA)	-0.119	0.030	***	-0.397	0.107	***	0.525	0.065	***	-0.307	0.082	***	0.333	0.091	***
Boston	0.104	0.036	***	0.217	0.059	***	0.239	0.102	**	-0.092	0.067		0.189	0.094	**
Portland	-0.166	0.020	***	-0.042	0.035		-0.091	0.044	**	-0.188	0.029	***	0.148	0.034	***
Oakland (AC Transit)	0.028	0.024		0.099	0.045	**	0.118	0.056	**	-0.109	0.041	***	0.232	0.047	***
Orange County	-0.112	0.027	***	0.049	0.039		-0.152	0.047	***	-0.399	0.034	***	0.038	0.084	
Detroit (DDOT)	-0.009	0.039		-0.224	0.046	***	-0.145	0.045	***	-0.266	0.088	***	0.098	0.113	
Baltimore	0.066	0.026	**	0.003	0.039		0.538	0.078	***	-0.255	0.041	***	0.435	0.031	***
Chicago (Pace Suburban)	-0.122	0.033		-0.028	0.036		-0.215	0.084	***	-0.297	0.046	***	-0.401	0.108	***
San Jose	0.102	0.027	***	0.208	0.064	***	-0.398	0.072	***	-0.148	0.075	**	-0.112	0.094	
San Francisco (MUNI)	0.051	0.038		0.191	0.090	**	-0.136	0.100		-0.910	0.162	***	0.620	0.199	***
Honolulu	-0.076	0.039	*	0.109	0.062	*	-0.192	0.077	**	-0.605	0.057	***	0.580	0.115	***
New Orleans	-0.147	0.028	***	-0.298	0.091	***	-0.037	0.050		-0.740	0.062	***	0.547	0.095	***

St. Louis	-0.099	0.042	**	-0.114	0.063	*	-0.470	0.074	***	-0.211	0.047	***	-0.207	0.038	***
Houston	-0.076	0.036	**	-0.421	0.107	***	0.216	0.080	***	0.083	0.035	**	0.019	0.098	
San Antonio	-0.480	0.032	***	-0.408	0.116	***	-1.092	0.107	***	-0.507	0.066	***	-0.180	0.050	***
Salt Lake City	-0.233	0.034	***	-0.295	0.102	***	-1.093	0.129	***	-0.301	0.086	***	-0.376	0.091	***
Seattle	0.162	0.028	***	0.179	0.049	***	0.358	0.087	***	0.201	0.035	***	0.005	0.057	
Milwaukee	-0.217	0.038	***	0.067	0.052		-0.089	0.068		-0.434	0.037	***	0.344	0.045	***
Time Trend	0.007	0.002	***	0.004	0.004		-0.007	0.004	*	0.021	0.002	***	-0.017	0.003	***
Dedicated Tax Variable	0.010	0.007		-0.005	0.011		-0.008	0.011		-0.010	0.007				
Constant	5.053	0.479	***	3.861	1.864	**	18.553	2.710	***	7.781	1.402	***	8.079	1.991	***
Adjusted R^2	0.95			0.78			0.91			0.99			0.98		
N = 184															

Notes: All variables transformed using natural logs except for dummy variables
* indicates significance at $p < 0.10$ level
** indicates significance at $p < 0.05$ level
*** indicates significance at $p < 0.01$ level