Capital Subsidies and the Infrastructure Crisis: Evidence from the Local Mass-Transit Industry

by Brian A. Cromwell

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Introduction

The condition of the public capital stock—perceived by many to be dilapidated and inadequate—has received considerable attention in political, media, and academic circles in recent years.

Pat Choate and Susan Walter's ***America in Ruins*** gave striking examples of crumbling infrastructure and suggested that enormous increases in infrastructure investment were needed just to maintain the existing levels of services. The media and political attention given this work was highlighted by tragedies such as the 1983 collapse of the Interstate 95 bridge in Connecticut. More systematic studies by the Urban Institute and the Congressional Budget Office (1983) catalogued the existing state of public infrastructure and projected the need for new public investment.[1]

More recently, the National Council of Public Works Improvement (1988) completed a series of studies examining the state of the nation's public infrastructure, entitled Fragile *Foundations* and concluded that "...the quality of America's infrastructure is barely adequate to fulfill current requirements, and ins cient to meet the demand of future economic growth and development."[2]

Debates and studies of the infrastructure "crisis" involve a wide range of policy issues related to measuring the costs and benefits of public capital. The issue of what level of infrastructure is optimal involves addressing questions of how to measure the current state of and future needs for public capital, how to measure the impact of infrastructure on productivity and regional growth, and how expenditures on public capital should be weighed against other uses of public monies. Questions of financing involve traditional issues of fiscal federalism and public finance, including what level of government should provide infrastructure services, who should pay, and what financing mechanisms raise revenue with the least economic cost.

While most studies argue that increased public investment is needed, a more provocative set of

1 The Urban Institute project included a series of case studies on municipal infrastructure. For example, see Humphrey et al. (1979). For a review of infrastructure needs studies, see Peterson et al. (1986).

2 National Council of Public Works Improvement (1988), p. 1.

questions focuses on how public infrastructure arrived at its present condition and critiques the decision-making process itself. In particular, it is alleged that the structure of infrastructure financing mechanisms, combined with political and budgetary pressures, induce public officials to systematically underfund the maintenance of the existing capital stock, leading to excessive deterioration of public infrastructure. The study of infrastructure maintenance, however, has received little empirical attention due to the lack of data on local maintenance policies and a lack of natural experiments with which to evaluate public-sector maintenance.

This article reviews questions regarding infrastructure policy with a focus on how the costs and benefits of public capital and maintenance decisions are potentially distorted by budget procedures, political pressures, and the structure of federal grant policies. I then describe how the local mass-transit industry provides an opportunity to investigate public-sector investment and maintenance decisions. Empirical evidence from two recent studies of the local mass-transit industry, Cromwell (1988a, 1988b), is then summarized. The results suggest the structure of federal grant policies has important effects on infrastructure decisions of state and local governments.

I. Infrastructure Policy Incentives

Budget Processes

Leonard (1986) argues that ignoring depreciation and deferring maintenance are both powerful forms of hidden spending that are not accounted for by local governments. Failure to reinvest or maintain existing infrastructure is, in effect, to live off an inherited bank account. Current taxpayers spend assets provided to them by previous generations. This spending is obscured, however, by the lack of records and comprehensive accounting for fixed-asset investments from year to year.

Current accounting procedures for capital and maintenance by local governments appear to be inadequate for effective management of public infrastructure.3 The Government Accounting Standards Board, which sets standards for public-sector accounting, requires governments to maintain records of fixed assets recorded at historical cost in a separate account group held apart from operating funds. Recording the value of immovable infrastructure assets—bridges, roads, sewers—is explicitly optional, as is the recording of depreciation. Even if a governmental unit does recognize depreciation, it is shown as an offset to the value of assets, not as an operating cost as in the private sector. When tight funds result in deferred maintenance, there is no notation in capital records of the decline in asset values from the failure to maintain them, making preventive and routine maintenance an attractive target for budget cuts.

In a 1983 survey of city and county officials by the American Planning Association, 29 percent reported having poor information on the current conditions of the city's or county's capital stock and 48 percent felt they had weak methods of evaluating the cost-effectiveness of proposed projects. Hatry et al. (1984, 1986) surveyed over 40 public works agencies and found capital investment decisions to be highly decentralized. In general, agency management determined what analysis should be undertaken and determined priorities. While most agencies had formal procedures for rating and ranking potential projects, these rankings were often based primarily on subjective information. They found few explicit estimates of expected improvement in service levels or expected reductions in future costs from individual proposed projects.

Budgeting procedures for maintenance were found to be even more deficient. The agencies surveyed undertook only a small amount of regular, systematic examination of capital maintenance and repair options and did not regularly and systematically examine trade-offs between preventive maintenance activity (such as painting bridges or cleaning sewers) and other major options, such as rehabilitation or reconstruction. The Hatry study found no examples in which a local government considered the costs of deferred maintenance.

Several proposals for maintenance evaluation procedures have surfaced in recent years for several common forms of public infrastructure. For example, Archuleta (1986) proposed a program for effective preventive maintenance for water and wastewater facilities. Pavement maintenance management systems promoted by the American Public Works Association (1987) enable managers to monitor road pavement conditions and schedule needed repairs. Carlson (1986) of the Federal Highway Administration proposed a similar systematic maintenance review process for bridges. Implementation of such proposals,

■ 3 These arguments were first advanced by Leonard (1986) and are also presented in Blumenfeld (1986) and the National Council of Public Works Improvement (1988).

however, often requires a crisis atmosphere. The state of Connecticut, for example, instituted a comprehensive bridge inspection and repair program that identified and ranked needed bridge reconstruction following the 1-95 tragedy. There is no obvious general groundswell of public opinion, however, for the reform of infrastructure accounting procedures.

Maintenance and Visibility

Many aspects of the infrastructure problem, particularly issues of maintenance and rehabilitation, have low levels of visibility and are not readily apparent to voters and elected officials. The costs of neglected infrastructure accrue over time and are not immediately apparent or measurable. As discussed in Eberts (1988), often they occur in the form of lost productivity and slower regional growth. Even when observed, the long-run benefits of maintenance practices are potentially discounted by elected officials with short time horizons. Cohen and Noll (1984), for example, demonstrate that legislators maximizing the probability of reelection seek to defer such costs.

Elected officials may also derive greater utility from new investment than from maintenance. Possible sources of utility from capital projects for public officials include political support and contributions from direct project beneficiaries. Weingast et al. (1981) present a model of legislative behavior in which the geographic incidence of benefits and costs systematically biases public decisions toward larger-than-efficient projects. Capital projects give benefits directly to a small group, while their costs are widely distributed.

Further political benefits come from being associated with large and visible investment projects that do not accrue from the more mundane activities of maintenance. An assistant secretary for Housing and Urban Development asked, "Have you ever seen a politician presiding over a ribbon-cutting for an old sewer line that was repaired?" Such effects further encourage the substitution of investment for maintenance.

Capital Financing Policies

The political and budgetary bias against infrastructure maintenance is reinforced by two common features of capital financing: debt-financing of new capital and the traditional emphasis of federal grant policies on capital subsidies.

Local governments often finance new purchases of capital, as well as major reconstruction and rehabilitation, through borrowing. Ordinary maintenance expenditures, however, are counted as operating expenses and are financed through current funds. This treatment of maintenance stems in part from the wide variance of maintenance activities. Certain maintenance activities, such as sweeping sidewalks or patching potholes, have immediate short-term benefits and, according to the benefit principle of public finance (those who benefit from public services should pay), should be paid for by the immediate beneficiaries through current revenues. The benefits of other maintenance activities, such as painting bridges or flushing sewers, accrue over many years. Maintenance of this sort constitutes a form of public investment that according to the benefit principle should be paid over many years through debt-financing.[5]

Treating all maintenance activities as current expenses ineligible for debt-financing ignores their investment component and results in underfinancing when operating budgets are tight. During periods of budget constraints, officials choose between funding preventive maintenance at the expense of cutting back on other programs, or allowing infrastructure to deteriorate until major reconstruction is needed, which can be funded through debt. As the mayor of Lincoln, Nebraska observed, "In the choice between laying off police and maintaining sewers, the sewers always lose."[6]

Federal grant policies for public infrastructure further exacerbate the bias against infrastructure maintenance. Under the rationale that local taxpayers should pay to operate the facilities presented to them, federal grants often heavily subsidize new construction, but provide no assistance for maintenance or other operating expense.

A wide range of federal grant programs provide major assistance for infrastructure at the

4 Newsweek, August 2, 1982. Also cited in Leonard (1986).

5 Maintenance is often considered in the operations research and investment literature to be a fixed operating expense. For a standard example, see the optimal equipment replacement model in Jorgenson et al. (1967) and the discussion in Nickell (1978). For good reviews of models of preventive maintenance, see Pierskall and Voelker (1976) and Sherif and Smith (1981). The treatment of maintenance as a form of investment is shown in Bitros (1976). This approach is used in models of housing stock maintenance, in which maintenance expenditures have important effects on rental income and sale price. See Vorst (1987), Amott et al. (1983), and Sweeney (1974) for examples of such models.

6 Newsweek, op. cit.

state and local level. In 1988, $25 billion in federal grants accounted for 26 percent of state and local capital spending. This included $13.7 billion granted by the Federal Highway Administration (FHWA) for the construction and rehabilitation of highways; $2.6 billion from the Environmental Protection Agency for pollution control and abatement; $2.4 billion in capital financing for mass transit administered by the Urban Mass Transit Administration (UMTA); and $3.1 billion granted through the Community Development Block Grant program.'

While the structure of grants varies from program to program, most provide capital assistance at a high matching rate, with the state and local government required to meet the matching share. The FWHA provides financing for completion, rehabilitation, and reconstruction of the interstate highway system at a 90 percent matching rate. Discretionary grants from UMTA for major rail and subway systems provide funds up to a 75 percent matching rate. Formula grants from UMTA pay 80 percent of the cost of regular transit vehicle replacement. No corresponding subsidies, however, are provided for maintenance. These subsidies distort the relative prices facing local governments for new investment versus maintenance of existing infrastructure. Even if the federal matching rate is not specified in formula, the expectation of federal aid potentially induces local officials to substitute away from maintenance. The empirical work we now turn to attempts to identify such substitution.

II. Local Mass Transit: A Natural Experiment on Subsidies and Infrastructure

As discussed in the previous section, several elements of public accounting, political and budget processes, and capital financing potentially lead to underfunding of infrastructure maintenance and result in excessive deterioration of public capital. Empirical research on the relative importance of these issues, however, has been limited by a dearth of data on capital assets and maintenance, and by a lack of obvious natural experiments with which to evaluate public-sector maintenance practices. In two recent studies, Cromwell (1988a) and Cromwell (1988b), however, I examine the impact of capital subsidies on investment and maintenance decisions of local governments, using data on the maintenance policies of both publicly and privately owned local mass-transit providers. While not addressing all issues of infrastructure maintenance, these studies suggest that the structure of federal grants has significant effects on the infrastructure decisions of state and local governments.

The data used were collected under the Section 15 Reporting System administered by the Urban Mass Transportation Administration (LJMTA). Section 15 data for fiscal year (FY) 1979 through FY1985 are available for 435 transit systems. The data set contains extensive information on vehicle fleets as well as expenditures and labor hours for vehicle maintenance, providing a consistent measure of public capital and maintenance efforts not previously seen. These data provide an unusually detailed panel of local governments' physical assets. Vehicle inventories for each system are broken down by model, year of manufacture, and mileage.

Data are also available for certain privately owned and operated systems. Their inclusion in the Section 15 data results from contracting with a public recipient of Section 9 funds to provide transit services. As these contracts often provide for the leasing of public vehicles, care was taken to examine maintenance and scrappage decisions only on vehicles owned outright by private operators.

Federal Transit Policies

The federal government finances a major part of local public mass transportation. The principal federal grant program for entities that only operate bus lines (the focus of these studies) is the Section 9 formula grant program that distributes funds to urbanized areas for use in transit operating and capital expenditures. The Section 9 capital funds are principally used for vehicle replacement and pay up to 80 percent of the cost of a new vehicle. As funds are adequate for normal vehicle replacement, this matching rate represents an enormous marginal subsidy for new capital.

Vehicle maintenance, however, is counted as an operating expense and is ineligible for the capital subsidy. Due to a desire by UMTA to wean local entities away from operating assistance, the Surface Transportation Act of 1982 capped the level of funds available for operating assistance for FY1983 and beyond to some 90 percent of the FY1982 level, or to 50 percent of a property's operating deficit, whichever was

7 See U.S. Office of Management and Budget (1989). For further discussion of federal grants-in-aid, see Delmar and Menendez (1986).

TABLE 1

Used Transit Vehicle Prices in 1987 and 1988

Year of Manufacture	Average Price	Max. Price	Min. Price	Number of Observations
Public				
1961-65	$ 301	$ 1,000	$ 100	255
1966-70	841	3,500	400	163
1971-75	1,648	6,000	250	239
1976-80	8,863	17,000	3,300	8
Private				
1961-65	$3,500	—	—	11
1966-70	6,590	—	—	11
1971-75	7,500	—	—	9
1976-80	18,000	—	—	1

SOURCE: Telephone survey by author.

lower. The overwhelming majority of public-transit properties are constrained by the cap and receive no operating assistance on the margin.

Federal control over maintenance principally consists of setting an upper limit for deterioration of federally purchased equipment. UMTA requires local transit properties to operate buses purchased with federal funds for at least 12 years or 500,000 miles.[8] Failure to do so results in a penalty in federal assistance for new capital purchases. This 12-year limit, however, is below the potential operating life of 15 to 20 years for standard bus models when properly maintained.

The structure of the UMTA grants results in a large distortion in the relative price of maintenance versus new investment for buses over 12 years old. If the capital and maintenance decisions of local government are sensitive to the structure of subsidies, we would expect the following results. First, publicly owned buses should depreciate quickly, with little physical or financial value left after 12 years. Second, we would expect higher average levels of maintenance in the private sector compared to the public sector. Finally, in the public sector we would expect low levels of scrappage before the 13-year point, a marked shift in scrappage at year 13, then high levels of scrappage thereafter. A similar pattern for privately owned vehicles is unlikely, as they are not subject to such a discontinuity in the price of new equipment[9]

III. Empirical Evidence on Subsidies and Transit Capital

Evidence from Used-Bus Prices

Evidence from used-bus prices supports the thesis that public equipment depreciates rapidly. The used-bus market is highly fragmented and ad hoc in nature. The disposition of equipment is not reported in the Section 15 data, and no central data source of used-bus prices or sales exists. UMTA officials report, however, that the used transit bus market is depressed. The supply of public vehicles over 12 years old far exceeds demand—and vehicles are most commonly sold for scrap. Depressed prices, however, are also consistent with systematic undermaintenance of equipment.

To confirm this, I collected transaction prices for some 645 transit vehicles sold in 1987 and 1988 by contacting all properties that solicited bids for used vehicles during this period.[10] The results of this survey are shown in table 1. Prices for publicly owned vehicles manufactured before 1971 ranged from $100 to $3,500, with an

■ 8 See UMTA (June 1985)

9 Previous studies on transit subsidies have used detailed engineering data from specific transit systems to simulate the effects of capital bias in the subsidy structure on scrappage dates. Tye (1969) used data from the Cleveland and Chicago transit systems to simulate the effect of subsidies in the late 1960s that paid for new capital at a 66.6 percent rate, but which provided no assistance for operating expenses. He calculated that the subsidy would lead a cost-minimizing transit firm to replace buses at half the efficient age. For average levels of utilization, this implied scrappage at 8 to 10 years versus an efficient 17 to 20 years, with the resulting waste of resources equaling 27 percent of the subsidy. Similarly, Armour (1980) used data from Seattle Metro and calculated that the 80 percent federal capital subsidy reduced the optimal scrappage point from 20.5 to 26 years to 8.5 to 10 years.

Frankena (1987) is the paper closest in spirit to the empirical work presented here. Using probit estimation with 1961 to 1983 data on scrappage of Canadian buses, this study shows that scrappage increases with age, and that significantly higher average scrappage rates followed the imposition of a capital-biased subsidy program in 1972. He finds no significant change, however, in the scrappage rate when the capital subsidies take effect at age 15 (the critical point in the Canadian subsidy program). In general, the hazard-model estimators used here dominate the probit approach. They allow for variation in the underlying hazard rate over time, and control for bias introduced by vehicles dropping out of the sample when scrapped. The results, as will be seen, show a significant impact on scrappage when subsidies take effect.

10 Used-bus prices were obtained by contacting all agencies soliciting bids in *Passenger Transport* between January 1987 and June 1988. Typically, less than 10 bids were received per auction with a mean of five bids reported by properties that would provide this information. Those bidding included Caribbean nations, church groups, charter-bus operators, people planning to make recreational vehicles, and farmers in need of storage space. If the vehicles were purchased with federal funds, UMTA collected 80 percent of the proceeds with an allowance made for administrative expenses. The costs of soliciting bids or holding an auction, however, often were reported to exceed the remaining local share.

TABLE 2

Vehicle Maintenance Expenses and Labor Hours[a]

	Private	Public
Expenses per mile ($1.00)	0.77 (0.12)	0.53 (0.02)
Labor hours per 1,000 miles	37.8 (3.6)	29.3 (1.4)
Percent of fleet > 12 years old	38.4	22.0
Percent mileage on vehicles > 12 years old	26.7	11.2
Number of observations	22	100

a. 1984 cross-section sample means (standard errors).
SOURCE: Author's calculations.

average price of $511. Even vehicles reported to be well-maintained typically did not sell for over $3,000. Prices for vehicles manufactured between 1971 and 1975 ranged from $250 for scrapped vehicles to $6,000 for well-maintained vehicles. Prices for newer vehicles manufactured between 1976 and 1980 averaged $8,863.

I was also able to obtain used-vehicle prices for a much smaller sample of privately owned vehicles. These prices, also shown in table 1, suggest that the private vehicles are in better condition and command a higher price, with prices averaging from $3,500 to $7,500 for vehicles manufactured before 1976. Other private companies, however, reported selling their vehicles for scrap at the depressed prices similar to those received by public agencies.

The extremely low prices on used buses suggest that maintenance practices can lead to rapid deterioration of equipment in the public sector. It is important, however, to distinguish between variations in maintenance and depreciation attributable to unavoidable operating conditions, and variations due to capital grant policies or bureaucratic behavior that are potential sources of government inefficiency. The empirical work that follows attempts to identify these separate effects.

Evidence on Maintenance

The impact of the capital grant structure on average levels of maintenance is examined in Cromwell (1988a). My initial empirical work examines a cross-section of Section 15 data for FY1984 from 122 transit properties. The sample consists of single-mode bus operators—properties that provide only fixed-route bus service as opposed to rail or demand-response service—that operated at least five revenue vehicles. Table 2 reports sample means for maintenance expenses and maintenance employees, scaled by annual vehicle miles. In general, the average levels of both expenses and labor hours follow the predicted patterns. The private systems, on average, spend 45 percent more on maintenance per mile and devote 29 percent more labor hours to maintenance than do the public systems.

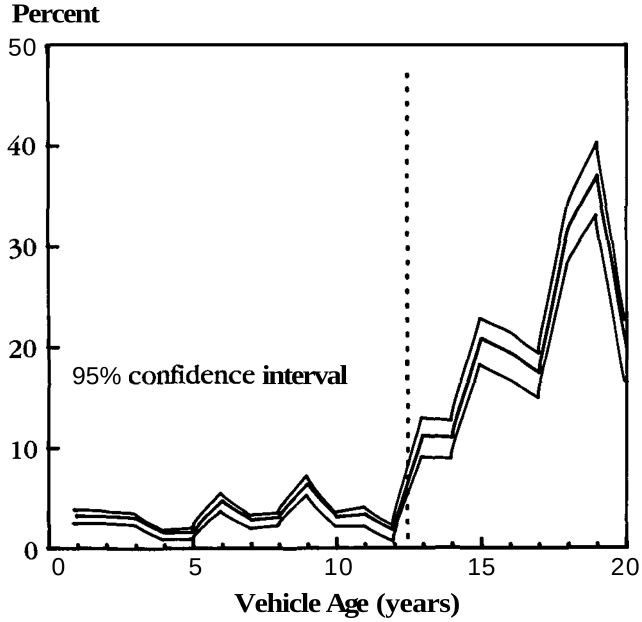
The average age of vehicles in private systems is substantially higher than that for public fleets, with 38.4 percent of the private fleets being more than 12 years old compared to 22.0 percent of the public fleets. The distribution of vehicles weighted by miles is similar, with 26.7 and 11.2 percent of the mileage being run on vehicles older than 12 years for the private and public systems, respectively. The older fleet in the private systems is consistent with privately owned capital deteriorating slower than publicly owned capital as a result of greater maintenance efforts.

The means shown in table 2, while consistent with the predicted results regarding the private versus public operators, do not control for systematic differences due to wages, operating conditions, and fleet composition. For example, many of the private systems operate in the New York metropolitan area, which is noted for its harsh operating conditions. To examine the public/private differential more systematically, I use pooled time-series cross-section regression analysis on a sample of systems between 1982 and 1985. Independent variables include maintenance wage rates, operating conditions, fleet composition, fleet age, and a dummy variable for operation in the New York area. The results show that, controlling for wages, operating conditions, and fleet composition, privately owned transit companies devote some 14 to 17 percent more labor hours to maintenance than do publicly owned and managed transit companies. The analysis then uses this public/private differential, along with cross-state variation in grant policies, to measure the elasticity of maintenance with respect to capital subsidies. The point estimates suggest an elasticity of –0.16, meaning that a 10 percent increase in the subsidy rate for transit capital reduces vehicle maintenance by 1.6 percent.

The estimates are statistically significant and suggest that average maintenance levels are higher in the private sector. They do not necessarily demonstrate, however, that public capital deteriorates at a faster rate than privately owned

FIGURE 1

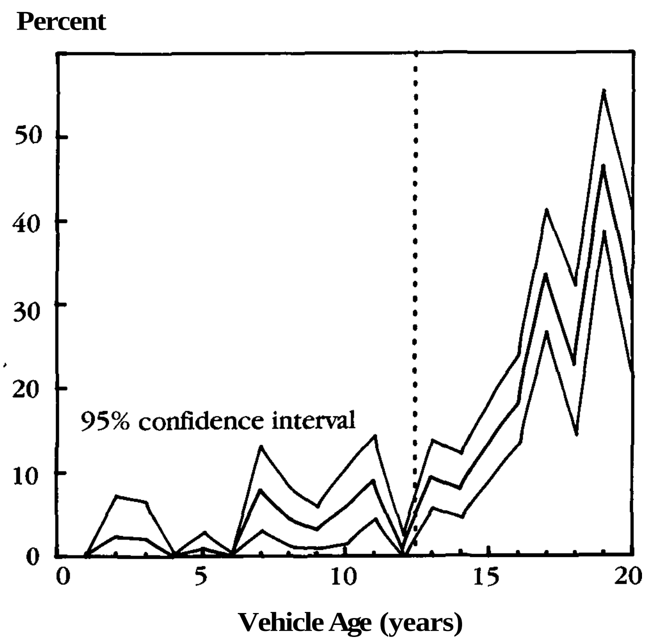
Scrappage Rate Public Vehicles



SOURCE: Author's calculations.

FIGURE 2

Scrappage Rate Private Vehicles



SOURCE: Author's calculations.

capital. The higher levels of maintenance labor hours could be attributed to less capital-intensive maintenance practices. Furthermore, an implicit assumption that maintenance is qualitatively similar between the two sectors could be false. If one sector fixes equipment upon failure, as opposed to conducting preventive maintenance, differences in overall maintenance levels could result. The companion analysis in Cromwell (1988b), however, directly examines the scrappage and retirement rates of private versus public equipment to determine whether the higher maintenance in the private sector is reflected in longer equipment life.

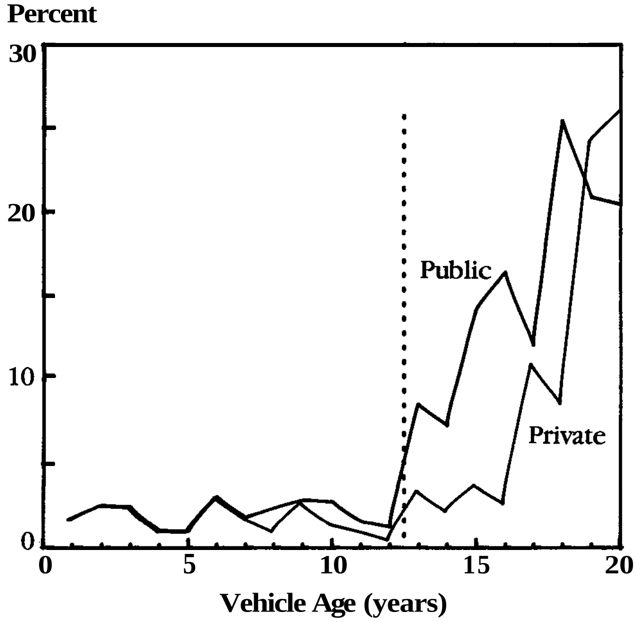
Evidence on **Scrappage**

Cromwell (1988b) examines the impact of subsidies on equipment life by tracking vehicles in the UMTA data set from 1982 through 1985. Scrappage decisions were observed for 15,829 vehicles, including 1,005 privately owned vehicles from 11 privately owned companies. Vehicles that changed from active to inactive status or that were dropped from the fleets between report years were counted as scrapped. The results provide strong evidence that federal grant policies have a direct impact on local scrappage decisions.

The probability of scrappage for public and private vehicles of different ages (or empirical hazard) can be estimated directly from the observed scrappage rates and is plotted, with 95 percent confidence intervals, in figures 1 and 2.[11] The estimates in general suggest the importance of federal grant policies for public-sector scrappage. The hazard for public vehicles averages under 4 percent for years prior to age 13, then jumps to over 11 percent at age 13, decreases slightly at age 14, then rises steadily to 37 percent by age 19. Standard errors calculated for these estimates suggest that the hazards for public vehicles are measured with much precision and that the shift at the 13-year point is statistically significant.

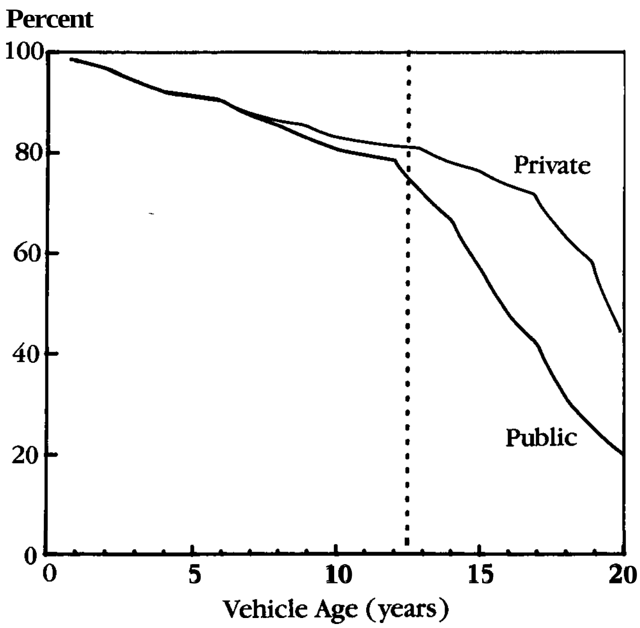
■ **11** The empirical scrappage rate presented here is also known as the Kaplan-Meier (1958) hazard estimator, which directly estimates the hazard function from the sample of vehicles. For each time t, the number of failures *D(t)* (that is, the number of vehicles scrapped) is divided by the total number of vehicles at risk at the start of time *t*, *R(t)*. Censored spells (that is, vehicles that are not observed to be scrapped) are included in the risk set previous to their censor time and are dropped thereafter. This treatment of censoring yields a consistent estimate of the true hazard at each time t as long as the censoring mechanism and vehicle age are independent of each other. The standard errors were estimated following a suggestion in Kalbfleisch and Prentice (1980).

FIGURE 3



SOURCE: Author's calculations.

FIGURE 4



SOURCE: Author's calculations.

The private-vehicle hazards are estimated with less precision and exhibit more volatility, but in general show a rise in scrappage from near 0 for the 1- to 6-year period to an average 5 percent for the 7- to 10-year period to 9 percent at the 13-year point. Due to only one scrappage out of 143 in the age-12 risk set, however, the estimated hazard at year 12 is quite low, and a shift appears to occur at the 13-year point—contrary to the predicted pattern. This shift can be attributed, however, to the smallness of the sample size and, given the estimated hazards in the surrounding years, the pattern of estimated hazards for private vehicles appears to be markedly different from the public sector.

These empirical hazard rates do not account for heterogeneity across transit systems in prices of maintenance and operating conditions. Given the large number of private vehicles operating in the New York metropolitan area, for example, adverse operating conditions might have a major impact on observed private-sector scrappage. To account for this heterogeneity, I employed a hazard estimator that allows for nonparametric estimation of the baseline scrappage rate, while permitting estimation of the impact of operating conditions, wage rates, and other explanatory variables.[12] The resulting baseline hazards are shown in figure 3. The impact of the grant structure on public-sector scrappage is readily apparent. While the private-sector baseline remains under 5 percent until year 16, and then rises steadily through year 20, the public-sector baseline takes a distinct and significant jump at the 13-year point from 1 percent to over 8 percent, twice that of the private sector. Scrappage then rises to over 14 percent for 15- and 16-year-old vehicles and remains above the private sector until year 19. The distinct difference in scrappage rates can be attributed to the availability of federal grants.

An alternative approach to examining public and private scrappage is to look at the survivor functions for the two sectors. The survivor function is defined as the percentage of vehicles of a given vintage that survive to a given age, as shown in figure 4. The functions further emphasize the difference between public and private

12 The baseline hazard estimates shown here are estimated using the semiparametric hazard estimator shown in Meyer (1988) and first developed in Prenlice and Gloeckler (1978). This estimator allows for control of explanatory variables without imposing a specific structural form on the underlying baseline hazard. Cromwell (1988b) also presents estimates using the fully parametric estimator which imposes the commonly used Weibull baseline as shown in Lancaster (1979) and Katz (1986).

scrappage policies. They track closely through year 12, then diverge as public scrappage sharply increases. Again, this shift in the survivor function at the 13-year point can be attributed to the sudden availability of federal subsidies. By age 16, only 47 percent of the public vehicles survive, compared to 73 percent for private vehicles. At age 20, 45 percent of private vehicles are still estimated to be in operation, versus 20 percent for the public sector.

The consistently lower survival rate of publicly owned vehicles after the availability of federal funds is direct evidence that federal capital grants reduce equipment life in the local public sector. It suggests that federal grant policies that subsidize the purchase of new capital, but that ignore the maintenance of existing capital, result in the increased deterioration of public infrastructure. The magnitude of savings for the transit industry from a shift in policies, however, may be small if increased maintenance expenses offset reduced vehicle expenditures. In a simulation of vehicle replacement reported in Cromwell (1988b), this is the case. In spite of increased deterioration of public capital, the net efficiency losses of the federal subsidies appear to be low. There may be unobserved costs, however, in terms of quality of service that result from lower maintenance levels and increased deterioration of equipment.

IV. Conclusion

Several aspects of public accounting, political and budgetary procedures, and capital financing potentially lead local governments to systematically underfund the maintenance of public infrastructure. The resulting excessive deterioration of public capital has been advanced as a possible source of the "infrastructure crisis" of recent years.

This article summarizes the results of two studies of one aspect of infrastructure maintenance: the impact of large federal capital subsidies for new investment with no corresponding subsidies for maintenance. Using data from the local mass-transit industries, the empirical results suggest federal subsidies for new transit vehicles lower maintenance levels and increase scrappage rates in public transit systems. The extremely low resale value of used vehicles further suggests excessive deterioration. In the case of local mass transit, however, the net cost of the distortion appears to be small. The results suggest that increased purchases of vehicles are offset by lower maintenance costs.

While the efficiency losses of the transit subsidies for new vehicles appear to be small, they still show that local governments respond significantly to incentives in the price of maintenance versus new investment introduced by federal subsidies. Given the several other biases against infrastructure maintenance discussed in section I, this suggests that federal policies should focus more on the maintenance and upkeep of facilities purchased with federal funds. Possible proposals to support maintenance include reducing the distortion in the relative price of maintenance versus new investment facing local authorities through direct federal subsidies of important maintenance activities or through a reduction in the federal subsidy rate for capital projects. Adoption of preventive maintenance programs developed by public works experts could also be a requirement of receiving federal aid. Leonard suggests the development of a maintenance schedule at the time of acquisition of a new capital facility. The financial requirements for maintenance would be a formal liability recorded on a jurisdiction's financial statement. Reforms in this direction would help ensure that existing capital is better preserved and that large projected investments in new infrastructure are not wasted.

Finally, future research in this area could include analysis on how the incentive effects described here for the local mass-transit industry apply to other forms of infrastructure. Using the standard optimal equipment replacement model in Cromwell (1988b), one would expect that the elasticity of optimal equipment life with respect to capital subsidies is larger for capital goods with shorter useful equipment lives, and larger for capital goods whose acquisition costs are large relative to maintenance costs. It would be interesting to examine the difference in magnitude of the distorting effects of federal subsidies for infrastructure with these characteristics.

Furthermore, the distorting effects of capital subsidies are likely to be more severe when the deterioration of infrastructure is less visible—as in the case of sewers, water mains, or the undersides of bridges. Less visibility reduces the ability of voters or federal bureaucrats to monitor the condition of local infrastructure. Such monitoring potentially acts as a check on the incentives to undermaintain that are introduced by capital subsidies.

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