MAIL CODE: EA & EG

WORKING PAPERS

CAPITAL-BIASED SUBSIDIES, BUREAUCRATIC MONITORING, AND BUS SCRAPPING

Mark W. Frankena

WORKING PAPER NO. 83

April 1983

BUREAU OF ECONOMICS
FEDERAL TRADE COMMISSION
WASHINGTON, DC 20580

Do not cite without permission. Comments solicited.

CAPITAL-BIASED SUBSIDIES, BUREAUCRATIC MONITORING, AND BUS SCRAPPING

Mark W. Frankena
Department of Economics
University of Western Ontario
London, Ontario N6A 5C2 Canada

December 1982

Abstract

A model of bus scrapping behavior yields the hypothesis that capital-biased subsidies will increase the scrapping probability and reduce the expected life for urban transit buses and hence waste resources. Governments have instituted bureaucratic approval requirements to prevent capital-biased subsidies from leading to "premature" scrapping of buses. If effective, these requirements would reduce the impact of capital-biased subsidies on the scrapping probability for buses which are less than 15 years old. Estimates of a probit model using data for Ontario in 1963-81 support the hypothesis that capital-biased subsidies increase the scrapping probability but do not support the hypothesis that bureaucratic monitoring has prevented "premature" scrapping.

1. Introduction

Government subsidies for the cost of producing a number of goods and services have been criticized by economists on the grounds that they are "capital biased," i.e., that the percentage rate of subsidy is greater for capital costs than for non-capital costs. Provided that the elasticity of substitution between capital and other inputs in the production function is positive, capital-biased subsidies provide producers with an incentive to choose an inefficiently high capital intensity because the capital intensity which will minimize private costs will exceed the capital intensity which will minimize social costs. The excess social cost of the chosen capital intensity represents a waste of resources.

In some cases governments have instituted bureaucratic monitoring and approval procedures to limit the extent to which subsidized producers can respond to the incentive to increase capital intensity. This does not eliminate the inefficiency, because the monitoring costs could be avoided if the capital bias were removed. However, the monitoring costs may be less than the waste of resources that would occur if producers were free to minimize private costs given a capital-biased subsidy.

The purpose of this paper is to evaluate empirically the impact of a capital-biased subsidy program for which the government claims to have bureaucratic checks sufficient to prevent any distortion in capital intensity. I analyze the effect of Ontario, Canada provincial government subsidies on the scrapping of urban transit buses. The results should be of interest to people concerned with the design of subsidy programs and with bureaucratic behavior.

2. Ontario Transit Subsidies[1]

Urban transit services in Ontario are provided mainly by firms owned by municipal governments and operated by quasi-independent commissions. All systems began to receive operating subsidies from their municipal governments at some time during the decade preceding 1972. These municipal government subsidies do not concern us here because they did not provide an incentive to change bus scrapping behavior.

Since December 1972 the Ontario provincial government has paid 75 percent of the cost of purchasing urban transit buses. The subsidy is paid on the difference between expenditures on new or used buses and revenues from the sale of used buses.[2] In addition, between 1971 and 1976 the province paid 50 percent of the operating losses of urban transit firms. Since 1977 the province has paid 13.5 to 25 percent (depending on urban area population) of the cost of non-capital inputs.

It is clear that since 1977 there has been a severe capital bias in provincial subsidies. It is hard to be certain exactly how much capital bias there was between December 1972 and 1976, however. Municipalities paid the 50 percent of operating losses not covered by the province. If the municipal operating subsidy was a lump-sum grant, then the provincial operating subsidy was a matching lump-sum grant; in this case, there was no subsidy for non-capital costs, and the capital bias was very severe. However, if the municipal subsidy was based on non-capital costs, then the province effectively gave an equal subsidy for non-capital costs; in this case, the capital bias was less. Still, since operating losses were always less than 75 percent of operating costs, the combined rate of provincial and municipal subsidies for non-capital costs was less than 75 percent, and there was some capital bias.

In short, until the end of 1972 there was no capital bias. Beginning in 1977 there was a severe capital bias. Between December 1972 and 1976 there was a capital bias, which may have been somewhat greater or less than the bias since 1977.

In order to obtain the 75 percent subsidy for the cost of buses, a transit system has to obtain the approval of the provincial ministry of transportation before placing an order for buses. The implications of this requirement for bureaucratic approval are important in this study and will be made clear shortly.

3. A Model of Bus Scrapping Behavior

In order to evaluate the effect of capital-biased subsidies, we begin with a model of bus scrapping behavior which is similar to the model of automobile scrapping used by Parks (1977).

Suppose that during each period a bus requires a number of units of maintenance and repairs in order to remain in operation. The amount of maintenance is assumed to be a random variable whose distribution depends on the durability of the bus-type and the age of the vehicle. Durability may, for example, be different for gasoline and diesel buses and for different makes. Let $M^i(A)$ be the amount of maintenance required for a bus of type i and age A. We assume that the expected value of such maintenance increases with age, i.e., $dE(M^i)/dA > 0$. This assumption is supported by a study by Puccini (1979, Fig. 11), which reports that for a transit firm in Ontario in 1976 average maintenance costs per kilometer increased by 0.69 cents with each year of bus age.

The decision to scrap a particular bus is assumed to be made not on the basis of the expected value of M^i but rather taking account of the realized value of M^i. Letting C(t) be the cost per unit of maintenance in period t, a transit firm will scrap a bus if and only if the realized maintenance cost $C(t)M^i(A)$ exceeds the difference between the value of an operable A year old bus of type i, $P^i(A,t)$, and its scrap value, $S^i(A,t)$.

Given $f^i(M^i;A)$, the density function for M^i, one can determine $Z^i(A,t)$, the conditional probability that a bus which has survived to age A will be scrapped at that age:

$$(1)\quad Z^i(A,t) = \int_B^\infty f^i(M^i;A)\,dM^i$$

where $B = (P^i - S^i)/C$. The probability of scrapping is an increasing function of bus age, of the cost per unit of maintenance, and of the scrap value of the bus and is a decreasing function of the value of an operable used bus.

4. Hypotheses Concerning the Effects of Subsidies

A "neutral" cost subsidy for urban transit which applies at the same percentage rate to all costs would not change the scrapping probabilities for buses, provided the supply of new buses and the demand for scrapped buses were perfectly elastic with respect to price. This is because it would not change the lower limit of integration in Equation (1) above. However, a capital-biased subsidy would reduce the lower limit of integration and increase the probability of scrapping.

The prediction that a capital-biased subsidy would increase the probability of scrapping for buses has not previously been tested empirically.[3] However, two studies have used engineering data to simulate the effects of capital-biased subsidies on the (expected) age at which urban transit vehicles would be scrapped. Tye (1969) simulated the effect of the capital-biased subsidies that existed in the U.S. in the late 1960s, when the federal government provided a 66 2/3 percent subsidy for the purchase of new transit vehicles but no subsidy for their operation or maintenance. Tye calculated that this subsidy would induce a transit firm which was minimizing private cost per vehicle mile to replace buses at half the efficient age. He also calculated that the resulting waste of resources would equal 27 percent of the amount of the subsidy.

Armour (1980) analyzed the effect of an 80 percent U.S. federal subsidy for the purchase of new transit vehicles, combined with no subsidy for operation or maintenance, on the age at which buses would be replaced in Seattle in order to minimize local costs. He concluded:

> For Seattle Metro, which operates a bus an average of 40,500 miles per year, the economic replacement age is between 20.5 and 26 years at full capital costs, depending on utilization. The same utilization would place the economic replacement age between 8.5 and 10 years if the 20 percent local share...is perceived as the only capital cost. Obviously the UMTA (U.S. Federal Urban Mass Transportation Administration) capital grant program can influence a premature retirement of vehicles. It reduces by about 60 percent the years a vehicle need be utilized at given outputs in order to minimize local costs. (p. 53)

Thus, standard economic models and simulation exercises predict that a capital-biased subsidy would increase the probability of scrapping for buses of all ages. However, this specification of the model ignores the implications of bureaucratic procedures designed to prevent "premature" scrapping of buses in response to the incentives provided by the subsidy. For example, in Ontario bureaucrats at the Ministry of Transportation and Communications, which administers the transit subsidy program, claim that they will not approve applications for subsidies to replace buses prematurely, i.e., at less than what they refer to as "the expected service life of 15-18 years." Similarly, Hilton

(1974, p. 59) reports that U.S. federal bureaucrats claim to require that buses be at least 15 years old before they will approve a subsidy for their replacement.

Suppose then that the government introduces a capital-biased subsidy for transit buses and imposes the condition that the subsidy for a new bus will be denied if a bus less than 15 years old is scrapped within Y months of the time the new bus is acquired. Some small transit systems might be able to evade this fairly easily because they could do their buying and scrapping at different times. However, larger systems would have difficulty doing this unless Y was small. (They might, however, hold on to but not use buses less than 15 years old and then scrap them when they reach 15 years old.) Suppose, therefore, that the condition is effective. The bureaucrats in question evidently believe that such a condition will prevent the subsidy program from affecting the expected life of a bus, but obviously this is not true in our model. The subsidy will still be capital biased for buses 15 years old and older, and hence we would predict that it would increase the probability of scrapping for such buses. By contrast, introduction of a subsidy for replacement of buses 15 or more years old would *reduce* the probability of scrapping for buses less than 15 years old because a transit firm has a strong incentive to postpone scrapping of a bus until it is 15 years old.

Thus, we have two alternative hypotheses, depending upon whether bureaucrats really would withhold subsidies if a bus under 15 years old were scrapped. If subsidies would not be withheld, we predict that a capital-biased subsidy program would increase the probability of scrapping for buses of all ages. If subsidies would be withheld, we predict that the same subsidy program would reduce the probability of scrapping for buses less than 15 years old and increase the probability of scrapping for buses 15 years old and older (assuming all buses scrapped are replaced, which is realistic during the period under study.)

5. Specification of the Econometric Model

In order to develop an econometric model for the purposes of estimation, we assume that the probit of the scrapping probability for a bus is a linear function of the relevant independent variables. The scrapping probability is, of course, unobservable. What we observe is whether or not a bus is scrapped. The variable SCRAP is defined to take a value of 1 if a bus is scrapped during a one-year period and 0 if it is not. The following independent variables were included in the analysis:

(a) FUEL

We initially estimated probit equations for diesel and gasoline buses combined. In these equations we included a dummy variable, FUEL, for type of fuel (1=diesel, 0=gasoline) to allow for any difference in durability between buses using different fuels. We had no theoretical reason for expecting one type of bus to be more durable, but casual observation suggested that diesel road vehicles are more durable and hence that the sign of the coefficient on FUEL would be negative. The fuel variable was omitted when the sample was partitioned by fuel and make.

(b) MAKE

We estimated the probit equations initially for all buses combined regardless of make. One might expect that different makes of buses would differ in durability. Since 88 percent of our observations were for General Motors Canada (GMC) buses, while the other 12 percent were for several different makes, we included a single dummy variable, MAKE (0=GMC, 1=other). We had no theoretical reason to expect GMC buses to be more or less durable than others. The make variable was omitted when the sample was partitioned by make and fuel.

(c) AGE

The theoretical model outlined in Section 3 above yields the hypothesis that the probability of scrapping increases with age (measured here in years).

(d) Subsidy Policy Variables

We considered two alternative specifications of the subsidy policy. First, we considered the possibility that capital-biased subsidies were introduced without bureaucratic monitoring to prevent "premature" retirement of buses. For this case, we used a dummy variable, S1, which takes a value of 1 when subsidy policies are capital-biased and 0 otherwise. The Ontario government introduced capital-biased subsidies in December 1972, and there was an order backlog of about a year for buses. Consequently, the capital bias would not have begun to affect scrapping decisions until 1974. We let S1=1 for observations during 1974-81 and S1=0 for 1963-73.[4] Our model suggests the hypothesis that the coefficient on S1 is positive.

Second, we considered the claim that the government introduced bureaucratic controls designed to prevent capital-biased subsidies from inducing "premature" scrapping of buses. Specifically, we considered the possibility that the government would have rejected capital subsidy applications from firms replacing buses that were less than 15 years old. In place of S1, we defined two variables. We let S2=1 for observations during 1974-81 for buses that were 15 or more years old and S3=1 for observations during 1974-81 for buses that were under 15 years old. For 1963-73, S2=S3=0 regardless of bus age. Our basic model suggests the hypothesis that the coefficients on both S2 and S3 will be positive. However, if bureaucratic monitoring is entirely effective, the coefficient on S3 should be zero or even negative.

(e) WAGE

Our model predicts that, other things equal, a higher cost per unit of maintenance in any period will lead to a higher probability of scrapping. Apart from this direct effect, a higher cost per unit of maintenance may lead to a higher anticipated future cost of maintenance and hence a lower price for used buses and a higher probability of scrapping. Because of availability, we used the real wage rate (in 1981 Canadian dollars per hour) for bus drivers as a proxy for the cost per unit of maintenance. However, because the results were mixed, we also estimated the equations without this variable and without the next three variables on the list.

(f) BUS-PRICE and INTEREST

The model predicts that an increase in the difference between the price of an operable used bus and the scrap value of a bus would reduce the scrapping probability. No data on these prices are available. However, an economic model of the market for used capital goods predicts that the price of an operable used bus would increase if the price of new buses increased of if expected future interest rates increased. The effect of the price of new buses is obvious. The effect of interest rates can be explained as follows: new buses yield a flow of services over a period longer than that for used buses. Hence the ratio of the present discounted value of the services for a new bus to that for a used bus, and the ratio of the price of a new bus to that for a used bus, will decline if the expected future interest rate increases. Since the price of new buses is determined by the cost of production, a decline in the price ratio implies a rise in the price of a used bus. We actually used two variables: the real price of new buses in thousands of 1981 Canadian dollars (BUS-PRICE), and the product of the real interest rate and the real price of new buses (INTEREST). The interest rate is used as a crude proxy for expected future rates. The interactive form was used because the underlying hypothesis was in terms of a ratio.

(g) POPULATION

One would expect that the probability of scrapping would depend not only on the age of a bus but also the number of miles it has been driven. It seems plausible that the number of miles a bus is driven per year varies systematicaly with urban area population, for example because larger cities offer service more hours per week. To allow for this, we included POPULATION, the population (in millions) of the area served by the transit system, as an independent variable. We would expect the coefficient on POPULATION to be positive. This effect would be reinforced during 1977-81 because the extent of capital bias in subsidy programs was positively correlated with the population of the urban area. This is a result of the fact that the operating cost subsidy varied from 13.5 percent for large cities to 25 percent for small ones.

(h) Specifications

Thus, the initial specification of the model used for the full sample of data was:[5]

$$(2) \quad F^{-1}(Z) = a_o + a_1 FUEL + a_2 MAKE + a_3 AGE + a_4 S1 + a_7 WAGE + a_8 BUS\text{-}PRICE + a_9 INTEREST + a_{10} POPULATION + e$$

We also estimated this equation, without the terms a_1FUEL and a_2MAKE, for each of the four fuel-make bus types: GMC diesel, other diesel, GMC gasoline, and other gasoline. In addition, we estimated two alternative specifications for the full sample and for each of the four subsamples. First, we replaced a_4S1 by (a_5S2 + a_6S3). Second, we deleted the last four variables. Thus, we estimated a total of 15 equations. The maximum likelihood estimates are presented in Table 1.

6. Data

The full sample for this study consists of observations of all full-size intraurban buses operated during 1963-81 by Ontario transit systems which were members of the Canadian Urban Transit Association. For each calendar year, we determined whether or not each bus was scrapped. This gave us 42,327 observations, of which 48 percent were for the period 1963-73 before capital-biased subsidies could have influenced scrapping decisions, and of which 3.8 percent represented scrapped buses. While there were four different fuel-make types of bus, 79 percent of the buses were GMC diesels. Because this is a relatively homogeneous subsample which included a large number of observations for buses of all ages both before and after introduction of capital-biased subsidies, we place greatest weight on the estimates for GMC diesels. By contrast, we give virtually no weight to the estimates for other makes of gasoline buses because this sample included only two observations for buses between 9 and 22 years old during the period 1974-81.

Table 1

Maximum Likelihood Estimates of the Probit of the Scrapping Probability

Independent Variables and Predicted Signs		Full Sample			Diesel						Gasoline					
					GMC			Other Makes			GMC			Other Makes		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Constant	(?)	-3.56[d] (-12.4)	-3.46[d] (-12.0)	-3.81[d] (-41.7)	-2.72[d] (-6.1)	-2.82[d] (-6.2)	-5.74[d] (-31.7)	-4.68[d] (-5.9)	-4.44[d] (-5.6)	-4.43[d] (-20.1)	-7.29[d] (-9.9)	-7.32[d] (-9.8)	-3.23[d] (-19.9)	-5.75[d] (-4.6)	-3.02[d] (-2.3)	-3.17[d] (-16.0)
FUEL	(?)	-.409[d] (-9.2)	-.444[d] (-9.8)	-.540[d] (-13.8)	--	--	--	--	--	--	--	--	--	--	--	--
MAKE	(?)	.466[d] (9.8)	.494[d] (10.4)	.532[d] (11.9)	--	--	--	--	--	--	--	--	--	--	--	--
AGE	(+)	.166[a] (40.3)	.151[a] (28.1)	.146[a] (28.8)	.244[a] (33.3)	.253[a] (24.1)	.237[a] (23.0)	.180[a] (14.8)	.203[a] (12.9)	.203[a] (14.4)	.125[a] (10.3)	.126[a] (9.3)	.136[a] (10.6)	.141[a] (9.8)	.190[a] (10.9)	.131[a] (11.9)
S1	(+)	.680[a] (11.5)	--	--	.927[a] (8.8)	--	--	.856[a] (7.2)	--	--	.111 (0.9)	--	--	1.272[a] (6.7)	--	--
S2	(+)	--	.751[a] (12.2)	.741[a] (15.0)	--	.906[a] (8.4)	.480[a] (6.4)	--	.732[a] (5.6)	.599[a] (5.6)	--	.0888 (0.6)	.511[a] (4.3)	--	.505[b] (2.2)	.340[c] (1.5)
S3	(?)	--	.518[d] (7.3)	.489[d] (8.8)	--	1.019[d] (9.0)	.599[d] (6.4)	--	1.252[d] (6.1)	1.197[d] (7.6)	--	.124 (0.9)	.480[d] (4.6)	--	2.826[d] (8.0)	1.632[d] (7.7)
WAGE	(+)	-.0757[e] (-3.4)	-.0615[e] (-2.7)	--	-.428[e] (-9.2)	-.427[e] (-9.2)	--	.152[a] (2.5)	.142[b] (2.3)	--	.0607 (1.1)	.0585 (1.1)	--	-.0724 (-1.5)	-.189[e] (-3.5)	--
BUS-PRICE	(-)	.0012 (0.5)	.0016 (0.6)	--	.0080[e] (1.9)	.0073[e] (1.7)	--	-.0086 (-1.0)	-.0138[c] (-1.5)	--	.0403[e] (5.6)	.0406[e] (5.5)	--	.0276[e] (2.3)	-.0015 (-0.1)	--
INTEREST	(-)	-.0351[a] (-3.6)	-.0352[a] (-3.6)	--	-.114[a] (-6.6)	-.113[a] (-6.5)	--	.114[e] (4.5)	.111[e] (4.4)	--	-.0521[a] (-2.5)	-.0521[a] (-2.5)	--	.0101 (0.9)	.0052 (0.3)	--
POPULATION	(+)	-.314[e] (-1.6)	-.356[e] (-1.8)	--	.111 (0.4)	.116 (0.4)	--	-1.09[e] (1.9)	-1.18[e] (-2.0)	--	-11.3[e] (-2.2)	-11.0[e] (-2.1)	--	3.38[a] (8.0)	4.01[a] (9.0)	--
Other Statistics																
Observations		42327	42327	42327	33601	33601	33601	3541	3541	3541	2588	2588	2588	2597	2597	2597
% 1974-81		52	52	52	60	60	60	36	36	36	25	25	25	5	5	5
% Scrapped		3.8	3.8	3.8	1.8	1.8	1.8	7.4	7.4	7.4	8.1	8.1	8.1	20.1	20.1	20.1
$-2\ln\lambda$ (d.f.)		5040 (8)	5060 (9)	5020 (5)	2729 (6)	2730 (7)	2590 (3)	611 (6)	616 (7)	597 (3)	402 (6)	402 (7)	364 (3)	248 (6)	276 (7)	192 (3)

Notes for Table 1

Notes: t-statistics in parentheses.

[a]Significantly different from zero at 1 percent level, one-tailed test.

[b]Significantly different from zero at 5 percent level, one-tailed test.

[c]Significantly different from zero at 10 percent level, one-tailed test.

[d]Significantly different from zero at 1 percent level, two-tailed test.

[e]Significantly different from zero at 10 percent level, two-tailed test, but sign opposite that predicted.

7. Empirical Results

In this section we discuss the maximum likelihood estimates which are presented in Table 1.

(a) FUEL and MAKE

Both FUEL and MAKE dummies are significantly different from zero at the 1 percent level in all three specifications used for the full sample. Diesel buses are more durable than gasoline buses, and GMC buses are more durable on average than other makes. Moreover, the effects of diesel fuel and GMC make on the probability of scrapping are approximately equal in magnitude.

(b) AGE

The age variable is positive and significantly different from zero at the 1 percent level in all three specifications for all five samples. For the full sample, the effect of a one-year increase in age on the probability of scrapping is about one-third as large as the effect of the MAKE dummy.[6]

(c) Subsidy Policy Variables

Our initial hypothesis concerning subsidies was that the introduction of capital-biased subsidies in December 1972 would increase the probability of scrapping during 1974-81. In fact, the coefficient of S1 is positive and significantly different from zero at the 1 percent level as hypothesized for all but one sample; the exception is GMC gasoline buses, which accounted for only 6 percent of the full sample.[7] For the full sample and for the diesel subsamples, which accounted for

88 percent of the full sample, S1 has about the same effect as a four-year increase in bus age.

It should be remembered, of course, that S1 is simply a dummy variable which takes a value of zero for 1963-73 and a value of one for 1974-81. The coefficient on S1 is biased if some other variable correlated with S1 has been omitted from the model. Because of the simple time pattern of S1, this possibility must be kept in mind.

We also tested a more elaborate hypothesis concerning the impact of subsidies, namely that because of bureaucratic monitoring intended to prevent "premature" replacement of buses, the effect of capital-biased subsidies on the scrapping probability for buses less than 15 years old would be negative, or negligible, or at least less than that for buses 15 years old and older. The data do not support this hypothesis about bureaucratic monitoring. The coefficient on S3 (like that on S2 and S1) is positive and significantly different from zero for all samples and both specifications in which it appears, except for one specification for GMC gasoline buses. Furthermore, while the coefficient on S3 is smaller than that on S2 for the full sample, the reverse is true for GMC diesel buses. As we explained above, we place the greatest weight on the GMC diesel estimates (particularly Equation 6).

(d) Other Variables

The results for the remaining four variables included in the regression--WAGE, BUS-PRICE, INTEREST, and

POPULATION--were all mixed. Often the signs were opposite those hypothesized. One possible explanation for some of these results is that the real wage rate and real bus price both followed very simple time paths over the period of the study, and hence may have been correlated with omitted variables. Fortunately, with the exception of the GMC gasoline subsample, the major conclusions of the study, which depend on the estimated coefficients of the subsidy variables, are not changed if the four variables in question are omitted. Thus, whatever specification problems underlie the mixed results for these four variables do not reduce our confidence in the other conclusions of this study. Because the estimates for these four variables do not appear sensible, we give greatest weight to the estimates which omit them (Equations 3, 6, 9, and 12).

8. Conclusions

In an earlier study [Frankena (1982)], I presented tabular data on the relative frequency of scrapping for GMC diesel, other diesel, and gasoline buses of various ages in four Ontario cities during 1963-72 and 1973-77. I concluded that "the data suggest that for gasoline and 'other diesel' buses thirteen years old and older the introduction of provincial capital-biased subsidies did lead to earlier scrapping and hence a waste of resources"(p. 137).

That conclusion was flatly rejected by the Ontario government. In response to my study, the Minister of Transportation and Communications, James Snow, issued a news release stating that "there may be a <u>perceived</u> bias in favour of capital replacement as opposed to maintenance, but if you examine Ontario's subsidy policy, there's no indication the <u>perceived</u> bias has influenced replace/repair decisions."[8]

My conclusion from the present study is that in fact introduction of capital-biased subsidies in December 1972 led to a statistically significant increase in the scrapping probability for buses and hence a reduction in the expected life of buses. The subsidy formula did therefore led to a waste in resources. Moreover, bureaucratic monitoring procedures did not prevent an increase in the scrapping probability even for buses under 15 years old.

It must be added, however, that while the capital-biased subsidies had a statistically significant effect on scrapping decisions, the extent to which scrapping decisions were distorted, and hence the waste of resources caused by the capital-biased nature of the subsidies, were a good deal less than is suggested by the simulations carried out by Tye and Armour, even allowing for the fact that the capital bias in the Ontario program was probably somewhat less than in the U.S. programs they considered.

An extensive theoretical and empirical literature demonstrates that there are significant potential efficiency gains from urban transit subsidies [Frankena (1982, Ch. 5)]. This paper demonstrates that capital-biased cost subsidies are less efficient than neutral cost subsidies. The merits of neutral cost subsidies compared to lump-sum and passenger subsidies are considered elsewhere [Frankena (1981), (1983)].

Footnotes

*Associate Professor of Economics. The author is grateful to Kul Bhatia and Christopher Robinson for suggestions, to the Social Sciences and Humanities Research Council of Canada for research funds, and to Joyce Johnston and Jason Morsink for research assistance. This paper was written while the author was a bureaucrat at the U.S. Federal Trade Commission, but the views expressed here are the author's and do not necessarily reflect the views of the Commission or any particular Commissioner.

[1] For a detailed description of these studies, see Frankena (1982, Ch. 6).

[2] The province has now introduced a 75 percent subsidy for rebuilding of used buses.

[3] A crude test was provided in Frankena (1982, pp. 134-41).

[4] In work which is not reported here, I found that scrapping probabilities in 1973 were not significantly different from those in 1963-72. Also, although the operating subsidy formula changed in 1977, I found that scrapping probabilities in 1974-77 were not significantly different from those in 1978-81.

[5] $F^{-1}(\ )$ is the inverse of the cumulative distribution function of a standardized normal variate. $F^{-1}(Z)$ is the probit of the scrapping probability.

[6]Because I have not included the price of used buses in the probit equation, AGE picks up the effect of age not only through $E(M^i)$ but also through P^i.

[7]The pattern of results suggests that if the last four variables were omitted from the GMC gasoline equation, the coefficient on S1 in that equation would be positive and significantly different from zero at the 1 percent level as well.

[8]James Snow, "Study is Narrow, Snow Raps Report," News Release, Ministry of Transportation and Communications, Downsview, Ontario, 18 August 1982.

References

Armour, R.F. (1980) "An Economic Analysis of Transit Bus Replacement," _Transit Journal_ **6**, 41-54.

Frankena, M.W. (1981) "The Effects of Alternative Urban Transit Subsidy Formulas," _Journal of Public Economics_ **15**, 337-48.

----- (1982) _Urban Transportation Financing: Theory and Policy in Ontario_, University of Toronto Press, Toronto.

----- (1983) "The Efficiency of Public Transport Objectives and Subsidy Formulas," _Journal of Transport Economics and Policy_ **17**.

Parks, R.W. (1977) "Determinants of Scrapping Rates for Postwar Vintage Automobiles," _Econometrica_ **45**, 1099-1115.

Puccini, R. (1979) _Urban Transit Operations: An Introduction_, Ministry of Transportation and Communications, Downsview, Ontario.

Tye, W.B. III (1969) "The Economic Costs of the Urban Mass Transportation Capital Grants Program," Ph.D. Thesis, Department of Economics, Harvard University, Cambridge, Mass.

Walker, F.V. (1968) "Determinants of Auto Scrappage," *Review of Economics and Statistics* **50**, 503-6.