Massimo Filippini e Paola Prioni

The influence of Ownership on the cost
of bus service provision in Switzerland.
An empirical illustration

Quaderno N. 01-01

THE INFLUENCE OF OWNERSHIP ON THE COST OF BUS SERVICE PROVISION IN SWITZERLAND–AN EMPIRICAL ILLUSTRATION-

by

Massimo Filippini and Paola Prioni

Department of Economics, University of Lugano
and
Switzerland Federal Institute of Technology Zürich

ABSTRACT

In deregulated transport markets, a firm's ownership status and management system represent an important issue. Economic theory suggests that productivity and performance are higher in the private than in the public sector. In Switzerland, providers of bus transportation are traditionally corporations, though a large part of their equity shares are still held by the public sector (federal government, cantons, municipalities). In this paper we examine the potential impact of ownership on the cost of bus service provision for a sample of private, public and mixed bus companies in Switzerland. We have considered the estimation of a translog cost model for 34 bus transit companies observed over 5 years (1991-1995). The results only partially confirm that if the private sector holds shares in the company's capital, efficiency is enhanced. In addition, measures of economies of scale and density are derived and discussed within the actual public transport policy.

1. Introduction

In recent decades the public transport policy of most industrialized countries has been characterized by deregulation and/or privatization policies[1].

Following the changes in the transport policy of the EC and the increasing subsidies for operations and infrastructures, the Swiss public transport policy has experienced several

---

[1] See Berechman (1993) for an exhaustive overview on the deregulation policies pursued in different industrialized countries.

unavoidable regulatory reforms. These reforms were also induced by the findings of studies by Filippini et al. (1992) and Filippini, Prioni (1994), which empirically demonstrated the relation between the poor performance of Swiss bus operators in the pre-reform years to the subsidies, public obligations and the compensatory payments for the approximated tariff[2].

Since 1996 the Swiss[3] government has been introducing important reforms in the regulation of the regional public transport system in order to encourage competition for the market[4]. The new regional transport policy recognizes the earlier regulatory failures. With the implementation of a bidding system for regional transport services and the removal of the compensations for revenue reductions and approximated tariffs, the new act introduced greater market incentives for competitive behavior and efficient production.

Although the studies by Filippini et al. (1992) and Filippini, Prioni (1994) provided evidence on the economic consequences of regulation, due to lack of information no attention was given to the effect of ownership type on performance. In Switzerland, private, public and mixed firms characterize the regional public transit industry.[5] The main function of these companies is to link mainly rural areas to an urban transport network or to the intercity railway line. The majority of these companies are stock companies created by private investors or by municipalities.

This mixed economy within the regional public transport market raises the interesting issue of the effects on costs of the different ownership structures and institutional organization form. Hence, the following question becomes central for policy makers: are private bus companies more efficient than public bus companies?

In a changing competitive environment such questions become increasingly relevant, first, for transport operators in terms of an improved knowledge about efficient organizational forms, and second, for transport regulators as input into establishing new competitive rules.

The paper is organized as follows. Section 2 reviews the theoretical background on the effects of ownership on efficiency. Section 3 discusses the cost model; section 4 presents the data, while section 5 illustrates the empirical results. Section 6 concludes the paper.

---

[2] See Filippini et al (1992) for a comprehensive description of the regulatory setting and subsidization system in the regional public transport system in Switzerland.

[3] Switzerland is a confederation composed of 26 cantons and approximately 3000 municipalities. This federal state is characterized by a high degree of decentralization in the provision of public services. For instance, each canton in cooperation with the municipalities has a high degree of autonomy in the organization, planning and regulation of the local public transport.

[4] See "revised Railway Act (revidierte Eisenbahngesetz), 1996.

2. The influence of ownership on the cost of bus service provision

In comparing the relative efficiency between public ownership and private ownership, property rights theory has been often employed. Following Alchian (1965) and Demsetz (1967), property rights theory analyses how the different incentives created by the system of property rights affect organizational behavior and company performance. A right of ownership comprises several rights: the rights to define the goals of a firm, to appoint the managers, to influence the conduct of a firm, to keep the extra profits and to sell the property rights. In a private firm, managers will make the day-to-day decisions for the owners. In reality, these agents probably acquire some independence and have the opportunity to act as imperfect agents. In this case we have a typical agency problem, where the principal cannot perfectly monitor the actions of the agent. Thus, the agent could have incentives to deviate from the pure profit-maximizing goal and try to attain some non-pecuniary benefits such as pleasant office space and extra staff.

In the case of a public firm, the taxpayers are the owners of the firm and control the way the firm conducts its activities through their representatives in the parliament and in the government. These representatives are charged with managing the company in such a way as to maximize social welfare. Public representatives in turn delegate control to a commission, which oversees the management of the company. In comparison to private firms, public firms experience a radical attenuation of property rights resulting in a more significant reduction of incentives for the management to minimize costs and to follow the owner's interests. Moreover, the principal-agent problems within state-owned companies are more complex than those in the private sector. In the case of a private-sector company, the management itself answers only to the shareholders, and the employment relationship involves the management and the employees. Within the public sector, the chain of command from the electorate to the management go through the parliament, the government and the commission. For instance, Niskanen's model of bureaucrats' behavior assumes that bureaucrats attempt to maximize their own utility rather than that of the electorate they serve.[6]

In a natural monopoly, however, the regulation of a private-sector firm can be more difficult than that of a public-sector firm, because of more asymmetric information between

---

[5] "Private firms" refers to those firms whose shares are held by the private sector; "public firms" refers to those firms whose shares are held by public bodies or governments, for example municipalities; and "mixed firms" refers to those firms whose shares are held by both sectors.)

[6] See Niskanen (1975).

the private firm and the regulator than between the public firm and the regulator. Therefore, in a situation of natural monopoly we can identify a trade-off between two sources of inefficiency in private and public companies: inefficiency from regulation of private firms and inefficiency from the attenuation of property rights in public firms.

A number of recent studies have compared the cost efficiency of public and private bus transit companies. The empirical results do not provide conclusive evidence regarding the efficient form of ownership.[7]

In this paper we test the effect of ownership on the production cost using a sample of Swiss bus companies. The test is performed by introducing in a cost model specification a dummy variable to differentiate the two forms of ownership: private and public.[8]

3. Specification of the Total Cost Function

Cost functions in the bus industry are well documented in empirical research (see Berechman, 1993 for a good overview). Cost specifications traditionally assume operating cost as a function of output and input prices (capital, labor and energy price). However, several authors go beyond this specification and identify other exogenous variables, which can further explain cost differences among the observations. For example, several studies recognize output heterogeneity by adding to the cost function specification a series of output and/or network characteristics such as the length of the network, the number of stops and the frequency[9]. Another group of factors likely to influence operating cost includes regulatory features, ownership form and environmental characteristics. Obviously such variables will be considered in the cost function specification provided that they respond to the research interest, that they are measurable and finally that a certain variability among the observations exists.

It is worth noting that, although such variables are theoretically justified, their inclusion in the cost function specification notably increases the number of explanatory variables, which in turn reduces the degrees of freedom, which requires more data for the econometric estimation.

---

[7] See for an overview of 13 early studies Perry et al. (1986) and Bhattacharyya et al. (1995) and Cowie, J., Asenova, D. (1999) for more recently published work.

[8] The sample of companies used in this study covers the period 1991-1995. In this period the bus companies operated as franchised local monopolies, assigned without a competitive tendering process.

[9] See for instance Spady and Friedlaender (1978) and De Borger (1991).

Given the above evidence and our focus on the ownership structure of bus operators, we specify the following cost function:

$$C = c\left(y, n, p_L, p_C, p_E, P, T\right) \tag{1}$$

We assume the total cost of a bus transit company C to be a function of the output y, the network characteristic n, the factor prices p (labor L, capital C and energy E) and the variable P representing the ownership variable. Finally, the variable T captures the effect of technical change occurring over the years.

Using a translog function, the expression in (1) can be approximated by the following total cost function:[10]

$$
\ln \frac{C_{it}}{p_{C_{it}}} = a_0 + a_y \ln y_{it} + a_n \ln n_{it} + a_{p_L} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{p_E} \ln \frac{p_{E_{it}}}{p_{C_{it}}} + \frac{1}{2} a_{yy}\left(\ln y_{it}\right)^2 + \frac{1}{2} a_{nn}\left(\ln n_{it}\right)^2
$$

$$
+ a_{yn} \ln y_{it} \ln n_{it} + \frac{1}{2} a_{p_L p_L}\left(\ln \frac{p_{L_{it}}}{p_{C_{it}}}\right)^2 + \frac{1}{2} a_{p_E p_E}\left(\ln \frac{P_{Ei}}{P_{Ki}}\right)^2 + a_{yp_L} \ln y_{it} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{yp_L} \ln Y_i \ln \frac{p_{L_{it}}}{p_{C_{it}}}
$$

$$
+ a_{np_L} \ln n_{it^i} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{np_E} \ln n_{it} \ln \frac{p_{E_{it}}}{p_{C_{it}}} + a_{p_L p_E} \ln \frac{p_{L_{it}}}{p_{C_{it}}} \ln \frac{P_{Ei}}{P_{Ki}} + a_{PRIV} P_i + a_t T + e_{it}
$$

$$\tag{2}$$

Note that by normalizing total cost and input prices by one of the input prices (here the price of capital), we impose the theoretical condition that the cost function is linearly homogeneous in input prices.

To improve the efficiency of the estimation, we will append the factor share equations derived by applying Shepard's Lemma to (2).

$$
S_L = a_{p_L} + a_{p_L p_L} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{yp_L} \ln y_{it} + a_{p_L p_E} \ln \frac{p_{E_{it}}}{p_{C_{it}}} + a_{np_L} \ln n_{it} + d_{it}
$$

$$
S_E = a_{p_E} + a_{p_E p_E} \ln \frac{p_{E_{it}}}{p_{C_{it}}} + a_{yp_E} \ln y_{it} + a_{p_L p_E} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{np_E} \ln n_{it} + d_{it}
$$

$$(3a) + (3b)$$

The empirical study is therefore focused on a cost model with estimation of the cost function and two factor share equations (the share equation of capital was dropped from the estimating system).

The estimation of a cost function enables us to derive some important characteristics of bus supply technology such as economies of density, economies of scale and elasticities of

---

[10] A translog function requires the approximation of the underlying cost function to be made at a local point, which in our case is taken at the median point of all variables. Thus, all independent variables are normalized at their median points.

substitutions. These technology characteristics are particularly interesting in a translog framework, as this functional form does not require restrictive a priori assumptions, allowing these measures to vary with the firm's size.

The distinction between economies of density and economies of scale is very important in industries that provide their services over a network (for example transport industries or energy distribution utilities). In such cases firm size is more closely tied to the size of the network than to the output provided over that network. For this reason it is important to distinguish cost changes that occur because of output changes only and cost changes that occur because of a proportional network and output change.

Economies of density are defined as the increase in total cost resulting from an increase in output, holding all input prices and the network size fixed (Caves, Christensen and Tretheway, 1984).

$$ED = \frac{1}{\frac{\partial \ln C}{\partial \ln y}} = \frac{1}{\boldsymbol{a}_y + \boldsymbol{a}_{yy} \ln y + \boldsymbol{a}_{yn} \ln n + \boldsymbol{a}_{yp_L} \ln \frac{p_L}{p_C} + \boldsymbol{a}_{yp_E} \ln \frac{p_E}{p_C}} \qquad (4)$$

Economies of density exist if ED is greater than 1. For values of ED below 1, we identify diseconomies of density. The existence of economies of density implies that the average costs of a bus operator decrease as physical output increases. In the case of $ED = 1$, no economies or diseconomies of density exist.

Slightly different is the definition of economies of scale. Here, the increase in the total cost is brought about by a proportional increase in output and in the network size, holding the factor prices constant. According to this definition, ES can be written as:

$$ES = \frac{1}{\frac{\partial \ln C}{\partial \ln y} + \frac{\partial \ln C}{\partial \ln n}} \qquad (5)$$

Applied to the translog specification in (2),

$$ES = \frac{1}{\boldsymbol{a}_y + \boldsymbol{a}_{yy} \ln y + \boldsymbol{a}_{yn} \ln n + \boldsymbol{a}_{yp_L} \ln \frac{p_L}{p_C} + \boldsymbol{a}_{yp_E} \ln \frac{p_E}{p_C} + \boldsymbol{a}_n + \boldsymbol{a}_{nn} \ln n + \boldsymbol{a}_{yn} \ln y + \boldsymbol{a}_{np_L} \ln \frac{p_L}{p_C} + \boldsymbol{a}_{np_E} \ln \frac{p_E}{p_C}}$$

$$(6)$$

Similarly, economies of scale exist if ES 1 is greater than 1. A value of ES below 1 indicates diseconomies of scale.

Another important feature of bus supply technology consists of the estimation of elasticities of substitution between two input factors to test whether complementary or substitution relationships dominate. The general expression for Allen elasticity of substitution between two inputs m and n ($m \neq n$) (see for example Williams, Dalal, 1981) is given by:

$$J_{mn} = \frac{C \cdot \dfrac{\partial^2 C}{\partial p_m \partial p_n}}{\left(\dfrac{\partial C}{\partial p_m}\right)\left(\dfrac{\partial C}{\partial p_n}\right)} \tag{7}$$

According to our translog model specification, the formula in (7) can be written as:

$$J_{mn} = \frac{a_{p_m p_n} + a_{p_m} a_{p_n}}{a_{p_m} a_{p_n}} \quad m \neq n \tag{8}$$

where the a_i are directly the parameters in the translog specification. Negative (positive) values of q_{mn} indicate complements (substitutes).

4. Data and variable specification

To estimate the cost model described in (2), financial and operating data from sampled operators was required. The Swiss Federal Statistics Office collects financial and operating data for all 178 regional bus transit companies in Switzerland. However, for some of the bus transit companies only incomplete information is available. For this reason, in a first trial we had to restrict our sample size to 90 operators, for which complete data was available.

In order to test the ownership hypothesis we conducted a survey using a mail questionnaire, where we asked the 90 pre-selected operators to report the institutional form of business organization and the ownership structure of the company's capital. We asked for the shareholders' composition because many bus companies, although corporations, are more than 50% held by public bodies. Accordingly the share of the company's capital held by the private sector varies between 0 and 100%. Of the 90 survey forms sent out, we received 34 useful replies. The results showed that, of the 34 bus transit companies, 8 are private (i.e. the private-sector share is equal to 100%), 4 are public (100% of the capital is in public hands) and 22 are mixed enterprises. Moreover, although corporations dominate (29), other institutional forms are represented in the sample (for example cooperatives).

In order to increase the sample size, the 34 bus transit companies were observed over 5 years (1991-1995), which gave us a sample of 170 observations.

The variables for the cost function specification were calculated as follows. Total cost C is calculated as the total expenditures of the bus companies per year. The output (y) is measured in bus kilometers and seat kilometers alternatively. The choice of these two output measures is twofold. First we recognize that output in cost function estimations is better represented by pure supply output measures. Alternatively some authors use passenger revenue (as in Button, 1985) or passenger trips (Berechman, 1987). We believe that such demand-related output measures are inadequate in cost function estimations as they mainly reflect consumed and not produced output. Second, bus-kilometers and seat-kilometers are the most commonly used supply-related output measures in the empirical literature[11]. Bus-kilometers assume vehicles as the relevant output unity, whereas the seat-kilometers allow for differences in the fleet capacity. "Seats" refer to seated places and standing places.

The output characteristic variable (n) is described by the length of the network and the number of stops alternatively. Other output characteristic variables such as a load factor or the number of stops per meter of network were initially considered; however, we dropped them from the model because of multicollinearity problems.

Input prices are defined as factor expenditures per factor unit. Labor price (p_L) is defined as the ratio of annual labor costs to total number of employees. Energy costs divided by the total annual fuel consumption approximates the unit cost of energy (p_E). Following Friedlaender et al (1983), the capital price (p_C) is calculated as residual cost (where residual cost is total cost minus labor and energy cost) divided by the number of vehicles in the operator's fleet. Unfortunately no data were available which would allow us to calculate the capital stock using the capital inventory method. The use of a simple indicator is justified by the fact that the bus companies do not possess a significant stock of capital apart from the rolling stock.

All input prices, total cost and variable cost are corrected for price changes over the years to 1993 constant Swiss franc Consumer Price Index. The variable T is a time variable, which captures the shift in technology.

As a final step, the dummy variable P is introduced to investigate the potential impact of ownership on the cost of bus service provision. P takes the value of 1 if the share of the company's capital held by the private sector exceeds 50%, otherwise it takes 0 as a

---

[11] See for example Berechman (1987), Viton (1986) and Filippini et al. (1994).

value[12]. The choice of this particular specification for P was mainly due to the fact that the majority of the firms are corporations in which the public sector (state, cantons, municipalities) holds a share. Therefore, we assume that companies in which the share held by the private sector exceeds 50% are controlled and managed following the strategy and goals of the private shareholders.

A description of some variables used in this analysis is included in Table 2.

Table 2: Descriptive statistics

Variables	Unit of measurement	1. Quartile	Median	3. Quartile
Total cost	SwF.	780500	1895000	3527500
Bus Kilometers		176'000	421'000	617'000
Seat Kilometers		11188000	29659000	65695000
No. of buses		5	9	20
No. of employees (external excl.)		5	13	28
Length of the network	Meters	20.8	40.1	62.6
Number of stops		25	44	82
Labor price	SwF. per worker	87676	104400	119770
Capital price	SwF. per seat kilometer	21367	32917	49610
Energy price	SwF. per liter	0.474	0.529	0.595
		No of 0	**No of 1**	
P: Dummy for private	Takes the value 0 or 1	21	13	

5. Estimation Results

The system of equations consisting of the cost function in (2) and the 2 factor share equations (3a+3b) was estimated using maximum-likelihood. Table 3 presents the parameter estimates and standard errors of the translog cost function. In Model 1, the output variable is measured by the total bus kilometres provided by each operator, and the network is represented by its length. In Model 2, output is represented by the total amount of seat kilometres and the network characteristics by the number of stops.

---

[12] Since data on P were collected during 1997-1998, we assumed that during 1991-1995 no significant changes occurred in the shares held by the private sector. This assumption was confirmed by interviews with several bus transit industry specialists and by the Federal Department of Transport.

Table 3: Total-cost parameter estimates (standard errors in parentheses)

Coefficient	Model 1 (Bus-kilometers/ network length)	Model 2 (Seat-Kilometers/ Number of stops)
Constant	14.712***	14.584***
	(0.085)	(0.099)
a_Y	0.729***	0.506***
	(0.047)	(0.051)
a_N	0.224***	0.348***
	(0.062)	(0.075)
a_{PL}	0. 563***	0. 561***
	(0.007)	(0.007)
a_{PE}	0.047***	0.045***
	(0.003)	(0.003)
a_{YY}	0.253***	0.191***
	(0.082)	(0.071)
a_{NN}	0.112	-0.013
	(0.133)	(0.165)
a_{PLPL}	-0.017	-0.015
	(0.012)	(0.013)
a_{PEPE}	-0.045***	-0.048***
	(0.006)	(0.006)
a_{YN}	-0.118	-0.058
	(0.091)	(0.097)
a_{YPL}	0.028***	0.026***
	(0.009)	(0.009)
a_{YPE}	0.014***	0.014***
	(0.004)	(0.004)
a_{NPL}	-0.029**	-0.028**
	(0.012)	(0.013)
a_{NPE}	-0.010*	-0.005
	(0.005)	(0.005)
a_{PLPE}	0.061***	0.069***
	(0.004)	(0.004)
a_{PRIV}	-0.243***	-0.108
	(0.068)	(0.082)
a_T	-0.038*	-0.043*
	(0.021)	(0.025)
Likelihood	-12.97	-12.60

*, **, ***: significantly different from zero at the 90%, 95%, 99% confidence level.

Both estimated functions are well-behaved**.** Most of the parameter estimates are statistically significant and carry the expected sign.

Since total cost as well as the output variables are in natural logarithms and have been normalized, the first order coefficients can be interpreted as cost elasticities evaluated at the sample median. Output elasticity in the first model, where we used bus kilometres as output variable, is 0.729, whereas it is 0.506 in the second model, where we used seat

kilometres[13]. This implies that a 1% increase in output will increase total cost by 0.729% and 0.506% respectively. It is not surprising that bus kilometres are more cost elastic than seat kilometres. If we assume the same percentage increase in output in terms of bus kilometres or seat kilometres, it follows that running an extra bus costs more than adding an extra seat to an existing bus. One reason for this may be the fact that the increase in output measured in bus kilometres implies higher costs that an increase in the seat capacity of the bus.

The cost elasticity of the network length (model 1) is as expected positive (0.141) and significant. In the second model the parameter estimate is 0.348, suggesting that a 1% increase in the number of stops affect operating cost more considerably than a 1% increase in the network length. Similar results were obtained by Filippini et al. (1992) and Filippini, Prioni (1994) for a sample of bus companies in Switzerland, and Windle (1988) for the U.S. bus industry.

The median cost elasticities with respect to factor prices are positive and of similar magnitude in both versions of the cost model. The estimated coefficients for price of labor (0.563/0.561) and price of energy (0.047/0.045) estimate the share of costs attributed to labor and energy at the median production. Although the share equation for capital was dropped, the linear homogeneity conditions imply that the coefficient for capital is (0.390/0.394). Summarizing, labor cost accounts for 56%, energy cost for 4.6% and capital cost for 40% at the median observation. These results are in the range of the previous findings.[14]

The trend variable is negative and significant at the 90% confidence level in both model specifications. This implies that the Swiss bus companies experienced neutral technological progress over these years (1991-1995).

The ownership hypothesis is accepted at the 95% confidence level in Model 1, whereas Model 2 does not seem to support our expectations. The negative coefficient for a_{PRIV} in Model 1 suggests that bus companies that are more than 50% held by the private sector operate at lower cost than bus companies less than 50% held by the private sector, or public companies. These results suggest that first, empirical findings are highly sensitive to the variable specification and second, that ownership can be of limited relevance in highly regulated markets. A study by Fazioli et al. (1993) came up with similar conclusions for a sample of bus operators in northern Italy. More recent studies (see Cowie, Asenova, 1999)

---

[13] In a previous study, Filippini, Prioni (1993) found a higher cost elasticity with respect to output (measured in seat-kilometers). However, this might be due to the different sample size, data type (cross section) and methodology.

identify British privately-held companies more technically efficient. However, the authors relate the poor performances of public companies to some industry characteristics rather than to the ownership structure. Finally, a study by Jorgenson et al. (1995) found no differences in the performance of private and public bus operators in Norway.

Apparently there is no strong empirical evidence supporting the ownership hypothesis in the bus industry, suggesting two main conclusions. First, differences may be conducted to different model specifications and estimation procedures and second, market structure could be a more important factor in explaining differences in efficiency.

Economies of Scale and Density

The following table presents the estimated economies of scale and economies of density for the median bus operator calculated according to the formula specified in (4) and (6). Note that factor prices are held constant equal to the median values. Table 3 presents the estimates obtained from both models.

Table 3 - Economies of scale and density (Standard errors in parenthesis)

	Economies of Density	Economies of Scale
Model1 : 421,000 Bus-Km, 40.1 Km	1.37 (0.08)	1.04 (0.10)
Model2 : 29,659,000 Seat-Km, 44 Stops	1.97 (0.17)	1.17 (0.15)

We note that the indicators for economies of density in both model specifications are greater than 1. This suggests that medium-sized operators fail in operating to an optimal density scale. More intensive use of a given network would decline cost per bus kilometer and seat kilometer respectively. However, such a strategy implies the existence of a market for bus services, which under the actual conditions and the constantly decreasing patronage levels cannot be assumed. Regarding the scale economies, medium-sized operators are better off (1.04 vs. 1.17). According to Model 1, bus companies manage to operate at an optimal scale level, suggesting an efficient network length and level of physical output, which should ensure all the rest remaining constant a continued existence. Slightly higher is the estimated value for the economies of scale in model 2 (1.17), indicating that the model specification influences results and policy implications. However, the difference in the result is relatively

---

[14] See Filippini et al. and Filippini, Prioni (1994) for previous results. Similar results for the bus industry in

small, suggesting that with high probability operators manage to operate at an optimal scale level. Similar results were obtained by the study undertaken by Berechman and Giulliano (1985). They found that empirical findings on scale and density economies are highly influenced by the choice of the output measure and the functional form adopted.

Elasticities

In this section we apply the expression derived in (7) to calculate the elasticity of substitution between energy and capital, energy and labor, and capital and labor. Our expectation is that technically superior buses (in some measure induced by capital subsidies) should improve fuel efficiency and enhance the substitution possibilities between energy and capital. The increasing commercialization of new vehicle and fuel options, due to a shift in priorities towards a sustainable public transport system, aim to reduce pollution and minimize petroleum fuel use in the bus transit industry. The incremental costs associated with operating alternative fuel buses are mainly increased capital outlays. Increased capital outlays are attributable to the additional costs (if any) of acquiring alternative fuel buses and modifying facilities.

The estimated parameters for q_{EC} are 0.0006 for Model 1 and 0.00007 for Model 2, indicating no significant relationship between the two inputs. In other words an increase in energy (fuel) price does not seem to affect capital demand. The reason could lie in the relatively long average vehicle life, which ranges from 12 to 25 years depending on the quality of maintenance and intensity of vehicle utilization (Williams, Dalal, 1981). Operators do not have any incentives to accelerate the replacement of older (not fully amortized) vehicles with new environmentally cleaner vehicles. Probably the introduction of ecological taxes would speed up the replacement process and get a more significant substitution relationship between capital and fuel.

The estimated elasticity between labor and energy is 0.007 in both model specifications, suggesting very limited substitution possibilities. This is not surprising as these two factors enter the production process in fixed proportions.

Considerably higher is the estimated partial elasticity of substitution between capital and labor (0.265 and 0.252 respectively). Although some literature recognizes only partial substitution capabilities between these two factors, this result indicates that substitution possibilities exist. For example the introduction of modern customer information systems and

---

Britain were found by Button O'Donnel (1985).

the more frequent use of automatic ticketing systems could explain this high degree of substitution between capital and labor.

6. Conclusions

In this paper we examine the potential impact of ownership on the cost of bus transit service provision for a sample of private, public and mixed regional bus companies in Switzerland. For this purpose we have considered the estimation of two translog cost models for 34 bus operators observed over 5 years (1991-1995). In the first model output and network characteristic are specified as bus kilometer and networks length, whereas in the second model seat kilometers and number of stops are used. The ownership variable enters the translog cost models as a dummy variable P. The dummy takes the value of 1 if the company's capital has a private equity share greater than 50%; otherwise it is zero. The results only partially confirm the expectations that private firms should operate more efficiently than public ones. The significance of the ownership's parameter is slightly dependent on the specification of the output and network variables. Similar ambiguous results are common in the literature, suggesting that the ownership hypothesis needs to be tested and discussed within the particular regulatory setting and the market structure.

The explanatory power of the model gives us an insight into the nature of the production technology of the regional bus system in terms of economies of scale and density. The results show that bus operators fail to operate at an efficient density. However, service intensification seems an inadequate strategy under the actual demand conditions. Regarding the economies of scale, the results indicate that medium-sized bus companies manage to operate at constant returns to scale.

Bibliography

Alchian, D.A. (1965) Some Economics of Property Rights, *Il Politico*, 30, 816-29.

Bhattacharyya, A., Kumbhakar, S. C.; Bhattacharyya, A. (1995), Ownership Structure and Cost Efficiency: A Study of Publicly Owned Passenger-Bus Transportation Companies in India, Journal *of Productivity Analysis*, 8(1), 35-52

Button, K. J., O'Donnel, K. J., 1985, An Examination of the Cost Structures Associated with Providing Urban Bus Services in Britain, *Scottish Journal of Political Economy*, 32(1), 67-81.

Berechman, J. (1993) *Public Transit Economics and Deregulation Policy*, Amsterdam, North-Holland.

Berechman, J. (1987) Cost Structure and Production Technology in Transit: An Application to the Israeli Bus Transit Sector, *Regional Science and Urban Economics*, 17 (4), 519-34.

Berechman, J., Giulliano, G. (1985) Economies of Scale in Bus Transit: A review of Concepts and Evidence, *Transportation*, 12, 313-32.

Caves, D.W., Christensen, L.R., Tretheway, M.W. (1984) Economies of density versus Economies of Scale: Why Trunk and Local Service Airline Costs differ, *Rand Journal of Economics,* 15, 471-89.

Cowie, J., Asenova, D. (1999) Organisation Form, Scale Effects and Efficiency in the British Bus Industry, *Transportation*, August 1, 26(3), 231-48.

De Borger, B. (1999) The Performance of Bus Transit Operators, Paper prepared for the Handbook on Transport Modelling, Hensher D., Button, K. Eds.

De Borger, B.L. (1991) Hedonic versus Homogeneous Output Specifications of Railroad Technology: Belgian Railroads 1950-1986, *Transportation Research A*, 25A (4), 227-38.

Demsetz, (1968), Why Regulate Utilities?, *Journal of Law and Economics*, 11, 55-65.

Fazioli, R., Filippini, M., and Prioni, P. (1993) Cost-Structure and Efficiency of Local Public Transport: The Case of Emilia Romagna Bus Companies, *International Journal of Transport Economics*, 20 (3), 305-24.

Filippini, M., Prioni, P. (1994) Is Scale and Cost Inefficiency in the Swiss Bus Industry a Regulatory Problem? Evidence from a Frontier Cost Approach, *Journal of the Economics of Business*, 1(2), 219-31.

Filippini, M., Maggi, R. and Prioni, P. (1992) Inefficiency in a Regulated Industry –The Case of the Swiss Regional Bus Companies-, *Annals of Public and Cooperative Economics*, 63 (3), 437-55.

Friedlaender, A., Wang Chiang, S. J. (1983) Productivity Growth in the Regulated Trucking Industry, *Research in Transport and Economics*, 1, 149-84.

Hensher, D.A. and Daniels, R. (1995) Productivity Measurement in the Urban Bus Sector, *Transport Policy*, 2 (3), 179-94.

Hensher, D.A. (1987) Productive Efficiency and Ownership of Urban Bus Service, *Transportation*, 14, 209-25.

Jørgensen, F., Pederson, P., Solvoll, G. (1995) The Costs of Bus Operations in Norway, *Journal of Transport Economics and Policy*, 29, 253-62.

Niskanen, W. A. (1975) Bureaucrats and Politicians, *Journal of Law and Economics*, 38, 617-44.

Perry, J. L., Babitsky, T. T (1986) Comparative Performance in Urban Bus Transit: Assessing Privatization Strategies, *Public Administration Review*, 46, 57-66.

Spady, R.H. and Friedlaender, A. (1978) Hedonic Cost Functions for the Regulated Trucking Industry, *Bell Journal of Economics*, 9, 159-79.

Viton, P.A. (1986) The Question of Efficiency in Urban Bus Transportation, *Journal of Regional Science*, 26 (3), 499-513.

Williams, M. Dalal, A. (1981) Estimation of the Elasticities of Factor Substitution in Urban Bus Transportation: A cost Function Approach, *Journal of Regional Science*, 21(2), 263-275.

Windle, R.J. (1988) Transit Policy and the Cost Structure of Urban Bus Transportation, in Dodgson, J.S. and Topham, N. (eds), *Bus Deregulation and Privatization: an International Perspective,* Avebury, Aldershot, 119-40.

QUADERNI DELLA FACOLTÀ

Quaderno n. 98-01
P. Balestra, *Efficient (and parsimonious) estimation of structural dynamic error component models*

Quaderno n. 99-01
M. Filippini, *Cost and scale efficiency in the nursing home sector : evidence from Switzerland*

Quaderno n. 99-02
L. Bernardi, *I sistemi tributari di oggi : da dove vengono e dove vanno*

Quaderno n. 99-03
L.L. Pasinetti, *Economic theory and technical progress*

Quaderno n. 99-04
G. Barone-Adesi, K. Giannopoulos, L. Vosper, *VaR without correlations for portfolios of derivative securities*

Quaderno n. 99-05
G. Barone-Adesi, Y. Kim, *Incomplete information and the closed-end fund discount*

Quaderno n. 99-06
G. Barone-Adesi, W. Allegretto, E. Dinenis, G. Sorwar, *Valuation of derivatives based on CKLS interest rate models*

Quaderno n. 99-07
M. Filippini, R. Maggi, J. Mägerle , *Skalenerträge und optimale Betriebsgrösse bei den schweizerische Privatbahnen*

Quaderno n. 99-08
E. Ronchetti, F. Trojani, *Robust inference with GMM estimators*

Quaderno n. 99-09
G.P. Torricelli, *I cambiamenti strutturali dello sviluppo urbano e regionale in Svizzera e nel Ticino sulla base dei dati dei censimenti federali delle aziende 1985, 1991 e 1995*

Quaderno n. 00-01

    E. Barone, G. Barone-Adesi, R. Masera, *Requisiti patrimoniali, adeguatezza del capitale e gestione del rischio*

Quaderno n. 00-02

    G. Barone-Adesi, *Does volatility pay?*

Quaderno n. 00-03

    G. Barone-Adesi, Y. Kim, *Incomplete information and the closed-end fund discount*

Quaderno n. 00-04

    R. Ineichen, *Dadi, astragali e gli inizi del calcolo delle probabilità*

Quaderno n. 00-05

    W. Allegretto, G. Barone-Adesi, E. Dinenis, Y. Lin, G. Sorwar, *A new approach to check the free boundary of single factor interest rate put option*

Quaderno n. 00-06

    G.D.Marangoni, *The Leontief Model and Economic Theory*

Quaderno n. 00-07

    B. Antonioli, R, Fazioli, M. Filippini, *Il servizio di igiene urbana italiano tra concorrenza e monopolio*

Quaderno n. 00-08

    L. Crivelli, M. Filippini, D. Lunati. *Dimensione ottima degli ospedali in uno Stato federale*

Quaderno n. 00-09

    L. Buchli, M. Filippini, *Estimating the benefits of low flow alleviation in rivers: the case of the Ticino River*

Quaderno n. 00-10

    L. Bernardi, *Fiscalità pubblica centralizzata e federale: aspetti generali e il caso italiano attuale*

Quaderno n. 00-11

    M. Alderighi, R. Maggi, *Adoption and use of new information technology*

Quaderno n. 00-12

    F. Rossera, *The use of log-linear models in transport economics: the problem of commuters' choice of mode*

Quaderno n. 01-01

    M. Filippini, P. Prioni, *The influence of ownership on the cost of bus service provision in Switzerland. An empirical illustration*