Cost-based Yardstick Regulation in the Swiss Regional Public Bus Industry

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Abstract

In this paper we estimate a cost function for a panel of 34 Swiss public bus operators over 5 years, and we propose to use the individual cost parameters as a basis for yardstick regulation in the sector. The heterogeneity of the sector is captured by the dimension of the network, the number of stops and the topography of the service area. The estimation results indicate that the bus companies generally produce on an efficient scale but an inefficient density. A proposed yardstick regulation should create appropriate incentives to adapt the network design.

Keywords

Yardstick regulation – Public bus transport – Cost function

1. Introduction

Privatization and deregulation of the transport sector have been introduce over the last decades in many countries. In Switzerland, one of the first parts of the public transport system to be deregulated has been regional public transport. This sector is characterised by the presence of may small railways and a large number of bus companies. The deregulation introduced in 1994, provided the regions with the possibility of organising a competitive tendering procedure whereby the most performing companies would be incited to offer a public transport service satisfying the conditions imposed by the regulator. This process of allocating a global budget to a specific company is hindered by the presence of asymmetric information regarding above all the cost structure. In Switzerland, a frequent argument of high cost companies is the topography. For these reasons it seems of interest to propose a yardstick regulation instead of a traditional cost based regulation and to try and create the appropriate incentives with regard to topographical and other network characteristics. In order to do so, the cost structure of the competing companies has to be analysed in detail.

Traditional regulation does not take into account the problem of inefficiency of the regulated firms. Rate-of-return or cost-of-service regulation typically allows firms to set prices that cover all costs, but no incentives for efficient production are provided. In recent years, price-cap regulation, which gives firms better incentives for efficient production, has been used to regulate natural monopolies (see Laffont and Tirole, 1993). The regulator sets a price cap (or price path) that will not be changed for a regulatory period (usually several years). However, due to the imperfect information available to the regulator there are problems with price-cap regulation, too. First, if price caps are set too high there is the possibility of a typical situation of deadweight loss. Second, the regulating authority might have a credibility or commitment problem if regulated firms are not viable due to price-caps that are set very low. Third, under price-cap regulation the regulator has only limited possibilities to react to general shocks that influence costs of all regulated firms in the same way.

Shleifer (1985) proposed yardstick competition in terms of price to regulate local monopolies producing a homogeneous good. The regulated price for the individual firms depends on the average costs of identical firms. Shleifer shows that under ideal circumstances it is the dominant strategy for each firm to choose the socially efficient level of cost reduction. Yardstick competition can also be used to set the informational basis for a more effective price-cap regulation because it reduces the informational asymmetries between firms and regulator regarding costs. It has the additional advantage of taking into account general shocks that might cause problems in a pure price-cap regulation.

The yardstick competition concept can also be applied to firms that are producing heterogeneous outputs if these outputs only differ in observable characteristics. To correct the yardstick for the heterogeneity the regulator can use a multivariate estimation of a cost function. The observable characteristics are included as explanatory variables and will in that way correct for cost differences that are only due to the heterogeneity of output. Only exogenous heterogeneity factors that cannot be altered by the regulated companies must therefore be incorporated in the yardstick regulation. The regulator sets, then, corrected yardstick prices for the individual firms that incorporate their heterogeneity.

The purpose of this paper is to make a contribution to the debate on the attribution of an operating license involving a specific budget to a company.. We suggest that yardstick regulation should be used to regulate budget or cost subsidy in form of a cap. Because of the heterogeneity of bus operated networks we follow Shleifer's suggestion to estimate a multivariate cost function that could be employed by the regulatory commission to benchmark requested subsidies. In the empirical part we use a panel of Swiss public bus companies to estimate a cost function and identify the relevant parameters for regulation.

2. 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). Traditionally cost specifications assume operational cost as a function of output and of the 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 like the length of the network, the number of stops and the frequency[1].

For the purpose of this paper, we specify the following cost function:

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

We assume the total cost of a bus operator C to be a function of the output y, the network length n, the factor prices p (labor L, capital C and energy E) and the dummy-variables DEN[2] and $REGIO$ reflecting two different aspects of bus service provision. The former is derived from the number of stops per meter of network and takes the value of 1 if the stop density measure exceeds its median value, 0 otherwise. The dummy variable $REGIO$ takes into account the different regional environment of bus operators, taking the value of 1 if the bus company is operating in a mountainous region, 0 otherwise.

The variable T captures the unknown effects occurring over time (e.g. technical change).

Using a translog function, the expression in (1) can be approximated by the following total cost function:[3]

$$\begin{aligned}
\ln\frac{C_{it}}{p_{C_{it}}} &= a_0 + a_y \ln y_{it} + a_n \ln n_{it} + a_{p_L} \ln\frac{p_{L_{it}}}{p_{C_{it}}} + a_{p_E} \ln\frac{p_{E_{it}}}{p_{C_{it}}} + \frac{1}{2}a_{yy}\left(\ln y_{it}\right)^2 + \frac{1}{2}a_{nn}\left(\ln n_{it}\right)^2 \\
&+ a_{yn} \ln y_{it} \ln n_{it} + \frac{1}{2}a_{p_L p_L}\left(\ln\frac{p_{L_{it}}}{p_{C_{it}}}\right)^2 + \frac{1}{2}a_{p_E p_E}\left(\ln\frac{P_{Ei}}{P_{Ki}}\right)^2 + a_{yp_L} \ln y_{it} \ln\frac{p_{L_{it}}}{p_{C_{it}}} + a_{yp_L} \ln Y_i \ln\frac{p_{L_{it}}}{p_{C_{it}}} \\
&+ a_{np_L} \ln n_{it^i} \ln\frac{p_{L_{it}}}{p_{C_{it}}} + a_{np_E} \ln n_{it} \ln\frac{p_{E_{it}}}{p_{C_{it}}} + a_{p_L p_E} \ln\frac{p_{L_{it}}}{p_{C_{it}}} \ln\frac{P_{Ei}}{P_{Ki}} + a_{DEN} DEN + a_{REGIO} REGIO + a_t T + e_{it}
\end{aligned} \tag{2}$$

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[1] See for istance Spady and Friedlaender (1978) and De Borger (1991).

[2] The estimation of model (1) with a continuous variable for density (number of stops) was highly affected by multicollinearity

[3] 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.

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).

$$S_L = a_{p_L} + a_{p_L p_L} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{yp_L} \ln y_{it} + a_{p_L p_E} \ln \frac{p_{E_{it}}}{p_{C_{it}}} + a_{np_L} \ln n_{it} + d_{it}$$
$$S_E = a_{p_E} + a_{p_E p_E} \ln \frac{p_{E_{it}}}{p_{C_{it}}} + a_{yp_E} \ln y_{it} + a_{p_L p_E} \ln \frac{p_{L_{it}}}{p_{C_{it}}} + a_{np_E} \ln n_{it} + d_{it} \qquad (3a) + (3b)$$

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).

3. Data and variable specification

To estimate the cost model described in (2) financial and operational data from sampled operators was required. The Swiss Federal Statistics Office collects financial and operational data for all 178 regional bus operators in Switzerland. However, some of the bus companies only have incomplete information. For this reason our sample was restricted to 34 operators 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. The output characteristic (n) is described by the length of the network.
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 was 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 an important 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 francs Consumer Price Index. The variable T is a time variable, which captures the shift in technology.
At last the two dummy variables *DEN* and *REGIO* are introduced to consider the influence of different network densities and of different geographical locations on the cost of bus service provision. As we stated above the variable *DEN* takes the value of 1 if the stop density exceeds its median value, 0 otherwise. Similarly *REGIO* takes the value of 1 if the bus company operates in hilly (mountainous) regions, 0 otherwise.
A description of some variables used in this analysis is included in table 2.

Table 2: Descriptive statistics

Variables	Measurement unit	1. Quartile	Median	3. Quartile
Total cost	SwF.	780500	1895000	3527500
Bus Kilometers		176'000	421'000	617'000
No. of buses		5	9	20
No.of employees		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 km	21367	32917	49610
Energy price	SwF. per liter	0.474	0.529	0.595

4. Estimation Results

The system of equations consisting of the cost function in (2) and the 2 factor share equations (3a+3b) was estimated using generalized least square. Table 3 presents the parameter estimates and standard errors of the translog cost function.

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

Coefficient	*Parameter estimate*	*(standard error)*
Constant	14.344***	0.078
a_{Y}	0.736***	0.045
a_{N}	0.228***	0.059
a_{PL}	0. 579***	0.007
a_{PE}	0.044***	0.004
a_{YY}	0.266***	0.057
a_{NN}	0.150	0.091
a_{PLPL}	0.07***	0.019
a_{PEPE}	0.078***	0.003
a_{YN}	-0.163***	0.063
a_{YPL}	0.004	0.009
a_{YPE}	0.020***	0.004
a_{NPL}	-0.029**	0.012
a_{NPE}	-0.010**	0.005
a_{PLPE}	0.061***	0.004
a_{DEN}	0.243***	0.057
a_{REGIO}	0.238***	0.056
a_{T}	-0.029*	0.015
R^2 (adjusted)	0.85	

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

The estimated function is well behaved. Most of the parameter estimates are statistically significant and carry the expected sign.

Since total cost as well as the output variable are in natural logarithms and have been normalized, the first order coefficients are interpretable as cost elasticities evaluated at the sample median.

The cost elasticity of the network length is as expected positive (0.228) and significant. Similar results were obtained in Filippini et al (1992) for a sample of bus companies in Switzerland and in Windle (1988) for the US Bus Industry. Given these parameters estimates it is interesting to derive the measures of economies of scale and density respectively.
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).

$$ED = \frac{1}{\frac{\partial \ln C}{\partial \ln y}} \qquad (4)$$

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:

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

Similarly, economies of scale exist if ES 1 is greater than 1. A value of ES below 1 indicates diseconomies of scale.
The following table summarizes the values for ED and ES evaluated at the sample median. (Note in this case that ES corresponds to the reciprocal value of the parameter estimate for the output (a_Y) and ED to the reciprocal of the sum of the parameters a_Y and a_N).

Table 3 - Economies of scale and density for the median bus company

	Economies of Density	**Economies of Scale**
Median bus company: 421'000 Bus-Km.	1.35 (0.08)	1.03 (0.094)

We note that the indicator for the economies of density is 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. 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. Alernatively, the current output should be produced on a network of reduced size. Regarding the scale economies, medium sized operators 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.

The estimated coefficients for price of labor (0.579) and price of energy (0.044) 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 (0.381). Summarizing labor cost account for about 58%, energy cost for 4.5% and capital cost for 37.5% at the median observation. These results are in the range of the previous findings.[4]

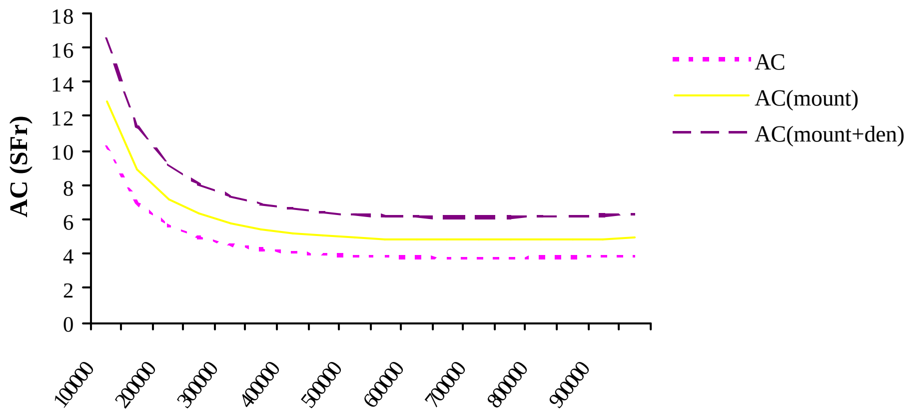
The trend variable is negative and significant at the 90% confidence level, implying that the Swiss bus companies experienced neutral technological progress over these years (1991-1995).
Finally the positive and significant coefficients for *REGIO* and *DEN* indicate that cost differences can further be explained from different geographical and network conditions. The coefficient for *DEN* suggests for example that bus companies operating on a relatively stop intensive network have higher cost than companies with a relatively lower number of bus stops per kilometer of network.

[4] See Filippini et al and Filippini, Prioni (1994) for previous results. Similar results for the bus industry in Britain were found in Button O'Donnel (1985).

5. Using the estimations results in the practice of regulation

According to the model specification it is possible to derive different kinds of average cost functions, which could be used for yardstick regulation. The following figure reports the average cost for bus operation in mountain regions (AC(mount)), in mountain regions with a relatively high bus stop density (AC(mount + den)) and finally the figure illustrates the average cost (AC) calculated for the case *DEN*=0 and *REGIO*=0. As expected, bus companies operating in more difficult conditions have higher average cost than companies operating in the valleys and with a relatively high bus stop density.

Figure 1: Average costs



According to figure 1, it is possible to calculate average costs under different regimes for different companies' sizes. The following table reports average cost for hypothetical small, medium and big bus companies. The different "regimes" are given by the different values of the dummy variables *REGIO* and *DEN* (1 or 0).

Table 3: Average cost per bus-km under different operating conditions and for different companies' sizes

	DEN=0, REGIO=0	DEN=1, REGIO=0	DEN=0, REGIO=1	DEN=1, REGIO=1
Small : 100000 Bus-Km 10 Km	7.17	9.14	9.09	11.60
Medium : 225000 Bus-Km,	4.58	5.68	5.65	7.21
Big : 506250 Bus-Km, 50.6 Km	4.08	5.01	4.98	6.35

For example the second column reports the estimated average cost for hypothetical bus companies operating a relatively stop intensive network but in a more favorable geographical region.
The regulator might use these costs estimates to calculate individual caps on the subsidy per output unit for different bus companies that reflect the heterogeneity of their service area and geographical characteristics. However, the size of the companies (*y*, measured by the bus kilometers) must not be included in the yardstick price calculation because it is not a characteristic of the service area and can be altered by the firms. The exclusion of *y* gives the bus companies incentives to adapt the size of their operations in order to optimise density of operation. The regulator might be willing to make also the network size a choice variable of the companies in order to give them more degrees of freedom to optimise density.
The yardstick regulation of firms with heterogeneous outputs is only appropriate if the observed characteristics allow the regulator to record most of the heterogeneity. The adjusted determination coefficient of our estimation is rather high, 0.85, suggesting that our model explains about 85% of the variation of total operating costs.

6. Conclusions

In this paper we have estimated a cost function for a panel of 34 Swiss bus operators as a basis for yardstick competition as suggested by Shleifer. Several variables measuring the heterogeneity of output were included in the model. This allows to differentiate production cost according to topographic specificity and network characteristics like density of stops and length of the network. Future research would have to develop more precise indicators.

The current process of deregulation of local public transport is slowed down among else by the lack of objective rules for attributing licenses to operators. Authorities, concerned about the continuing provision of minimal public services and trying to avoid the pitfalls of competitive tendering hesitate to proceed. It is in this context that the proposed research wants to open new options for discussion.

It is believed that providing information of production cost differentiated by type of service and topography will permit the regulating bodies to proceed to the implementation of a price-cap type of regulation of the tendering process. In this case, the authorities would define the cap on the average cost and hence – in case of an operating deficit due to regulated end prices – on the subsidy per output unit. Such a regulation might help to speed up the reform of public transport provision in Swiss regions.

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