The Impact of Ownership on the Cost of Bus Service Provision: An Example from Piedmont

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The impact of ownership on the cost of bus service provision: an example from Piedmont

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Abstract

The paper examines the potential impact of ownership on the cost of bus service provision for a sample of 48 private and 11 public companies providing local public transit (LTP) in Piedmont (Italy) from 1998 to 2002. A translog cost frontier has been estimated using the model in Battese and Coelli (1995) where inefficiency scores are allowed to vary across firms and over time. Two specifications are compared: in the first one the ownership and the type of service supplied by the LPT company directly enter the cost function, while in the second one these variables are able to explain the differences in mean inefficiencies. Data reject the second specification in favour of the first one: public firms and firms supplying only intercity services have a different cost structure. Density and scale economies and cost inefficiencies are then computed. Private companies seem to experience density and scale economies, whereas public ones don't. Cost inefficiency and estimated average costs appear higher in the public sample.

J.E.L.: C1, L33, L92

Key words: Public transport, ownership, cost frontier

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1 Introduction

The aim of this paper is to investigate the influence of ownership on the cost characteristics of a sample of bus companies operating public local transport (LPT) in Piedmont, a North Western region of Italy and to draw some policy conclusions from such evidence.

The choice of a regional extent is particularly relevant because of its consistency with the Italian regulatory framework issued from the LPT reform process started with Law 549/1995, which transfers functions, tasks, goods, infrastructures, human, financial and organizational resources to the local authorities corresponding to the Italian regions, making them responsible for planning and policies relative to LPT in their territorial jurisdiction.

As regards the influence of ownership on the provision of local public transport, the issue is relevant as private, public and mixed firms are present in the LPT Italian market and the data we use convey important information as companies are distinguished according to ownership, whereas Italian empirical studies have so far referred to public sector companies only.

Economic theory, following Alchian (1965), suggests that productivity and performance are higher in the private than in the public sector because of an attenuation of property rights in the latter causing a reduction of public managers' incentives to minimize costs and to follow owners' interests, that is to say citizens' interests.

Many recent empirical studies have tackled the problem of a different efficiency in private and public companies, without reaching any conclusive evidence. In the field of LPT Perry and al. (1986) and Berechman (1993) found that private companies are more efficient than public ones, although they attributed the result to the competing structure and not to the structure of ownership. For Chang and Kao (1992) and Kerstens (1996) private companies perform better in Taiwan and in France, whereas Viton (1997) doesn't find any significative difference in the U.S. market, just as Jorgensen et al (1997) and Odeck and Alkadi (2002) in their research on Norwegian buses. Finally Filippini and Prioni (2003) in their work, not based on data envelopment analysis, but on the estimation of two cost models, reach ambiguous results.

The paper is organized as follows. Next section describes the characteristics of the supply of transport services in the considered Italian region. Section 3 sets forth the econometric model used for the identification of the main efficiency indicators. The flexible translog cost function is exploited in order to identify density, scale and cost inefficiencies, comparing the different features of private and public companies. In section 4 the dataset is described and the estimated cost function is briefly discussed. Section 5 discusses the main findings. The last section presents some concluding remarks.

2 The characteristics of the industry

We deal with data for 59 LPT companies supplying bus transportation at urban, intercity and mixed (both urban and intercity) level in Piedmont. For our empirical investigation we decided to investigate the differences in cost structure and efficiencies of two sets of companies: a group of private firms and a, considerably smaller, set of firms owned by public institutions (mainly local municipal entities). Data sources and their transformation for the estimation are detailed in section 4, here a simple descriptive analysis of data is carried out. The aim is to give some initial insights on the characteristics of the industry in Piedmont.

Table 1 presents descriptive statistics for the two groups of firms: large differences in size and structure characterize the two samples. However high variability is present (standard errors are often 1.5 times the mean values for private firms and even larger in the public sample) and we are going to comment on median values.

Private firms cover about 470,000 vehicle-Km per year employing 15 employees and 16 vehicles. On the contrary, public companies travel more than 1.3 million vehicle-Km per year and their median size in terms of number of employees and vehicles is 60 and 40 respectively.

Also the cost structure considerably differs according to ownership: public firms median total costs are about four times the median total costs for private companies. Labour price and the cost for other variable inputs are also significantly higher.

Table 1. Descriptive statistics for the samples of privately and publicly owned bus transportation companies (annual observations from 1998 to 2002, unbalanced panel).

	Mean	***Std. Dev.***	***First quartile***	***Median***	***Third quartile***
Private firms, 48 firms, n. obs. 221					
Total cost (th Euro)	1748.331	2424.361	197.902	891.405	2079.772
Total variable cost (th Euro)	1384.286	1993.654	161.225	644.209	1537.504
Vehicle - Kilometres (Y)	962,160	1,344,539	124,478	467,685	1,267,520
Network (KM)	391.810	429.021	81.00	251.10	485.75
Employees	30.427	41.849	4.30	14.50	35.00
Vehicles	24.720	28.641	5.00	16.00	32.00
Total cost of personnel (th Euro)	893.510	1316.009	100.729	410.067	931.841
Total cost of other inputs (th Euro)	490.777	706.080	53.323	230.340	599.745
Total variable cost/vehicle - Km (Euro)	1.815	1.777	1.193	1.468	1.872
Total variable cost /vehicles (th Euro)	47.376	18.070	35.271	47.660	57.701
Total cost of personnel / n. employees (th Euro)	27.405	7.667	24.348	28.230	30.382
Total cost of personnel / vehicle - Km (Euro)	1.206	1.502	0.722	0.929	1.173
Total cost of other inputs/ vehicle - Km (Euro)	0.610	0.366	0.433	0.546	0.711
Public firms , 11 firms, n. obs. 47	***Mean***	***Std. Dev.***	***First quartile***	***Median***	***Third quartile***
Total cost (th Euro)	26,197.470	62,424.870	896.569	3462.430	6897.916
Total variable cost (th Euro)	20,981.590	49,127.640	774.247	2701.696	6082.456
Vehicle - Kilometres (Y)	6,477,287	14,100,000	304,087	1,371,150	2,736,284
Network (KM)	519.190	872.620	135.00	197.60	444.000
Employees	447.119	1036.954	14.00	60.00	180.750
Vehicles	141.295	276.333	12.00	40.00	68.000
Total cost of personnel (th Euro)	14,860.930	35,126.520	590.723	2,107.395	4,378.242
Total cost of other inputs (th Euro)	6120.658	14347.710	271.626	643.653	1710.039
Total variable cost/vehicle - Km (Euro)	2.373	0.789	1.908	2.357	2.725
Total variable cost /vehicles (th Euro)	85.310	35.720	62.851	65.872	93.394
Total cost of personnel / n. employees (th Euro)	33.220	6.724	30.273	33.144	35.339
Total cost of personnel / vehicle - Km (Euro)	1.681	0.531	1.387	1.644	2.080
Total cost of other inputs/ vehicle - Km (Euro)	0.692	0.337	0.510	0.641	0.800
All firms , 59 firms, n. obs. 268	***Mean***	***Std. Dev.***	***First quartile***	***Median***	***Third quartile***
Total cost (th Euro)	6036.053	27622.150	222.031	1028.596	2374.459
Total variable cost (th Euro)	4821.128	21790.760	191.862	774.037	2005.623
Vehicle - Kilometres (Y)	1929365	6348746	144336	524132	1367116
Network (KM)	414.149	534.044	89.635	228.00	482.43
Employees	103.504	460.327	5.25	18.00	44.00
Vehicles	45.164	125.715	6.00	17.00	37.00
Total cost of personnel (th Euro)	3343.021	15566.730	117.059	511.949	1317.358
Total cost of other inputs (th Euro)	1478.107	6362.204	71.362	274.607	696.572
Total variable cost/vehicle - Km (Euro)	1.913	1.660	1.235	1.570	2.041
Total variable cost /vehicles (th Euro)	54.029	26.415	37.361	51.549	64.376
Total cost of personnel / n. employees (th Euro)	28.424	7.819	25.507	28.771	31.662
Total cost of personnel / vehicle - Km (Euro)	1.289	1.393	0.765	0.999	1.370
Total cost of other inputs/ vehicle - Km (Euro)	0.624	0.362	0.436	0.569	0.723

Table 1 also reports some simple efficiency indicators. All indicators point to a lower performance for publicly owned firms. While total variable costs per travelled vehicle - Km are almost 1.6 times larger, total variable cost per vehicle is 1.4 times larger in the public sample (65.9 vs 47.6 thousand Euro). Labour cost per employee and per travelled vehicle-Km are about 17% and 77% higher, respectively, for public companies.

Public and private companies are also characterised by different forms of differentiation in supplied services (table 2). Public companies mainly supply mixed services (both urban and intercity transport), while private firms mainly provide intercity service.

Firms supplying only urban services experience higher total variable costs, travelling the largest amount of kilometres with the largest number of vehicles.

The proportion of firms that supply other non transport services is very high among both private and public firms. In the full sample almost 88% of firms (92% of private firms and 63% of public companies) also offer services such as car and bus renting, parking ticketing, car park management, etc.

Table 2. Descriptive statistics by type of bus services supplied (median values)[iv].

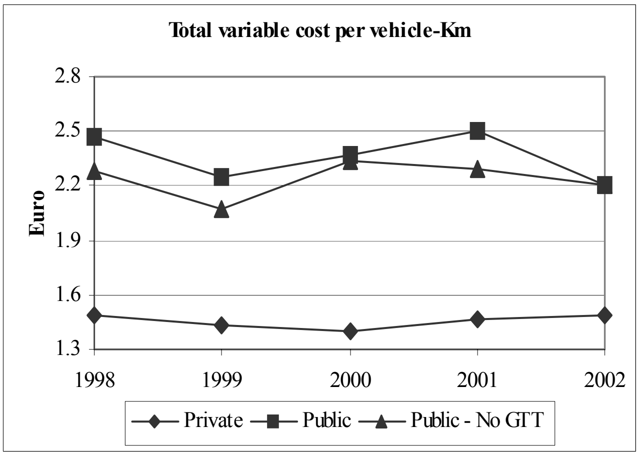
	Urban service only		***Intercity service only***		***Mixed service***	
	Private	***Public***	***Private***	***Public***	***Private***	***Public***
Total variable cost (th Euro)	1,638.11	3,604.40	512.22	128.81	776.25	2,719.94
Vehicle-kilometres (Y)	1,520,448	1,432,045	355,236	69,736	492,553	1,388,028
Network (KM)	125.20	154.08	251.1	75	273.25	197.6
Employees	51	82	12	3	19	64
Vehicles	37	49	15	2	17	40
Total cost of personnel / n. employees (th Euro)	26.63	35.46	28.92	32.81	26.80	31.98
Total cost of other inputs/ vehicles - Km (Euro)	0.26	0.60	0.55	0.46	0.56	0.65
N. Firms	2	3	35	2	16	7

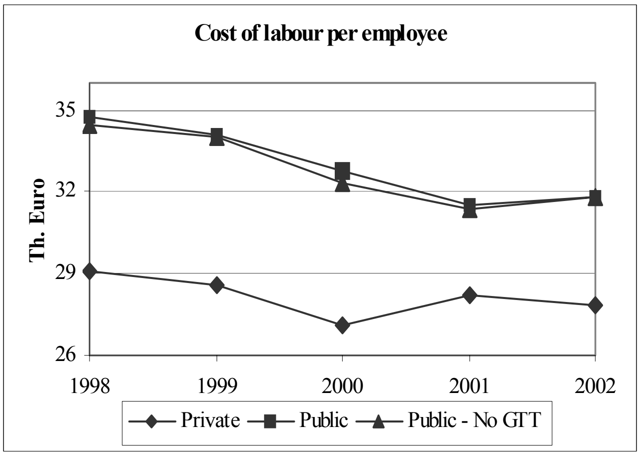
Figure 1 shows four panels with the evolution over time of two simple efficiency indicators (total variable cost per travelled vehicle-Km and labour cost per employee) for different sets of companies.

[iv] The total number of private and public firms do not sum to 48 and 11 respectively because over the covered time period, 5 private firms and 1 public firm change their mix of supplied services.

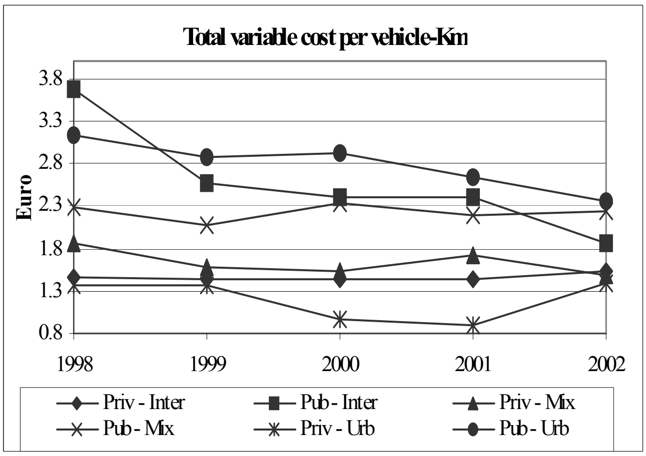
Figure 1. Comparing private and public firms over time according to simple performance indicators: total variable cost per travelled vehicle - kilometre and total labour cost per employee (median values).

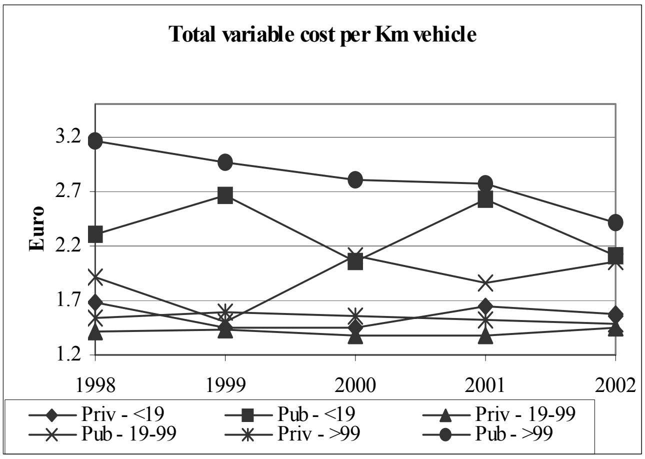
Panel A. Private vs Public firms





Panel B. Private vs public firms by type of service supplied (Urban, Intercity and Mixed) and dimensional class (less than 19 , 19-99 and more than 99 employees).





In panel A of figure 1 public and private firms are compared considering two sets of public firms: all public firms and a restricted set of public firms without the biggest public transport company, called GTT, serving the metropolitan area of Turin[v]. Private firms always lay below public firms and for both the sets of public firms the cost per vehicle kilometre is particularly high. The median cost of an employee is also lower for private

[v] GTT is the name for the former ATM-Turin and SATTI.

firms (the difference is about 5 thousand Euro per year). Labour cost is decreasing over the considered period, especially in the public sample.

Panel B of figure 1 includes the public GTT firm.

The two graphs report the total variable cost per vehicle - kilometre for different sets of public and private firms according to the type of supplied service (see also table 2) and for dimensional classes.

Public firms supplying only urban services have the highest costs, while, surprisingly, private firms supplying only urban services have the lowest cost per vehicle-Km. Private and public firms are much closer when they supply mixed services.

In the two groups best performances are found in the medium sized class (19-99 employees), while the largest companies are less efficient (public and to a less extent private).

Summing up public firms are characterised by larger size and mixed urban and intercity services, while private firms mainly supply intercity services and they are smaller in terms of number of employees, vehicles and travelled kilometres. Simple performance indicators all point to a worst performance of publicly owned companies.

3 The empirical model

Efficiency measures

The aim of the paper is to give some evidence of the role of ownership on the efficiency of LPT firms.

The panel structure of the data is exploited and the model in Battese and Coelli (1995), which allows for the estimation of firm specific inefficiencies that vary over time, is thus implemented (see Coelli et al., 1998 and Kumbhakar and Lovell, 2000, for a review of the theoretical and empirical literature on productivity analysis; see Piacenza, 2001, for a survey of cost function specifications in the analysis of efficiency in the bus transportation industry).

The cost frontier function we are going to estimate has the following structure:

(1) $$C_{it} = c(Y_{it}, p_{it}; \alpha)\exp(v_{it}+u_{it})$$

where the cost for firm i at time t, C_{it}, is a function of output Y_{it} and input prices p_{it}, while α is a vector of unknown parameters to be estimated.

While c(.) is the deterministic cost structure, exp(v) represents the effect on costs of exogenous shocks and exp(u) is the inefficiency. The term v represents random noise (such as measurement errors), out of the control of firms, and they may take positive or negative sign. The term u captures inefficiency and it can only be positive.

Once we are able to control for random shocks, any difference among the observed cost level and the situation where u=0 (i.e. the cost frontier where inefficiencies are absent), is due to inefficiency. Cost inefficiencies are thus computed as the following ratio:

$$\text{Cost Inefficiency for firm i at time t} = CI_{it} = C_{it} / c(Y_{it}, p_{it}; \alpha)\exp(v_{it}) = \exp(u_{it})$$

Cost inefficiencies range from 1 to infinity. Firms that display a CI score equal to one are the most efficient, since they lay on the frontier, firms with CI greater than one are relatively less efficient. It is important to highlight the « relative » nature of such efficiency scores: the efficiency (or inefficiency) of each firm is measured relative to the other companies in the considered sample, not in absolute terms.

Distributional assumptions are imposed to the last two terms, v and u. The exogenous shocks v are usually assumed to be i.i.d. normally distributed with mean zero and constant variance σ^2_v. The inefficiency term u is going to be assumed truncated normal in our estimation.

The idea is to include environmental characteristics into the analysis of the cost frontier specification.

Two possible procedures have been identified in the literature on stochastic frontiers.

Following Coelli et al. (1999) we are going to call the two choices case 1 and case 2 respectively.

Under case 1, environmental and other external features (of the industry, the market or the firm) are included in the cost function, together with output measures and input prices. For example Good et al. (1993) embed environmental factors into the production function assuming that the environment alters the shape of the production function.

On the contrary, case 2 is the classical Battese and Coelli (1995) model.

Case 1 is characterised by the fact that environmental aspects are included into the cost function and explain the cost structure that assumes the following form:

(2) $$C_{it} = c(Y_{it}, p_{it}, Z_{it}\,;\, \alpha, \theta)\, \exp(v_{it}+u_{it})$$

Where Z_{it} is a vector of external factors which shift the cost function, α is the vector of unknown parameter associated to output and input prices, while θ is the vector of coefficients for the environmental variables Z.

u_{it} is the usual inefficiency term and it is assumed to be i.i.d. truncated normal $u_{it} \sim N^{+}(\delta_0, \sigma^2_u)$, where δ_0 is a constant to be estimated.

Under case 2 the cost structure is not affected by environmental aspects and we assume that a unique "cost technology" exists for all LPT firms.

What external factors may influence is the inefficiency term u_{it}.

Following the model in Battese and Coelli (1995), the cost frontier is now:

(3) $$C_{it} = c(\, Y_{it}, p_{it};\, \alpha)\exp(v_{it}+u_{it})$$

Where $u_{it} \sim N(\delta' Z_{it}, \sigma^2_u)$

i.e. u_{it} is independently but not identically distributed across time and firms, as long as external factors influence its mean ($E(u_{it}) = \delta' Z_{it}$) .

From an operational point of view we simultaneously estimate the cost frontier in (3) and the following linear relationship for the inefficiency term [vi]:

(4) $$u_{it}= \delta' Z_{it} + \varepsilon_{it}$$

where ε_{it} is i.i.d. normal with mean zero and variance σ^2_ε

Theoretically it is not possible to discriminate among case 1 and case 2: in principle both models can be adequate. Coelli et al. (1999) thus suggest to let the data drive the

[vi] Early empirical papers (Pitt and Lee, 1981 and Kalirajan, 1989) used a two step procedure for the estimation of the relationship in (3). However Kumbhakar et al. (1991) and Battese and Coelli (1995) addressed the inconsistency of the two stage method and suggested the simultaneous estimation of the production(cost) frontier and the inefficiency equation.

choice. The two models are not nested and we cannot directly test one model against the other. However it is possible to estimate a full nested model, where the same external factors explain both the costs and the inefficiencies:

(5) $$C_{it} = c(Y_{it}, p_{it}, Z_{it}; \alpha, \theta) \exp(v_{it}+u_{it})$$

$$u_{it} = \delta' Z_{it} + \varepsilon_{it}$$

and then testing case 1 against the full nested model and case 2 against the full nested model through likelihood ratio tests.

Case 1 and case 2 models give different measures of firm inefficiencies. In particular case 1 allows for the estimation of cost inefficiency measures that are net of environmental influences, while case 2 cost inefficiencies are gross, because they include the external factors. The two sets of measures are thus not directly comparable (unless some modifications in the formulas for the computation of the inefficiencies are implemented, see Coelli et al., 1999, for some details in the case of a production frontier).

The main caution when estimating case 2 model is the exogeneity of the included environmental factors. The variables that we include as "external" factors may be under the firm control. If the efficiency levels influence such factors, the interpretation of the estimated coefficients is going to be misleading.

We are going to use a set of different variables as external influences, assuming that they all are exogenous (i.e. out of the firm control) at least in the five years of our panel.

The translog cost function

A variable cost function seems to be the appropriate choice for the bus industry (see, among the others, De Borger, 1994).

Transportation firms usually operate with excess capacity and the imposition of a total cost minimization may be inappropriate. We assume that firms minimize their variable cost function and operate at a suboptimal level of capital stock.

The variable cost function for a firm with fixed level of capital stock is:

$$VC = c(Y, p_L, p_M, K, N, t)$$

where the variable cost VC is a function of output Y, input prices for labour and other variable inputs, respectively (p_L, p_M), capital stock K, network dimension N and a time trend which approximates technology t.

The chosen functional form for the deterministic part of the cost relation is the translog cost function (Christensen and Greene, 1976; Berndt, 1991). It represents a second order approximation of the true cost function at a point (the chosen point in the estimation is the sample median) and it is widely used in transport studies:

$$(6)\quad \ln(VC^*) = \alpha_0+\alpha_L\ln(p_L^*) +\alpha_N\ln(N) +\alpha_Y\ln(Y) +\alpha_K\ln(K)+\alpha_T t +0.5\alpha_{LL}(\ln(p_L^*))^2+0.5\alpha_{NN}(\ln(N))^2+0.5\alpha_{YY}(\ln(Y))^2+ 0.5\alpha_{KK}(\ln(K))^2+0.5\alpha_{TT}(t)^2+\alpha_{NL} \ln(N)\ln(p_L^*)+\alpha_{YL}\ln(Y)\ln(p_L^*)+\alpha_{LK} \ln(p_L^*)\ln(K)+ \alpha_{TL}(t)\ln(p_L^*)+\alpha_{YN}\ln(Y)\ln(N)+ \alpha_{NK} \ln(N)\ln(K)+ \alpha_{tN}(t)\ln(N) +\alpha_{YK}\ln(Y)\ln(K)+ \alpha_{YT}\ln(Y)(t)+ \alpha_{KT}(t)\ln(K)+ v +u$$

where the α_j's are the unknown parameters to be estimated, t is a time trend, v and u are the error terms as previously defined.

In order to deal with a well behaved cost function, homogenous of degree one in input prices, total variable costs and labour price are normalized by the price of the other input (raw material and fuel price). In (6) starred variables have been divided by the price of this input.

The following restrictions are checked after the estimation, in oreder to deal with a cost function that is monotonically increasing and strictly quasi concave in input prices :

- Fitted costs and fitted inputs' shares are non negative;

- Fitted marginal costs (with respect to output) are non negative;

- The matrix of substitution elasticities is negative semidefinite.

The objective is to evaluate scale economies and the degree of cost inefficiencies, bearing in mind that in industries where services are given over a network returns to scale are distinguished from returns to density (see Caves et al., 1984) . While returns to scale (RS) are measured by the inverse of the percent change in total variable cost as a consequence of a percent change in output and network size, returns to density (RD) are defined as the percent change in total variable cost caused by a percent change in output, keeping network size and input prices fixed:

(7) $$RS = 1/(\partial \ln(VC)/\partial \ln(Y) + \partial \ln(VC)/\partial \ln(N)); \quad RD = 1/(\partial \ln(VC)/\partial \ln(Y));$$

When returns to scale are greater than one, economies of scale are present and total variable costs increase less than proportionately with output and network size, given capital and all input prices. Similarly returns to density greater than one indicate the presence of economies of density and total variable costs increase less than proportionately with output. Diseconomies of scale/density occur for values of RS / RD smaller than one. When RS / RD equal one, neither economies nor diseconomies exist.

4 Data and the estimated cost function

The dataset consists of an unbalanced panel of 59 public transit companies operating in the Italian region of Piedmont observed over the period 1998-2002.The sample has the peculiarity of including both public and private companies, whereas the preceding Italian studies were based on municipal companies only. LPT operators are either specialized or multiproduct, where services offered refer to urban and intercity transport. In general the 11 public companies mainly supply urban services, while the 48 private ones mainly supply intercity services. As institutional form is concerned, corporations dominate, but other forms, such as cooperatives are present.

All variables used in the estimation have been normalized by their median (e.g. $\ln(p_L)=\ln(p_L/\text{median}(p_L))$) and the consumer price index for transport services has been used in order to deflate monetary amounts[vii].

The total variable cost (VC) is given by the sum of labour cost and material cost.

[vii] CPI for 1998=100; 1999 = 102.3; 2000 = 106.4; 2001 = 108; 2002 = 110, source Istat, Italian Statistical Institute.

Two inputs are present: labour (L) and material (M) and in order to meet the required condition of homogeneity of the cost function in input prices, total cost and the price of labour are divided by the price of materials.

The price of labour is given by the ratio of total personnel expenses to the total number of employees (drivers, maintenance workers and administrative staff).

The total cost of materials is obtained as the sum of the cost of raw materials (mainly fuel cost) and the cost of services (maintenance and other services). The price for these inputs used in the estimation is obtained by dividing their total costs by the total number of travelled kilometres.

The output measure (Y) is given by the product of the number of travelled kilometres by the number of available vehicles. This is a supply oriented measure of output since it is a proxy for the potential supply of the considered companies. A demand oriented measure would be the total number of passengers actually transported, but unfortunately this kind of data are unavailable for our sample of firms and besides the cost of providing a transport service doesn't seem to depend on the number of passengers effectively transported.

The measure of capital (K) included in the regression equals the total number of available vehicles.[viii] The output characteristics variable is as customary described by the length (in kilometres) of the network (N) each company covers.

A time trend and time dummies are also added to the specifications. While time dummies simply account for differences in the level of total variable costs across the five years, the time trend (and its interactions) allows for the identification of technological changes. It is the percentage change in variable costs over time, ceteris paribus (see Kumbhakar, 2004 for a discussion on different cost function specifications for technical change measurement):

$$-\partial \ln(VC_{it})/\partial t = -(\alpha_T + \alpha_{TT}\, t + \alpha_{LT}\, p_{Lit} + \alpha_{NT}\, N_{it} + \alpha_{YT}\, Y_{it} + \alpha_{KT}\, K_{it})$$

[viii] Fraquelli et al. (2004) highlight the importance of dealing with a capital measure that accounts for the age of the stock of working vehicles since it influences the use of variable inputs (in particular fuel, maintenance and services costs) and they construct a weighted capital stock where the number of vehicles are weighted by the relative average fleet age. We recognize the importance of such a correction but data availability constraints us to deal with a less "sophisticated" measure of capital.

A negative sign for the above magnitude indicates technical progress, while a positive sign stands for technical regress (all else equal, costs increase over time).

Finally the environmental factors. As already discussed in the previous section, we are going to assume the exogeneity of all the included factors given the short period covered by our data.

The first environmental term that is going to be included is ownership. The variable PUBLIC is a dummy equal to one if the firm is publicly owned and zero otherwise. Among the others Kumbhakar and Sarkar (2004) in their study on Indian banks and Botasso and Sembenelli (2004) in their analysis of twelve Italian manufacturing industries, account for ownership in a similar fashion[ix].

The second factor captures the effect of the type of service supplied. The dummy INTER equals one if the LPT firm only supplies intercity transport services. The estimated parameter is thus relative to those firms that either only supply urban services or supply both urban and intercity transit. A similar approach was followed by Fraquelli et al. (2004) and Piacenza (2002).

The following tables present the results of the estimates.

Table 3 contains 4 specifications: the simple translog model, where no external factors are included, the case 1 model, the case 2 model and the full nested model (see section 3).

Estimates are performed using the software FRONTIER 4.1 by Coelli (1996).

Since all variables are expressed in logarithms, the coefficients can be interpreted as elasticities. Moreover given the normalization of all regressors by their sample median, all elasticities are evaluated at sample medians.

Table 3. Estimation results. The dependent variable is logarithm of variable cost. Unbalanced panel for the time period 1998-2002. Bold coefficients are significant at 5% level. 268 observations, 59 firms.

	TRANSLOG		*CASE 1*		*CASE 2*		*NESTED*	
	Coefficient	*Std.-Err.*	*Coefficient*	*Std.-Err.*	*Coefficient*	*Std.-Err.*	*Coefficient*	*Std.-Err.*

[ix] Bottasso and Sembenelli actually assume that ownership affects the variance instead of the mean of the inefficiency tem u.

Constant	**6.319**	**0.106**	**6.258**	**0.088**	**5.931**	**1.522**	**6.296**	**0.088**
α_L	**0.518**	**0.051**	**0.496**	**0.046**	**0.516**	**0.049**	**0.488**	**0.046**
α_N	**-0.115**	**0.033**	-0.031	0.032	-0.048	0.033	-0.020	0.032
α_Y	**0.719**	**0.079**	**0.768**	**0.072**	**0.759**	**0.073**	**0.767**	**0.074**
α_K	**0.415**	**0.091**	**0.281**	**0.084**	**0.292**	**0.085**	**0.272**	**0.088**
α_T	**0.286**	**0.118**	**0.390**	**0.099**	**0.367**	**0.107**	**0.392**	**0.100**
α_{LL}	**0.083**	**0.018**	**0.086**	**0.017**	**0.055**	**0.017**	**0.093**	**0.017**
α_{NN}	0.021	0.014	-0.001	0.013	0.004	0.014	-0.004	0.013
α_{YY}	**0.220**	**0.069**	**0.263**	**0.063**	**0.268**	**0.062**	**0.220**	**0.064**
α_{KK}	**0.205**	**0.081**	**0.225**	**0.075**	**0.196**	**0.074**	**0.166**	**0.076**
α_{TT}	-0.031	0.018	**-0.035**	**0.016**	**-0.034**	**0.017**	**-0.035**	**0.016**
α_{LN}	-0.019	0.030	0.015	0.028	-0.017	0.028	0.010	0.027
α_{LY}	**-0.195**	**0.051**	**-0.227**	**0.047**	**-0.198**	**0.047**	**-0.212**	**0.047**
α_{LK}	**0.254**	**0.057**	**0.267**	**0.053**	**0.275**	**0.054**	**0.248**	**0.055**
α_{LT}	-0.003	0.015	-0.004	0.014	-0.004	0.014	0.001	0.014
α_{NY}	**-0.113**	**0.051**	**-0.119**	**0.049**	**-0.116**	**0.049**	**-0.109**	**0.048**
α_{NK}	0.104	0.056	**0.142**	**0.053**	**0.136**	**0.053**	**0.133**	**0.052**
α_{NT}	0.008	0.010	0.000	0.010	0.000	0.010	-0.005	0.010
α_{YK}	**-0.403**	**0.144**	**-0.484**	**0.133**	**-0.458**	**0.131**	**-0.383**	**0.135**
α_{YT}	0.027	0.021	0.023	0.019	0.029	0.020	0.021	0.019
α_{KT}	-0.038	0.025	-0.028	0.022	-0.035	0.024	-0.023	0.023
1999	**-0.199**	**0.070**	**-0.292**	**0.058**	**-0.262**	**0.063**	**-0.290**	**0.060**
2000	**-0.341**	**0.105**	**-0.523**	**0.089**	**-0.470**	**0.096**	**-0.523**	**0.091**
2001	**-0.444**	**0.116**	**-0.701**	**0.103**	**-0.622**	**0.111**	**-0.703**	**0.106**
2002	**-0.429**	**0.128**	**-0.759**	**0.125**	**-0.679**	**0.129**	**-0.769**	**0.130**
PUBLIC			**0.228**	**0.030**			**0.215**	**0.030**
INTER			**-0.063**	**0.024**			**-0.117**	**0.025**
Inefficiency equation								
Constant	-9.943	17.202	-8.991	5.227	0.445	1.519	**-5.424**	**1.855**
PUBLIC					**0.233**	**0.032**	0.238	0.199
INTER					**-0.059**	**0.026**	**2.832**	**0.843**
sigma-squared	1.481	2.399	1.209	0.669	**0.023**	**0.002**	**0.445**	**0.152**
γ	0.993	0.012	0.993	0.004	0.369	1.573	0.980	0.009
LLF	100.446		134.309		122.894		136.611	
LR test (d.f.)	19.126	(2)	22.831	(2)	64.021	(4)	27.436	(4)
Mean Ineffic.	1.169		1.150		1.585		1.143	

Notes:

- PUBLIC is a dummy equal to one if the firm is owned by public institutions (mainly municipal entities).
- INTER is a dummy equal to one if the firm only supplies intercity services.
- Sigma squared is the estimation for the variance term: $(\sigma^2_u+\sigma^2_v)$.
- γ is the estimated ratio: $\gamma = \sigma^2_u/(\sigma^2_u+\sigma^2_v)$.
- LLF is the Log Likelihood function.

- LR Test is the Likelihood ratio test for the one sided error: if the null hypotehsis is not rejected the correct specification for the model is the absence of any efficiency term u. The null hypothesis is: Ho : $\gamma + \delta = 0$, where γ is the ratio defined above and δ is the vector of estimated parameters in the specification of the inefficienncy equation ($u = Z\delta + \varepsilon$). The null hypothesis is always rejected at 1% level. The statistics has a mixed square distribution. The critical values are obtained from table 1 in Kobbe and Palm, 1986:
    - for 2 degrees of freedom and a significance level of 5%, the critical value is 5.138 (8.273 for 1% significance level)
    - for 4 degrees of freedom and a significance level of 5%, the critical value is 8.761 (12.483 for 1% significance level)
- Mean Ineff. is the arithmetic mean of the inefficiency scores across firms and time.

The coefficients are quite similar across the three specifications where external factors are included and a brief comment of their magnitudes is given in the following.

The coefficient for output is always significant and ranges from 0.76 to 0.77. A one percent increase in the number of travelled kilometres/bus, increases costs for the median firm by almost 0.8%.

The coefficient for labour price can be interpreted as the estimated input share. For the median LPT firm, labour accounts for 49-52% of total variable costs, while the other variable inputs represent the remaining 48-51%. These figures are slightly smaller than the actual factor shares (median labour share is 65%).

The coefficient for the network size is the elasticity of variable costs with respect to a particular characteristic of the output supplied by the companies. A one percent increase in the network length seems not to increase total costs and in some cases total variable costs decrease (the coefficient is significantly different from zero only in the classical translog specification).

The coefficient for the capital stock has not the expected sign, since a positive sign for such variable is inconsistent with microeconomic theory. The shadow value of capital is given by the first derivative of the variable cost with respect to capital, changed in sign. A negative shadow value for the median firm would be here present. Many interpretations have been given in the empirical literature in order to justify such quite common counterintuitive finding (for a discussion see Fabbri, 1998). We agree with the interpretation given in Fraquelli et al. (2004) according to whom an inefficient use of capital is present in the industry (firms are not minimizing their long run cost function and too much capital is present).

Finally from the estimated cost function, technical change can be computed. If we only consider the coefficients that are significantly different from zero, α_T and α_{TT}, the positive sign and the large magnitude of the estimates for time trend point to a technical regress over the 1998-2002 period: all the rest equal, variable costs increase over time.

The negative sign for the time dummies indicates lower costs in 1999-2002 than in 1998.

The positive sign for the dummy PUBLIC in case 1 specification points to the evidence of higher total costs for public firms. The deterministic cost function is thus shifted upwards for public firms which, all else equal, experience higher costs.

Under case 2 specification the public dummy has a positive sign, indicating the presence of significant higher inefficiencies for publicly owned companies.

The dummy for intercity services is significant and negative in both cases: firms supplying only intercity services have lower costs and lower inefficiencies than firm supplying either only urban or both urban and intercity transits.

Following Coelli et al. (1999) a likelihood ratio test is used in order to choose the specification that better fit the data. Table 4 reports the likelihood ratio test results.

Table 4. Log Likelihood ratio test for case 1 and case 2.

Null Hypothesis	*LR Statistics (d.f.)*	*p-value*
Test 1: *Ho: Case 1 is the correct specification*	-2(134.31-136.61) = 4.61 (2)	0.10
Test 2: *Ho: Case 2 is the correct specification*	-2(122.89-136.61) = 27.44 (2)	0.00

Case 1 seems to be the specification that better fit the data: the dummies for ownership and type of service supplied are better able to explain a different cost structure rather than the inefficiencies. Inefficiency scores will thus be estimated using case 1 specification.

Table 5 shows the estimates for the two separate samples of public and private firms.

Table 5. Separate cost frontier estimation for private and public firms. The dependent variable is logarithm of variable cost. Unbalanced panels for the period 1998-2002. Bold coefficients are significant at 5% level.

	PRIVATE				*PUBLIC*			
	Case 1		*Case 2*		*Case 1*		*Case 2*	
	Coeff.	*Std. Err.*	*Coeff.*	*Std. Err.*	*Coeff.*	*Std. Err.*	*Coeff.*	*Std. Err.*
Constant	**5.973**	**0.118**	**5.904**	**0.117**	**7.650**	**0.169**	**7.597**	**0.093**
α_L	**0.556**	**0.051**	**0.557**	**0.054**	**0.474**	**0.086**	**0.507**	**0.108**
α_N	-0.038	0.037	-0.061	0.038	-0.059	0.080	**-0.125**	**0.032**
α_Y	**0.697**	**0.076**	**0.650**	**0.082**	**1.128**	**0.179**	**1.128**	**0.198**
α_K	**0.350**	**0.091**	**0.431**	**0.096**	-0.024	0.229	0.020	0.204
α_T	**0.519**	**0.135**	**0.526**	**0.134**	0.242	0.159	**0.296**	**0.099**
α_{LL}	**0.057**	**0.019**	**0.059**	**0.020**	**0.137**	**0.068**	0.121	0.139
α_{NN}	0.013	0.015	0.023	0.015	**0.562**	**0.143**	**0.571**	**0.097**
α_{YY}	**0.294**	**0.066**	**0.301**	**0.069**	**0.842**	**0.344**	0.524	0.397
α_{KK}	**0.245**	**0.075**	**0.282**	**0.077**	0.454	0.465	0.078	0.450
α_{TT}	**-0.059**	**0.021**	**-0.059**	**0.021**	-0.005	0.012	-0.012	0.012
α_{LN}	-0.021	0.031	-0.023	0.033	**0.272**	**0.138**	0.188	0.170
α_{LY}	**-0.212**	**0.051**	**-0.217**	**0.054**	**-0.506**	**0.167**	-0.311	0.256
α_{LK}	**0.307**	**0.058**	**0.321**	**0.059**	**0.456**	**0.221**	0.236	0.357
α_{LT}	-0.007	0.015	-0.004	0.016	0.015	0.025	0.014	0.033
α_{NY}	**-0.127**	**0.053**	**-0.136**	**0.055**	**-1.423**	**0.218**	**-1.346**	**0.534**
α_{NK}	**0.134**	**0.054**	**0.134**	**0.056**	**0.617**	**0.287**	0.504	0.514
α_{NT}	-0.001	0.012	0.003	0.012	-0.002	0.017	0.008	0.014
α_{YK}	**-0.533**	**0.135**	**-0.571**	**0.140**	-1.035	0.783	-0.341	0.786
α_{YT}	0.028	0.021	0.029	0.022	-0.007	0.037	-0.002	0.044
α_{KT}	-0.032	0.024	-0.035	0.026	0.010	0.039	0.000	0.047
1999	**-0.347**	**0.078**	**-0.360**	**0.077**	-0.235	0.125	**-0.260**	**0.069**
2000	**-0.587**	**0.118**	**-0.605**	**0.117**	**-0.476**	**0.245**	**-0.510**	**0.116**
2001	**-0.716**	**0.131**	**-0.743**	**0.130**	**-0.695**	**0.341**	**-0.738**	**0.156**
2002	**-0.709**	**0.145**	**-0.727**	**0.146**	**-0.864**	**0.438**	**-0.913**	**0.193**
INTER	**-0.080**	**0.026**			-0.099	0.238		
Inefficiency equation								
Constant	-8.072	5.726	-7.975	7.416	**0.042**	**0.013**	**0.081**	**0.040**
INTER			-0.591	0.435			**-0.220**	**0.073**
sigma-squared	0.976	0.662	1.097	0.953	**0.004**	**0.001**	**0.004**	**0.001**
γ	0.990	0.009	0.991	0.009	1.000	0.000	1.000	0.003
LLF	111.43		106.69		80.17		81.53	
LR test (df)	13.61	(2)	12.38	(3)	4.11	(2)	8.83	(3)
Mean ineff.	1.13		1.14		1.0714		1.0851	
N.obs N.firms	221/48		221/48		47/11		47/11	

Notes:

- INTER is a dummy equal to one if the firm only supplies intercity transit.
- Sigma - squared is the estimation for the variance term: $(\sigma^2_u+\sigma^2_v)$.

- γ is the estimated ratio: $\gamma = \sigma^2_u/(\sigma^2_u+\sigma^2_v)$.
- LLF is the Log Likelihood function.
- LR Test is the Likelihood ratio test for the one sided error: if the null hypotehsis is not rejected the correct specification for the model is the absence of any efficiency term u. The null hypothesis is: Ho = $\gamma + \delta = 0$, where γ is the ratio defined above and δ is the vector of estimated parameters in the specification of the inefficiency equation ($u = Z\,\delta + \varepsilon$). The null hypothesis is always rejected at 5% level (except for the case 1 specification for public firms where the null hypothesis is rejected at 10% level) . The statistics has a mixed square distribution. The critical values are obtained from table 1 in Kodde and Palm, 1986:
    - for 2 degrees of freedom and a significance level of 5%, the critical value is 5.138 (8.273 for 1% significance level)
    - for 3 degrees of freedom and a significance level of 5%, the critical value is 7.045 (10.501 for 1% significance level)
- Mean Ineff. is the arithmetic mean of the inefficiency scores across firms and time.

Estimated parameters do not significantly differ across the case 1 and case 2 specifications, but do differ across the two samples of firms.

For private firms a smaller elasticity of output and a higher labour share are found. Technical regress seems particularly severe for private firms that are also characterised by a positive significant and large in magnitude coefficient for the capital stock: the inefficient use of capital is here particularly evident.

The dummy for intercity services is always negative. Private and public firms supplying intercity transit have lower costs and lower inefficiencies than firms supplying mixed and urban services. However lower costs are significant only for private firms, while lower inefficiencies are significant in the publicly owned sample.

Mean inefficiency is higher in the private sample than among public firms (both net and gross inefficiencies as measured by case 1 and case 2 specifications respectively). However this does not mean that private firms are less efficient than public firms. The estimated inefficiency scores are relative measures, to be interpreted with respect to the set of firms included in the analysis. On average public firms are closer to the cost efficiency frontier than private firms, but the two frontiers are different and cannot be directly compared.

5 Efficiency indicators and economies in the bus industry

Table 6 presents the estimated scale and density economies. They are estimated for the whole sample and for the two samples of public and private firms by re-running the translog cost function on the two sub-samples (tables 3 and 5 estimation results). The specification used for this computation is case 1.

The two sets of firms differ in the two measures: the difference in density economies, can be explained by the type of service supplied by the two sets of firms: while private firms mainly provide intercity connections, public firms operate at urban level. The number of travelled kilometres is much lower for intercity transport firms and this evidence allows for the existence of economies of density, that cannot be exploited as long as the type of service does not change and is constrained by a low level of demand.

Economies of scale on the contrary are much more informative, as this measure is central for defining the optimal size of a service area in the regional bus industry to be assigned through a competitive tendering process [x]. Public companies show small diseconomies of scale (a test verifying that economies of scale equal one for public firms is rejected) while for private firms economies of scale are present. While mergers could allow for the exploitation of these economies of scale for private firms, it seems that the scale is almost optimal for public firms[xi].

Local authorities, responsible of the tendering procedures introduced by the 1997 Local Transport reform, should be aware of these results in defining the boundaries of the service area, while it seems that, so far, this size simply reflects the province jurisdictional boundaries, without taking into account the scale economies or diseconomies experienced by bus companies.

[x] For a comprehensive analysis see Cambini e Filippini (2003).
[xi] This result is insensitive to the elimination of the public GTT firm (ATM and SATTI).

Table 6. Short run estimated economies of scale and density for the median firm. Results based on case 1 estimates, table 3 and table 5. Asymptotic standard errors in parenthesis.[xii]

	Private companies	***Public companies***	***All***
Economies of density	1.435	0.887	1.303
	(0.157)	(0.020)	(0.121)
Economies of scale	1.517	0.935	1.358
	(0.172)	(0.034)	(0.134)

Finally table 7 reports inefficiency dimensions: we deal with "net" inefficiency measures because they do take into account environmental influences (case 1 specification).The most efficient firm in the sample has a degree of inefficiency equal to 1. The average value in the sample is 1.15: this means that LPT firms have a cost inefficiency equal of 15%, i.e. firms have costs almost 15% above the cost frontier. The degree of inefficiency is higher for public firms (16.2% ves 14.7% of private firms), however differences across the two groups are present depending on the considered service, the size and the year.

Inefficiency is higher for private firms supplying only urban services and for public firms supplying intercity services. Only when supplying mixed services public and private firms are quite close (15%).

Companies with less than 19 employees are the most inefficient in both ownership groups. The degree of inefficiency decreases with dimension for public firms, while it is smallest for medium sized private companies.

Over the period 1998-2000 the degree of inefficiency is decreasing for private firms and increasing for public firms. Public firms start decreasing their inefficiencies from 2001, while for private firms 2001 represents a year of dramatic increase in inefficiencies, followed by a quick drop to pre-2001 levels. This result probably need some further investigation.

[xii] Asymptotic standard errors are computed using delta method. For the whole sample Cov($\alpha_Y \alpha_N$)= -0.0004; for private firms Cov($\alpha_Y \alpha_N$) = -0.0008; for public firms Cov($\alpha_Y \alpha_N$) = 0.0072.

Table 7. Mean inefficiency scores (standard deviation in parenthesis). Estimation based on case 1, table 3 specification.

	Private	*Public*	*All*	*N. private companies*	*N. public companies*
All	1.147 (0.173)	1.162 (0.156)	1.150 (0.170)	52	11
Only Urban services	1.170 (0.099)	1.149 (0.147)	1.157 (0.128)	2	3
Only Intercity services	1.143 (0.154)	1.207 (0.178)	1.146 (0.155)	35	2
Mixed Services	1.157 (0.220)	1.152 (0.155)	1.156 (0.201)	16	7
< 19 employees	1.153 (0.192)	1.232 (0.220)	1.161 (0.195)	30	4
19-99 employees	1.129 (0.098)	1.139 (0.104)	1.130 (0.099)	18	4
> than 99 employees	1.197 (0.277)	1.120 (0.105)	1.156 (0.205)	3	4
1998	1.158 (0.222)	1.124 (0.091)	1.153 (0.207)	45	8
1999	1.128 (0.112)	1.165 (0.116)	1.135 (0.113)	47	11
2000	1.125 (0.081)	1.183 (0.204)	1.136 (0.114)	47	11
2001	1.192 (0.250)	1.164 (0.213)	1.187 (0.242)	47	11
2002	1.129 (0.122)	1.163 (0.090)	1.134 (0.118)	35	6

The last table presents the estimated average variable cost by type of service and firm size. As already pointed out in the estimation results the cost structure of public firms is different from that of private firms and average costs result lower for the private companies firms in all types of services supplied (either urban, intercity or mixed), in all dimensional classes and in all years.

Table 8. Estimated average yearly variable costs by type of service and firm size (Euro per vehicle-Km)

	Private	Public	All
All	1.508	2.110	1.614
Only Urban services	1.040	2.631	2.035
Only Intercity services	1.536	2.245	1.575
Mixed Services	1.485	1.880	1.609
< 19 employees	1.658	2.061	1.700
19-99 employees	1.286	1.685	1.351
> than 99 employees	1.365	2.528	1.983
1998	1.659	2.557	1.794
1999	1.535	1.964	1.617
2000	1.483	2.028	1.587
2001	1.410	2.166	1.554
2002	1.445	1.828	1.501

6 Concluding remarks

The paper examines the potential impact of ownership on the cost of bus service provision for a sample of 48 private and 11 public companies providing local public transit in Piedmont (Italy) from 1998 to 2002. A translog cost frontier has been estimated using the model in Battese and Coelli (1995) where inefficiency scores are allowed to vary across firms and over time. Two specifications are compared: in the first one the ownership and the type of service supplied by the LPT company directly enter the cost function, while in the second one these variables are able to explain the differences in mean inefficiencies. Data reject the second specification in favour of the first one: public firms and firms supplying only intercity services have a different cost structure.

Bearing in mind the caveat stemming from the fact that companies owned by public institutions, mainly local municipal entities, come in a very limited number and have a bigger size, the results show some nice features.

As regards the estimated short run scale and density economies, the two sets of firms significantly differ in these measures: the difference in density economies can be explained by the type of service supplied by the two sets of firms: while private firms mainly provide intercity connections, public firms operate at urban level. The number of travelled kilometres is much lower for intercity transport firms and this evidence allows for the existence of economies of density, that cannot be exploited as long as the type of service does not change.

Economies of scale are much more informative, as this measure is central for defining the optimal size of a service area in the regional bus industry to be assigned through a competitive tendering process.

Public companies show small diseconomies of scale while for private firms economies of scale are present: it seems that public companies are too big and private firms are too small. While mergers could allow for the exploitation of these economies of scale for private firms, it seems that de-mergers should be carried out in the public sector

Italian local authorities, responsible of the tendering procedures introduced by the 1997 Local Transport reform, should be aware of these results in defining the boundaries of the service area, while it seems that, so far, this size simply reflects the province jurisdictional boundaries, without taking into account the scale economies or diseconomies experienced by bus companies.

The degree of inefficiency is, on average, 15% in the sample, and it is slightly higher for public companies. Only large public firms reach an acceptable degree of efficiency (costs about 12% above the cost frontier), while small firms have very high degrees of inefficiency (23% among public firms).

Average costs result lower in private companies for all types of services supplied, either urban, intercity or mixed: this finding goes against the explanation relating the different performances of private and public transport companies to the different nature of service they offer, the public being more urban oriented and the private more intercity oriented.

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