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► To cite this version:

Elisabetta Ottoz, Graziella Fornengo, Marina Di Giacomo. The impact of ownership on the cost of bus service provision: an example from Italy. *Applied Economics*, 2009, 41 (03), pp.337-349. 10.1080/00036840601007260 . hal-00582052

HAL Id: hal-00582052

<https://hal.science/hal-00582052>

Submitted on 1 Apr 2011

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Journal:	<i>Applied Economics</i>
Manuscript ID:	APE-06-0038.R1
Journal Selection:	Applied Economics
JEL Code:	C23 - Models with Panel Data < C2 - Econometric Methods: Single Equation Models < C - Mathematical and Quantitative Methods, L92 - Railroads and Other Surface Transport: Autos, Buses, etc. < L9 - Industry Studies: Transportation and Utilities < L - Industrial Organization, L33 - Public versus Private Enterprises; Privatization < L3 - Nonprofit Organizations and Public Enterprise < L - Industrial Organization
Keywords:	local 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 local public 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 consistent with the Italian regulatory framework issued from the LPT reform process, started with Law 542/1997, which transferred functions, tasks, goods, infrastructures, human, financial and organizational resources to the local authorities corresponding to the Italian regional governments, making them responsible for planning and policies relative to LPT in their territorial jurisdiction.

In particular local authorities are responsible for the competitive tendering procedure introduced for the assignment of franchised monopolies in LPT services. Boundaries of the service areas, which generally reflect the provinces and municipalities jurisdictional boundaries, have been defined through transport plans obtained simply by adding up the existing routes, without taking into account scale economies or diseconomies experienced by bus companies or the fact that the area size determines which firm will be able to compete for tenders.

The example of Piedmont, with the metropolitan area of Torino can be generalised to the other Italian regions, being one of the most important Italian areas both in terms of population and economic relevance. Responsibility and financial resources for local public transport have been here assigned by the regional government to the delegated authorities, identified in 8 Provinces responsible for inter-city transport and in 16 large municipalities for urban services. Single LTP firms, both publicly and privately owned, which previously had the licence to provide bus service on the different lines, are now gathered in temporary groups to supply local transport in a service area.ⁱ

ⁱ In order to allow the widest possible participation of small and medium firms in tenders, which because of their technical, organisational and financial complexity would otherwise be beyond the possibility of a single firm or small firms, the EU law maker explicitly admits that groups of economic operators may submit tenders or put themselves forward as candidates.

As both publicly and privately owned firms are involved in the LTP industry and in the temporary groups recently created to take part in provincial tenders, the influence of ownership on the provision of bus service appears to be a relevant issue for policy makers, with particular attention to efficiency and economies of scale of the two groups, which should be carefully taken into account in the design of a transport policy, aimed at improving efficiency.

Many theoretical arguments suggest that privately owned firms should outperform publicly owned ones: “the dominant positive model on the effect of ownership is the public choice or property rights model.” (Boardman and Vining, 1989).

According to this view politicians, senior bureaucrats and tax-payers have attenuated property rights, as compared to private owners, to the gains associated with improved performance and, hence, lesser incentives to foster improvements; on the other hand public sector managers have more incentives to act on their own self interest, pursuing goals other than those of their agency.

These arguments have been challenged, though: both ownership and the degree of competition faced by a firm are relevant when assessing its performance (Vickers and Yarrow, 1989) and in a natural monopoly the presence of regulations, incomplete information and transaction costs may hamper the role of markets, so that there might be inefficiency from regulation of private firms (Hodge, 2000). Finally there is little evidence that bureaucrats effectively behave in a manner predicted by public choice theory (Martin and Parker, 1997).

Many recent empirical studies, based on both parametric and non parametric approaches, have recently tackled the problem of a different level of efficiency in private and public companies, without reaching any conclusive evidence.

In the field of LPT Perry and Babitsky (1986) and Berechman (1993) find that private companies are more efficient than public ones, although they attribute such a result to the competing structure and not to 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), as well as Odeck and Alkadi (2001) in their research on Norwegian buses. Finally Mizutani and Urakami (2003) in the Japanese case and Roy and Billion (2005) in urban transport in France, find that private firms are more efficient, whereas Filippini and Prioni (2003) reach ambiguous results.

We deal with an unbalanced panel of 77 LPT companies operating 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. A translog cost frontier is estimated using the model in Battese and Coelli (1995) and the public ownership dummy, included in the inefficiency model, is always positive and significant pointing to higher inefficiencies for public companies. Inefficiencies are also increasing with firm size for both public and private units. Density and scale economies are then computed and private companies seem to experience higher density and scale economies than public ones.

The paper is organized as follows. Section 2 sets forth the econometric model: 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. Section 3 describes the dataset. Section 4 discusses the main findings. The last section presents some concluding remarks.

2 The empirical model

2.1 Measuring inefficiency

The aim of the paper is to give some evidence on 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 $c(\cdot)$ is the deterministic cost structure, $\exp(v)$ represents the effect 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 it may take either positive or negative sign. The term u captures inefficiency and 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 (CI) are thus computed as the following ratio:

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

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.

In the empirical literature on stochastic frontier functions, where panel data are available, at least two sets of estimators have been proposed (see Sickles, 2005 and Greene, 2002, 2004 for recent surveys on panel estimators for parametric and non parametric frontiers): fixed effects and random effects estimators.

The two groups mainly differ in the assumption about the correlation among the regressors and the (individual specific component of the) error term, given by the random shocks and the individual specific inefficiency, i.e. v_{it} and u_{it} . While random effects estimators are consistent and efficient under the assumption of no correlation among the independent variables and the error term, the fixed effects estimator allows for such a

correlation and a within transformation of variables is performed in order to get rid of the individual specific part of the error term.

In a fixed effects model (firstly proposed by Schmidt and Sickles, 1984, in a frontier context) no distributional assumptions are imposed on the inefficiency term while since Pitt and Lee (1981) seminal contribution, random effects estimators are based on the imposition of a particular distribution on the inefficiencyⁱⁱ.

Our choice is in favour of a particular version of a random effects model. Under the assumption of no correlation among the error terms and the regressors, distributional assumptions are imposed to both v and u terms.

In order to complete the analysis we want to include environmental characteristics into the analysis of the cost frontier specification and many possible procedures have been identified in the literature. Environmental and other external features (of the industry, the market or the firm) can be 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. Another possibility is to include environmental aspects into the first or the second (or both) moment of the distribution of the inefficiency term: in this case the cost structure is not affected by environmental aspects and a unique technology is assumed to exist for the sampled firms: what external factors may influence is the distribution of the inefficiency term u_{it} . Among the others, Kumbhakar et al. (1991) and Battese and Coelli (1995) proposed models where the mean of the truncated distribution of u_{it} is a function of a number of exogenous external factors; Gumbau-Albert and Maudos (2002) use a two step procedure for the identification of the inefficiency determinants; Caudill and Ford (1993) parameterize the variance of the distribution of the inefficiency term while Wang (2002) estimates a model where both the mean and the variance are functions of a set of exogenous variables.

In our empirical application we decided: (a) to impose the influence of a set of external factors on the mean value of the truncated distribution of the inefficiency term and (b) to test the validity of the inclusion of another set of external factors into the cost technology.

ⁱⁱ The most commonly used distributions are half normal, truncated normal, exponential and gamma.

Our first aim is to obtain some insights about the influence of ownership on the inefficiency of the considered firms and we thus include ownership in the mean of the truncated distribution of the inefficiency term. We then test for differences in the cost technology comparing two specifications that only differ in the included variables in the cost structure (next sections give more details on such factors).

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

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

Where $u_{it} \sim N^+(\delta'Z_{it}, \sigma_u^2)$, i.e. u_{it} 's are non-negative truncations of a normal distribution and they are independently but not identically distributed across time and firms and external factors influence its mean ($E(u_{it}) = \delta'Z_{it}$). Moreover the cost inefficiency term is independently distributed from the random shocks v that follow a normal distribution with zero mean and constant variance σ_v^2 .

From an operational point of view we simultaneously estimate the cost frontier in (2) and the following linear relationship for the inefficiency model ⁱⁱⁱ:

$$(3) u_{it} = \delta'Z_{it} + \varepsilon_{it}$$

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

The main caution when estimating (2) and (3) is the exogeneity of the included environmental factors: if the environmental factors (that enter matrix Z) are functions of inefficiencies, u , 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 additional assumption we are going to impose in the estimation of (2) and (3) is homoscedasticity for the inefficiency and the shock terms. Both σ_u^2 and σ_v^2 are constant and they are simultaneously estimated via maximum likelihood together with the other

ⁱⁱⁱ 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 model. See Wang and Schmidt (2002) for Monte Carlo evidence on the severity of the biases in two - step models.

parameters in the model, i.e. the vectors α and δ . The validity of such a restriction may be questionable given the high degree of variability in our dataset. However inspection of the plots of the estimated residuals against fitted values, the dependent variable and the set of regressors does not seem to point to severe heteroscedasticity issues.

2.2 The translog cost function

A total cost function is estimated:

$$TC = c(Y, N, p_L, p_M, p_K, \tau, \text{Type of service})$$

where total cost TC is a function of output Y, network dimension N, input prices for labour, other variable inputs and capital respectively (p_L, p_M, p_K) and a time trend which approximates technology, τ . In one specification we also include a set of dummies that control for the type of service the bus company supplies: only intercity, only urban or both intercity and urban transits.

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 mean) and it is widely used in transport studies:

$$\begin{aligned} (4) \ln(TC^*) = & \alpha_0 + \alpha_L \ln(p_L^*) + \alpha_M \ln(p_M^*) + \alpha_N \ln(N) + \alpha_Y \ln(Y) + \alpha_\tau \tau \\ & + 0.5\alpha_{LL}(\ln(p_L^*))^2 + 0.5\alpha_{MM}(\ln(p_M^*))^2 + 0.5\alpha_{NN}(\ln(N))^2 + 0.5\alpha_{YY}(\ln(Y))^2 + 0.5\alpha_{\tau\tau}(\tau)^2 + \alpha_{LM} \\ & \ln(p_L^*)\ln(p_M^*) + \alpha_{NL} \ln(N)\ln(p_L^*) + \alpha_{YL} \ln(Y)\ln(p_L^*) + \alpha_{\tau L}(\tau)\ln(p_L^*) + \alpha_{NM} \\ & \ln(N)\ln(p_M^*) + \alpha_{YM} \ln(Y)\ln(p_M^*) + \alpha_{\tau M}(\tau)\ln(p_M^*) + \alpha_{YN} \ln(Y)\ln(N) + \alpha_{\tau N}(\tau)\ln(N) + \\ & \alpha_{Y\tau}(\tau)\ln(Y) + [\alpha_{Intercity}(\text{Intercity}) + \alpha_{Urban}(\text{Urban})] + v + u \end{aligned}$$

where the α_j 's are the unknown parameters to be estimated, τ is a time trend, v and u are the random shocks and the cost inefficiency term respectively, and firm and time subscripts are omitted to simplify notation.

In order to deal with a well behaved cost function, homogenous of degree one in input prices, the total cost and the input prices (the price of labour and the price for raw material

and fuel price) are normalized by the price of capital. In (4) starred variables have been divided by the price of capital, p_K .

The following restrictions are checked after the estimation, in order to deal with a cost function that is monotonically increasing in input prices and output 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.

It can be anticipated that for all specifications, the first two requirements are satisfied at all observation points, except for the fitted factor share for materials that is negative for 30 (out of 332) observations while the third restriction is satisfied for about ninety percent of the observations.

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 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 costs caused by a percent change in output, keeping network size and input prices fixed:

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

When returns to scale are greater than one, economies of scale are present and total costs increase less than proportionately with output and network size, given all input prices. Similarly returns to density greater than one indicate the presence of economies of density and total 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.

3 Data description

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The dataset consists of an unbalanced panel of 77 local public transit (LPT) 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 offered services refer to urban and intercity transport. As institutional form is concerned, corporations dominate, but other forms, such as cooperatives are present. 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).

Table 1 presents descriptive statistics for the whole sample of firms and for the two groups of private and public companies.

Table 1
[ABOUT HERE]

Private firms cover on average about 833,000 vehicle-Km per year employing 26 employees and 22 vehicles. On the contrary, public companies cover more than 6.3 million vehicle-Km per year and their mean size in terms of number of employees and vehicles is 366 and 142 respectively.

Also costs considerably differ according to ownership: the mean value of total costs for public firms are about thirteen times the mean value of total costs for private companies. Labour price and the cost for other variable inputs are also significantly higher.

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

Most private firms are small in size (less than 50 employees), while public firms are either very small or very large (with more than 150 employees).

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 supplied bus-kilometres.

All variables used in the estimation, except for the time trend, have been normalized by their mean and the general consumer price index has been used in order to deflate monetary amounts^{iv}.

Total cost (TC) is given by the total expenditures of the bus companies for each year.

Three inputs are present: labour (L), material and other variable inputs (M) and capital (K) and in order to meet the required condition of homogeneity of the cost function in input prices, the total cost, the price of labour and the price of materials have been divided by the price of capital.

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 the sum of the cost of raw materials (mainly fuel cost) and the cost of services (maintenance and other services). The price for this input is obtained by dividing its total cost by the total number of vehicles.

Following Friedlaender and Wang Chiang (1984) who analysed the trucking industry and Filippini and Prioni (2003) who studied the bus service, the cost for capital is obtained as a residual measure and it equals the difference between total costs and the costs for labour and material. This measure is far from being ideal but the unavailability of accounting data on the capital stock made the computation of the capital cost via the perpetual inventory technique unfeasible.

The output measure (Y) is given by the total number of kilometres covered by all the vehicles in the rolling stock. This is a supply oriented measure of output since it is a proxy for the potential supply of the considered companies.^v The variable describing the output characteristics is as customary described by the length (in kilometres) of the network (N) each company covers.

^{iv} CPI for 1998=100; 1999 = 101.7; 2000 = 104.3; 2001 = 107.1; 2002 = 109.8. Source Istat, Italian Statistical Institute.

^v A demand oriented measure would be the total number of passengers actually transported, but unfortunately this kind of data are not available 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.

A time trend (τ) is also added to the specification and it allows for the identification of technological changes. A negative sign for $-\partial \ln(TC_{it})/\partial \tau$ (the percentage change in total costs over time) indicates^{vi}, ceteris paribus, technical progress, while a positive sign stands for technical regress (all else equal, costs increase over time).

In one specification we also include dummy variables that control for the type of service. INTERCITY is a dummy variable that equals one if the LPT company only supplies intercity services, URBAN equals one if only urban activity is offered and MIX equals one if the firm offers both intercity and urban transits

Finally a set of environmental or external factors is included as explanatory variables of the mean of the pre-truncated normal distribution of the inefficiency term u_{it} . 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. Other studies on the bus industry have included the effect of ownership in a similar fashion. Table 2 compares a small number of recent studies that account for ownership in a parametric model^{vii}. The results are mixed: while Filippini and Prioni (2003) do not reach clear-cut outcomes, the papers by Mizutani and Urakami (2003) and Roy and Billion (2005) point to higher costs and higher inefficiencies respectively for publicly owned bus companies. Our approach is more similar in spirit to the one presented in Bhattacharyya et al. (1995b), where, within a translog cost model framework, ownership is among the factors that affect inefficiency. However our approach differs on a number of grounds. In their study Bhattacharyya et al. (1995b) consider only publicly owned companies that are characterized by different degrees of government control, while we consider both publicly and privately owned companies. Bhattacharyya et al. (1995) propose a 2 step procedure for the estimation of firm- and time- specific inefficiencies that takes into account firm- and time-

^{vi} See Kumbhakar (2004) for a discussion on different cost function specifications for technical change measurement.

^{vii} See De Borger et al. (2002) and Mizutani and Urakami (2003) for a more comprehensive survey of studies on the bus industry where the effect of ownership is investigated.

specific variances, while we adopt the one step procedure introduced by Battese and Coelli (1995).

Table 2
[ABOUT HERE]

The second external factor captures the joint effect of ownership and the type of service supplied. The interaction dummy variable PUBLIC*INTERCITY equals one if intercity services are supplied by a public firms while the dummy variable PUBLIC*URBAN equals one if a state (or municipal) owned LPT firm only supplies urban transport services. The inclusion of variables that account for the type of service has been proposed, among the others, by Fraquelli et al. (2004) and by Piacenza (2006). In both these studies a dummy for the type of service supplied is included in the specification of the cost function and they find significant lower costs for bus companies supplying only intercity or mixed networks. In our framework we are going to test whether the type of activity is able to affect the cost function and we also control for systematic differences among public firms supplying different services in the inefficiency model.

Finally in the two specifications size dummies are also included. Since public firms are, on average, larger than private firms, our results may be biased as long as the ownership dummy may capture other effects, e.g. the influence of the firm dimension on inefficiency. In order to control for the possibility of spurious relationships, we decided to include a set of dummy variables: SMALL, that equals one if the firm has less than 50 employees, MEDIUM, equal to one if the firm has more than 50 and less than 150 employees and LARGE that equals one if the firm has more than 150 employees. A firm can switch from one group to the other in each observed time period.

Table 1 presents descriptive statistics also for the set of external factors that influence inefficiency.

The final specification for the cost inefficiency model (3) is thus:

$$(5) u_{it} = \delta_0 + \delta_1(\text{Public})_i + \delta_2(\text{Public*Intercity})_{it} + \delta_3(\text{Public*Urban})_{it} + \delta_4(\text{Medium})_{it} + \delta_5(\text{Large})_{it} + \varepsilon_{it}$$

where δ_0 is a constant and the dummy PUBLIC is time invariant.

4 Results

4.1 Cost Function

Table 3 contains two specifications for the model in (4)-(5) that only differ in the set of variables included in the cost function. In the first specification we assume that a unique cost technology is available for all LPT firms, in the second model two dummy variables that control for the type of offered service are included in the cost function. A likelihood ratio test is performed and the first specification is rejected in favour of the second one^{viii}. The cost technology is actually different across LPT companies supplying different types of services (intercity, urban or mixed) and this supports previous results for the Italian market (see Fraquelli et al., 2004 and Piacenza, 2006). We are going to comment on the results from the preferred specification (the second one in table 3) but point estimates for the cost coefficients are quite similar across the two specifications.

Estimates are performed using the software FRONTIER 4.1 by Coelli (1996) and the formula for the log likelihood function can be found in Battese and Coelli (1993).

Since all variables are expressed in logarithms (except for the time trend), the coefficients can be interpreted as elasticities. Moreover given the normalization of all regressors by their sample mean, all elasticities are evaluated at sample means.

Table 3
[ABOUT HERE]

The coefficients for labour and material / other variable input prices are both statistically significant and can be interpreted as the estimated input shares. For the mean LPT firm, labour accounts for 53% of total costs, while the other variable inputs represent 36% of total costs. The remaining 11% is the share of capital. The actual factor shares for labour and materials are somehow smaller than the estimated one, with an average labour share that equals 50% and an average variable input share that corresponds to 27%.

^{viii} Likelihood ratio = 32.10, the null hypothesis that both the coefficients for intercity and urban dummies equal zero is rejected at 1% level

The estimated coefficient for output is 0.87: a one percent increase in the number of vehicle-kilometres, increases costs for the mean firm by almost 0.87%. The coefficient for the network size is the elasticity of total costs with respect to a particular characteristic of the output supplied by the companies. A one percent increase in the network length increases total costs by 0.02%. Unfortunately this coefficient is very imprecisely estimated and one possible cause may be the high degree of correlation between the output Y and the network length N .

A similar multicollinearity problem probably affects most of the second order and interaction variables that hardly are statistically significant^{ix}. The only exceptions are squared labour price and the interactions between output and material price (positive and significant) and the dummy variable INTERCITY. The negative and significant coefficient for the latter points to lower costs for firms supplying only intercity services (with respect to firms supplying both urban and intercity networks), while the costs of urban LPT companies do not significantly differ from those with mixed services.

The parameter estimates for the single time trend introduced in the specification are not significant. We obtain no evidence of technical change over the five years 1998-2002. This can be considered a reasonable result given the short time series and it is consistent with other studies of the public transit sector (e.g. Fazioli et al., 1993) where no technical change is found^x.

We now comment on the results from the inefficiency model. The statistical significance and the magnitude of the included variables change across the two specifications. In particular while the dummy for ownership reduces its magnitude, its interactions with supplied services and the dummies for size increase in magnitude and precision in the second model.

^{ix} A Cobb-Douglas specification is however rejected by the data. The log –likelihood function for a model nested in specification 2 equals –81.38 and the likelihood ratio is 100.45. The null hypothesis for 15 degrees of freedom is rejected at 1% level.

^x We checked the robustness of this finding by estimating a multiple time trend model (see Heshmati, 1996, and Kumbhakar et al., 1999). In this specification the single time trend is replaced by its interaction with the five time dummies while the interactions between time and the other regressors are unchanged. Time trend coefficients are still not significant.

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The parameter estimates for PUBLIC dummy is positive (0.069) indicating the presence of significant higher inefficiencies for publicly owned companies. However the estimations for the interaction terms with PUBLIC*INTERCITY and PUBLIC*URBAN dummies are negative and bigger than 0.069 in absolute values. This means that only publicly owned firms supplying both services are actually less efficient than private firms^{xi}.

The dummies for the dimension (medium sized and large firms) are both positive and significant: inefficiencies increase with firm dimension.

4.2 Density and scale economies in the bus industry

Although the frontier studies are not specifically designed to study returns to scale, they may produce interesting results as an automatic byproduct. (see De Borger and al., 2002). Table 4 presents the estimated density and scale economies, estimated for the whole sample and for a number of groups of firms using the corresponding mean values of the output and network variables. Input prices are held fixed at the mean value of the whole sample.

Table 4
[ABOUT HERE]

The indicators for economies of density is 1.145 for the whole sample, but it is 1.088 for public firms and 1.184 for private firms. This difference, meaning that private firms are mainly underutilizing their capacity, 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 vehicle-kilometres is much lower for intercity transport firms and this evidence allows for the existence of higher 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.

^{xi} This result is almost completely due to two very big firms, both publicly owned, one providing urban and the other intercity transport in the Torino area. They present an inefficiency score of 1.033, whereas public firms in the range 150-250 employees, have an inefficiency score of 1.30. This result is not very reliable, though, as it concerns only two firms, which are evident outliers.

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.^{xii}

Public companies show on average small economies of scale (1.072) while for private firms economies of scale are more relevant (1.151). The results show that while mergers could allow for the exploitation of these economies of scale for private firms, nothing similar is recommended 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.

The resulting density and scale economies are comparable with those in Filippini and Prioni (2003) for the Swiss case, whereas they are smaller than those calculated in recent Italian works dealing with LPT publicly owned firms only (Cambini and Filippini, 2003; Fraquelli et al., 2004).^{xiii}

More generally, as pointed out by Berechman and Giuliano (1985), empirical findings on scale and density economies are highly influenced by the choice of the output measure and the functional form adopted.

4.3 Inefficiency indicators

Table 5 reports the estimates of the mean cost-inefficiency for the whole sample and separately for the two groups of public and private firms by different size classes to examine the possible correlations between firm size and inefficiency. Total employees are used as an indicator of size of a firm.^{xiv}

The most efficient firm in the sample has a degree of inefficiency equal to 1. Both groups of firms are cost-inefficient: the average value in the sample is 1.07, meaning that firms have costs almost 7% above the cost frontier: this measure hides some important

^{xii} For a comprehensive analysis see Cambini and Filippini (2003).

^{xiii} The methodology itself is different as Fraquelli et al. compute the long run scale economies using the total number of places offered times km run as output variable and network size is not included. The estimated returns to scale incorporate both size and network density economies as the effects on costs due to an increase in the number of places offered, the network length or the service frequency are not distinguishable.

^{xiv} Cost inefficiencies are computed for each observation in the sample as a prediction of the following magnitude $CI_{it} = \exp(u_{it})$. The formula for the computation of the expected value $\hat{CI}_{it} = E(\exp(u_{it}) | \Psi_{it} = \psi_{it})$, where $\Psi_{it} = (u_{it} + v_{it})$, is a generalization of the results by Jondrow et al. (1982) and can be found in Battese and Coelli (1993).

information which comes out clearly when public and private firms are considered separately. The degree of inefficiency is higher for public firms (12.3% vs 5.7%).

For both groups the level of cost-inefficiency is the lowest for the firms under 50 employees. However private firms are comparatively less inefficient in the medium sized class (1.13 vs. 1.17) and the large dimension group when the two biggest public firms, characterised by particularly low levels of inefficiencies are excluded, (1.21 vs. 1.30, see footnote xiv)^{xv}.

Table 5
[ABOUT HERE]

It is worth stressing, though, that cost inefficiencies and scale inefficiencies are two different measures, that do not necessarily coincide (see De Borger et al., 2002, for a discussion). It may happen that a company is scale inefficient, but cost efficient and vice versa. The fact that both efficiency and scale economies are decreasing with firm size is not contradictory, but merely shows that inefficiency captures aspects which are not included in scale economies. Transaction costs, overhead costs, high wages obtained in large firms because of trade unions' higher bargaining power are also included in efficiency scores. While cost inefficiencies have to do with total costs, scale inefficiencies deal with the ideal production size.

Efficiency scores are computed on the basis of the results from the preferred specification, but we checked for differences in the ranking of LPT companies across the two specifications presented in table 3. Estimated inefficiencies are much higher under specification 1 (mean inefficiency 18%) but this result is not surprising as long as the two specifications give different measures of inefficiency. As outlined by Coelli et al. (1999) under specification 1 we deal with gross inefficiencies, while specification 2 allows for net inefficiencies, i.e. the estimated inefficiencies are net of the effect of the external factors included in the cost technology (i.e. the supplied service). However, as table 6 shows, the

^{xv} Bhattacharyya et al. (1995a) in the case of water utilities reached somehow comparable results, finding that inefficiency raises with the size of the firm, but for small scale operations privately owned firms are more cost-efficient, while for large scale operations publicly owned firms are comparatively more efficient.

ranking of firms does not substantially change and the correlation among efficiency scores from the two models is high and significant (0.81).

Table 6
[ABOUT HERE]

5 Concluding remarks

The aim of the work was to examine the potential impact of ownership on the cost of bus service provision in the light of the recent Italian Reform of local public transport, started with Law 542/1997, which introduced wide-ranging decentralization for planning and assigning contracts, making local authorities responsible for the competitive tendering procedure introduced for the assignment of franchised monopolies in LPT services in distinct bus service areas.

What has happened, so far, in Piedmont, but generally in Italy, is that the new boundaries of the service areas merely reflect the provinces and municipalities jurisdictional boundaries, so that transport plans have been defined simply by adding up the existing routes, both in urban and intercity services. This passive transport policy seems rather awkward as the definition of the optimal size of the service areas to be tendered is a critical step in promoting public transport efficiency and should be handled by local authorities bearing in mind its effects on two distinct levels. The first one refers to the exploitation of density and scale economies, whereas the second has to do with the behaviour and the size of the competitors participating to the tenders.

The influence of ownership on the provision of local public transport appears to be a relevant issue for policy makers, with particular attention to efficiency and economies of scale of the two groups, which should be carefully taken into account in the design of a transport policy.

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.

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Publicly owned firms are on the whole more inefficient than private companies when they provide mixed services, and inefficiencies increase with firm size, for both private and public companies.

The results show that while mergers could allow for the exploitation of economies of density and scale for private firms, a firm’s size fit to exploit density and scale economies seems to have already been reached by large publicly owned transport firms.

Acknowledgments

We wish to thank Luca Sanlorenzo for excellent assistance on the data and Massimo Filippini and Massimiliano Piacenza for helpful comments.

We are also grateful to the participants to the Hermes Workshop on Local Public Transit, Moncalieri, July 18, 2005 and to the 4th North American Productivity Workshop (NAPW), New York, June 27-30. Financial support from Hermes (Higher Education and Research on Mobility Regulation and the Economics of Local Services) Research Centre is acknowledged. The usual caveats apply.

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For Peer Review

TABLES

Table 1. Descriptive statistics for the whole sample of bus transportation companies. Annual observations from 1998 to 2002, unbalanced panel.

	Full sample		Public firms		Private firms	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Total cost (th Euro)	4702.7	20541.9	20803.6	47374.1	1505.8	2244.3
Vehicle-Kilometres (th)	1752.5	5570.3	6385.4	12500	832.6	1236.9
Network (Km)	413	589.5	728.3	1081.7	350.4	405.2
Employees	82.4	360.1	365.5	830.4	26.2	38.5
Vehicles	41.6	112.9	142.2	249.3	21.7	26.5
Total cost of personnel / n. employees (th Euro)	28.1	8.1	33.8	6.6	26.9	7.9
Total cost of material /vehicles (th Euro)	17.4	8.7	23.2	10.4	16.3	7.8
Total cost of capital/ vehicles (th Euro)	14.3	8.9	18.4	12.3	13.5	7.8
Public	0.17	0.37				
Intercity	0.62	0.49	0.16	0.37	0.71	0.46
Urban	0.05	0.23	0.22	0.42	0.02	0.15
Mix	0.33	0.47	0.62	0.49	0.27	0.45
Small	0.79	0.41	0.44	0.50	0.86	0.34
Medium	0.11	0.32	0.16	0.37	0.10	0.30
Large	0.10	0.30	0.40	0.49	0.04	0.19
N. observations	332		55		277	
N. firms	77		12		65	

Notes:

- *Public* is a dummy equal to one if the firm is owned by public institutions (mainly municipal entities).
- *Intercity* is a dummy equal to one if the firm only supplies intercity services, *Urban* is a dummy equal to one if the firm supplies only urban services; *Mix* is a dummy equal to one if the firm supplies both urban and intercity services.
- *Small* is a dummy that equals one if the number of employees in the considered year is less than 50; *Medium* is a dummy that equals one if the number of employees in the considered year is more than 50 and less than 150; *Large* is a dummy that equals one if the number of employees in the considered year is more than 150;

Table 2. Empirical findings about public – private ownership of LPT companies. Parametric specifications.

<i>Author</i>	<i>Country</i>	<i>Method</i>	<i>Public vs private companies</i>
Filippini and Prioni, 2003	Switzerland	Translog cost function. The output is seat*Km run and vehicle*Km run. Network size (in Km and number of stops) is included. Total costs are the dependent variable.	A dummy for ownership is included in the translog specification. The dummy is negative and significant only for one specification: lower costs for private firms.
Mizutani and Urakami, 2003	Japan	Translog cost function. The output is vehicle*Km run. Various measures of network characteristics are included. Total costs are the dependent variable. Also a wage function is estimated.	A dummy for ownership is included in the translog specification. The dummy is positive and significant: higher costs for public firms by 20.2% and higher wages for public firms by 14.5%
Roy and Billon, 2005	France	Translog production frontier. The output is vehicle*Km run. Network size (in Km) is included.	A dummy for ownership is included in the specification of the technical inefficiency. The two dummies for ownership are positive and significant: public and semi-public companies exhibit higher technical inefficiency than private operators. Mean inefficiency score for public and semi-public firms is 0.98, for private firms is 0.99.

Table 3. Estimation results. The dependent variable is logarithm of total cost. Unbalanced panel for the time period 1998-2002: 332 observations, 77 firms.
***, ** and * indicate significance levels 1%, 5% and 10% respectively.

	Specification 1			Specification 2		
	Coefficient	Std-error		Coefficient	Std-error	
Constant	7.740	0.089	***	7.962	0.095	***
α_L	0.562	0.127	***	0.531	0.319	*
α_M	0.344	0.100	***	0.364	0.227	*
α_N	-0.010	0.054		0.019	0.132	
α_Y	0.877	0.053	***	0.873	0.129	***
α_T	0.025	0.062		0.027	0.126	
α_{LL}	0.157	0.048	***	0.175	0.037	***
α_{MM}	-0.018	0.041		-0.015	0.085	
α_{NN}	0.019	0.027		0.018	0.043	
α_{YY}	0.036	0.016	**	0.041	0.038	
α_{TT}	0.000	0.010		-0.001	0.020	
α_{LM}	-0.068	0.069		-0.098	0.090	
α_{LN}	0.032	0.065		0.018	0.034	
α_{LY}	0.004	0.050		-0.004	0.023	
α_{LT}	0.001	0.030		-0.003	0.081	
α_{MN}	-0.013	0.053		0.003	0.033	
α_{MY}	0.065	0.038	*	0.069	0.018	***
α_{MT}	-0.024	0.026		-0.015	0.063	
α_{NY}	-0.013	0.038		-0.012	0.077	
α_{NT}	-0.009	0.017		-0.015	0.040	
α_{YT}	0.018	0.013		0.023	0.032	
Intercity				-0.224	0.041	***
Urban				0.056	0.234	
Inefficiency model						
Constant	0.099	0.036	***	-0.062	0.077	
Public	0.195	0.078	**	0.069	0.006	***
Public*Intercity	-0.883	0.106	***	-0.606	0.121	***
Public* Urban	-0.029	0.127		-0.276	0.113	**
Medium	0.124	0.105		0.176	0.073	**

<i>Large</i>	0.155	0.127		0.252	0.094	***
σ^2	0.078	0.006	***	0.074	0.005	***
γ	0.066	0.025	***	0.071	0.021	***
<i>LLF</i>	-47.207			-30.120		
<i>LR test (d.f.)</i>	24.789 (7)			12.127 (7)		
<i>Mean inefficiency</i>	1.179			1.068		

Notes:

- Public*Intercity and Public*Urban are interactions between the corresponding dummies, T stands for a time trend.
- σ^2 is the estimation for the variance term: $(\sigma_u^2 + \sigma_v^2)$.
- γ is the estimated ratio: $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$.
- LLF is the Log Likelihood function.
- LR Test is the Likelihood ratio test for the one sided error: if the null hypothesis is not rejected the correct specification for the model is the absence of any efficiency term u. The null hypothesis is: $H_0 : \gamma + \delta = 0$, where γ is the ratio defined above and δ is the vector of estimated parameters in the specification of the inefficiency model ($u = Z\delta + \varepsilon$). The null hypothesis is always rejected at conventional levels. The statistics has a mixed square distribution. The critical values are obtained from table 1 in Kobbe and Palm, 1986. For seven degrees of freedom, critical values at 10%, 5% and 1% significance levels are 11.38, 13.40 and 17.76 respectively.

Table 4. Economies of density and scale for the mean firm of each group (computations based on specification 2 from table 4).

	<i>Economies of density</i>	<i>Economies of scale</i>
<i>All</i>	1.145	1.121
<i>Public</i>	1.088	1.072
<i>Private</i>	1.184	1.151
<i>Small</i>	1.217	1.180
<i>Medium</i>	1.133	1.104
<i>Large</i>	1.068	1.047

Table 5. Mean Efficiency Scores, standard deviations in parenthesis (computations based on specification 2 from table 4).

	<i>All</i>	<i>Public</i>	<i>Private</i>
<i>All</i>	1.068 (0.065)	1.123 (0.117)	1.057 (0.041)
<i>Small</i>	1.042 (0.010)	1.042 (0.027)	1.042 (0.006)
<i>Medium</i>	1.141 (0.042)	1.170 (0.076)	1.131 (0.016)
<i>Large</i>	1.198 (0.113)	1.192 (0.137)	1.212 (0.006)

Table 6. Degree of correlation between efficiency scores from the two specifications. All correlation coefficients are significant at 1% level.

	<i>All</i>	<i>Public</i>	<i>Private</i>
<i>Efficiency scores</i>	0.806	0.767	0.955
<i>Rankings</i>	0.768	0.768	0.769