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COSTS AND TECHNOLOGY OF PUBLIC TRANSIT SYSTEMS IN ITALY: SOME INSIGHTS TO FACE INEFFICIENCY

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Costs and Technology of Public Transit Systems in Italy: Some Insights to Face Inefficiency♣

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Abstract

This study provides fresh evidence about the characteristics of technology and cost structure of public transit systems in Italy. The aim is to suggest useful guidelines for facing detected inefficiencies. The analysis is carried out through the estimation of a translog variable cost function. The sample includes 45 Italian public companies. Firms are observed in the years 1996, 1997 and 1998, and operate both in the urban and extra-urban compartments. Results support previous evidence on the existence of natural monopoly at local level and stress the importance of the average speed of vehicles in explaining cost differences between companies. We conclude that cost benefits can be achieved by promoting mergers between firms (whenever possible), introducing some forms of "competition-for-the-market" (e.g., competitive tendering for the single license) and taking more care of the local traffic regulation.

Key words: local public transport, cost structure, technology, regulation

JEL: L5, L92, R41

1. Introduction

In most of continental Europe, local public transportation (LPT) is a regulated activity. A local authority (Region or smaller local body) regulates each network whereas a single multi-modal company provides the transit service. The services operated by more than one firm are an exception. Public transit systems generally face universal service obligation and the demand for this service is promoted through low user charges and considerable subsidies.

At present, the high operating costs of the local firms constitute a great challenge for political authorities, given the permanent deficit characterizing the sector. They have to ensure the economic-financial equilibrium of the utilities avoiding waste and inefficiencies.

In order to assess operating costs, a thorough investigation of the knowledge of the firms' technology is necessary. An empirical investigation of the sources of inefficiency in this industry is then useful to change the traditional state intervention and design new short and long run policies.

The aim of this paper is to provide fresh evidence about the features of technology and cost structure of public transit systems in Italy, useful to improve local policy. This is particularly relevant in the current evolution of the Italian regulatory framework. As in many other countries, it has undergone radical changes since the second half of 1990s. A structural reform started following the law 549/1995 and the *Decreti Legislativi* 422/1997 and 400/1999, turning the efforts towards a permanent economic recovery of the whole sector.

The empirical investigation is based on a sample of 45 Italian companies providing both urban and extra-urban transport service, observed during the period 1996-1998. The analysis is run through an econometric estimation of a translogarithmic variable cost function. This functional form allows us to verify the behavior of scale economies within the industry and to assess the effects on costs of factors considered relevant in explaining differences between operators.

The remainder of the paper is organized as follows. After a concise description of the Italian situation (Section 2), in Section 3 we briefly review the empirical literature on the LPT sector. Section 4 is devoted to the presentation of the

functional form, the explanatory variables and the methodology used. Section 5 contains a description of the database, paying attention to the nature of each variable, while Section 6 comments on the results of the estimates. Conclusion and policy suggestions (Section 7) complete the work.

2. Local public transit in Italy

2.1. Modal composition

The Italian LPT sector[1] concerns urban and extra-urban transport systems and is composed of different transit modes. These include:

- bus-lines, operating in both the urban and the extra-urban areas;
- tramways, that provide urban service in five cities (Turin, Milan, Trieste, Rome, and Naples) and extra-urban service only in Milan;
- subways, with urban service in Rome, Milan and Genoa;
- railways in regime of government license or management, operating on an extra-urban scale;
- regional railways coming from the recent breakup of local rail-lines from the State Railways (FS) company.

As in the majority of European countries, the road-mode of transportation in Italy has been progressively increasing in importance[2] and at present the supply of bus services dominates the sector.[3] It is well worth remarking the recent attempts to develop inter-modal systems by the emanation of the law 211/92. This law, concerning the highway mass transit, defined a package of interventions allowed to benefit from government contributions.[4]

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[1] For a critical discussion on the regulatory framework in Italy, see Piacenza (2000a).

[2] This is due to higher costs of infrastructure investments which usually have to be supported to develop alternative means of transport.

[3] Bus-lines system embraces more than 1,100 firms, 18 per cent of which provide only urban services, 67 per cent only extra-urban services, and the remaining 15 per cent supply both types of service (source: Ministero dei Trasporti e della Navigazione, 1997).

[4] In particular, the development of subway and tramway networks and local railway systems. 44 projects are known to have been approved at the present time.

2.2. *Ownership structure of supplying companies*

In addition to the local monopoly which characterizes the service provision in most of continental Europe, in Italy one can note the predominant position of public companies.[5]

Management conditions for LPT services adopted in the past were set out in the law n.151/81: 1] on a shoestring of the local government units (direct management); 2] through the formation of *special companies* whose full ownership is under the local body; 3] in regime of concession, by means of the direct allotment of the transport lines to public-owned or private-owned firms. In particular, the indirect management through the resort to the special company institute has undoubtedly represented the most recurring model. Traffic data (number of buses, service workers and passengers) during the years 1985-1995 certainly highlights a progressive relevance of the private sector. Nevertheless, the weight of the local public-owned companies continues to be decisive, especially in terms of the number of passengers (85 percent public versus 15 percent private, during 1995).

2.3. *Costs and productivity trend*

The Italian system, when compared to European standards, presents inadequate tariff levels, but mainly differs with respect to the structure of costs, that are too high, given the poor level of productivity reached by the sector.

Table 1 (ISOTOPE Project of the European Commission, 1998), shows the main efficiency indicators for Italy, "Other European Countries" and United Kingdom.[6] In terms of labour productivity, the Italian sector shows lower performance (14.77 vehicle-kms for each service worker) against the other European realities (19.38 for the "Other European Countries" and 20.39 for the United Kingdom). The data concerning the operating costs per vehicle-km (3.02 ECU against 2.16 for the "Other European Countries" and 1.44 for the United Kingdom) points to the same direction.

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[5] In some European countries, private ownership dominates the public sector. The French case is emblematic, where public firms fall short of 35 per cent.

[6] Statistics were obtained through the experimental data (relative to urban bus service) of the information base developed inside the project. Data refer to a sample of 108 European towns.

On the other hand, a recent study carried out by CNR (1999) underlines that, in the period from 1992 to 1997, the gap between costs and proceeds grew by a further 13 percentage points, in spite of the positive dynamics of the tariffs level.

3. Literature review

3.1. International findings

The results of the international empirical studies addressed to the analysis of technology in LPT can be subdivided into two groups: the analysis of *cost elasticity*[7] and the study of *substitution elasticity between factors*.

The picture relating to scale economies can be summarized as follows:[8]

- almost all the studies confirm the presence of *short-run economies of size*.[9] This seems to reveal the existence of unused capacity. Two circumstances are relevant for the economy of the transportation companies: the massive public contribution to the capital investments and the importance of the so-called *peak-load problem*. Indeed, the capacity necessary to satisfy the peak demand unavoidably creates unused capacity in the low demand phases.

- the evidence of *long-run economies of size* is uncertain. It seems that the nature of the sample and the way of computing the capital price are crucial elements

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[7] The analysis of the production and cost structure of a particular industry often concentrates on the degree of *returns to scale*. It summarizes how fast costs rise with respect to output(s). If output *y* is a scalar, returns to scale are simply defined as the inverse of the output cost elasticity:

$$s = \frac{AC}{MC} = \frac{C}{y.(\partial C / \partial y)}$$

If marginal costs ($MC = \partial C/\partial y$) are less than average costs ($AC = C/y$), so that $s > 1$ (equivalently, if AC is falling in y), we have *increasing returns*, also called *economies of scale*. The opposite case ($s < 1$) is denoted *decreasing returns* or *diseconomies of scale*; and $s = 0$ defines *constant returns*. In the specific context of the transportation industry it is possible to make a distinction between expanding the *density* of output, for example by adding more vehicles or attracting more passengers on a given route, and expanding the *spatial scale* of output, for example by adding new routes with similar densities. The former often allows more intense use of equipment, thereby lowering average cost. This form of increasing returns to scale is usually called *increasing returns to density* or *economies of density*, to distinguish it from the degree of returns to scale that characterizes an expansion of the entire productive dimension, denoted *increasing returns to size* or *economies of size*. For more details on these aspects, see Braeutigam (1999).
[8] On this point, see also Fabbri (1998).
[9] See, among the others, Viton (1981), De Borger (1984), Obeng (1984), Thiry and Lawarree (1987), Caves and Christensen (1988), Gagnepain (1998), Matas and Raymond (1998). As an example of study that found diseconomies in the short-run, refer to Dalen and Gomez-Lobo (1996).

in orienting the results. In particular, in the studies on the extra-urban transport systems the presence of remarkable economies of size is found which decrease with increasing firm scale;[10]

- the existence of *economies of network density* is confirmed by many works.[11] The average costs are decreasing at the growing of the output, given the network size;

- the sector benefits of significant *economies of use intensity*.[12] This fact reveals the existence of excess capacity regarding the intermediate output (potential for trips).

As regards the analysis of the elasticity of substitution between productive factors (usually identified with fuel, labor, capital and maintenance), it emerges that:[13]

- the production technology can be substantially defined as a quasi-fixed coefficients technology, given the small values of the substitution elasticity;

- labor and capital turn out to be complementary inputs;

- labor and fuel are instead substitutes, even if the substitutability degree appears to be very low;

- between capital and maintenance too there is substitutability, more marked than in the previous case.

Moreover, on the basis of substitution elasticity, one can directly estimate the values of the own- and cross- price elasticity of the input demands. The evidence indicate a demand for the productive factors that is substantially inelastic to own price and very low values for the cross-elasticity.

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[10] To this regard, see De Borger (1984), Berechman (1987), Filippini, Maggi and Prioni (1992). As far as urban transport is concerned, the presence of significant economies of scale was found in the studies carried out by Thiry and Lawarree (1987), Andrikopoulos, Loizidis and Prodromidis (1992), Gagnepain and Ivaldi (1999).

[11] Among the others, refer to Windle (1988), Filippini, Maggi and Prioni (1992), Matas and Raymond (1998), Gagnepain (1998).

[12] This is another concept of density economies which is very recurrent in the transportation literature that uses the final output (e.g. passenger-kilometers) oriented specification of the production function. With it one means the reduction of unitary per passenger cost deriving from the increase of served users on a given transit system. Some examples in literature are found in the works of Berechman (1983), Button and O'Donnel (1985), Caves and Christensen (1988), Windle (1988).

[13] See the studies mentioned in the previous notes and Fabbri (1998).

3.2. Italian findings

As far as Italian studies are concerned, the few articles published in recent years are summarized in Table 2, with their main characteristics and results.

All listed contributions adopt the flexible translog cost function and focus on the bus service.[14] Only one of these studies (Fazioli, Filippini and Prioni, 1993) chose to analyze the productive structure in terms of total costs, while the other two (Fabbri, 1998 and Levaggi, 1994) considered a variable cost model more appropriate. The strict dependence on the government grants-in-aid program suggested to treat the capital stock[15] as fixed in the short run.[16]

Fazioli et al. and Levaggi focused only on the extra-urban and urban transport respectively; Fabbri analyzed both compartments. Levaggi works on a sample of companies operating throughout Italy, while Fabbri and Fazioli et al. concentrate only on a region of North-Italy (Emilia Romagna). The three studies differ also in the measure of the output: vehicle-kilometers and seat-kilometers (both "supply-oriented" measures) in Fabbri and Fazioli et al. respectively, passenger-kilometers ("demand-oriented" measure) in Levaggi.

We will just list the main findings:

- both studies using a variable cost model reveal the existence of *short-run economies of size*;

- as regards *long-run economies of size*, the evidence is uncertain. The results seem crucially to depend on the index employed to represent the output and on the type of sample. In particular, the studies using "supply-oriented" measures of output (Fabbri and Fazioli et al.) and focusing on LPT firms operating in Region Emilia Romagna reveal the existence of significant economies of size, decreasing with increasing company size. The authors deduce that these firms were globally sub-dimensioned with respect to the long run equilibrium;

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[14] Indeed, this transit mode accounts for over 80 per cent of LPT services in terms of supplied seat-kilometers. To this regard, see previous section (2.1).

[15] Defined as the number of buses in operation owned by a company in Fazioli et al. (1993) and Levaggi (1994), and the average number of buses owned by a company weighted by the average age of the buses in Fabbri (1998).

[16] Levaggi (1994) underlines (page 71) that the main consequence of the grants-in-aid program providing funds to purchase capital has been that «the price of capital the firms face is much lower than its actual price. If this is the case, the firms are no longer minimizing costs with respect to all inputs in the short run, rather they minimize costs with respect to the variable inputs».

- the analysis of *economies of network density* leads to inconclusive outcomes. While in Fazioli et al. remarkable increasing returns to network density are observed at all data point,[17] Levaggi found evidence of positive returns only in the short run;

- finally, Levaggi gives evidence of a very high degree of *economies of use intensity*, both in the short and the long run.[18]

4. The cost model

To analyze the productive structure of the Italian LPT industry we chose a variable cost model. The fixed assets investments in this sector are strictly related to government financial programs, so it is not convenient to suppose that firms exhibit cost-minimizing behavior with respect to capital. As Windle (1988), Levaggi (1994) and Fabbri (1998) suggest, the capital stock should be considered as a fixed factor in the short-run.

Our model includes one output and three variable inputs: labor (*L*), fuel (*F*), materials and services (*MS*). A technical-environmental variable, the average commercial speed, is also included to take into account the influence on costs of different traffic conditions and the specific characteristics of the service area. The translog specification of the cost function is the following:

$$\ln VC = \beta_0 + \beta_y \ln Y + \beta_k \ln K + \sum_i \beta_i \ln P_i + \beta_{SP} \ln SP + \sum_i \beta_{iy} \ln P_i \ln Y +$$

$$+ \sum_i \beta_{ik} \ln P_i \ln K + \sum_i \beta_{iSP} \ln P_i \ln SP + \beta_{yk} \ln Y * \ln K +$$

$$+ \beta_{ySP} \ln Y * \ln SP + \beta_{kSP} \ln K * \ln SP + \frac{1}{2} \beta_{yy} (\ln Y)^2 + \qquad [1]$$

$$+ \frac{1}{2} \beta_{kk} (\ln K)^2 + \frac{1}{2} \beta_{SPSP} (\ln SP)^2 + \frac{1}{2} \sum_i \sum_j \beta_{ij} \ln P_i P_j + \psi_{CV}$$

$$i, j \in \{ L, MS, F \}$$

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[17] The range between 2.64 for the small companies to 2.47 for the larger companies.

[18] The author suggests that bus companies in Italy have been facing insufficient levels of demand, as confirmed by CNR (1999). This can be due to the concurrence of other vectors (tramways, subways, private cars and so on) and stresses the importance of developing inter-modal public transit systems.

where *VC* is the variable operating cost, *Y* is the output measure, *K* is the quasi-fixed input, P_i is the price of the productive factor *i*, *SP* is the average commercial speed, and ψ_{VC} is a random noise reflecting the stochastic structure of the cost function. Definitions and measurement procedures of these variables are discussed in the following section.

Given the regularity conditions assuring duality, the estimation of a translog cost function does not impose any other a priori restriction on the characteristics of the below technology.[19] In particular, the elasticity of substitution and the returns to scale are variable, regarding both the level of the output and the combination of the inputs. This fully satisfies the criterion of model generality, but can give rise to serious problems of statistical efficiency of the estimation, in addition to the well-known issues concerning the multicolinearity of the regressors.

A typical solution to the efficiency problem consists in increasing the freedom degrees by jointly estimating, with the *SUR* method (Zellner, 1962), the cost function and the related *factor-share equations*, obtained applying the *Shephard lemma* to expression [1] of the cost relationship:

$$\frac{\partial \ln VC}{\partial \ln P_i} = \frac{P_i x_i}{VC} = S_i \qquad\qquad i \in \{\ L,\ MS,\ F\ \} \qquad\qquad [2]$$

where x_i is the amount of factor *i* used in the production process and S_i is the related share with respect to the variable cost.

Since these factor-shares add up to one ("adding-up" condition), we would have a system with an equation linearly depending on the others. To solve the singularity problem of the variance-covariance matrix of the disturbance terms, we have to drop an arbitrary equation (in this case S_{MS}) and estimate the remaining

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[19] In order to be consistent with cost minimization, [1] must satisfy the symmetry conditions ($\beta_{ij} = \beta_{ji}$ for all *i, j*) and the following properties:
– *VC* is non-negative;
– *VC* is homogeneous of degree 1 in vector *P*. We imposed this condition with a priori restrictions on the parameters estimation;
– *VC* is non-decreasing in *Y*;
– *VC* is non-decreasing in *P*;
– *VC* is concave in *P*.

factor-share equations by the SUR procedure.[20] So, applying [2] to [1], we obtain the following equations to estimate jointly with [1]:

$$S_i = \beta_i + \beta_{iy} \ln Y + \beta_{ik} \ln K + \sum_j \beta_{ij} \ln P_j + \beta_{iSP} \ln SP + \psi_i \qquad [3]$$

$$i \in \{\, L, F \,\} \quad ; \quad j \in \{\, L, MS, F \,\}$$

where ψ_i is a random noise reflecting the stochastic structure of the cost-share i.

5. Data

Data set relates to 45 municipal local transit companies associated to Federtrasporti,[21] operating over the years 1996, 1997 and 1998, for a total of 135 *pooled* observations.[22] The sample includes operators providing both urban and extra-urban services.[23] The data was collected from the annual reports of Federtrasporti and was integrated with a detailed questionnaire addressed to each firm.

In our model, we use a composite measure of the output (Y) to reflect the global productive structure of the firm. It is well-known in transport literature, as for the network services, that the definition of the output is contrivers and can lead to different results, for example in terms of economies of scale. Our measure of output is computed by multiplying the transit firm's fleet size, measured in terms of total places offered,[24] and the total traveled kilometers. We want to point out

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[20] It should be mentioned that the parameter estimates are invariant to the choice of which equation is deleted as long as the *Iterated SUR* (or *Maximum Likelihood*) estimation method is employed on the $M - 1$ factor-share equations.

[21] Federtrasporti associate the public firms of LPT Italian industry.

[22] Since we were working on a panel data in which each firm was observed over a period of three years, we had to choose whether to do a simple pooling on cross-section and time-series data, or to add to the model a fixed effect for every year or eventually a time-trend variable. For this reason, we did a Wald test on the joint significance of the time dummies for the first and third year added to the model. We also did the Wald test when we included in the model a time-trend variable. At the usual confidence levels, both the null hypothesis of constancy of the intercept over time and the null hypothesis of not significant time-trend effect could not be rejected, so we opted for a simple regression on the whole sample.

[23] Data mainly refers to bus transit mode. Only 8 companies provide tramway, trolley-line or railways service.

[24] The total places offered were calculated by multiplying the number of bus and their average capacity.

some remarks about this kind of output. If we consider the operative context of the LPT industry, a firm must supply the service on a certain number of lines, offering a certain number of places and trips on this network. Our definition of output allows us to take into account the length of the network, the frequency of the service and the size of the fleet. Furthermore, this measure is particularly suitable to our specific firm sample, which includes both urban and extra-urban services. As it was not possible to separate the urban activity from the extra-urban one, we defined an aggregate output and aimed to weight their specific characteristics. Generally speaking, the extra-urban firms can perform a higher number of kilometers than the urban units, covering a larger network, but the operative context is very different (a lower number of passengers, longer trips, different traffic conditions). On the other hand, a urban firm reasonably offers a higher number of places (buses are larger and also their number is higher, because there is a more intensive demand to satisfy).

The capital stock (K) plays the role of fixed input in our short-run cost model. It is represented through the number of vehicles used by LPT companies weighted by the average fleet age.[25]

The prices of variable factors were calculated paying attention to the balance-sheet statistics. The labor price (P_L) was obtained by dividing total labor costs by the total number of service workers (drivers, maintenance workers and administrative staff). The average price of fuel (P_F) was obtained by dividing fuel costs by the number of liters consumed.[26] Expenses for materials and services represent a residual cost category. It has been divided by the seat-kilometers[27] offered to obtain an average price for this input (P_{MS}). It is reasonable to assume that this kind of expense strictly depends on the actual exploitation of the network.

In addition to the standard variables of a proper cost function, we included in the model the average commercial speed (SP), already considered in some works on the LPT industry (Windle, 1988; Levaggi, 1994; Wunsch, 1996; Dalen &

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[25] We calculated the capital stock as follows: $K_i = (number\ of\ vehicles) * \left(\dfrac{age_c}{age_i} \right)$ where age_c is the average fleet age in the whole analyzed sample, while age_i is the average fleet age of the i-th firm.

[26] For a few firms which utilize tramways, trolley-lines or railways and consume electricity, kilowatt-hours were transformed in "equivalent" liters.

[27] Seat-kilometers are the multiplication of traveled kilometers by the average capacity of the vehicles used by the firm.

Gomez-Lobo, 1996; Gagnepain, 1998). The territorial context in which the service is offered makes it difficult to compare the cost performance between firms. In fact, the traffic conditions and the environmental characteristics of their network are peculiar. Adding the average commercial speed to the cost function, costs are expected to lower with increasing speed.

Table 3 contains descriptive statistics (mean and standard deviation) for all the variables of the model and the *cost-shares*. We can note that there is great variability, especially on costs, output and capital stock.

6. Results

Table 4 presents the results of the joint estimation of the translog cost function and related factor share equations for labor and fuel. We see that the model fits the data very well. 98.5 percent of the variance in the dependent variable is explained by the variance in the regressors included in the system of equations. Moreover, the estimated relationship must satisfy the usual neo-classical conditions required for a cost function. While linear homogeneity in input prices was imposed as a constraint on the parameters estimation, the other conditions (see note 19) must be checked ex-post. The estimated cost function satisfies *each* of these conditions at 83 percent of the sample data points.[28]

The above results support the functional specification, highlighting the goodness of the model in explaining the cost structure of the Italian LPT industry. It is also important to note that input cost-shares estimates for the average firm of the sample (parameters β_L, β_{MS} and β_F) are very similar to their sample average values reported in Table 3.[29]

Almost all of the estimated parameters are strongly significant and consistent with the expectations. The only exception concerns the coefficient sign associated

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[28] More specifically, fitted *VC* is always non-negative, non-decreasing in input prices (fitted factor shares are positive at each observation) and non-decreasing in output (positive marginal costs). The condition of concavity of the cost function in input prices (hessian matrix based on the fitted factor share negative semi-definite) is satisfied for 112 observations on 135.

[29] The *average firm* is an hypothetical firm exhibiting sample average values for each variable of the cost model. As we have normalized all independent variables on their respective sample mean before the transformation in logarithms., parameters related to first-order price terms return a direct estimate of corresponding input cost-shares, computed for the average firm.

to the fixed input.[30] The interpretation proposed by Caves, Christensen, Tretheway and Windle (1985) and Windle (1988) is that the positive sign of *K* reflects an industry that does not minimize cost in the long term and therefore employs too much capital in the production process. This argument has been later advanced also in a study on the Italian urban transit systems carried out by Levaggi (1994). In this work the author argues that the inefficient use of capital could derive from the generous government programs of subsiding investments. This way of providing funds to purchase capital distorted the input allocation.

The coefficient of output indicates that a 10 percent increase in output increases short-run variable costs by only about 4.2 percent at the mean production. The reciprocal of output cost elasticity (ε_y) gives the estimate of *short-run returns to scale* (*SRS*). For the average firm, the computation is the following:

$$SRS = \frac{1}{\varepsilon_y} = \frac{1}{0.4218} = 2.37 \qquad [4]$$

We can evaluate the *long-run returns to scale* (*LRS*) by applying the following algorithm, first suggested by Caves et al. (1981):

$$LRS = \frac{1 - \varepsilon_k}{\varepsilon_y} = \frac{1 - 0.2124}{0.4218} = 1.86 \qquad [5]$$

It is worthwhile to remark that the adopted model does not allow us to separate the dimensional effects on costs (*size economies*) from the density effects (*network density economies*).[31] In fact, as already noted, we used a composite output so the effects on costs due to an increase in the number of places offered, the network length or the frequency are not distinguishable.

The short-run scale economies indicate that a proportional increase of all variable inputs (labor, fuel, materials) produce a more than proportional increase in the output. This means that Italian companies are not fully exploiting their

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[30] The evidence that the variable costs increase with increasing capital stock is not consistent with the microeconomic theory. With regards to this problem, an intense debate arose in the literature. In fact, it seems to be a general problem that characterizes the use of a variable cost model, not only in the transportation industry. For a discussion on these issues see Fabbri (1998), pp. 82-83.
[31] See Caves et al. (1984).

capital stock, i.e., the fleet owned by the operators would enable the offer of a greater service.

In the same way, the long-run scale economies are very significant: a firm can reduce its average cost by increasing its production. The increasing returns to scale imply that the Italian LPT sector is a local natural monopoly.[32] These results are consistent with some findings of previous transportation literature in Italy. Fazioli (1993) analyzed extra-urban transit companies in a region of Italy (Emilia Romagna) and proposed mergers between firms operating in contiguous areas, in order to reduce the average cost of the service. Now we can suggest the extension of this policy indication to the entire Italian sector.

As the translog specification allows us to obtain values of returns to scale for each observation in the sample, we computed the punctual elasticity of cost in output and capital:[33]

$$\varepsilon_y = \beta_y + \sum_i \beta_{iy} \ln P_i + \beta_{yk} \ln K + \beta_{yy} \ln Y + \beta_{ySP} \ln SP \qquad [6]$$

$$\varepsilon_k = \beta_k + \sum_i \beta_{ik} \ln P_i + \beta_{yk} \ln Y + \beta_{kk} \ln K + \beta_{kSP} \ln SP \qquad [7]$$

$$i \in \{ L, MS, F \}$$

The variability registered in the punctual scale elasticities is very low (*standard error* 0.04) and justifies the analysis of the industry in terms of average firm. Figure 1 shows the decreasing trend of the estimated average costs, consistent with the presence of scale economies discussed above.

The translog cost function also allows us to analyze the factor substitutability that characterizes the LPT industry technology. *Allen* partial elasticities of substitution are obtained by applying the following formulas (see Uzawa, 1962 and Berndt and Wood, 1975):

$$\sigma_{ij}^{\ A} = \frac{\beta_{ij} + S_i S_j}{S_i S_j} \qquad i, j \in \{ L, MS, F \} \ ; \ i \neq j \qquad [8]$$

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[32] According to the economic theory the presence of scale economies in a mono-product industry is a sufficient condition to have sub-additivity of the cost function and then to establish the existence of natural monopoly (Panzar, 1989; Petretto, 1993).

[33] Note in [6] that the elasticity of cost in output is different for each observation due to the second-order effects. The level of output also influences the elasticity of cost in capital [7]. So the

$$\sigma_{ii}{}^A = \frac{\beta_{ii} + S_i^2 - S_i}{S_i^2} \qquad i \in \{\ L,\ MS,\ F\ \} \tag{9}$$

where S_i e S_j are the estimated cost-shares for the input i and j, whereas β_{ij} and β_{ii} are the estimated parameter for the second-order terms related to input prices interaction. [8] is the cross-Allen and [9] is the own-Allen elasticity. We used these results to derive the *Morishima* elasticity:

$$\sigma_{ij}{}^M = S_j(\sigma_{ij}{}^A - \sigma_{jj}{}^A) \qquad i,j\ \in \{\ L,\ MS,\ F\ \} \tag{10}$$

This measure of substitution is more informative than the Allen one, because it permits asymmetry in elasticities.[34] The Morishima elasticity $\sigma_{ij}{}^M$ measures the curvature of the isoquant when adjustments are made in inputs i and j in response to a change in the price ratio P_i/P_j due to an increase in the price P_i. This will generally be different from the curvature moving in the other direction, when changes in P_i/P_j are due to an increase in P_j.[35]

Table 5 summarizes technological characteristics for the average firm of the sample. All elasticities of substitution are quite low and less than one, so we can state that LPT technology allows a poor opportunity of substitution between factors.[36] These results confirm the evidence found in almost all the studies concerning the transport industry (Section 3.1) and justifies the use of a translog cost function instead of a more simple Cobb-Douglas form.[37] To the use of Morishima elasticities, in our case they are quite symmetric.

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production of the firm (Y) has both a direct (by ε_y) and an indirect impact (by ε_k) on the long-run returns to scale.

[34] On this point, see Blackorby and Russell (1989) for a general discussion and Seldon, Jewell and O'Brien (2000) for an application to media substitutability in the advertising industry.

[35] Morishima elasticities will be symmetric only in the case of CES production functions (Blackorby and Russell, 1989).

[36] Substitution between labor and fuel is possible whereas an increase in commercial speed can reduce driving-hours with a simultaneous increase in fuel consumption. Furthermore, fuel consumption can be reduced through a more intensive maintenance.

Labor can be substitute of composite input "materials and service" in relation to the maintenance service. Indeed, this can be done inside the firm or assigned to an external supplier. At the administrative level, a more capital-intensive management system requires a lower number of workers.

Finally, substitution between fuel and materials is possible when we think of the materials required for the maintenance service: a greater care in vehicles efficiency can reduce fuel consumption.

[37] A Cobb-Douglas would not be appropriate because the elasticity of substitution is imposed to be equal to unity for all productive factors.

The Allen elasticities can also be used to calculate the own-price elasticities of the derived demand for inputs (Berndt and Wood, 1975).[38] Table 5 highlights sticky factor demands, in particular for labor. In Italy, the strong influence of labor unions and collective negotiation make the labor market in the LPT sector particularly rigid. However, the elasticity in prices is strictly connected with the quasi-fixed technology reflected by hard possibilities of substitution between inputs.

A final issue we consider in this work is related to the specific environmental conditions that characterize the supply of the service by each firm. To this end, we have included in the model as an explanatory variable the commercial speed of LPT vehicles. Our findings show that it is a determinant factor in understanding the differences in the operating costs of single firms. For the sample average firm, increasing speed by 10 percent can reduce variable costs by about 2.3 percent. This implies important consequences in terms of local programs concerning traffic regulation.

7. Conclusions and policy suggestions

The econometric analysis of cost structure of the Italian public transit systems, carried out through the estimation of a variable cost function for a panel of 45 companies over the period 1996-1998, indicates the presence of significant long-run scale economies for the average firm of the sample. This implies that a medium-sized company could gain advantages in terms of average operating costs by expanding its production level.[39]

We realize that this may not be easy to implement, given the close connection within the LPT sector between the service supply and the specific constraints the company has to face when operating in a local context. Actually, it could be desirable to induce mergers between firms operating in contiguous territorial areas, by creating productive units that operate on an integrated local network and

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[38] They are obtained from the following formula: $\eta_{iP_i} = S_i \, \sigma_{ii}^A$; $i \in \{ L, MS, F \}$.
[39] As we found a low variability of the scale elasticity throughout the sample, the result can also be extended to both the small- and large-sized firms.

supply both urban and extra-urban services. This strategy might be particularly suitable in Italy, given the high-density distribution of urban centers throughout the country. It is also supported by the results of a preliminary analysis of the Italian LPT sector based on factor productivity and average cost indices.[40] Companies operating in both compartments (urban and extra-urban) seem to enjoy significant cost economies. A thorough investigation into the presence of possible cost advantages associated with the joint supply of urban and extra-urban transit service (*scope economies*) represents an interesting research cue.[41] Although it could be difficult to collect data from every single compartment, this type of analysis constitutes an appealing challenge for future studies.

The presence of persistent economies of scale also confirms a natural monopoly at the local level. This would call for a corrective regulatory policy to achieve an acceptable outcome in terms of social welfare (Braeutigam, 1989; Petretto, 1993). A good indirect intervention could be to redesign the conditions of accessibility to the network by promoting some forms of "competition-for-the-market" (e.g., competitive auction for the single license). The LPT reform in progress in Italy seems really oriented towards such a direction. The principal goal is to curb the waste that has often conditioned the decisions of sector operators in the past.[42]

Public regulators must also define policies for local mobility. To this end, they dispose of many instruments, such as: inter-modality development, LPT lanes, parking regulation, tariff policies, focusing public opinion on environmental problems. Mobility regulation plays an important role both on the effectiveness side and the cost efficiency of the public transit service. Indeed, the control of traffic congestion can improve the commercial speed of LPT vehicles. Reducing the number of labor-hours required to supply a given service would have positive effects on the level of operating costs. Our analysis tends to confirm these

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[40] See Fraquelli, Piacenza and Abrate (2001).

[41] This would require the specification of a multi-product cost function including two categories of output.

[42] We can find many examples regarding this issue. From our econometric analysis, it emerges that companies are overcapitalized, probably due to a financing government policy which has been too generous in the last decades. This aspect led the firms to invest also when it was not necessary and, on the contrary, a more intensive exploitation of the existing rolling stock was required.

arguments and suggests that in future greater interest with regards to these aspects must be taken.

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Table 1. Efficiency indicators for the urban bus service in Europe (yearly values)

Country	Vehicle-kms (thousands) /service worker	Operating costs (Ecu) /vehicle-km
Italy	14.77	3.02
"Other European Countries" (France, Denmark, Finland, Sweden)	19.38	2.16
United Kingdom	20.39	1.44

Source: European Commission (1998)

Table 2. Econometric cost studies on the Italian LPT sector

Authors	Type of Model	LPT sample	Output	Economies of scale (*mean point values in parenthesis*)
Fabbri (1998)	Variable cost function, translog form	9 urban and extra-urban bus companies, Region Emilia Romagna, 1986-1994	Vehicle-kms	- high economies of size in both the short (1.66) and the long run (1.71); - importance of size economies decrease with increasing firm dimension.
Fazioli, Filippini and Prioni (1993)	Total cost function, translog form	40 extra-urban bus companies, Region Emilia Romagna, 1986-1990	Seat-kms	- high economies of size (1.70) and network density (2.61); - importance of size and network density economies decrease with increasing company dimension.
Levaggi (1994)	Variable cost function, translog form	55 urban bus companies, Italy, 1989	Passenger-kms	- very high economies of use intensity in both the short (8.29) and the long run (5.40); - relevant size economies in the short run (1.43) but weak size diseconomies in the long run (0.92); - relevant network density economies in the short run (1.38) but weak network density diseconomies in the long run (0.89).

Source: Piacenza (2000b)

Table 3. Descriptive statistics

Variable	Mean	Standard deviation
Variable operating cost (VC, millions Lire)	56,422	71,871
Production (Y, millions)	437,708	1,232,347
Capital (K)	257	246
Labor price (P_L, millions Lire/worker)	70.2	5.5
Fuel price (P_F, Lire/litre)	1,056	102
Materials & Services price (P_{MS}, Lire/seat-km)	16.24	5.97
Average commercial speed (SP, Kms/h)	23.1	8
Cost-shares:		
- Labor (S_L)	0.672	0.069
- Fuel (S_F)	0.085	0.016
- Materials & Services (S_{MS})	0.243	0.063

Table 4. Parameter estimates of the translog variable cost function [1]

Regressor*	Coefficient	Standard Error	T-Ratio[Prob]
Constant	25.02178	.0297544	840.943[.000]
lnY	.4218691	.042314	9.970[.000]
lnK	.2124467	.0903969	2.350[.019]
lnP_L	.6309403	.0074312	84.904[.000]
lnP_{MS}	.2857707	.0066851	42.747[.000]
lnP_F	.0832891	.0018148	45.894[.000]
$lnSP$	-.2282836	.050155	-4.552[.000]
$lnY*lnP_L$	-.036973	.007648	-4.834[.000]
$lnY*lnP_{MS}$	.0397335	.0068685	5.785[.000]
$lnY*lnP_F$	-.0027604	.0018446	-1.497[.135]
$lnK*lnP_L$	.0768739	.0161639	4.756[.000]
$lnK*lnP_{MS}$	-.0833033	.0145134	-5.740[.000]
$lnK*lnP_F$	.0064294	.0038806	1.657[.098]
lnY^2	-.0700894	.0382592	-1.832[.068]
lnK^2	-.2795114	.1909448	-1.464[.144]
$lnY*lnK$	.1374421	.0849561	1.618[.107]
lnP_L*lnP_{MS}	-.1338625	.0056409	-23.731[.000]
lnP_L*lnP_F	-.0297197	.0058807	-5.054[.000]
$lnP_{MS}*lnP_F$	-.0154124	.0021078	-7.312[.000]
lnP_L^2	.1635822	.0082994	19.710[.000]
lnP_{MS}^2	.1492748	.0056848	26.258[.000]
lnP_F^2	.0451322	.0057094	7.905[.000]
$lnY*lnSP$	-.1794898	.0493105	3.640[.000]
$lnK*lnSP$	-.3990247	.0988443	-4.037[.000]
lnP_L*lnSP	-.0549743	.0120147	-4.576[.000]
$lnP_{MS}*lnSP$	.0280444	.0107604	2.606[.010]
lnP_F*lnSP	.0269299	.0028739	9.371[.000]
$lnSP^2$	.0512246	.0042156	0.367[.714]
R-Squared		.9851	

*All the independent variables have been divided by their sample mean value before the transformation in logarithms.

Table 5. Technology characteristics evaluated at the mean of the data (average firm)[*]

Returns to scale		1.86 [0.04]	

Morishima elasticities of substitution

	j=L	j=F	j=MS
I=L	-	0.41 [0.08]	0.27 [0.16]
i=F	0.38 [0.06]	-	0.29 [0.17]
I=MS	0.27 [0.14]	0.40 [0.08]	-

Own-price elasticities

	L, PL	F, PF	MS, PMS
	-0.11 [0.05]	-0.37 [0.07]	-0.19 [0.12]

* Standard errors in square brackets.

Figure 1. Estimated average costs