Diversification strategies and scope economies: Evidence from a sample of Italian regional bus transportation providers

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Working Paper 7, anno 2007

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Diversification strategies and scope economies: Evidence from a sample of Italian regional bus transportation providers

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December 2007

Abstract

A growing number of local public transportation (LPT) companies diversify their production lines by providing a large set of services. In particular different strategies are observed depending on the ownership structure: while private firms mainly supply competitive markets, usually highly correlated to the core business (e.g. bus renting and coaching activities), publicly owned companies (mainly municipal firms) offer a very large set of products in regulated sectors, ranging from car park management to waste disposal, water and sewage treatment and gas and electricity distribution. The cost properties of a sample of LPT companies operating in Piedmont, a Northern Italy region, are investigated and the presence and the magnitude of scope economies are assessed. The results from different functional forms are compared and estimates point towards the presence of global economies of scope. Scope economies for the median firm range between 16% and 30% depending on the output definition and the chosen cost function. Public firms always show lower scope economies. Global density economies are also detected, but they disappear when product specific density economies are considered.
The general picture seems to be characterized by local public transport firms that enjoy global scope economies, that are particularly high for private firms, i.e. for small to medium sized firms that diversify in competitive industries. Public firms are characterized by lower scope economies, and sometimes diseconomies, both because of their larger size and because of their chosen production structure.

Keywords: cost function, scope economies, transport companies
JEL: C33, L25, L33, L92

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Acknowledgements: We wish to thank Graziella Fornengo for fruitful discussions and Luca Sanlorenzo for outstanding assistance on the data. Financial support from Hermes (Higher Education and Research on Mobility Regulation and the Economics of Local Services) Research Centre is gratefully acknowledged. All errors are our own.

1. Introduction

Only few papers analysed scope economies in the local public transport (LPT) industry where a growing number of companies diversify their production lines by providing a large set of services.

This study tries to fill this gap using data from a sample of Italian bus companies observed over the period 1998-2004, that diversify their core activities supplying also transport related services and / or non transport services.

The sample of firms is also characterized by different ownership structures that are coupled with different diversification strategies. Private firms mainly supply services that are highly related to the core business (e.g. bus renting and coaching activities), while publicly owned companies (mainly municipal firms) offer a very large set of products, ranging from car park management to waste disposal, water and sewage treatment and gas and electricity distribution. In particular, while private firms mainly diversify in competitive markets, public companies are usually active in regulated sectors. The analysis aims to better understand the economic justification for such managerial choices and the presence of actual cost savings from the diversification in competitive *versus* regulated markets.

Our strategy is to estimate a cost function, using different model specifications. Many authors indicated the unreliable results from the standard translog specification when the main object is the analysis of scope economies and cost complementarities. Findings from the generalized (Box-Cox) translog function model are compared to those from the composite cost function introduced by Pulley and Braunstein (1992) that appear to be more suitable for studying the cost properties of multi- product firms.

Next section briefly reviews the main literature on scope economies in the bus transport industry and on functional choice for a cost model. Section 3 gives details on the different cost specifications that are estimated, while section 4 describes the dataset. Section 5 presents the main estimation results and a discussion on the economies of scope and size is given in section 6. Section 7 concludes and the appendix contains the tables showing the full set of estimation results.

2. Literature review

A scant number of papers consider scope economies in the public transit industry.

Viton (1992) considers urban transit companies supplying their services in six modes (motor bus, street cars, rapid rail, etc.) and the presence of scope and scale economies is uncovered. Similarly Colburn and Talley (1992) analyze a four modes urban company and find only limited cost complementarities. Viton (1993) estimates a quadratic cost frontier for bus companies operating in the San Francisco bay area and he is able to evaluate the cost savings deriving from the merger of the seven companies in the sample. Cost savings depend on the modes being offered and on the number of merging firms, with benefits decreasing as the number of integrated companies increases.

Farsi et al. (2007) study a sample of Swiss companies supplying urban services using three modes: trolley bus, motor bus and tramway systems. They detect global scope economies for multi-modal operators from the estimation of a quadratic cost function.

Many studies have considered the issue of the choice of the functional form for a cost model when the main purpose is to quantify the existence of scope economies from the simultaneous provision of different outputs. In general there seems to be a trade off among flexible functional forms that satisfy all regularity conditions that are required for a cost function to be an adequate representation of the production technology (concavity in input prices, non decreasing in input prices and outputs) and the dimension of the region over which such regularity conditions are fulfilled. Roller (1990) emphasizes that “this ‘regular’ region may be too small to be able to model demanding cost concepts such as economies of scope and subadditivity”. The most popular flexible functional forms, such as the standard translog model (see Christensen et al., 1971), have a degenerate behaviour in the region which is relevant for the derivation of scope economies and subadditivity measures (in general zero outputs levels) even if they satisfy the regularity conditions for a larger set of points (see Diewert, 1974 and Diewert and Wales, 1987).

Pulley and Braunstein (1992) and Pulley and Humphrey (1993) introduce the composite specification that unlike the translog models is defined in the neighbourhood of zero output levels and allows for the estimation of scope economies. McKillop et al. (1996), McKenzie and Small (1997), Bloch et al. (2001), Fraquelli et al. (2004), Piacenza and Vannoni (2004) and Fraquelli et al. (2005) all adopted the composite specification as their preferred model for the derivation of scope economies in different industries (ranging from the banking sector to the public utilities).

3. The cost function model

Our aim is to study the cost structure of a sample of transportation companies operating in the administrative region of Piedmont, in Northern Italy. In particular we are going to estimate a multi output cost function since firms may provide a large set of services.

A stochastic cost function can be written as:

$$C_{ft} = C(\mathbf{y}_{ft}, \mathbf{p}_{ft}; \theta) + \nu_f + u_{ft}$$

where C_{it} is total cost for firm $f=1,...,F$, at time $t=1,...T$, $\mathbf{y}_{ft}$ is the vector of outputs for firm f at time t, $\mathbf{p}_{ft}$ is the vector of input prices, θ is the vector of unknown parameters to be estimated, ν_f is the firm specific time invariant error term, while u_{ft} is the remainder stochastic error term that varies over time and across companies. Given the panel structure of the data, we are going to assume the absence of correlation among the individual specific effects ν_f and the included regressors, i.e. $E(\nu_f \mid \mathbf{y}_{ft}, \mathbf{p}_{ft}) = 0$. This assumption allows for the consistency of the pooled nonlinear estimation procedure while panel robust standard errors that take into account the likely correlation among errors for the same individuals should ensure robust inference. When dealing with nonlinear functional forms, the estimation of fixed effects or random effects models, as for linear specifications, is not straightforward (see Cameron and Trivedi, 2005, chapter 23 for a survey) and solutions are mainly case specific. At the same time including a large set of firm specific dummy variables may lead to inconsistent estimates as the incidental problem arises (see Lancaster, 2000). Our choice of a pooled model is justified by the lower computational burden and the unreliable estimates that were obtained when trying to estimate a model where all individual dummy variables are included.

We are going to present results from a two outputs and a three outputs cost models, that mainly differ in the way the considered outputs are aggregated (see Pulley and

Humphrey, 1993, for a similar approach when studying scope economies in the banking sector). Section 4 gives details on the dataset construction.

We are also going to compare results from different cost specifications. Baumol et al. (1982) recommend a quadratic output structure when examining scope economies because this form allows for the direct handling of zero outputs, without any need for substitutions or transformations as in the translog models. We thus estimate a composite and a separable quadratic cost specification that have a quadratic structure in outputs and a log – quadratic structure in input prices, but also a standard translog and a generalized translog model.

The composite specification that we consider has the following form (see Carroll and Rupert, 1984, 1988 and Pulley and Braunstein, 1992 for more details):

$$\ln(C) = \ln\left(\alpha_0 + \sum_i \alpha_i y_i + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_j y_i + \sum_i \sum_r \alpha_{ir} y_i \ln p_r + \lambda_1 Trend + \lambda_2 Trend^2\right) +$$
$$\left[\sum_r \beta_r \ln p_r + \frac{1}{2}\sum_r \sum_q \beta_{rq} \ln p_r \ln p_q\right] = \ln[h(\mathbf{y},\mathbf{p})] + f(\mathbf{p}) \qquad (1)$$

where C is the total cost, y_i is output i, $i= T, TR, NT$, for transport, transport related and non transport services respectively; p_r is price for input $r=L, M, K$, for labour, material and capital respectively and $Trend$ - $Trend^2$ are a linear and a quadratic time trend respectively.

By applying the Shephard's Lemma, the associated input share equation is:

$$S_r = \frac{x_r p_r}{C} = \frac{\partial \ln(C)}{\partial \ln p_r} = \left[\beta_r + \sum_q \beta_{rq} \ln p_q\right] + \left(\sum_i \alpha_{ir} y_i\right) \cdot$$
$$\left(\alpha_0 + \sum_i \alpha_i y_i + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_j y_i + \sum_i \sum_r \alpha_{ir} y_i \ln p_r + \lambda_1 Trend + \lambda_2 Trend^2\right)^{-1}.$$

where x_r is the derived demand for input r ($x_r=\partial C/\partial p_r$).

The separable quadratic model only differs from the composite specification in the assumed restriction that $\alpha_{ir} = 0$ for all i and r.

The generalized translog function is:

$$\ln(C) = \alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \alpha_{ir} y_i^{(\pi)} \ln p_r + \sum_r \beta_r \ln p_r + \frac{1}{2}\sum_{r,q} \beta_{rq} \ln p_r \ln p_q + \lambda_1 Trend + \lambda_2 Trend^2 \quad (2)$$

where $y_i^{(\pi)}$ is the Box – Cox (1964) transformation of the output measure *i*:

$$y_i^{(\pi)} = (y_i^{\pi} - 1)/\pi \qquad if \qquad \pi \neq 0$$
$$= \ln(y_i) \qquad if \qquad \pi = 0$$

The standard translog specification follows from the imposition of the restriction $\pi = 0$ in equation (2).

The input share equation associated to the generalized translog specification is:

$$S_r = \frac{x_r p_r}{C} = \frac{\partial \ln(C)}{\partial \ln p_r} = \sum_i \alpha_{ir} y_i^{(\pi)} + \beta_r + \sum_q \beta_{rq} \ln p_q$$

Global economies of scope can be computed starting from the estimated cost functions as the difference among the sum of the costs associated to the disjoint productions and the total cost from the joint production. In the case of *m* outputs, global scope economies are given by:

$$SCOPE = (C[y_1, 0, \ldots, 0; \overline{p}] + C[0, y_2, \ldots, 0; \overline{p}] + \ldots + C[0, 0, \ldots, y_m; \overline{p}] - C[y_1, y_2, \ldots, y_m; \overline{p}]) / C[y_1, y_2, \ldots, y_m; \overline{p}]$$

where *C* is total cost, y_i is output *i* and *p* is the vector of input prices that are kept constant, usually at their sample median or mean level. Scope economies are detected if the value of *SCOPE*>0, while diseconomies arise if *SCOPE*<0.

It is also possible to compute product specific scope economies when more than two outputs are simultaneously produced:

$$SCOPE_i = (C[0, 0, \ldots, 0, y_i, 0, \ldots, 0; \overline{p}] + C[y_1, y_2, \ldots, y_{i-1}, 0, y_{i+1} \ldots, y_m; \overline{p}] - C[y_1, y_2, \ldots, y_m; \overline{p}]) / C[y_1, y_2, \ldots, y_m; \overline{p}]$$

where the cost of producing product *i* only (first term in the formula of $SCOPE_i$) is summed to the production cost associated to all the other outputs (second term in the formula) and then compared to the total joint production cost. If $SCOPE_i > 0$, it follows that there are cost savings from the joint production of product *i* together with all the other goods.

Finally we can calculate scope economies for different pairs of products:

$$SCOPE_{ij} = (C[0,0,\ldots,0,y_i,0,...,0;\overline{p}] + C[0,0,\ldots,0,y_j,0,...,0;\overline{p}] -$$
$$C[0,0,\ldots,0,y_i,0,...,0,y_j,0,...,0;\overline{p}]) / C[0,0,\ldots,0,y_i,0,...,0,y_j,0,...,0;\overline{p}]$$

for products *i* and *j*, with $i \neq j$, $SCOPE_{ij}>0$ indicates the presence of scope economies from the joint production of the two goods, given the estimated cost structure.

Following Pulley and Humphrey (1993) we are also going to distinguish among the sources of cost savings. Using the composite (and separable quadratic) specification it is possible to distinguish among the fixed costs and variable costs savings, once scope economies are assessed. Given the formula in (1) for the composite cost function, it follows that global scope economies are given by:

$$SCOPE = \frac{\left((m-1)\alpha_o - \sum_{i,j\neq i} \alpha_{ij} y_i y_j\right)}{h(\mathbf{y},\mathbf{p})}$$

where the portion of scope economies that can be ascribed to fixed costs savings, i.e. a reduction in excess capacity that allows for the spreading of fixed costs over a larger production set, is given by:

$$SCOPE_{FixedCost} = \frac{\left((m-1)\alpha_o\right)}{h(\mathbf{y},\mathbf{p})} \qquad (3)$$

and scope economies attributable to savings from cost complementarities, i.e. savings associated to variable inputs that can be shared by different production lines, equal:

$$SCOPE_{Complement\ Cost} = \frac{-\left(\sum_{i,j\neq i} \alpha_{ij} y_i y_j\right)}{h(\mathbf{y},\mathbf{p})}$$

The estimated fixed costs savings in (3) represent an upper – bound estimate of the true effects from spreading fixed costs over a larger set of outputs. In fact as Pulley and Humphrey (1993) highlight, we are not able to identify product specific fixed costs and we use the estimated fixed costs from joint production (the constant term α_0 in the composite specification, see equation (3)) as a proxy for fixed costs of producing each output separately. The correct formula of the fixed cost savings, e.g. for a three outputs cost function (*i=1, 2, 3*), is:

$$SCOPE_{FixedCost} = \frac{\left(\alpha_{0;1} + \alpha_{0;2} + \alpha_{0;3} - \alpha_{0;1,2,3}\right)}{h(\mathbf{y}, \mathbf{p})}$$

where $\alpha_{0;1}$ is a measure of fixed costs associated to the first output that can be estimated as the coefficient of a dummy variable that takes the value of one for companies that produce only output *1* and zero otherwise. Similarly $\alpha_{0;2}$ and $\alpha_{0;3}$ can be estimated as intercepts specific to outputs 2 and 3 respectively, while $\alpha_{0;1,2,3}$ is the estimated fixed cost for joint production. Identification of the different components of the correct formula is feasible when data on specialized firms are available. Unfortunately this is rarely the case and in our dataset we do not observe any specialized companies.

Size economies are also evaluated. As pointed out by Caves et al. (1984) when dealing with industries where network represents an important attribute of the production, it should be considered the difference among density and scale economies. While density economies consider how the average costs change when output increases, keeping the network dimension fixed, in the computation of scale economies the enhancement of both outputs and network size are taken into account. We are not going to consider any network measure in the estimation of the cost function, thus we are able to evaluate the magnitude of global density economies (*DENSITY*) and product specific density economies ($DENSITY_i$) respectively:

$$DENSITY = \left(\sum_i \frac{\partial \ln(C)}{\partial \ln(y_i)} \right)^{-1}$$

where the derivatives need to be interpreted as cost elasticities with respect to the *i*th output;

$$DENSITY_i = \frac{(C(y_1, y_2, \ldots, y_m; \overline{p}) - C(y_1, y_2, \ldots, y_{i-1}, 0, y_{i+1}, \ldots, y_m; \overline{p})) / y_i}{\frac{\partial C}{\partial y_i}}$$

where the numerator is the average incremental cost (*AIC*), i.e. the additional costs of increasing product *i* from zero to y_i, holding all other outputs (and the input prices) fixed; while the denominator is the marginal cost with respect to product *i*.

Economies of density are present when *DENSITY* is greater than one, while diseconomies of density are present if *DENSITY* is smaller than one. Neither economies nor diseconomies exist if *DENSITY* is equal to one.

Finally the effect of technical change on total costs is computed. The inclusion of a linear and a quadratic time trend in all specifications should proxy for technical change. Technical progress is detected if $-\partial \ln(C)/\partial Trend > 0$, while technical regress follows if the derivative is smaller than zero.

4. Industry and data description

Data come from two sources: the database owned by the administrative region of Piedmont, which yearly collects information on transport services supplied by the companies of the area and the official accounting reports of the firms.

The regional database reports data on total costs, input costs and outputs for all the companies supplying local public transportation services. We complement these data, providing information on transport activities only, with companies' financial statements. The aim is to obtain a comprehensive picture of the whole set of services and outputs that transport companies offer.

Our final sample is an unbalanced panel of 40 firms whose annual observations cover the period 1998-2004.

We define three broad outputs: subsidized local public transportation services, non subsidized transport related activities and non transport services.

Local public transportation comprises urban and intercity transport connections that represent the main business for all the firms in our sample. Non subsidized transport related activities may range from coach renting to touristic travel organization.

Non transport services mainly relate to regulated markets and they represent a broad and varied set of productions such as waste disposal, water and sewage treatment, parking areas management, cemetery services and gas and electricity distribution. Information on such services come from the companies' financial statements.

We use total revenues from each of the three production sets as our output measures in the estimation of the cost function. The prices for transport outputs and for other transport related activities are approximated by the consumer price indexes for transport services while we use the consumer price index for housing, water, electricity and fuels as a proxy for non transport outputs' price. The output quantities for transport services (y_T) are thus computed as the transport revenues divided by the price index of transport facilities. The output quantities for transport related activities (y_{TR}) are calculated dividing total revenues from these services by the price index for transportation, while the outputs for the other non transport productions (y_{NT}) are obtained dividing total revenues associated to such products by the consumer price index for housing, water, electricity and fuels. Estimation results from a two outputs technology are also reported. In this case subsidized local public transportation services (y_T as defined above) are contrasted to non subsidized activities, given by the sum of total revenues from transport related services and all the other services. The consumer price index for transportation and the consumer price index for housing, water, electricity and fuels are used as proxies for output prices for the two production sets respectively.

The choice of such values as our outputs was mainly motivated by measurement difficulties. Many outputs definition have been adopted in transport studies, usually grouped into demand oriented measures (such as passengers-kilometres) and supply oriented outputs (like vehicle- kilometres or seat- kilometres). More ambiguous is the definition of a measure for the other two outputs. Transport related activities could in principle be measured by vehicle – kilometres or seat – kilometres as for transport services, however such values are not available for all companies in our sample. Even more demanding is the task for other non transport services as they are a very heterogeneous category (car parks management, electricity and gas distribution, water and sewage treatment, waste disposal, etc.), and we were not able to disentangle the information on each single activity. Total revenues were finally selected as they were readily available while index prices should control for price effects. A similar approach was followed, among the others, by McKillop et al. (1996) in their study of giant Japanese banks, Cowie and Asenova (1999) for the assessment of cost inefficiencies in the British bus industry, Silk and Berndt (2004) for marketing firms and Asai (2006) for the broadcasting industry.

Total costs for a firm are given by the total production costs as they are reported by the annual company profit and loss accounts.

Three inputs are considered: labour, materials and capital.

Labour price (p_L) is calculated dividing total labour costs as they appear in the profit and loss account, by the total number of employees of the company. Labour cost share is computed dividing total labour costs by total costs.

Total material costs are obtained from the corresponding company account item and include raw materials, consumption and maintenance goods' purchases, energy and fuel expenses. The price for this heterogeneous input is measured by the production price index for energy and gas, since most of the expenditures for materials were for energy and fuels. The cost share for materials is given by the ratio of total material costs to total production costs.

Following Christensen and Jorgenson (1969), price for capital (p_K) is computed by *PPI(IR+D)/(1-T)*, where *PPI* is the production price index for investment goods, *IR* is the yearly average long term prime lending interest rate as assessed by the Italian Banking Association (ABI[1]), while *D* is the depreciation rate and *T* is the corporate tax rate.

D is computed as the ratio of total depreciation expenses to book-valued fixed assets at the beginning of the period. *T* is obtained as total taxation divided by operating profits taken from the financial statements. A similar approach for the derivation of capital and material prices is followed by Adams et al. (2004) and Asai (2006).

Data on yearly consumption price indexes (for transportation and for housing, energy and fuels) and production price indexes (for energy and for investments goods) are obtained from ISTAT, Italian Statistical Institute[2]. The consumption price indexes are town (province) specific and we apply the appropriate price index according to the town (province) where the company runs its businesses.

Tables 1 and 2 report some descriptive statistics for the sample.

Firms are quite heterogeneous in their operating size: standard deviations for total operating costs and total revenues are quite high and the median is always smaller than the mean. Companies are asymmetrically distributed and few very large firms share the market with many small – medium sized LPT firms. The largest firms in the sample are publicly owned and table 2 splits the sample according to ownership. Apart

[1] Data available from the Bank of Italy website, www.bancaditalia.it
[2] Data available from www.istat.it

from the size differences[3], it is interesting to note the different production lines for the two groups of firms considering the median output levels: while publicly owned firms, mainly municipal entities, are diversified in regulated markets, such as e.g. waste disposal, water and sewage treatment and gas and electricity distribution; private companies diversify their activities in competitive unregulated sectors, like transport related services, such as bus renting, coaching activities and touristic services.

Differences across the firms in the sample and between public and private companies are less evident when we look at the inputs: labour and capital prices as well as labour and material costs shares on total costs are characterized by small standard deviations.

Table 1. Descriptive statistics for the whole sample. Unbalanced panel: 40 firms over the period 1998-2004, 184 observations.

	Mean	Std. Dev.	Median
Total operating costs (th. Euro)	8958.98	33294.42	3416.91
Total revenues from transport services (th. Euro)	3990.99	9732.31	1717.06
Total revenues from non transport services (th. Euro)	2282.80	6821.18	101.02
Total revenues from transport related services (th. Euro)	3017.14	19798.13	604.86
y_T	36.34	83.85	16.10
y_{NT}	20.21	58.65	0.95
y_{TR}	26.43	168.61	5.48
Labour price p_L (th. Euro)	35.68	32.65	33.86
Material price p_M (price index)	119.70	12.84	124.10
Capital price p_K	34.40	20.90	28.02
Labour share	0.45	0.10	0.44
Material share	0.18	0.08	0.17
Total cost of personnel (th. Euro)	4423.29	17786.84	1436.71
Number of employees	134.44	539.38	40.50
Total cost of materials (th. Euro)	1421.05	3690.66	626.81

Notes: See the text for the definition of the output measures y_T, y_{NT}, , y_{TR} and the capital price p_K,.

[3] The largest firm in the dataset is GTT (Gruppo Torinese Trasporti), owned by the municipality of Turin.

Table 2. Descriptive statistics for the samples of publicly and privately owned companies.

	11 public firms, 49 obs. Mean	Std. dev.	Median	29 private firms, 135 obs. Mean	Std. dev.	Median
Total operating costs (th. Euro)	22725.86	62704.37	10013.16	3962.12	3315.54	2422.29
Total revenues from transport services (th. Euro)	7505.56	17820.75	2902.14	2715.34	3072.04	1635.00
Total revenues from non transport services (th. Euro)	7674.42	11640.51	1583.73	325.84	718.80	48.25
Total revenues from transport related services (th. Euro)	8152.90	38131.81	88.90	1153.04	1141.38	770.32
y_T	66.75	152.37	24.97	25.30	28.72	15.85
y_{NT}	67.43	99.38	13.65	3.07	6.95	0.47
y_{TR}	69.79	324.74	0.81	10.69	10.48	7.19
Labour price p_L (th. Euro)	42.49	61.69	33.93	33.21	8.31	33.75
Material price p_M (price index)	123.38	9.92	124.30	118.36	13.53	124.10
Capital price p_K	30.05	23.42	26.18	35.98	19.77	29.19

Notes: See the text for the definition of the output measures y_T, y_{NT}, y_{TR} and the capital price p_K.

Before estimation all variables, except for the linear and the quadratic time trends (*Trend* and *Trend*^{2}) that should capture technical change, are normalised by their sample median levels. Moreover in order to cope with the required regularity conditions for cost functions, a number of restrictions are imposed in all models. Symmetry is ensured by the imposition of the following equalities in all cost specifications (see equations (1) and (2)): $\alpha_{ij} = \alpha_{ji}$ and $\beta_{rk} = \beta_{kr}$. Linear homogeneity, requiring $\Sigma_r\alpha_{ir} =0$ *for all i;* $\Sigma_r\beta_r=1$ and $\Sigma_k\beta_{rk}=0$ *for all k*, is obtained dividing both the dependent variable (total costs) and the labour and material prices by the capital price which does not directly appear in the estimated function. The other regularity conditions (nonnegative marginal costs with respect to outputs, non decreasing costs in input prices and concavity of the cost function in input prices) are checked after estimation for all sample observations.

5. Estimation results

Table 3 presents the estimated parameters for the cost functions that use the two most general specifications: the generalized translog and the composite forms. Results for the two outputs and the three outputs models are shown. The appendix reports the estimation results for the four specifications that are described in section 3 (that include also the standard translog and the separable quadratic models).

The estimated parameters greatly differ according to the definition of outputs. The considered three outputs are transport, transport related and non transport services, while in the specification with two outputs, non transport services are defined as the sum of transport related and all the other non transport activities.

The first order terms for outputs are positive and statistically significant in all specifications. The second order and the interaction coefficients for outputs are never significant for the composite model (except for the interaction among transport and transport related services), while they are precisely estimated under the generalized translog model. The second order output coefficients are not particularly large (when compared to the first order coefficients) and, as Bloch et al. (2001) suggest, this produces reliable scale and scope economies since output cost elasticities are more stable[4].

First order parameters for the labour price are always precisely estimated and differ across specifications, with larger magnitudes from the composite models. The coefficients for material prices are significant only under the first specification (generalized translog with two outputs) and are much smaller than those for labour price, paralleling the different median cost shares (labour costs represent 45% of total operating costs, while material costs correspond to 18%).

The time trend parameter is negative and significant in all specifications, indicating cost reductions over time. The positive second order trend coefficients, however, indicates that such cost savings diminish over time.

[4] Large second order output coefficients imply that a marginal increase in an output causes a large change in cost elasticity. This happens, for example, with the standard translog model (see table 1A and 2A in the appendix) where the second order coefficient for transport services is quite large, resulting in implausible transport specific density returns estimates.

Table 3. Estimation results. Dependent variable: natural logarithm of total operating costs, normalized by the capital price. Cluster robust standard errors in parenthesis, 184 observations.

Dependent variables	2 outputs: Generalized Translog	2 outputs: Composite	3 outputs: Generalized Translog	3 outputs: Composite
y_T	0.560***	1691.533***	0.658***	1700.896***
	(0.01)	(58.20)	(0.04)	(63.97)
y_{NT}	0.396***	1050.135***	0.077***	99.285***
	(0.01)	(28.89)	(0.01)	(6.81)
y_{TR}			0.172***	545.735***
			(0.01)	(29.79)
y_T2	0.136***	41.682	-0.098***	38.188
	(0.02)	(24.80)	(0.02)	(25.52)
$y_{NT}2$	0.092***	10.362	-0.001**	0.037
	(0.01)	(8.58)	(0.00)	(0.12)
$y_{TR}2$			0.074***	10.704
			(0.02)	(9.56)
$y_T * y_{NT}$	-0.287***	-46.327	-0.046***	1.972
	(0.01)	(36.08)	(0.01)	(5.81)
$y_T * y_{TR}$			-0.142***	-74.822**
			(0.02)	(33.50)
$y_{TR} * y_{NT}$			-0.011***	0.317
			(0.00)	(3.11)
$y_T * lnp_L$	-0.148***	-852.265***	-0.131*	-937.415***
	(0.03)	(155.77)	(0.07)	(167.38)
$y_{NT} * lnp_L$	0.124**	-156.916	-0.015	-7.039
	(0.04)	(121.34)	(0.01)	(11.10)
$y_{TR} * lnp_L$			-0.099	-237.887**
			(0.07)	(79.23)
$y_T * lnp_M$	0.101**	1187.209***	0.112**	1515.650***
	(0.04)	(325.18)	(0.05)	(199.39)
$y_{NT} * lnp_M$	-0.122**	427.031**	0.014	45.327**
	(0.05)	(187.02)	(0.01)	(12.99)
$y_{TR} * lnp_M$			0.090	468.431***
			(0.07)	(91.15)
Trend	-0.112***	-189.490**	-0.145***	-152.146**
	(0.02)	(56.99)	(0.03)	(58.10)
Trend2	0.025***	38.345**	0.029**	31.030**
	(0.01)	(13.87)	(0.01)	(13.47)
lnp_L	0.226***	0.585***	0.395**	0.685***
	(0.05)	(0.05)	(0.13)	(0.06)
lnp_L2	-0.211***	0.233	-0.423***	0.810**
	(0.04)	(0.26)	(0.10)	(0.33)
lnp_M	0.181***	0.182	0.154	0.170
	(0.07)	(0.17)	(0.13)	(0.11)
lnp_M2	0.029	0.450	-0.051	1.861**
	(0.26)	(0.38)	(0.42)	(0.68)
$lnp_L * lnp_M$	0.117	-0.311	0.258	-1.235**
	(0.13)	(0.24)	(0.23)	(0.46)
Constant	8.176***	488.800***	8.064***	389.278**
	(0.04)	(101.17)	(0.06)	(115.78)

π	0.137*** (0.01)	1	0.600*** (0.05)	1
Cost function R2adj	0.995	1.000	0.988	1.000
LogL	175.782	187.125	105.990	189.114
RSS	1.594	1.409	3.404	1.379
AIC	-315.56	-340.25	-163.98	-332.23
BIC	-257.70	-285.60	-86.82	-258.28
LR test [p-value]	110.30 [0.00] d.f.=1	7.62 [0.11] d.f.=4	188.85 [0.00] d.f.=1	12.56 [0.05] d.f.=6

Notes:
- The subscripts for the output variables are *T* for transport services, *TR* for transport related activities and *NT* for non transport services, that include also the transport related activities in the two outputs specifications. The subscripts for the input prices are *L* for labour and *M* for other variable inputs (i.e. raw materials and fuels).
- R2adj is the centered adjusted R2, LogL is the value of the log-likelihood function, assuming errors are iid normal, while RSS is the residual sum of squares
- AIC and BIC are the Akaike's and Schwarz's Bayesian information criteria respectively
- LR test is the likelihood ratio test over the restricted specifications. The standard translog specification is the restricted model for the generalized translog (H0: π=0), while the separable quadratic model is the restricted specification for the composite model (H0: all interactions among input prices and output measures are zero).
- Significance levels: * 10%; ** 5%; *** 1%.

Table 3 also shows a number of summary statistics for each cost function model. The translog and the composite specifications are non nested models that cannot be directly tested, however the composite specifications are characterized by the largest log likelihood and the lowest residual sum of squares, Akaike and Schwarz information criterion, suggesting a better statistical fit.

A set of likelihood ratio tests are reported, where the restrictions imposed by the standard translog model and the separable quadratic model are tested against the unrestricted generalized translog and composite specifications respectively. The generalized translog is always preferred to the standard translog model that imposes $\pi=0$. In particular in the three outputs case, the π parameter is significant and particularly large (π=0.6), suggesting sizeable differences among the estimated economies of density and scope from the two models, with more reasonable magnitudes from the generalized translog (see McKillop et al., 1996).

The restrictions imposed by the separable quadratic model are not rejected in the two outputs specification and rejected at the 5% level under the three outputs case.

6. Economies of scope and size

Scope and density economies are computed using all the estimated specifications. Table 4 presents the results for the generalized translog and the composite specifications, while table 3A in the appendix reports the results for the four specifications (standard translog, generalized translog, separable quadratic and composite).

As expected results significantly change with different outputs' definitions and cost function specifications.

Scope economies for the median firm range between 16% and 30% depending on the output definition and the chosen cost function. For a two outputs technology, economies of scope are not significantly different from zero under the generalized translog model, while they are precisely estimated and amount to 16% when the composite specification is used.

Results from the three outputs models are also conflicting: both estimates are significantly different from zero, but the magnitude almost double when moving from the generalized translog to the composite model (16% vs. 30%).

Global scope economies for the median public firm are significantly different from zero for both the composite models and the generalized translog with three outputs and they range between -13% and 17%. Economies of scope for privately owned firms range between 16% and 29%. In general lower global scope economies for public firms are always found and in one case diseconomies arise (i.e. the joint production of three outputs leads to higher costs than a disjoint production).

Table 4 also reports global and product specific density economies. They are always significant (except for the product specific density returns from the two outputs generalized translog) and global density economies point towards the presence of moderate economies of size: proportionally increasing the operating size for all outputs, lower average costs can be achieved.

Results from the product specific density returns are mixed: from the composite model absence of economies or small diseconomies of size are obtained, while the generalized translog reports large density economies for the non transport services (1.58) that are operated at a too low scale.

Cost elasticities with respect to output is a measure of how total operating costs change when production is changed. The two cost specifications give similar results and differences arise only with the outputs' definitions. The highest cost elasticity is found for transport outputs (0.53-0.66), the smallest is for non transport services (0.04-0.08) and transport related activities are in between the other two (0.17-0.19).

Finally technical change at the median point in the sample is computed. Technical progress is observed in the sample, with yearly cost reductions between 1% and 3%.

Table 4. Global scope and density economies. Asymptotic standard errors in parenthesis.

	2 outputs		*3 outputs*	
	Generalized translog	Composite	Generalized translog	Composite
Global scope economies	0.282	0.158	0.159	0.299
	(0.29)	(0.027)	(0.038)	(0.073)
Scope economies public firms	0.702	0.114	-0.128	0.166
	(0.372)	(0.020)	(0.038)	(0.046)
Scope economies private firms	0.233	0.165	0.159	0.294
	(0.251)	(0.028)	(0.038)	(0.071)
Global density economies	1.046	1.177	1.103	1.173
	(0.014)	(0.036)	(0.045)	(0.049)
$DENSITY_T$	0.642	0.988	1.077	0.989
	(0.671)	(0.007)	(0.022)	(0.008)
$DENSITY_{NT}$	0.906	0.995	1.579	1.000
	(0.342)	(0.004)	(0.011)	(0.001)
$DENSITY_{TR}$			0.976	0.990
			(0.120)	(0.010)
Cost elasticity transport	0.560	0.529	0.658	0.625
	(0.012)	(0.020)	(0.035)	(0.030)
Cost elasticity non transport	0.396	0.321	0.077	0.037
	(0.013)	(0.012)	(0.008)	(0.003)
Cost elasticity transport related			0.172	0.191
			(0.014)	(0.014)
Technical change	0.011	0.011	0.030	0.010
	(0.004)	(0.002)	(0.006)	(0.003)

Notes: Global scope and density economies are evaluated for the median firm in the sample, scope economies for public and private firms are evaluated for the median public and private firm respectively. Input prices are always kept at the sample median value.

Table 5 reports the estimated global scope economies at two different sample points: the first and the third quartiles of the whole sample and the two subsamples of public and private firms. Scope economies decrease with size: larger firms exhibit lower scope economies and in some cases (under the generalized translog specification) also diseconomies.

Table 5. Estimated global scope economies at different sample points: generalized translog and composite specifications, 3 outputs. Asymptotic standard errors in parenthesis.

		Generalized translog (3 outputs)		*Composite (3 outputs)*	
Whole sample	1st quartile	0.624	(0.043)	0.574	(0.124)
	3rd quartile	-0.103	(0.059)	0.148	(0.038)
Public firms	1st quartile	0.780	(0.061)	0.805	(0.148)
	3rd quartile	-0.334	(0.054)	0.152	(0.047)
Private firms	1st quartile	0.574	(0.041)	0.534	(0.118)
	3rd quartile	-0.085	(0.041)	0.204	(0.050)

We suspect that the differing global scope economies for the two groups of firms (public and private) are the result of two effects: on one side the size effect; on the other side the effect of different diversification strategies. In general public firms are larger than private firms and they exhibit lower global scope economies as table 5 makes clear. Moreover public firms mainly diversify in regulated industries (non transport services), while private firms in competitive markets (transport related activities) and we are interested in the sign and dimension of the scope economies deriving from the strategic choice of diversification. In order to disentangle these effects, we follow Fraquelli et al. (2005), computing global scope economies for different combination of the three outputs.

Table 6 presents the estimated scope economies when the scale of operation of the median firm in the whole sample is increased or reduced proportionally. λ_i is the scaling factor for output *i*: when $\lambda_i = 1$ the output is at its median value, when $\lambda>(<)1$ the output value is proportionally increased (decreased) with respect to its median point.

Sizeable scope economies are found for any combination of the scaling factors (see panel A of table 6). Scope economies always decrease with the operating dimension and they often are statistically significant, in particular when the size is very large, the estimates are not precise and display large standard errors

Panel B and C present scope economies when the operation size of transport related and non transport services is increased. Scope economies decrease with dimension but they always are positive and significant under the composite specification. Scope economies decrease more steadily when transport related services are considered, while scope economies are still sizeable (about 10%) when the output is 50 times the sample median level and the composite specification is considered.

Estimated scope economies from the generalized translog decrease in size for non transport output and they seem to display an U shaped structure for transport related activities: economies of scope decrease with size, but after a threshold they increase again.

Table 6. Estimated global scope economies for different combination of the three outputs: generalized translog and composite specifications, 3 outputs. Asymptotic standard errors in parenthesis.

Panel A. Symmetric change in the operation scale of the three outputs

Value of the output			*Scaling factor*			*Global scope economies*	
y_T	y_{TR}	y_{NT}	λ_T	λ_{TR}	λ_{NT}	*Composite (3 outputs)*	*Generalized translog (3 outputs)*
1.6	0.6	0.1	0.1	0.1	0.1	1.249 (0.14)	1.166 (0.04)
4	1.4	0.2	0.25	0.25	0.25	0.801 (0.15)	0.774 (0.05)
8	2.7	0.5	0.5	0.5	0.5	0.505 (0.11)	0.451 (0.04)
16.1	5.5	0.9	1	1	1	0.299 (0.07)	0.159 (0.04)
40.2	13.1	2.4	2.5	2.5	2.5	0.163 (0.04)	-0.059 (0.05)
80.5	27.4	4.7	5	5	5	0.143 (0.04)	0.086 (0.16)
161	54.8	9.5	10	10	10	0.194 (0.09)	1.702 (1.00)
804	274.1	47.5	50	50	50	1.037 (0.96)	1.99e+11 (9.95e+11)

Panel B. Change in the operation scale of transport related output

Value of the output			*Scaling factor*			*Global scope economies*	
y_T	y_{TR}	y_{NT}	λ_T	λ_{TR}	λ_{NT}	*Composite (3 outputs)*	*Generalized translog (3 outputs)*
16.1	2.7	0.9	1	0.5	1	0.323 (0.08)	0.225 (0.04)
16.1	13.1	0.9	1	2.5	1	0.248 (0.06)	-0.014 (0.04)
16.1	27.4	0.9	1	5	1	0.197 (0.05)	-0.220 (0.05)
16.1	54.8	0.9	1	10	1	0.147 (0.03)	-0.389 (0.04)
16.1	137.1	0.9	1	25	1	0.094 (0.02)	-0.151 (0.14)
16.1	274.1	0.9	1	50	1	0.064 (0.01)	0.800 (0.51)

Panel C. Change in the operation scale of the non transport output

Value of the output			*Scaling factor*			*Global scope economies*	
y_T	y_{TR}	y_{NT}	λ_T	λ_{TR}	λ_{NT}	*Composite (3 outputs)*	*Generalized translog (3 outputs)*
16.1	5.5	0.5	1	1	0.5	0.305 (0.07)	0.197 (0.04)
16.1	5.5	2.4	1	1	2.5	0.283 (0.07)	0.086 (0.04)
16.1	5.5	4.7	1	1	5	0.259 (0.06)	0.008 (0.04)
16.1	5.5	9.5	1	1	10	0.222 (0.06)	-0.086 (0.04)
16.1	5.5	23.7	1	1	25	0.153 (0.04)	-0.212 (0.04)
16.1	5.5	47.5	1	1	50	0.099 (0.04)	-0.259 (0.05)

Panel D. Change in the operation scale of transport output

Value of the output			*Scaling factor*			*Global scope economies*	
y_T	y_{TR}	y_{NT}	λ_T	λ_{TR}	λ_{NT}	*Composite (3 outputs)*	*Generalized translog (3 outputs)*
8	5.5	0.9	0.5	1	1	0.424 (0.1)	0.307 (0.05)
40.2	5.5	0.9	2.5	1	1	0.163 (0.04)	0.084 (0.04)
80.5	5.5	0.9	5	1	1	0.098 (0.02)	0.208 (0.09)
161	5.5	0.9	10	1	1	0.058 (0.01)	0.626 (0.23)
402.5	5.5	0.9	25	1	1	0.031 (0.01)	2.446 (0.93)
804	5.5	0.9	50	1	1	0.020 (0.01)	10.154 (6.57)

Further analysis of the differences among publicly owned and private firms is carried out in the next two tables.

First we present product specific scope economies. Table 7 presents results for the generalized translog and the composite specifications with a three outputs technology. Differences among the two functional forms replicate previous results and larger estimates are always found for the composite model. We expect actual magnitudes to be somewhere between the two bounds, since the generalized translog estimates seem to be as reliable as the composite results[5] and all standard errors are small.

Product specific scope economies give a measure of the cost savings associated to the joint production compared to the productions of one output only on one side and the remaining two products on the other side. The estimates from the generalized translog

[5] In fact the estimated π parameter, characterizing the generalized translog model, is large and significant, see section 5.

give larger cost savings for transport related and non transport activities for the whole sample and private firms. Public firms are characterized by diseconomies of scope from transport and non transport outputs (about -20%), while larger transport correlated scope economies are found (10% for public companies, 7% for the whole sample and 5% for the private firms). Results from the composite specification give evidence of a slightly different picture: product specific scope economies are quite similar across different outputs and are always positive and sizeable, estimates for the private firms are very similar to those for the whole sample, while public firms are characterized by smaller cost savings.

Pair specific scope economies are also interesting, given the different production sets supplied by public and private firms. Public firms mainly provide transport and non transport services and scope economies associated to this pair of outputs are always smaller for public firms (diseconomies are found under the generalized translog, -22%, while economies are present for the composite model, 8%). Private firms, that are specialized in transport and transport related activities, have smaller scope economies from this pair of outputs, however scope economies are always positive (6% from the generalized translog and 16% from the composite). It seems that public firms could reach larger cost advantages from the joint production of transport and transport related activities, but also private firms can still enjoy scope economies from this pair of outputs. Non transport services also can allow for cost savings, especially for private firms.

Table 7. Estimated product specific scope economies: generalized translog and composite specifications, 3 outputs. Asymptotic standard errors in parenthesis.

	Generalized translog (3 outputs)			*Composite (3 outputs)*		
	Whole sample	Public firms	Private firms	Whole sample	Public firms	Private firms
$SCOPE_{T}$	0.012	-0.197	0.007	0.156	0.082	0.156
	(0.026)	(0.029)	(0.026)	(0.036)	(0.025)	(0.036)
$SCOPE_{NT}$	0.078	-0.208	0.104	0.143	0.080	0.138
	(0.022)	(0.029)	(0.019)	(0.037)	(0.025)	(0.036)
$SCOPE_{TR}$	0.073	0.095	0.045	0.157	0.086	0.156
	(0.024)	(0.015)	(0.025)	(0.036)	(0.023)	(0.036)
$SCOPE_{T, NT}$	0.104	-0.222	0.145	0.176	0.081	0.182
	(0.030)	(0.033)	(0.029)	(0.044)	(0.025)	(0.046)
$SCOPE_{T, TR}$	0.093	0.142	0.059	0.163	0.126	0.159
	(0.024)	(0.014)	(0.025)	(0.038)	(0.033)	(0.036)
$SCOPE_{TR, NT}$	0.507	0.297	0.503	0.374	0.204	0.334
	(0.033)	(0.046)	(0.031)	(0.070)	(0.048)	(0.067)

Notes: All magnitudes are evaluated for the median firm in the sample, scope economies for public and private firms are evaluated for the median public and private firm respectively. Input prices are always kept at the sample median value.

Finally it is possible to split global scope economies into the fixed costs savings and the variable inputs cost complementarities for the composite model. Table 8 shows the estimates from the two outputs and three outputs technology, since from expression (3) it is evident that the contribution to economies of scope from fixed costs savings increases with the number of outputs and it could be interesting to compare the different magnitudes. The largest cost savings are associated to fixed costs and they range between 10% (public firms) and 16% (private companies) in the two outputs cost model and 17% (public firms) and 28% (private companies) in the three outputs model. Cost complementarities are small and in some cases not significantly different from zero (for private firms in the two outputs case and for public firms in the three outputs model). Fixed cost savings from the joint production of different outputs may be associated to the possibility to share fixed assets, like the rolling stock, the hardware and software organization, buildings, offices and parking areas. Cost savings from the variable inputs that can be shared by different product lines, are modest, probably because the most important variable input is labour (accounting for about 45% of total costs) that is not completely interchangeable between transport and other services.

As discussed in section 3, however it is worth to stress that the estimated fixed costs savings represent an upper bound estimate of the true savings.

Table 8. Fixed costs and cost complementarities effects: composite specifications, 2 and 3 outputs. Asymptotic standard errors in parenthesis.

	Composite 2 outputs			*Composite 3 outputs*		
	Whole sample	Public firms	Private firms	Whole sample	Public firms	Private firms
Fixed costs savings	0.151	0.102	0.158	0.286	0.169	0.277
	(0.027)	(0.019)	(0.028)	(0.074)	(0.046)	(0.072)
Cost complementarities	0.007	0.012	0.007	0.013	-0.003	0.017
	(0.006)	(0.009)	(0.005)	(0.007)	(0.015)	(0.008)

Notes: All magnitudes are evaluated for the median firm in the sample, scope economies for public and private firms are evaluated for the median public and private firm respectively. Input prices are always kept at the sample median value.

Table 9 gives evidence of the time evolution of technical change. In all cases technical change deteriorates over time: technical progress is present till 2001, while technical regress is found afterwards. Public firms start with smaller cost reductions associated to technical change, but the decline that private firms experience is faster. There seems to be a common weakening in the ability of firms to reduce their total operating costs over time (all else equal), that is particularly intense for private firms starting from 2001-2002.

Table 9. Estimated technical change: composite specification, 3 outputs. Asymptotic standard errors in parenthesis.

Year	Whole sample		Public firms		Private firms	
1998	0.044	(0.015)	0.026	(0.009)	0.043	(0.014)
1999	0.033	(0.010)	0.020	(0.006)	0.032	(0.010)
2000	0.022	(0.006)	0.013	(0.004)	0.021	(0.006)
2001	0.010	(0.003)	0.006	(0.002)	0.010	(0.003)
2002	-0.001	(0.005)	-0.001	(0.003)	-0.001	(0.005)
2003	-0.012	(0.009)	-0.007	(0.005)	-0.012	(0.008)
2004	-0.024	(0.013)	-0.014	(0.008)	-0.023	(0.013)

Notes: All magnitudes are evaluated for the median firm in the sample, technical change for public and private firms are evaluated for the median public and private firm respectively

7. Conclusions

This study gives evidence on the presence of cost savings from the joint production of transport services, transport related activities and other non transport productions using different functional forms and different output definitions.

In particular estimates from different cost function specifications are compared and different outputs aggregates are assessed. As expected, scope and density economies largely differ according to the chosen output definition or cost model.

Global scope and density economies are found in all cases. Global scope economies range between 16% and 30% depending on the cost functional form and the number of outputs. Product specific and pair specific scope economies are also positive and significantly different from zero. The group of publicly owned firms differs from the private companies in their median size and in their diversification strategies. Public firms are larger, in terms of number of employees, total costs and total revenues, than private firms and they mainly supply subsidized local public transportation services and non transport services.

Private firms mainly supply subsidized local public transportation services and non subsidized transport related activities. Global scope economies are larger for private firms (between 16% and 30%), while diseconomies of scope are found for public firms in one specification (estimated global scope economies range between -13% and 17%). It is possible to split estimated global scope economies (from the composite specifications) into fixed costs savings and cost complementarities effects. Larger costs savings result from fixed costs, especially for private firms.

The general picture seems to be characterized by local public transport firms that enjoy global scope economies, that are particularly high for private firms. Public firms are characterized by lower scope economies, and sometimes diseconomies, probably because of their chosen production structure where a large and heterogeneous set of non transport services is supplied together with transport.

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Appendix

Table 1A. Estimation results: 2 outputs (transport, y_T , and other non transport services, y_{NT}), 3 inputs. Dependent variable: natural logarithm of total operating costs normalized by the price of capital. Unbalanced panel: 40 firms, 184 observations. Cluster robust standard errors in parenthesis.

Dependent variables	Standard Translog	Generalized Translog	Separable quadratic	Composite
y_T	0.558	0.560	1714.680	1691.533
	(0.01)	(0.01)	(53.58)	(58.20)
y_{NT}	0.451	0.396	1052.752	1050.135
	(0.02)	(0.01)	(29.50)	(28.89)
y_T2	0.230	0.136	31.472	41.682
	(0.02)	(0.02)	(25.37)	(24.80)
$y_{NT}2$	0.059	0.092	12.575*	10.362
	(0.01)	(0.01)	(7.09)	(8.58)
$y_{NT}*y_T$	-0.245	-0.287	-53.536*	-46.327
	(0.01)	(0.01)	(30.35)	(36.08)
y_T*lnp_L	-0.154**	-0.148		-852.265
	(0.07)	(0.03)		(155.77)
$y_{NT}*lnp_L$	0.255**	0.124**		-156.916
	(0.07)	(0.04)		(121.34)
y_T*lnp_M	0.080	0.101**		1187.209
	(0.07)	(0.04)		(325.18)
$y_{NT}*lnp_M$	-0.215**	-0.122**		427.031**
	(0.07)	(0.05)		(187.02)
Trend	-0.090**	-0.112	-210.817**	-189.490**
	(0.03)	(0.02)	(63.27)	(56.99)
Trend2	0.023	0.025	43.046**	38.345**
	(0.01)	(0.01)	(15.53)	(13.87)
lnp_L	0.288	0.226	0.271	0.585
	(0.06)	(0.05)	(0.06)	(0.05)
lnp_L2	-0.233	-0.211	-0.166	0.233
	(0.04)	(0.04)	(0.05)	(0.26)
lnp_M	0.175	0.181	0.171	0.182
	(0.07)	(0.07)	(0.06)	(0.17)
lnp_M2	0.086	0.029	-0.243	0.450
	(0.30)	(0.26)	(0.21)	(0.38)
lnp_L*lnp_M	0.149	0.117	0.203*	-0.311
	(0.14)	(0.13)	(0.10)	(0.24)
Constant	8.143	8.176	532.534	488.800
	(0.05)	(0.04)	(102.84)	(101.17)
π	0	0.137	1	1
		(0.01)		
Cost funct. R2adj	0.990	0.995	1.000	1.000
LogL	120.630	175.782	183.315	187.125
RSS	2.903	1.594	1.469	1.409
AIC	-207.26	-315.56	-340.63	-340.25
BIC	-152.61	-257.70	-298.84	-285.60

Table 2A. Estimation results: 3 outputs (transport, y_T, transport related activities, y_{TR}, and other non transport services, y_{NT}), 3 inputs. Dependent variable: natural logarithm of total operating costs normalized by the price of capital. Unbalanced panel: 40 firms, 184 observations. Cluster robust standard errors in parenthesis.

Dependent variables	Standard Translog	Generalized Translog	Separable quadratic	Composite
y_T	0.620	0.658	1711.710	1700.896
	(0.04)	(0.04)	(56.50)	(63.97)
y_{NT}	0.069	0.077	99.461	99.285
	(0.01)	(0.01)	(6.34)	(6.81)
y_{TR}	0.128	0.172	539.380	545.735
	(0.03)	(0.01)	(27.39)	(29.79)
$y_T 2$	0.201	-0.098	32.724	38.188
	(0.04)	(0.02)	(26.13)	(25.52)
$y_{NT} 2$	0.008	-0.001**	0.060	0.037
	(0.00)	(0.00)	(0.09)	(0.12)
$y_{TR} 2$	0.008*	0.074	10.844	10.704
	(0.00)	(0.02)	(8.86)	(9.56)
$y_T * y_{NT}$	0.030**	-0.046	2.309	1.972
	(0.01)	(0.01)	(5.55)	(5.81)
$y_T * y_{TR}$	0.056	-0.142	-68.875*	-74.822**
	(0.01)	(0.02)	(35.27)	(33.50)
$y_{TR} * y_{NT}$	-0.062	-0.011	-0.330	0.317
	(0.01)	(0.00)	(2.74)	(3.11)
$y_T * lnp_L$	-0.243**	-0.131*		-937.415
	(0.11)	(0.07)		(167.38)
$y_{NT} * lnp_L$	0.010	-0.015		-7.039
	(0.01)	(0.01)		(11.10)
$y_{TR} * lnp_L$	0.015	-0.099		-237.887**
	(0.03)	(0.07)		(79.23)
$y_T * lnp_M$	0.118	0.112**		1515.650
	(0.14)	(0.05)		(199.39)
$y_{NT} * lnp_M$	-0.030	0.014		45.327**
	(0.02)	(0.01)		(12.99)
$y_{TR} * lnp_M$	-0.035	0.090		468.431
	(0.03)	(0.07)		(91.15)
Trend	-0.096	-0.145	-206.272**	-152.146**
	(0.06)	(0.03)	(62.58)	(58.10)
Trend2	0.021	0.029**	41.488**	31.030**
	(0.01)	(0.01)	(15.41)	(13.47)
lnp_L	0.438**	0.395**	0.269	0.685
	(0.21)	(0.13)	(0.05)	(0.06)
$lnp_L 2$	-0.433**	-0.423	-0.176	0.810**
	(0.15)	(0.10)	(0.04)	(0.33)
lnp_M	0.151	0.154	0.172	0.170
	(0.18)	(0.13)	(0.06)	(0.11)
$lnp_M 2$	-0.356	-0.051	-0.192	1.861**
	(0.65)	(0.42)	(0.22)	(0.68)
$lnp_L * lnp_M$	0.512	0.258	0.185*	-1.235**
	(0.33)	(0.23)	(0.11)	(0.46)
Constant	8.089	8.064	540.743	389.278**
	(0.10)	(0.06)	(103.88)	(115.78)

π	0	0.600 (0.05)	1	1
Cost funct. R2adj	0.968	0.988	1.000	1.000
LogL	11.563	105.990	182.833	189.114
RSS	9.501	3.404	1.477	1.379
AIC	22.87	-163.98	-331.67	-332.23
BIC	96.82	-86.82	-277.01	-258.28

Notes to the tables:

- In the estimation of the standard translog specification, zero output levels are substituted by the value 0.00001
- Standard errors are robust to heteroschedasticity of unknown form and to the likely presence of intra cluster correlation. Each cluster is represented by a different firm. Number of clusters 40 in all specifications.
- R2adj is the centered adjusted R2, LogL is the value of the log-likelihood function, assuming errors are iid normal, while RSS is the residual sum of squares
- AIC and BIC are the Akaike's and Schwarz's Bayesian information criteria respectively
- Significance levels: * 10%; ** 5%; 1%.

Table 3A. Global scope and density economies. Asymptotic standard errors in parenthesis.

Panel (a). 2 outputs, 3 inputs

	Std. translog	Generalized translog	Separable quadratic	Composite
Global scope economies	1526067.8	0.282	0.170	0.158
	(9.58e+07)	(0.29)	(0.027)	(0.027)
Scope economies public firms	2584624.7	0.702	0.124	0.114
	(2.56e+8)	(0.372)	(0.021)	(0.020)
Scope economies private firms	1266425.6	0.233	0.176	0.165
	(7.48e+07)	(0.251)	(0.028)	(0.028)
Global density economies	0.992	1.046	1.195	1.177
	(0.025)	(0.014)	(0.038)	(0.036)
$DENSITY_{T}$	-2.74E+06	0.642	0.991	0.988
	(5.01E+06)	(0.671)	(0.007)	(0.007)
$DENSITY_{NT}$	1.006	0.906	0.994	0.995
	(0.444)	(0.342)	(0.004)	(0.004)
Cost elasticity transport	0.558	0.560	0.522	0.529
	(0.013)	(0.012)	(0.019)	(0.020)
Cost elasticity non transport	0.451	0.396	0.315	0.321
	(0.019)	(0.013)	(0.014)	(0.012)

Panel (b). 3 outputs, 3 inputs

	Std. translog	Generalized translog	Separable quadratic	Composite
Global scope economies	3927109	0.159	0.387	0.299
	(1.42E+07)	(0.038)	(0.061)	(0.073)
Scope economies public firms	5203062	-0.128	0.223	0.166
	(1.89E+07)	(0.038)	(0.041)	(0.046)
Scope economies private firms	3389150	0.159	0.380	0.294
	(1.23E+07)	(0.038)	(0.060)	(0.071)
Global density economies	1.224	1.103	1.237	1.173
	(0.065)	(0.045)	(0.047)	(0.049)
$DENSITY_{T}$	-6.51E+04	1.077	0.990	0.989
	(2.93E+05)	(0.022)	(0.008)	(0.008)
$DENSITY_{NT}$	2.403	1.579	1.000	1.000
	(0.951)	(0.011)	(0.000)	(0.001)
$DENSITY_{TC}$	4.848	0.976	0.989	0.990
	(1.290)	(0.120)	(0.009)	(0.010)
Cost elasticity transport	0.620	0.658	0.594	0.625
	(0.040)	(0.035)	(0.024)	(0.030)
Cost elasticity non transport	0.069	0.077	0.035	0.037
	(0.013)	(0.008)	(0.003)	(0.003)
Cost elasticity transport related	0.128	0.172	0.179	0.191
	(0.031)	(0.014)	(0.014)	(0.014)

Notes: Global scope and density economies are evaluated for the median firm in the sample, scope economies for public and private firms are evaluated for the median public and private firm respectively. In the computation of scope economies for the standard translog model, zero output levels are substituted with 0.000001.