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WORKING PAPER SERIES

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

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Working paper No. 2/2008

Università di Torino

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Abstract

A growing number of local public transport (LPT) companies diversify their production lines by providing a large set of services. We investigate the cost structure of a sample of LPT companies operating in Italy in order to assess the presence and the magnitude of scope economies. We split the whole sample of firms according to the diversification strategy: private firms, mainly diversifying in competitive transport-related services and public firms providing non-transport services in regulated markets. Regardless of the functional form and the method used, scope economies appear sizeable for both groups but higher for firms pursuing a transport related strategy, suggesting it should be preferable to the multi-utility development pursued by public LPT firms.

Keywords: cost function, scope economies, transport companies

JEL: L25, L33, L50, L92

Introduction

Only few papers analyse 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.

Our aim is twofold. On one side we evaluate the existence and dimension of scope economies for a set of firms operating in the local public transport industry, on the other side, however we compare different diversification strategies.

In particular we assess whether horizontal diversification in industries or sub-industries close to the core transport activity ensures higher cost savings than horizontal diversification in non-related sectors. To sum up, from a social point of view, is the horizontal diversification of multi-utilities in regulated sectors justified? The analysis aims at better understanding the economic justification for such managerial choices and the presence of actual cost savings from the diversification in competitive *versus* regulated markets. The paper tries to fill the gap between research on scope economies in multi-utility firms and research on scope economies within local transport industry.

We use data from a sample of Italian bus companies observed over the period 1998-2004, that diversify their core activities supplying transport related services and / or non-transport services. The sample is also characterized by different ownership structures coupled with diversification strategies. Private firms mainly supply services 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 transport related competitive markets, public companies are usually active in regulated sectors unrelated to transport.

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 standard translog and the generalized (Box-Cox) translog function model are compared to those from the separable quadratic and 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.

Our results show that, for all functional forms, diversification economies are sizeable for both groups; however a diversification strategy close to the core business, generally practised by private firms, appears to allow for higher cost savings, suggesting this kind of strategy should be preferable to the multi-utility development pursued by public LPT firms.

Next section briefly reviews the empirical literature on scope economies 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.

Literature review

Our perspective does not completely coincide either with the research on scope economies in multi-utilities, or the studies on scope economies within the local public transport, but these two strands of research are somehow the boundaries within which our work develops, so that we briefly review some of them.

Multi-utilities are the object of some ongoing policy reforms. Recent decisions by the European Union require the functional unbundling for vertical integrated utilities. Horizontal unbundling, on the contrary, obtains less attention as there is no clear-cut evidence on its anti-competitive effects. Among the others, Calzolari and Scarpa (2007) show that economies of scope may justify, from a social point of view, the horizontal diversification of multi-utilities in unregulated sectors. Some empirical investigations find support to the presence of scope economies for multi-utility firms (Fraquelli et al., 2004, Farsi et al., 2007b).

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

Viton (1992) considers urban transport 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) analyse a four modes urban company and find only limited cost complementarities. Viton (1993), by estimating a quadratic cost frontier for bus companies operating in the San Francisco bay area, evaluates 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. (2007a) 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 satisfying all regularity conditions required for a cost function to be an adequate representation of the production technology (concave in input prices and 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 model 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).

The cost function model

Our aim is to study the cost structure of a sample of transport 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:

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

where C_{ft} is total cost for firm $f = 1, \ldots, F$, at time $t = 1, \ldots T$, $\mathbf{y}_{ft}$ 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, v_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 v_f and the included regressors, i.e. $E(v_f \mid \mathbf{y}_{ft}, \mathbf{p}_{ft}) = 0$. This assumption ensures 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 individual, should guarantee robust inference.

When dealing with nonlinear functional forms, the estimation of fixed effects or random effects models 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 present results for a three outputs cost model and section 4 gives details on the dataset construction.

We compare estimates from four 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 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[1] (see Carroll and Rupert, 1984, 1988 and Pulley and Braunstein, 1992 for more details):

$$\ln(C) = \ln\left(\alpha_0 + \sum_i \alpha_i y_i + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_i y_j + \sum_i \sum_r \alpha_{ir} y_i \ln p_r + \gamma_1 Trend + \gamma_2 Trend^2\right) + \left[\sum_r \beta_r \ln p_r + \frac{1}{2}\sum_r \sum_q \beta_{rq} \ln p_r \ln p_q\right] = \ln[h(\mathbf{y},\mathbf{p})] + f(\mathbf{p}) \tag{1}$$

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 the price for input $r=L, M, K$, for labour, material and capital respectively, while *Trend* and $Trend^2$ are a linear and a squared time trend respectively.

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:

$$\ln(C) = \alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \alpha_{ir} y_i^{(\pi)} \ln p_r + \sum_r \beta_r \ln p_r + \frac{1}{2}\sum_r \sum_q \beta_{rq} \ln p_r \ln p_q + \gamma_1 Trend + \gamma_2 Trend^2 \tag{2}$$

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).

[1]In the following formulas we omit firm and time subscripts for notational brevity.

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:

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

where *C* is the 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.

Quasi scope economies differ from global scope economies in the definition of the specialized productions. Instead of zero outputs, positive small amounts (ε) are assumed:

$$QSCOPE = [C((1-(m-1)\varepsilon)y_1,\varepsilon y_2,\ldots,\varepsilon y_m;\overline{\mathbf{p}}) + C(\varepsilon y_1,(1-(m-1)\varepsilon)y_2,\ldots,\varepsilon y_m;\overline{\mathbf{p}}) + \ldots$$
$$+ C(\varepsilon y_1,\varepsilon y_2,\ldots,(1-(m-1)\varepsilon)y_m;\overline{\mathbf{p}}) - C(y_1,y_2,\ldots,y_m;\overline{p})] / C(y_1,y_2,\ldots,y_m;\overline{\mathbf{p}})$$

ε ranges between *0* and *1/m*. For $\varepsilon = 0$, quasi scope economies are identical to global scope economies (*QSCOPE = SCOPE*) while for increasing values of ε production is less and less specialised, implying different output mix. When $\varepsilon = 1/m$, each output is produced in equal proportion and *QSCOPE* becomes a measure of scale economies along an output ray (see Pulley and Humphrey, 1993).

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

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

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:

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

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.

We also distinguish among the sources of cost savings. Using the composite (and separable quadratic) specification it is possible to distinguish among the fixed costs and the variable costs savings, once scope economies (or quasi 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 is given by:

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

Fixed costs savings may arise from the reduction of the excess capacity that allows for the spreading of fixed costs over a larger production set.

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

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

However the estimated fixed costs savings in (3) represent only an upper-bound estimate of the actual savings from spreading fixed costs over a larger set of outputs. A correct measure requires identification of product specific fixed costs (e.g. introducing a full set of dummy variables associated to specialized productions) that we approximate by the constant term α_0 in the composite specification (see Pulley and Humphrey (1993) for more details)[2]. Identification of the different components of the

[2] The correct formula of the fixed cost savings, e.g. for a three outputs cost function (*i=1, 2, 3*), is:

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 evaluate how the average costs change when output increases, keeping the network dimension fixed, in the computation of scale economies the expansion 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*):

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

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

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.

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

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.

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 transport services. We complement these data, providing information on transport activities only, with companies' annual reports. 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 transport services, non-subsidized transport related activities and non-transport services.

Local public transport 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 tourist 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, 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 measure in the estimation of the cost function. The prices for transport outputs and for other transport related activities are approximated by the consumer price index for transport services while we use the consumer price index for housing, water, electricity and fuels as a proxy for non-transport outputs' price[3]. The consumption price indexes are town and province specific and we apply the appropriate price index according to the town and province where the company runs its business.

The output quantities for transport services (y_T) are therefore computed as the transport revenues divided by the price index of transport facilities. Similarly the output quantities for transport related activities (y_{TR}) are calculated dividing total

[3] The source for price indexes is Istat, Italian Statistical Institute, www.istat.it

revenues (for these services) by the price index for transportation, and the output for the non-transport productions (y_{NT}) are obtained as the ratio of total revenues associated to such products to the consumer price index for housing, water, electricity and fuels.

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 physical 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 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.

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 are for energy and fuels.

Following Christensen and Jorgenson (1969), price for capital (p_K) is computed as:

$$p_k = \frac{PPI(IR + D)}{(1 - T)}$$

where *PPI* is the production price index for investment goods[4], *IR* is the yearly average long term prime lending interest rate as assessed by the Italian Banking Association [5] (ABI), 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 paid taxes divided by operating profits, as they appear in the financial statements. A similar approach for the derivation of capital and material prices is followed by Adams et al. (2004) and Asai (2006).

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

[TABLE 1 ABOUT HERE]

[TABLE 2 ABOUT HERE]

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 and medium sized LPT firms. The largest firms in the sample are publicly owned and table 2 splits the sample according to ownership. Apart from the size differences[6], it is interesting to note the different production lines for the two groups of firms considering the median output levels and the revenues' shares: 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 transport related unregulated sectors, such as bus renting, coaching activities and tourist services.

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[4] Data source: Istat, Italian Statistical Institute, www.istat.it

[5] Data available from the Bank of Italy website, www.bancaditalia.it

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

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 smaller standard deviations.

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 (non-negative 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. In particular we need to check that fitted costs and fitted marginal costs with respect to outputs and input prices are non-negative and that the Hessian matrix of the cost function with respect to input prices is negative semi-definite. Comfortingly about 97% of observations satisfy all regularity conditions under any specification[7].

Estimation results

Table 3 presents the estimated parameters for the four specifications of the cost function: the standard translog, the generalized translog, the separable quadratic and the composite forms.

[TABLE 3 ABOUT HERE]

[7] In the composite specification we obtain that: a) fitted costs are always non-negative; b) fitted labour and material shares are negative for three and one observations respectively, c) fitted marginal costs with respect to transport services are negative for three observations, fitted marginal costs with respect to transport related output are negative for four observations, fitted marginal costs for non-transport services are always non-negative; d) the Hessian matrix of the cost function with respect to input prices is always negative semi-definite, except for one observation.

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 separable quadratic and composite models (except for the interaction among transport and transport related services), while they are precisely estimated under the two translog forms.

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 not significant only under the last specification (composite model) and are quite similar in magnitude to those for labour price.

The interpretation of such first order coefficients, however, differs across the models: while they represent estimates of cost elasticities (with respect to output and with respect to input prices respectively) in the translog specifications, they do not have straightforward interpretation in the separable quadratic and composite forms. We compute cost elasticities also for the last two specifications and we obtain similar magnitudes. The highest cost elasticity is found for transport outputs (0.62 under the standard translog specification, 0.66 under the generalized translog and 0.63 under the separable quadratic and composite models), the smallest is for non-transport services (ranging from 0.04 for the composite, to 0.08 from the generalized translog) and transport related activities are in between the two (in the interval 0.13-0.19, whose limits are obtained from the standard translog and the composite specifications respectively).

Cost elasticities with respect to input prices are unexpectedly low for labour price when the composite or separable quadratic specifications are considered (0.25-0.27), while it seems more plausible under the translog models (0.40-0.44). Cost elasticities for material prices are comparable across models and range in the interval 0.51-0.72.

The time trend parameter is always negative and significant in the last three specifications, indicating cost reductions over time. The positive second order trend coefficient, however, indicates that such cost savings diminish over time.

Table 3 also shows a number of goodness-of-fit statistics. The translog and the quadratic specifications are non-nested models that cannot be directly tested, however larger log likelihood and lower residual sum of squares, Akaike and Schwarz information criteria for the separable quadratic and the composite models suggest 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 $\pi=0$. 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 rejected at the 5% level.

Economies of scope and size

Table 4 presents scope and density economies computed using all the estimated specifications. As expected results significantly change across different cost function models.

[TABLE 4 ABOUT HERE]

Scope economies computations based on the standard translog specification are unreliable: they are extremely large and imprecisely estimated for any sample (whole, public firms or private firms sub-samples) and for any considered sample point (first, second or third quartile). The explanation can be found in the degenerate behaviour of such cost function when outputs are close to zero (see Roller, 1990).

The generalized translog, the separable quadratic and the composite specifications, on the contrary, provide comparable results.

Scope economies for the median firm in the sample range between 16% and 39% depending on the chosen cost function and they always are significantly different from zero.

Global scope economies for the median public firm are significantly different from zero and range between -13% and 22%. Economies of scope for privately owned firms range between 16% and 38%. In general global scope economies are lower when computations are based on the generalized translog model, while the largest estimates are for the separable quadratic function. The composite specification is in between the two.

Table 4 also reports the estimated global scope economies at the first and the third quartile points of the whole sample and the two sub-samples of public and private firms. Scope economies always decrease with size, especially if the generalized translog cost function is adopted or the sub-sample of public firms is considered.

Table 4 finally shows global density economies. They are always significantly different from one indicating the presence of economies of size: proportionally increasing the operating size (with respect to all outputs) lowers average costs.

Our preferred specifications are the generalized translog and the composite cost functions and next tables present results based on these two specifications only. We already mentioned the unreliable and unstable results from the standard translog specification with respect to global scope economies, that make it inadequate for our purposes. The composite specification is preferred to the separable quadratic function on the basis of the likelihood ratio test that rejects the restrictions imposed by the separable quadratic model (i.e. the strong separability between inputs and outputs) but also on the statistical significance of the interaction terms between input prices and output quantities (see table 3). We finally decided to keep the information from both the generalized translog and the composite (instead of considering the composite only, as suggested by other authors, e.g. Pulley and Brauenstein, 1992, Fraquelli et al. 2004, 2005) because the Box-Cox parameter is sizeable and significantly different from zero (π=0.6, see table 3) suggesting the generalized translog is not a close approximation of the standard translog and that it can actually well describe the technology of the firms in our sample. In particular we expect actual magnitudes to be somewhere between the two bounds of the generalized translog and the composite specifications, since both estimates seem reliable and statistically precise.

Quasi scope economies measure savings associated to a joint production with respect to a "quasi-specialized" production. We confront the cost structure of a firm supplying the three outputs and the costs of three "quasi-specialized" firms, each supplying different amounts of the three products (see section 3). Table 5 reports the results for different definitions of the "quasi-specialized" productions. The pattern of quasi-scope economies is quite different for the two specifications. As ε, that measures an equal rate of variation in all three activities, moves from 0.01 to 0.33, cost savings slightly reduce for the composite model (from 30% to 29%), while they increase for the generalized translog (from 21% to 35%).

[TABLE 5 ABOUT HERE]

The different shape of the two cost models is confirmed by figures 1 and 2, where quasi scope economies are mapped against different levels of specialization (ε) for the median firm in the sample and for the median public and private firms.

Quasi scope economies are always larger for the median private firm, confirming the results found for global scope economies in table 4.

[FIGURE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

Table 6 presents product specific scope economies and scope economies for couples of products.

Differences among scope economies from the two functional forms replicate previous results, i.e. larger estimates for the sample of private firms.

[TABLE 6 ABOUT HERE]

Product specific scope economies give a measure of the cost savings associated to the joint production when compared to the production of one output only on one side and the remaining two products on the other. The estimates from the generalized translog give larger cost savings for transport related and non-transport activities for the whole sample and 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.

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).

Differing global scope economies for the two groups of public and private firms might be 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 (see table 2) and they exhibit lower global scope economies as table 4 and figures 1 and 2 make 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 and to check the robustness of our results, table 7 reports some summary statistics about global scope economies computed for each observation in the sample (see Farsi et al., 2007b, for a similar approach). While in table 4 (and also tables 5 and 6, figures 1 and 2) computations are based on the construction of some "hypothetical" firms, characterized by a production set that alternatively coincides with the first, the second and the third quartiles for the three measures of output, in table 7 we estimate global scope economies at each actual sample point[8]. The distribution of global scope economies in the sample mimics the results from table 4. The median value range between 17% and 23% in the whole sample, while in the sub-samples of public and private firms the median global scope economies are in the intervals 5-9% and 21-27% respectively. Estimates based on the generalized translog model or the sub-sample of public firms display lower diversification economies.

[TABLE 7 ABOUT HERE]

Table 7 also shows global scope economies for different dimensional classes. In particular we identify four classes (small, medium-small, medium and large) according to the revenues' size and we compute the median scope economies for each group of companies. Scope economies decrease with size and lower economies are

[8]However input prices are kept at the sample median level for all firms.

found for public firms, in all classes, under the composite specification. For the generalized translog the pattern is similar with the only exception for the medium sized private firms that display sizeable diseconomies of scale. This is a consequence of a small number of private firms in this group that display large diseconomies and that probably are outliers.

The composite model allows for the decomposition of global scope economies into the fixed costs savings and the variable inputs cost complementarities (see section 3). Table 8 shows the estimates for the median firm in the sample and for the whole distribution of firms.

[TABLE 8 ABOUT HERE]

The largest cost savings are associated to fixed costs and they range between 17% (median public firm) and 28% (median private firm). Cost complementarities are small and in some cases not significantly different from zero (for the median public firm). The picture is similar when the two magnitudes are computed for each observation in the sample: fixed costs savings range between 8% (median in the sub-sample of public firms) and 26% (median in the sub-sample of private firms), while cost complementarities are small and highly volatile.

Fixed cost savings from the joint production of different outputs may be associated to the possibility to share fixed assets, like rolling stock, buildings, offices and parking areas. Cost complementarities savings associated to variable inputs that can be shared by different product lines (e.g. information on customers and market's conditions, etc.) are modest probably because those variable inputs are not completely interchangeable between transport and other services.

As discussed in section 3, the estimated fixed costs savings represent an upper bound estimate of the true savings, since unavailability of data on specialised production does not allow us to correctly estimate product-specific fixed costs.

On the whole, the evidence points to the presence of sizeable global scope (and quasi-scope) economies for the median firm in the sample. Cost savings from the joint production reduce as the operation scale increases. The largest part of the cost savings is associated to the possibility to reduce excess capacity, i.e. from the ability to spread fixed costs over the three production lines.

We split the whole sample of firms according to the diversification strategy and find that firms providing non-transport services in regulated markets (publicly owned companies) always display lower scope economies (and in some cases also diseconomies), for any considered sample point and for any cost specification. The two groups of firms differ both in the operation scales and in the diversification strategies. Privately owned firms are small and mainly diversify in non-subsidized transport related services, while publicly owned firms operate at a larger scale and provide services in regulated markets. In an attempt to isolate the effect of the diversification strategy, we compute scope economies at each actual sample point and find that firms diversifying in non-transport activities are characterized by lower cost savings that are close to zero for the largest firms.

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.

As expected, scope and density economies differ according to the chosen cost model, but they are always present. Global scope economies, for the median firm in the sample, range between 16% and 30% under the two preferred specifications, the generalized translog cost model and the composite function: costs savings mainly result from the fixed costs component.

We split the whole sample of firms according to diversification strategy: private firms, mainly diversifying in competitive transport related services and public firms providing non-transport services in regulated unrelated markets. Regardless of the functional form and the method used, scope economies appear sizeable for both groups but higher for firms diversifying in industries or sub-industries that are close to the core transport activity.

As scope economies appear to be decreasing with firm's size we calculate them at each sample point, so as to compare homogeneous dimensional classes, in order to exclude the possibility that public LPT firms' lower scope economies should merely depend on their larger dimension: results remain unaltered.

Applying the usual caveat, the analysis, then, suggests that, from a social point of view, horizontal diversification of LPT firms in non related activities should not be fostered, as it ensures smaller scope economies as compared to transport related diversification.

Acknowledgements

We wish to thank Graziella Fornengo for fruitful discussions and Luca Sanlorenzo for outstanding assistance on the data. Financial support from HERMES Research Centre (www.hermesricerche.it) is gratefully acknowledged. The usual disclaimer applies.

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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)	8,958.98	33,294.42	3,416.91
Total revenues (th Euro)	9,290.93	34,572.25	3,443.30
Share of total revenues from transport (%)	56.07	25.74	56.86
Share of total revenues from non-transport (%)	17.95	28.50	4.41
Share of total revenues from transport related (%)	25.98	21.85	23.98
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)	4,423.29	17,786.84	1,436.71
Number of employees	134.44	539.38	40.50
Total cost of materials (th. Euro)	1,421.05	3,690.66	626.81

Notes: See the text for the definition of the output measures y_T, y_{NT}, y_{TR} and the input prices p_L, p_M, p_K

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

	11 public firms, 49 obs.			29 private firms, 135 obs.		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Total operating costs (th. Euro)	22,725.86	62,704.37	10,013.16	3,962.12	3,315.54	2,422.29
Total revenues (th Euro)	23,332.88	65,183.99	9,718.74	4,194.22	3,467.14	2,651.03
Share of total revenues from transport (%)	48.20	33.75	52.13	58.93	21.59	57.88
Share of total revenues from non-transport (%)	44.82	37.80	34.53	8.20	15.42	1.51
Share of total revenues from transport related (%)	6.98	12.67	3.45	32.87	20.36	32.75
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
Labour share	0.50	0.13	0.53	0.43	0.08	0.42
Material share	0.19	0.13	0.14	0.18	0.05	0.18
Total cost of personnel (th. Euro)	11,534.70	33,574.90	3,555.44	1,842.11	1,747.94	1,064.00
Number of employees	351.12	1,017.88	94.00	55.79	52.71	34.00
Total cost of materials (th. Euro)	3,311.56	6,777.43	1,165.80	734.87	648.08	471.87

Notes: See the text for the definition of the output measures y_T, y_{NT}, , y_{TR} and the input prices p_L, p_M, p_K

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	*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)
$Trend^2$	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	0.511***	0.554***	0.721***	-0.070
	(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***	1	1
		(0.05)		

Cost funct. R^2adj	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
LR test [p-value]		188.85		12.56
		[0.00] d.f.=1		[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. The subscripts for the input prices are *L* for labour and *M* for other variable inputs (i.e. raw materials and fuels).

- 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 (40 clusters - firms in all specifications).

- R^2adj is the centered adjusted R^2, LogL is the value of the log-likelihood function, assuming errors are i.i.d. normal, while RSS is the residual sum of squares

- AIC and BIC are the Akaike and Schwarz 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 (H_0: π=0), while the separable quadratic model is the restricted specification for the composite model (H_0: all interactions among input prices and output measures are zero).

- Significance levels: * 10%; ** 5%; *** 1%.

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

	Std. translog	*Generalized translog*	*Separable quadratic*	*Composite*
Global Scope Economies:				
Whole sample				
1st quartile	3089650	0.624	0.714	0.574
	(1.12e+07)	(0.04)	(0.09)	(0.12)
Median	3927109	0.159	0.387	0.299
	(1.42E+07)	(0.04)	(0.06)	(0.07)
3rd quartile	2836232	-0.103	0.189	0.148
	(1.04e+07)	(0.06)	(0.04)	(0.04)
Public firms sample				
1st quartile	1.24E+07	0.780	0.964	0.805
	(4.42E+07)	(0.06)	(0.10)	(0.15)
Median	5203062	-0.128	0.223	0.166
	(1.89E+07)	(0.04)	(0.04)	(0.05)
3rd quartile	2699751	-0.334	0.180	0.152
	(9937547)	(0.05)	(0.05)	(0.05)
Private firms sample				
1st quartile	2347817	0.574	0.670	0.534
	(8652940)	(0.04)	(0.09)	(0.12)
Median	3389150	0.159	0.380	0.294
	(1.23E+07)	(0.04)	(0.06)	(0.07)
3rd quartile	3757452	-0.085	0.263	0.204
	(1.37E+07)	(0.04)	(0.05)	(0.05)
Global density economies	1.224	1.103	1.237	1.173
	(0.07)	(0.05)	(0.05)	(0.05)

Notes: Global scope economies are evaluated for an hypothetical firm with the first quartile, median and third quartile level of each output in the whole sample and in the sub-samples of public and private firms respectively. Input prices are always kept at the sample median value. In the computation of scope economies for the standard translog model, zero output levels are substituted with 0.000001. Density economies are computed for the median firm in the sample.

Table 5. Estimated quasi scope economies: generalized translog and composite specifications. Asymptotic standard errors in parenthesis.

ε	*Generalized Translog*	*Composite*
0.01	0.207	0.299
	(0.04)	(0.07)
0.05	0.263	0.296
	(0.04)	(0.07)
0.1	0.296	0.294
	(0.04)	(0.07)
0.15	0.316	0.292
	(0.05)	(0.07)
0.2	0.330	0.290
	(0.05)	(0.07)
0.25	0.339	0.289
	(0.05)	(0.07)
0.33	0.345	0.289
	(0.05)	(0.07)

Notes: All magnitudes are evaluated for the hypothetical median firm in the sample. Quasi scope economies for public and private firms (figures 1 and 2) are evaluated for the hypothetical median public and private firm respectively. Input prices are always kept at the sample median value.

Figure 1. Quasi scope economies: generalized translog model

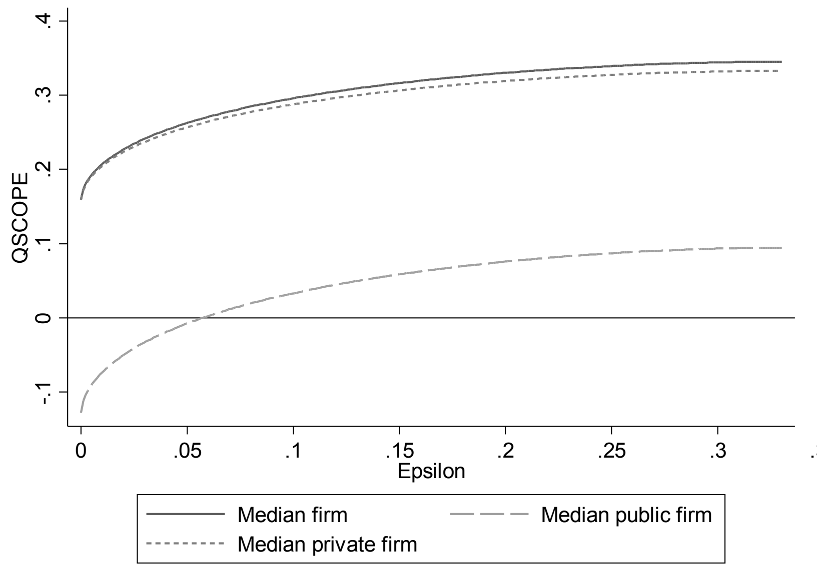

Figure 2. Quasi scope economies: composite model

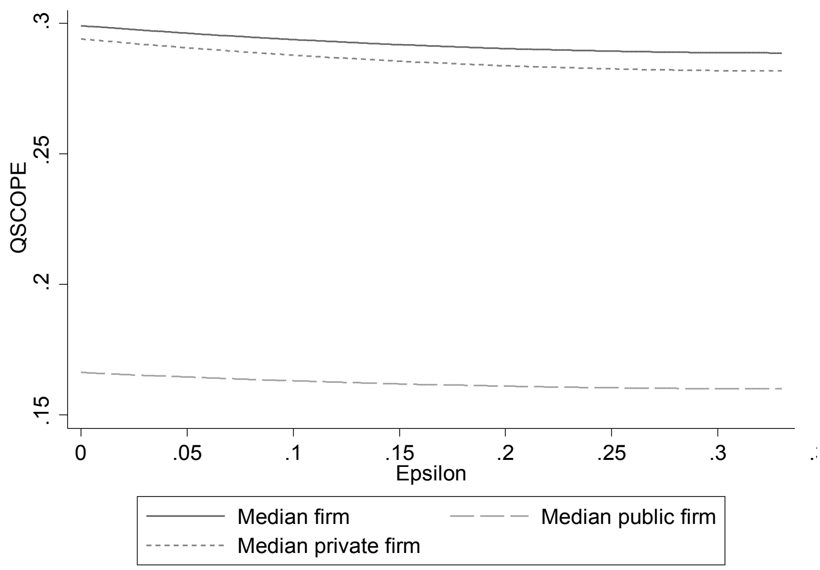

Table 6. Estimated product specific scope economies: generalized translog and composite specifications. Asymptotic standard errors in parenthesis.

	Generalized Translog			*Composite*		
	Whole sample	Public firms	Private firms	Whole sample	Public firms	Private firms
$SCOPE_{T}$	0.049	-0.199	0.042	0.056	-0.008	0.059
	(0.03)	(0.05)	(0.03)	(0.07)	(0.04)	(0.06)
$SCOPE_{NT}$	0.129	-0.200	0.152	0.041	-0.008	0.041
	(0.04)	(0.06)	(0.03)	(0.06)	(0.04)	(0.06)
$SCOPE_{TR}$	0.096	0.089	0.070	0.060	0.026	0.062
	(0.03)	(0.01)	(0.03)	(0.06)	(0.03)	(0.06)
$SCOPE_{T, NT}$	0.170	-0.205	0.209	0.051	-0.010	0.055
	(0.05)	(0.06)	(0.04)	(0.08)	(0.04)	(0.08)
$SCOPE_{T, TR}$	0.119	0.158	0.085	0.061	0.039	0.062
	(0.03)	(0.02)	(0.03)	(0.07)	(0.05)	(0.07)
$SCOPE_{TR, NT}$	0.591	0.353	0.580	0.143	0.064	0.122
	(0.04)	(0.08)	(0.04)	(0.18)	(0.08)	(0.16)

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

Table 7. Median value of global scope economies estimated for each actual firm. Distribution by dimensional classes.

	Generalized Translog			*Composite*		
	Whole sample	Public firms	Private firms	Whole sample	Public firms	Private firms
All firms	0.167	0.046	0.211	0.234	0.089	0.270
Small firms	0.370	0.170	0.400	0.440	0.376	0.459
Medium-Small firms	0.210	0.124	0.217	0.299	0.273	0.304
Medium firms	0.182	0.032	-0.109	0.182	0.094	0.187
Large firms	0.070	-0.002	0.211	0.070	0.059	0.098

The four dimensional classes are defined according to the quartiles of the distribution of total revenues. Small firms are those with revenues smaller than 1,956 th. Euro (1st quartile), medium-small are those firms with revenues in the range 1,956-3,443 th. Euro (median), medium firms are in the interval 3,443-9,641 th. Euro (3rd quartile) while large firms are those with revenues larger than 9,641 th. Euro

Table 8. Fixed costs and cost complementarities effects. Results based on the composite specification.

	Median firm			*Whole distribution*		
	Whole sample	Public firms	Private firms	Whole sample	Public firms	Private firms
Fixed costs savings	0.286	0.169	0.277	0.207	0.076	0.255
	(0.07)	(0.05)	(0.07)	(0.20)	(0.12)	(0.20)
Cost complementarities	0.013	-0.003	0.017	0.012	-0.0004	0.014
	(0.01)	(0.02)	(0.01)	(0.16)	(0.31)	(0.02)

Notes: Magnitudes in the columns under the heading *Median firm* are evaluated for the hypothetical median firm in the sample, scope economies for public and private firms are evaluated for the hypothetical median public and private firm respectively. Asymptotic standard errors in parenthesis.
Scope economies under the heading *Whole distribution* are evaluated for each company in the sample and the table shows the median for the whole distribution. Standard deviations in parenthesis.
Input prices are always kept at the sample median value.