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Abstract

In this paper, using a sample of Italian passenger transport firms, we compare the estimates from a Composite Cost Function econometric model (Pulley and Braunstein, 1992) with the ones coming from other traditional functional forms such as the Standard Translog, the Generalized Translog, and the Separable Quadratic. The results highlight the presence of global *scope* and *scale* economies only for multi-service firms (providing urban, intercity and for-hire bus transport services) with output levels lower than the ones characterising the 'average' firm. This indicates that relatively small, specialised firms would benefit from cost reductions by evolving into multi-service firms providing urban, intercity and for-hire bus transport. As for the intercity service, the most efficient solution seems the integration with urban operators rather than integrating with for-hire bus services.

Keywords: Multi-Service Firms, Scope and Scale Economies, Composite Cost Function.
JEL Code: L97, L5, L21, C3.

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1. Introduction

Constant changes in the economic, social and environmental systems also require adaptation in the transportation structure. The search for a more widespread capillary of supply and a close interconnection with other modes of transport has made for-hire services an essential complement of transit systems. As argued by Talley (2007), the classification of passenger transportation services involves a wide range of variables. Unlike scheduled transport services purely geared to predetermined destinations on fixed and authorized routes, for-hire transit services are typically characterized by non-scheduled times and non-fixed routes. Given these characteristics, this service is mainly addressed to occasional users, as it occurs, for example, in the tourism sector.

Despite its increasing importance, for-hire services received only little attention in the literature. In order to fill this gap, this paper analyses the cost function of a sample of Italian transit firms which are providers, in combination or as specialised units, of urban, intercity and for-hire transport services in the years 2008 to 2012. Given the presence in the sample of specialised, two-output and three-output firms, we can investigate the presence of economies of scope for multi-service firms. From a methodological point of view, we differ from the standard literature, which uses the Translog Cost Function or the Generalised (Box-Cox) Translog Cost Function, and we test the advantage of using the Composite Cost Function model introduced by Pulley and Braunstein (1992), which appears to be well suited to analyse the cost properties of multi-product firms.

The remaining of the paper is organised as follows. Section 2 shortly reviews the relevant empirical literature. Section 3 develops the Composite Cost Function model upon which is based the subsequent econometric analysis. Section 4 illustrates the main characteristics of our sample and shows some descriptive statistics concerning the variables included in the cost model. Section 5 presents the results of our estimates and Section 6 concludes.

2. Literature review

Early studies on the analysis of costs in the transportation literature were mainly focused on the effects of differentiation among transit modes, such as motor-bus, rapid-rail, streetcar, trolley-bus, etc. Colburn and Talley (1992), for example, by analysing four modes of transport in urban systems find limited cost complementarities. Viton (1993), by investigating the processes of aggregation between different suppliers, show that cost savings resulting from mergers depend on the transport modes of the companies as well as on the number of firms involved in the merger. More recently, Farsi *et al*. (2007), exploring multi-modal transport systems show that economies of scale and scope exist, thus favouring integrated multi-mode operations as opposed to unbundling.

A second category of studies provides empirical evidence on the impact on costs of scale and the horizontal integration between urban and intercity services, by using a multi-output specification of the cost function, in order to estimate scale and scope economies, which are key structural elements to define the technology behind an industry.

As for scale economies, Gagnepain *et al*. (2011) report that a significant number of empirical studies are in line with a U-shaped average cost curve, exhibiting increasing returns to scale for smaller operators and decreasing return beyond a certain output level. As an example, Cowie and Asenova (1999) estimate that small companies (with a bus fleet of less than 200 vehicles) experience some economies of scale. Looking at a set of medium and large Italian municipalities, Cambini et al. (2007) find evidence of short-run and long-run economies of scale in most cases, suggesting that operators should operate on the entire system of urban network, without fragmentation of the service. They also argue that mergers between operators of neighbouring urban centres or between suppliers of urban and intercity transit services would be desirable in order to reduce operating costs.

By investigating the existence of scope economies, Fraquelli *et al*. (2004) find evidence of lower costs for integrated bus transport firms, using in the estimation a set of dummy variables to distinguish between specialized companies (in urban or intercity service) and integrated operators. Di Giacomo and Ottoz (2010) model the total cost function for multi-service Local Public Transport (LPT) companies. The results of the estimations highlight the presence of very mild scope economies (around

2%). However, by decomposing the effects related to the sharing of fixed costs from the ones stemming from cost complementarities (i.e. relative to the variable costs component), they find that horizontally integrated firms can save up to 6.3% of fixed costs. The extent of scope economies tends to decrease as the firm size increases, and modest scale economies (of the order of 1.040) are also observed for the median firm.

More recently, Ottoz and Di Giacomo (2012), analysing the LPT system of a specific Italian region (Piedmont), provide empirical evidence of the impact on costs of different diversification strategies. In particular, they observe that diversification depends on ownership type. While privately-owned firms generally choose to diversify into transit-related activities offered in competitive markets (such as, for instance, rental bus services), publicly-owned bus companies are more likely to diversify in regulated businesses (such as electricity, water and sewerage, car parking management). Due to unavailability of data on supply-oriented output quantities (like travelled kilometres), they used revenue as proxy of the output of each activity. The authors present estimates from cost functions with two outputs (local public transit and a sum of transport-related and non-transport activities) and three outputs (local public transit, transport-related and non-transport activities). The results show the presence of scope economies for the median firm which range between 16% and 30%, depending on the cost function specification as well as on the number of outputs. Lower global scope economies are found for publicly-owned firms, and, more in general, for large operators. Finally, pairwise scope economies are found (16%) between core business transport services (urban plus intercity) and transport-related services considering the composite cost function.

To the best of our knowledge, no existing empirical research has estimated multi-product cost functions including for-hire bus transport, urban and intercity passenger services as three separate outputs.

2. **The econometric cost function model**

The availability of data on costs, outputs and inputs for Italian firms providing urban, intercity and for-hire bus transport allows us to undertake a detailed study of the cost function in order to detect the presence of aggregate and product-specific economies of scale and scope. According to the well-known *Generalized Translog* (GT) *Specification* (Caves et al., 1980), the cost function is given by:

$$\ln C = \alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \delta_{ir} y_i^{(\pi)} \ln w_r$$
$$+ \sum_r \beta_r \ln w_r + \frac{1}{2}\sum_r \sum_l \beta_{rl} \ln w_r \ln w_l \quad [1]$$

where C is the long-run cost of production, y_i refers to outputs (in our three-output case i, $j = U, I, H$), w_r indicates factor prices (in our three-input case $r, l = L, K, F$), and the superscripts in parentheses π represent Box-Cox transformations of outputs ($y_i^{(\pi)} = (y_i^{\pi} - 1)/\pi$ for $\pi \neq 0$ and $y_i^{(\pi)} \to \ln y_i$ for $\pi \to 0$).

The associated input cost-share equations are obtained by applying the *Shephard's Lemma* to expression [1]

$$S_r = \sum_i \delta_{ir} y_i^{(\pi)} + \beta_r + \sum_l \beta_{rl} \ln w_l \quad [2]$$

Setting $\pi \to 0$ in [1] and [2] yields the nested *Standard Translog* (ST) *Specification*, with all output terms in the cost function and in the corresponding cost-share equations assuming the usual logarithmic ($\ln y$) form.

For small values of π, the estimated GT function is a close approximation to the ST functional form. Due to its log-additive output structure, the latter suffers from the well-known inability to evaluate cost behavior when any output is zero. This has been proved to yield unreasonable and/or very unstable values of the estimates for scope economies and product-specific scale economies (e.g., Pulley and Braunstein, 1992; Piacenza and Vannoni, 2004; Bottasso et al., 2011).

To overcome the above problems, Pulley and Braunstein (1992) proposed as an alternative functional form for multi-product technologies the *Generalized Composite* (PB_G) *Specification*.

$$C^{(\phi)} = \left\{ \exp\left[\left(\alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \delta_{ir} y_i^{(\pi)} \ln w_r \right)^{(\tau)} \right] \right.$$
$$\left. \cdot \exp\left[\beta_0 + \sum_r \beta_r \ln w_r + \frac{1}{2}\sum_r \sum_l \beta_{rl} \ln w_r \ln w_l \right] \right\}^{(\phi)} \quad [3]$$

where $c(y;w)$ is the long-run cost of production, y_i and w_r refer to outputs and factor prices, respectively, and the superscripts in parentheses ϕ, π and τ represent Box-Cox transformations (for example $C^{(\phi)} = (C^{\phi} - 1)/\phi$ for $\pi \neq 0$ and $C^{(\phi)} \to \ln C$ for $\theta \to 0$).

By applying the *Shephard's Lemma*, one can easily obtain the associated input cost-share equations:

$$S_r = \left(\sum_i \delta_{ir} y_i^{(\pi)}\right) \cdot \left[\alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2}\sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \delta_{ir} y_i^{(\pi)} \ln w_r\right]^{\tau-1}$$

$$+ \beta_r + \sum_l \beta_{rl} \ln w_l + \sum_i \mu_{ri} y_i^{(\pi)} \qquad [4]$$

Equation [3] embraces several of the most commonly used cost functions. The *Generalized Translog* (GT) and the *Standard Translog* (ST) models can be easily obtained by imposing the restrictions $\phi = 0$ and $\tau = 1$ (and $\pi = 0$ for the ST model). The *Composite Specification* (PB_C) is a nested model in which $\pi = 1$ and $\tau = 0$, while the *Separable Quadratic* (SQ) functional form requires the further restrictions $\delta_{ir} = 0$ and $\mu_{ri} = 0$ for all *i* and *r*. The PB_G and PB_C specifications originate from the combination of the log-quadratic input price structure of the ST and GT specifications with a quadratic structure for multiple outputs. This makes the model particularly suitable for the empirical cost analysis. The quadratic output structure is appropriate to model cost behavior in the range of zero output levels and gives the PB specification an advantage over the ST and GT forms as far as the measurement of both economies of scope and product-specific economies of scale are concerned. In addition, the log-quadratic input price structure can be easily constrained to be linearly homogeneous.

In this paper, we estimate the system [3]-[4] and carry out LR tests in order to select the specification best fitting observed data. We then obtain estimates of aggregate and output-specific scale and scope economies for our sample of LPT firms. Finally, by fully exploiting the informational content of our specification, we investigate the presence of scope economies for couples of services.

Given the regularity conditions ensuring duality, the PB specification does not impose a priori restrictions on the characteristics of the below technology. A more parsimonious and less general form is the *Separable Quadratic* (SQ) *Specification*, in which all terms δ_{ir} are set equal to 0. The SQ function allows estimating the costs in the range of zero outputs, but has the disadvantage of imposing strong separability between outputs and inputs.

3.1. Measures of scale and scope economies

Assume the multi-product cost function to be represented by $C = C(y; w),$ where $y = (y_U, y_I, y_H)$ and $w = (w_L, w_K, w_F)$. Local measures of global and product-specific scale and scope economies can be easily defined. *Global* or *aggregate scale economies* are computed via

$$SCALE_T(y;w) = \frac{C(y;w)}{\sum_i y_i MC_i} = \frac{1}{\sum_i \varepsilon_{Cy_i}} \qquad [5]$$

where $MC_i = \partial C(y;w)/\partial y_i$ is the marginal cost with respect to the *i*th output and $\varepsilon_{Cy_i} = \partial \ln C(y;w)/\partial \ln y_i$ is the cost elasticity of the *i*th output.

The above measure describes the behavior of costs as all outputs increase by strictly the same proportion. However, since product mixes rarely remain constant as output changes, additional dimensions of scale behavior can be measured by product-specific scale economies indicators. These latter show how costs changes as the output of one or two products changes with the quantities of other products held constant. *Product-specific economies of scale* for the couple of products (*i*, *j*; *i*≠*j*) are defined by

$$SCALE_{ij}(y;w) = \frac{IC_{ij}}{y_i MC_i + y_j MC_j} = \frac{IC_{ij}}{[\varepsilon_{Cy_i} + \varepsilon_{Cy_j}]C(y;w)} \qquad [6]$$

where $IC_{ij} = C(y;w) - C(y_{-ij};w)$ represents the incremental cost of the couple (*i*, *j*), and $C(y_{-ij};w)$ is the cost of producing all the other products different from *i* and *j*.

The degree of scale economies specific to the product *i* are finally

$$SCALE_i(y;w) = \frac{IC_i}{y_i MC_i} = \frac{IC_i}{\varepsilon_{Cy_i} C(y;w)} \qquad [7]$$

where $IC_i = C(y;w) - C(y_{-i};w)$ is the incremental cost relating to the *i*th product and $C(y_{-i};w)$ is the cost of producing all outputs except the *i*th one. Returns to scale defined by expressions [5], [6] and [7] are said to be increasing, constant or decreasing as $SCALE_T$, $SCALE_{ij}$ and $SCALE_i$ are greater than, equal to, or less than unity, respectively.

Scope economies (diseconomies) are reflected into cost savings (cost disadvantages) associated with the joint production of many outputs. The measure of *global* or *aggregate scope economies* for our three-output case can be computed via

$$SCOPE_T(y;w) = \frac{[C(y_U,0,0;w) + C(0,y_I,0;w) + C(0,0,y_H;w) - C(y;w)]}{C(y;w)} \qquad [8]$$

with $SCOPE_T > 0$ (< 0) denoting global economies (diseconomies) of scope.

Product-specific economies of scope for output *i* are

$$SCOPE_i(y;w) = \frac{[C(y_i;w) + C(y_{-i};w) - C(y;w)]}{C(y;w)} \qquad [9]$$

where $C(y_i;w)$ is the cost of producing only output *i*, and $SCOPE_i > 0$ (< 0) indicates a cost disadvantage (advantage) in the "stand-alone" production of output *i*.

Finally, it is also possible to assess the degree of economies of scope for couples of outputs under the assumption that the production of the remaining output is zero. Formally, scope economies for the couple of products (i, j; $i \neq j$) are defined by

$$SCOPE_{Cij}(y_{ij};w) = \frac{\lfloor C(y_i;w) + C(y_j;w) - C(y_{ij};w) \rfloor}{C(y_{ij};w)} \qquad [10]$$

with $C(y_{ij}; w)$ denoting the cost of producing the outputs i and j alone.

It can be helpful to report some relationships which summarize the links between scale and scope economies:

$$SCALE_T(y;w) = \frac{\gamma_i SCALE_i(y;w) + (1-\gamma_i) SCALE_{-i}(y;w)}{1 - SCOPE_i(y;w)} \qquad [11a]$$

for all i = (U, I, H). $SCALE_{-i}(y;w)$ is the measure of product-specific economies of scale for the set of outputs other than i and $\gamma_i = \frac{\varepsilon_{Cy_i}}{\sum_i \varepsilon_{Cy_i}}$. According to equation [11a], the degree of global scale economies depends on both product-specific scale economies and product-specific economies of scope. In particular, if $SCOPE_i > 0$ ($SCOPE_i < 0$), the degree of global scale economies is greater (lower) than the weighted average of product-specific scale economies.

Another useful formula for disaggregating the factors that contribute to form the measure of global scope economies is the following:

$$SCOPE_T(y;w) = \left(\sum_i SCALE_i(y;w)\varepsilon_{Cy_i} + \sum_i SCOPE_i(y;w) \right) - 1 \qquad [11b]$$

Thus, global scope economies depend on the joint play of product-specific economies of scale (weighted by the output cost elasticities) and product-specific economies of scope.

Finally, the following relationship nicely highlights the links between aggregate and product specific scope economies:

$$SCOPE_T(y;w) = SCOPE_{Cij}(y;w) * \frac{C(y_{ij};w)}{C(y;w)} + SCOPE_{-ij}(y;w) \qquad [11c]$$

2. Data description

Data on costs, output quantities and input prices have been obtained by integrating the information available in the annual reports of each company with additional information drawn from questionnaires sent to managers. Long-run cost (C) is the sum of fuel and other raw materials consumption, labor and capital costs of the firm. The three output categories are: urban transit (y_U), intercity transit (y_I) and for-hire transit (y_H). Productive factors are labor, capital and materials. The price of labor in each utility (w_L) is given by the ratio of total salary expenses to the number of employees. Capital price (w_K) is obtained by dividing the amortization costs by the total number of vehicles. Finally, the price of fuel (w_F) is the cost of fuel and other raw materials per liter of fuel consumption. Summary statistics are provided in Table 1.

The dataset is an unbalanced panel of 47 firms observed during the years 2008-2012, for a total of 147 observations. 30 observations refer to specialized firms, while 9 observations refer to fully integrated firms. The vast majority is however represented by firms performing a couple of services, in particular intercity and for-hire services, or intercity and urban.

5. Estimation and empirical results

All the specifications of the multi-product cost function are estimated jointly with their associated input cost-share equations. Because the three share equations sum to unity, to avoid singularity of the covariance matrix the capital share equation (S_K) was deleted and only the labor equation (S_L) and the (S_F) were included in the systems. Before the estimation, all variables were standardized on their respective sample means, and regional and time dummies were included in all regressions. Assuming the error terms in the above models are normally distributed, the concentrated *log-likelihood* for the estimated *cost function* and related *labor-share equation* and *material-share equation* can be respectively computed via

$$\begin{aligned} \ln L_C &= -\sum_{t=1}^{T} \ln C_t - \frac{T}{2}[1+\ln(2\pi)] - \frac{T}{2}\ln\left[\frac{1}{T}\sum_{t=1}^{T}\hat{\psi}_{C\,t}^{2}\right] \\ \ln L_{S_L} &= -\frac{T}{2}[1+\ln(2\pi)] - \frac{T}{2}\ln\left[\frac{1}{T}\sum_{t=1}^{T}\hat{\psi}_{L\,t}^{2}\right] \\ \ln L_{S_F} &= -\frac{T}{2}[1+\ln(2\pi)] - \frac{T}{2}\ln\left[\frac{1}{T}\sum_{t=1}^{T}\hat{\psi}_{F\,t}^{2}\right] \end{aligned} \qquad [12]$$

where t is the single observation (t = 1, …, 147), $\hat{\psi}_C$, $\hat{\psi}_L$ and $\hat{\psi}_F$ are the estimated residuals of the two regressions, and ($-\Sigma_t \ln C_t$) is the logarithm of the Jacobian of the transformation of the dependent variable from C_t to $\ln C_t$ ($J = \prod_{t=1}^{T} J_t$ with J_t = | $\partial \psi_{C t} / \partial C_t$ | = 1/C_t). Similarly, the concentrated *system log-likelihood* is defined by:

$$\ln L_{(C,S_L)} = \ln J - \frac{T}{2}\left[2(1+\ln(2\pi)) + \ln|\Omega|\right] \qquad [13]$$

where J is the Jacobian of the transformation of (C_t, S_{Lt}, S_{Ft}) to $(\ln C_t, S_{Lt}, S_{Ft})$, and Ω is the (3×3) matrix of residual sum of squares and cross products for the system, with the pqth element of Ω, Ω_{pq}, equal to $\frac{1}{T}\sum_{t=1}^{T} \hat{\psi}_{p t} \hat{\psi}_{q t}$ and p, $q = C$, S_L ,S_F

The summary results of the NLSUR estimations for the ST, GT, SQ, and PB models are presented in Table 2. In the first row the value of the Box-Cox parameter (π) for the GT specification is positive (0.1787) and significantly different from zero (t-ratio = 6.324). The small value of π suggests that, being a close approximation to the standard translog form, the GT model would suffer from the same drawbacks of the ST specification when used to estimate cost properties of multi-product firms. The following five rows present the estimates of cost elasticities with respect to outputs and factor prices for the 'average' firm.

While the four estimated cost function models seem to perform similarly with respect to input-price elasticities, the estimates for the output elasticities show a greater variability, with SQ and PB models according more weight to the urban service. The R^2 for the cost function and for the cost-share equations are very similar, except for the SQ specification. The lower ability of the SQ specification to fit the observed factor-shares is not surprising given that it assumes a strong separability between inputs and outputs. McElroy's (1977) R^2 (R_*^2) can be used as a measure of the goodness of fit for the NLSUR system. The results suggest that the fit is slightly lower for the ST (R_*^2 = 0.97) and GT (R_*^2 = 0.96) functional forms.

Since the PB, SQ, GT and ST models are all nested into the PB_G specification, standard likelihood ratio (LR) hypothesis testing based on system log-likelihoods can be applied to see which model adjusts better observed data. The LR statistics lead to reject the ST and GT specifications (critical ${}_{0.01}\chi^2_{(3)}$ = 11.34; computed $\chi^2_{(3)}$ = 262.29 for the ST model and critical ${}_{0.01}\chi^2_{(2)}$ = 9.21; computed $\chi^2_{(2)}$ = 271.61 for the GT model). Similarly, the null hypothesis that PB_G and SQ models are equally close to the true data generating process is rejected in favor of the PB_G specification (critical ${}_{0.01}\chi^2_{(2)}$ = 9.21; computed $\chi^2_{(2)}$ = 177.22). However, the restricted composite model PB cannot be rejected (critical ${}_{0.01}\chi^2_{(2)}$ = 9.21; computed $\chi^2_{(2)}$ = 1.50).

Table 3 shows the estimates of global and output specific scope and scale economies, computed for the average firm in the sample. The estimates of scale economies are similar across models (except for the GT model were the estimate is larger), and suggest that the average firm is exhibiting constant returns to scale (all figures are not statistically different from one). The relative advantages of the composite specification can be appreciated by comparing the measures of global economies of scope as well as product specific scale and scope economies.

In the ST (GT) specification the average firm exhibits scope diseconomies of the order of -28% (-4%), while the PB_G, PB and SQ models all point towards the absence of economies of scope. In a similar vein, the ST and GT models provide estimates for product specific scale and scope economies which are not acceptable. This is in line with expectations, since the ST cost model, as well as the GT specification for small values of the Box-Cox parameter (in this case $\pi = 0.1787$), often provide unreasonable and/or very unstable estimates when outputs are set near to zero.

The preference for the composite specification on the base of statistical fit and as a result of LR based statistics is thus further strengthened by the better ability of quadratic models in measuring global scope economies. In the remaining of the paper we will then focus on the PB_G functional form in carrying out the empirical tests concerning scope and scale economies.

5.1. Global and product specific economies of scale and scope

Table 4 reports the estimates for global scale and scope economies evaluated at the output sample means, $y^* = (y^*_U, y^*_I, y^*_H)$, and at ray expansions and contractions of y^*. More precisely, we consider the following output scaling: $\lambda y^* = (\lambda y^*_U, \lambda y^*_I, \lambda y^*_H)$, with outputs ranging from one fourth (λ=0.25) to four times (λ=4) the values observed for the ‘average’ firm. The results show the presence of aggregate economies of scale (SC_T= 1.10 for λ=0.25) and economies of scope ($SCOPE_T$= 0.21 for λ=0.25 and 0.10 for λ=0.5) for small firms, while for firms larger than the average, economies of scope are absent and decreasing returns to scale appear.

By looking more deeply into the contribution of each product or couples of products in determining the above global scope and scale economies results, it emerges that

scope economies are mostly due to the intercity bus service, since both $SCOPE_I$, $SCOPE_{CUI}$ and $SCOPE_{CHI}$ are positive and significant at the different size levels.
Therefore, a small firm (i.e. a firm with a bus fleet of less than 150 buses and employing less than 300 workers) which provides the urban transport or the bus renting service (or both), can benefit from cost synergies if it adds the intercity bus service. As far as the size of the firm increases, these synergies remain only for the pairwise combination of urban and intercity service. Therefore, for large firms operating in the renting service, it is better to remain specialized rather than diversifying into the urban and/or the intercity service.

Using the decompositions [11a] through [11c] to summarize our main results, for the average firms there appear to be constant output specific returns to scale, which coupled with the absence of scope economies, leads to constant aggregate scale economies (equation 11a). For smaller firms, the presence of scope economies for the intercity service leads to both aggregate scope economies (equation 11c) and aggregate scale economies. For firms larger than the average, the presence of output specific decreasing returns to scale counterbalances the effect of scope economies and results into the absence of global scope economies (equation 11b) and the presence of decreasing aggregate returns to scale.

Summarizing, there is evidence that small multi-service firms benefit from cost reductions of the order of 10%-20% with respect to specialized operators. As the size of the firm increases, the cost savings remain only for the intercity bus service, while both output specific and aggregate decreasing returns to scale emerge.

6. Conclusions

The paper explores the presence of scale and scope economies in the passenger transport sector, using a Composite Cost Function econometric model (Pulley and Braunstein, 1992). The methodology allows to disentangle potential synergies emerging when firms provides different combinations of three type of transit services: urban, intercity and for-hire. The results highlight the presence of global scope and scale economies only for multi-service firms with relatively low level of outputs.

A number of interesting policy implications emerge. Within the context of local transit systems, especially in the urban case, the possibility to increase outputs might be rather limited unless firms diversify towards other similar activities. The diversification towards intercity and also for-hire services should be considered as a valid option in small environments, when the size of the urban area does not allow public transport firms to reach a minimum dimension. On the other hand, the demand for mobility in large metropolitan areas create the conditions for having separate operators providing urban, intercity or for-hire services. As to for-hire services, their peculiar characteristic due to non-scheduled times and non-fixed routes do not favor too much their integration with other transit services. Nonetheless, for small companies, the integration might still be a viable solution, especially when the more competitive environment faced in rental coach sector makes it difficult to grow in the core activity. Intercity services represent the activity that can more easily be coupled with either urban or for-hire services: however, at least if the urban context is not too big, the most efficient solution seems to be the integration with urban operators (coherently with Di Giacomo and Ottoz, 2010) rather than diversifying into for-hire bus services.

Table 1. Summary Statistics

	Mean	Std. dev.	Min	Median	Max
Total Cost (10^6 Euros)	24.373	60.159	0.275	6.489	499.328
Output					
Urban (10^6 kilometers)	11.202	11.900	2.190	8.300	56.740
Intercity (10^6 kilometers)	3.403	4.857	0.090	1.545	22.060
For-hire (10^6 kilometers)	0.852	0.753	0.010	0.610	3.500
Input prices					
Price of capital (10^3 Euros)	12.659	7.329	1.754	11.443	41.170
Price of fuel (Euros per liter)	2.893	0.923	1.570	2.630	5.960
Price of labor (10^3 Euros)	38.942	6.221	23.824	38.708	50.455
Cost shares					
Capital share	0.109	0.066	0.001	0.090	0.372
Fuel share	0.426	0.113	0.193	0.422	0.688
Labor share	0.465	0.118	0.204	0.477	0.713

Table 2. NLSUR estimation: Standard Translog (ST), Generalized Translog (GT), Separable Quadratic (SQ), and Composite (PB) cost function models [a]

	PB_G model	PB model	SQ model	GT mo

Box Cox Parameters				
π	0.9763*** (0.1600)	1	1	0.1787***
τ	-0.0620 (0.0571)	0	0	1
θ	0.5562*** (0.0364)	0.5605 *** (0.0354)	0.4656*** (0.0411)	0
Output and factor price elasticities [b]				
ε_{Cy_U}	0.6193*** (0.0378)	0.6220*** (0.0164)	0.6261*** (0.0144)	0.3424***
ε_{Cy_I}	0.3366*** (0.0549)	0.3235*** (0.0284)	0.3244*** (0.0256)	0.3223**
ε_{Cy_H}	0.0951 (0.0657)	0.0998** (0.0426)	0.1051*** (0.0390)	0.2863*
S_l	0.5456*** (0.0156)	0.5437*** (0.0149)	0.4580*** (0.0095)	0.5189***
S_F	0.3727*** (0.0137)	0.3744*** (0.0132)	0.4288*** (0.0090)	0.4123***
R^2 *Cost function*	0.9969	0.9969	0.9970	0.98
R^2 *Labor share equation*	0.6076	0.6015	0.2923	0.62
R^2 *Material share equation*	0.4609	0.4530	0.2325	0.47
System log-likelihood	528.734	527.984	440.123	392
Goodness of fit [c]	0.9918	0.9919	0.9913	0.96
LR test statistic	-	PB_G vs. PB: LR = 1.50	PB_G vs. SQ: LR = 177.22	PB_G v LR = 2

[a] Estimated asymptotic standard errors in parentheses. *** Significant at 1%, ** Significant at 5%, * Significant at 10%.
[b] The values are computed for the average firm. The coefficient subscripts are *U* = urban, *I* = intercity, H = for-hire, *L* = labor, *F* = materials.
[c] The goodness-of-fit measure for the NLSUR systems is McElroy's (1977) R^2.

Table 3. Estimates of global and output specific scale economies and global and output specific scale economies for the ST, GT, SQ, and PB models (at the average values of outputs and input price variables)[a]

	PB_G model	PB model	SQ model	GT model	ST model[b]
$SCALE_T$	0.9515 (0.0666)	0.9567 (0.0426)	0.9474** (0.0256)	1.0515 (0.1558)	0.9520 (0.0930)
$SCALE_U$	0.9143 (0.1359)	0.8766 (0.0999)	0.9568 (0.1264)	-0.6442 (1.2879)	-0.8327 (6.3224)
$SCALE_I$	0.9613 (0.0672)	0.9570*** (0.0099)	0.9609*** (0.0087)	0.0894* (0.6345)	0.2763* (0.3723)
$SCALE_H$	1.0065 (0.1044)	0.9864 (0.0406)	1.0014 (0.0467)	-2.7719 (7.3610)	1.0794 (0.4338)
$SCALE_{UI}$	0.9818 (0.0834)	0.9926 (0.0174)	0.9960 (0.0155)	1.4469 (0.0174)	1.0494 (0.1548)
$SCALE_{UH}$	0.9934 (0.0897)	0.9635 (0.0237)	0.9692 (0.0218)	0.7594* (0.1493)	0.6935** (0.1563)
$SCALE_{IH}$	0.8939 (0.0978)	0.8698** (0.0563)	0.8893** (0.0546)	0.9826 (0.8782)	1.6484 (0.5623)

SCOPE$_T$	-0.0059 (0.6097)	0.0258 (0.0441)	-0.0130 (0.0419)	-0.0418 (0.3248)	-0.2840* (0.1539)
SCOPE$_H$	-0.0255 (0.0713)	-0.0260 (0.0439)	-0.0472 (0.0406)	0.2226 (0.3274)	0.1505 (0.7851)
SCOPE$_U$	-0.0242 (0.0469)	-0.0031 (0.0319)	-0.0178 (0.0283)	-0.1776 (0.1201)	-0.1305 (0.1420)
SCOPE$_I$	0.0226* (0.0140)	0.0531* (0.0330)	0.0250 (0.0352)	2.2758 (2.3684)	-0.4324 (0.3821)
SCOPEc[c]					
SCOPEc$_{HU}$	-0.0043 (0.1027)	-0.0400 (0.0615)	-0.0563 (0.0535)	-0.6958** (0.3471)	0.3432 (1.1902)
SCOPEc$_{HI}$	0.0450 (0.0622)	0.0714 (0.0516)	0.0120 (0.0611)	0.4775 (1.3764)	-0.4689 (0.3043)
SCOPEc$_{UI}$	0.0214* (0.0137)	0.0568** (0.0292)	0.0380* (0.0222)	-0.2232 (0.3080)	-0.3908 (0.3174)

[a] Estimated asymptotic standard errors in parentheses. *** Significant at 1%, ** Significant at 5%, * Significant at 10%.

[b] For the ST model, we used y = 0.001 to simulate the costs of specialized firms.

[c] Scope economies for couples of outputs under the assumption that the production of the remaining output is zero. See equation [10].

Table 4. Estimates of economies of scope and scale for the PB$_G$ model by scaled values of the average outputs (at the average prices)[a]

	SCALE$_T$	***SCOPE$_T$***	*SCOPE$_H$*	*SCOPE$_U$*	*SCOPE$_I$*	*SCOPEc$_{HU}$*	*SCOPEc$_{HI}$*	*SCOPEc$_{UI}$*
Scaling procedure								
λ = 0.25	1.0986* (0.0644)	0.2078** (0.1082)	0.0945* (0.0542)	0.1000* (0.0542)	0.1137** (0.0551)	0.1396* (0.0763)	0.2328** (0.1054)	0.1177** (0.0562)
λ = 0.5	1.0193 (0.0315)	0.0967* (0.0602)	0.0287 (0.0346)	0.0403 (0.0319)	0.0686** (0.0338)	0.0421 (0.0510)	0.1316*** (0.0164)	0.0719** (0.0341)
λ = 1	0.9515 (0.0666)	-0.0059 (0.6097)	-0.0255 (0.0713)	-0.0242 (0.0469)	0.0226* (0.0140)	-0.0043 (0.1027)	0.0450 (0.0622)	0.0214* (0.0137)
λ = 2	0.8891*** (0.0441)	-0.0295 (0.0656)	-0.0882 (0.0786)	-0.0449 (0.0541)	0.0611 (0.0543)	-0.1261 (0.0981)	0.0403 (0.0764)	0.0686* (0.0465)
λ = 4	0.8079*** (0.0575)	-0.0867 (0.1106)	-0.1732 (0.1313)	-0.0968 (0.0908)	0.0908 (0.0937)	-0.2257* (0.1393)	0.0280 (0.1413)	0.1135 (0.0912)

[a] Estimated asymptotic standard errors in parentheses. Parameter λ refers to the coefficient used to scale down (λ = 0.25, 0.5) and up (λ = 2, 4) the average values of the three outputs.
*** Significant at 1%, ** Significant at 5%, * Significant at 10%.

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