

# Economies of Scale and Scope in Local Public Transportation

**Mehdi Farsi, Aurelio Fetz, and Massimo Filippini**

---

*Address for correspondence:* Aurelio Fetz, Department of Management, Technology and Economics, ETH Zurich, Zurichbergstr. 18, CH-8032 Zurich, Switzerland (afetz@ethz.ch). Mehdi Farsi and Massimo Filippini are also at D-MTEC, ETH Zurich; Professor Filippini is also at the Department of Economics, University of Lugano.

The authors acknowledge the financial support of the Swiss National Science Foundation through research grant 100012-108288. They also wish to thank the editor Steven Morrison and an anonymous referee for their helpful suggestions and Martin Hohmann for his assistance in compiling the data.

## Abstract

This paper analyses the cost structure of the Swiss urban public transport sector in order to assess scale and scope economies. A multi-output cost function has been estimated for a panel data set of companies operating trolley-bus, motor-bus and tramway systems. The results suggest increasing returns to scale and economies of scope. This analysis has important policy implications in view of the ongoing reforms in several European countries in which competitive tendering is occasionally used to assign the provision of transport services to unbundled franchised monopolies. The significant scope economies provide some evidence in favour of integrated multi-mode operation as opposed to unbundling.

*Date of receipt of final manuscript: January 2007*

## 1.0 Introduction

During the last two decades several EU-member countries have introduced a competitive tendering procedure in the assignment of franchised monopolies in the local transport industry. This process has been initiated by the European Directive 1191/69/EU (modified by 1893/91/EU) that encourages the member countries to use competitive tenders in cases where the providers are not owned by home states. The implementation of tendering procedures in the urban transit industry is, however, not straightforward, because in many cases the incumbents are large multi-mode transit operators that combine different transport systems such as motor-bus, tramway, and trolley-bus. In such cases companies specialising in a single transit service face a barrier to market entry because of the comparative advantage of the incumbent multi-mode companies. Therefore, due to fewer potential bidders for the multi-mode transit services, the benefits from competitive tendering would not be exploited completely.<sup>1</sup>

In order to induce more competition and avoid an insufficient number of bids, there is a tendency among the public authorities towards opening separate competitive tenders for different modes of transport. This kind of ‘unbundling’ has already been used in the urban public transport systems in several European countries.<sup>2</sup> When transport modes are unbundled,<sup>3</sup> bidding can be opened to both single-mode operators and multi-mode companies. On the other hand, a multi-mode transit company serving the entire local market can completely exploit the potential scope and scale economies and reduce the planning costs of urban transport, since the local authority must not coordinate a large set of services provided by different operators in order to have a well integrated network. Moreover, such integrated companies potentially provide a better quality of service with more stable and coordinated timetables to the extent that the disruptions can be minimised by substituting across transport modes.

The choice between a single tendering procedure for the entire transport services and unbundling the modes into separate tenders is a crucial policy question that has extremely important impacts on the organisation of the local transport system, namely, the operation mode (single or multiple) in different parts of a network as well as the planning of final services

---

<sup>1</sup>For a discussion of the problems in the application of competitive tendering processes in the local transport sector see Cambini and Filippini (2003).

<sup>2</sup>For instance, in Rome a competitive tendering procedure for some additional lines has already been utilised. See Cambini and Boitani (2006) for a discussion of this issue.

<sup>3</sup>By unbundling we refer to legal unbundling (as opposed to ownership unbundling), which means the divestiture into more than one company. In principle the resulting companies can belong to a single holding firm.

such as frequencies, number of lines, and so on. Therefore it is relevant for the local authorities to know if and to what extent multi-mode suppliers could use the scope and scale economies to reduce their costs in comparison to a group of single-mode operators. This question is in line with the important issue of natural monopoly raised by Baumol *et al.* (1982), applied to the local transport sector.

In the presence of economies of scope a multi-output firm is more economical than separate specialised firms. Following Baumol *et al.* (1982) and Bailey and Friedlaender (1982) the scope economies can result from sharing or the joint utilisation of inputs. In the case of local public transport such sharable inputs are labour, capital, and energy. Local public transport companies that combine several transport modes use similar equipment such as wires, overhead line, and similar skills such as driving, management, and network maintenance. Such synergies also apply to activities such as advertising, scheduling, and ticketing. Another source of cost savings is economies of massed reserves (Waldman and Jensen (2001)). Multi-output transport companies can make use of the same reserve capacity for maintenance and buildings.

The purpose of this study is to make a contribution to the debate on the introduction of competitive tendering procedures in the urban bus transport sector. This paper explores the empirical evidence of scale and scope economies in 16 multi-mode transport companies operating in Switzerland from 1985 to 2003. A normalised total cost function with quadratic form has been estimated. The results suggest that scope economies exist at most of the output levels observed in the data. This study provides some evidence in favour of the status quo regarding multi-mode transport companies. The potential competition benefits of unbundling remain to be explored.

The rest of the paper proceeds as follows. Section 2 provides a brief review of the relevant literature and presents the adopted specification. The concepts of scope and scale economies are defined in Section 3. The data are described in Section 4. Section 5 presents the estimation results and discusses their implications. The main conclusions are summarised at the end.

## 2.0 Model Specification and Econometric Methods

There is a substantial body of literature on the cost structure of single output bus companies. Filippini and Prioni (1994), Fraquelli *et al.* (2004a) and Shaw-Er *et al.* (2005) are among the recent empirical examples.

However, only a few studies have addressed the issue of scope economies in urban transit systems. Authors such as Gillen and Oum (1984) studied companies operating with a single transport mode but in a multi-product set-up. In these cases the multiple outputs are defined on the basis of service type, namely, urban, intercity, and so on. Previous studies on the economies of scope across different modes of transport (such as motor-bus, tramway, and trolley-bus) are rare and mostly outdated. The most relevant ones in this category are Viton (1992, 1993) and Colburn and Talley (1992), all of which analysed the long-run cost structure of urban multi-mode transit system in the US.

Viton (1992) studied the cost structure of a sample of 289 urban transit companies operating in the US between 1984 and 1986. Six modes are distinguished: motor-bus, rapid-rail, streetcar, trolley-bus, demand responsive mode, and a last mode including all other modes. Viton uses a quadratic total cost function with the following explanatory variables: six outputs, measured in vehicle-miles, price of labour, and the average speed in each one of the six modes. Empirical results highlight the presence of economies of scale and scope. However, the extent of the economies of scope depends on the post-consolidation level of the wage: if wages remain unchanged after consolidation, economies of scope exist for certain transport modes. If, on the other hand, wages rise due to consolidation, economies of scope are smaller or even negative. Colburn and Talley (1992) analyse the economies of scale and scope of a single urban multi-service company using quarterly data from 1979 to 1988. Four modes are distinguished: motor-bus, dial-a-ride, elderly service, and van pool service. Colburn and Talley use a translog total cost function with the following explanatory variables: four outputs, measured in vehicle-miles, and three factor prices (labour, fuel, and capital). The empirical results reported in that study indicate unexploited scale economies. However, the evidence of cost complementarity is limited to certain combinations involving motor-bus and the three para-transit services (elderly service and van pool service).

In this paper we consider three modes that are typically used in most European urban transit systems namely, motor-bus, trolley-bus, and tramway. We will employ a panel data econometric approach. To our knowledge this paper is the first empirical study of a European urban transit system that provides evidence about the economies of scale and scope across transport modes.

The model specification is based on a cost function with three outputs, namely, transport services in three modes and two inputs, labour and capital. The model also includes a measure of network size and a time trend. If it is assumed that the firm minimises cost and that the technology

is convex, a total cost function can be written as:

$$C = C(y^{(1)}, y^{(2)}, y^{(3)}, w^{(1)}, w^{(2)}, n, t), \quad (1)$$

where  $C$  represents total costs;  $y^{(1)}$ ,  $y^{(2)}$  and  $y^{(3)}$  are the numbers of seat-kilometres provided by trolley-bus, motor-bus, and tramway systems respectively; and  $w^{(1)}$  and  $w^{(2)}$  are the factor prices for labour and capital respectively. The network size ( $n$ ) is measured by the number of stops<sup>4</sup> and  $t$  is the linear trend that captures the shift in technology representing technical change.

Following Baumol *et al.* (1982) and Mayo (1984) we use a quadratic cost function.<sup>5</sup> Unlike logarithmic forms, this functional form accommodates zero values for outputs, and thus allows a straightforward identification of scope economies. Although logarithmic functions could be used with an arbitrary small value transformation for zero values, it has been shown that this approach could result in large errors in the estimation of scope economies (Pulley and Humphrey, 1993). As in our case, many output values for trolley-buses and tramways are zero, such estimation errors may lead to misleading conclusions about scope economies. However, one disadvantage of the quadratic form is that the linear homogeneity of the cost function in input prices cannot be imposed by parametric restrictions without sacrificing the flexibility of the functional form (Caves *et al.* (1980)).

The quadratic cost function specification can therefore be written as follows:

$$\begin{aligned} C_{it} = & \alpha_0 + \sum_m^M \alpha^m y_{it}^{(m)} + \frac{1}{2} \sum_m^M \sum_n^M \alpha^{mn} y_{it}^{(m)} y_{it}^{(n)} \\ & + \sum_p^P \beta^p w_{it}^{(p)} + \alpha^n n_{it} + \alpha^t t_t + \varepsilon_{it}, \end{aligned} \quad (2)$$

where superscripts  $m$  and  $p$  denote respectively the number of products (1, 2, 3) and the number of input factors (1, 2), and subscripts  $i$  and  $t$  denote respectively company and year. Variable  $y$  is a product quantity,  $w$  a factor price,  $t$  a time trend, and  $n$  is a network characteristic. The factor

<sup>4</sup>In two alternative specifications we respectively used area size and network length (sum of the three modes) instead of number of stops. Neither variable has shown any statistically significant effect at the 5 per cent significance level. This can be partly explained by relatively high density variation within a service area and also variation of shape and complexity across different networks.

<sup>5</sup>A quadratic function requires an approximation of the underlying cost function at a local point, which in our case is taken at the sample mean. Thus, all independent variables are normalised by their sample mean values.

prices and the network variable are introduced in a linear way (following Mayo (1984) and Viton (1992), respectively).

The linear homogeneity in input prices can be imposed by normalisation of prices, namely, by dividing the costs and all factor prices by one common factor price (see Featherstone and Moss (1994) and Jara-Diaz *et al.* (2003)).

The normalised quadratic cost function takes the following form:

$$\begin{aligned} C'_{it} = \alpha_0 + \sum_m^M \alpha^m y_{it}^{(m)} + \frac{1}{2} \sum_m^M \sum_n^M \alpha^{mn} y_{it}^{(m)} y_{it}^{(n)} \\ + \sum_p^{P-1} \beta^p w_{it}^{(p)} + \alpha^n n_{it} + \alpha^t t_t + \varepsilon_{it}, \end{aligned} \quad (3)$$

where  $C'_{it}$  is the normalised cost and  $w_{it}^{(p)}$  is the normalised input prices. In this case, given that the model does not have any second-order term for input prices, the linear homogeneity restriction is equivalent to excluding one price coefficient.

The econometric model (3) is estimated for an unbalanced panel data set consisting of 16 companies over 19 years (300 observations).<sup>6</sup> The repeated observations of a same company allow the use of panel data models that can account for unobserved heterogeneity across companies. However, as the number of companies is smaller than the number of periods ( $N < T$ ), this data set is an unusual case for widely used panel data specifications such as fixed effects and random effects models, in which  $T$  is small relative to  $N$ .<sup>7</sup> When the sample period is relatively short, one can assume that the individual effects remain constant. In long panel data, on the other hand, these effects might change over time, resulting in serial correlation of errors.<sup>8</sup> Both fixed and random effects models can be extended to include serial correlations with an autoregressive model of order 1 as in the Cochrane–Orcutt approach (Cochrane and Orcutt (1949)). However, in fixed/random effects models a large part of the between variations (variations among companies) can be suppressed into the firm-specific effects. Given the small size of the sample and the relative importance of between variations in identifying the scope and scale economies, a pooled model seems to be adequate for our study.

<sup>6</sup>We have also estimated the model without a linear homogeneity restriction (as in equation 2). The results (available upon request) are more or less similar to those of the normalised model. However, the statistical significance for scope and scale economies is slightly different across the two models with the normalised model having generally more significant values.

<sup>7</sup>For a detailed presentation of panel data models, see Greene (2003) and Baltagi (2001).

<sup>8</sup>The significant test statistics from autocorrelation test in panel data (Wooldridge (2002)) indicates the presence of serial correlation in the data.

Therefore, we decided to use a heteroscedastic model with autoregressive errors, as proposed by Kmenta (1986).<sup>9</sup> The Kmenta approach, also known as the cross-sectionally heteroscedastic and time-wise autoregressive model, is attractive when  $N$ , the number of units, is lower than  $T$ , the number of periods, or when the within variation of many explanatory variables is low. In this model, the cross-sectional heteroscedasticity captures the unobserved heterogeneity across companies,<sup>10</sup> while the serial correlation is modelled through the autoregressive error structure as follows:

$$\varepsilon_{it} = \rho_i \varepsilon_{i,t-1} + u_{it} \text{ (autoregressive errors)} \quad (4)$$

$$\mathbf{E}(u_{it}^2) = \sigma_i^2 \text{ (heteroscedasticity),} \quad (5)$$

where  $\rho_i$  is a coefficient of first-order autocorrelation. It is assumed that the correlation parameter varies across the firms. Therefore, the unobserved heterogeneity across firms is accounted for by firm-specific variances and serial correlation coefficients. The Kmenta method consists of two sequential feasible generalised least squares (FGLS) transformations to remove autocorrelation and cross-sectional heteroscedasticity respectively (Baltagi (2001) and Kmenta (1986)).

### 3.0 Scale and Scope Economies

Following Baumol *et al.* (1982) global economies of scale<sup>11</sup> in a multi-output setting are defined as:

$$SL = \frac{C(y)}{\sum_m^M y^{(m)} * (\partial C / \partial y^{(m)})}, \quad (6)$$

where  $y = (y^{(1)}, y^{(2)}, y^{(3)})$  for  $m = 1$  (trolley-bus), 2 (motor-bus) and 3 (tramway). Global economies of scale describe the cost behaviour due to proportional changes in the entire production.

In addition, product-specific economies of scale are based on changes of one output or an output pair, while all other outputs are held constant.

<sup>9</sup>The model has been also estimated using the fixed and random effects approaches. The results (available upon request) show that the estimated coefficients are generally similar to those reported in the paper. However, in the fixed effects model the coefficient of the network size variable is negative. This counterintuitive result could be due to the extremely low within variation of that variable.

<sup>10</sup>A modified Wald test on an OLS model shows the existence of heteroscedasticity in our data.

<sup>11</sup>In the definition of economies of scale we do not follow Caves *et al.* (1984) by distinguishing between economies of scale and economies of density due to the complexity of the weighting of different network elements.

Product-specific economies of scale to the product  $m$  are defined as:

$$SL_m = \frac{C(y) - C(y^{(-m)})}{y^{(m)} * (\partial C / \partial y^{(m)})}, \quad (7)$$

where  $C(y) - C(y^{(-m)})$  represents the incremental cost resulting from output  $m$  and  $C(y^{(-m)})$  is the costs of producing all the outputs jointly except output  $m$ .

Similarly, in the case of joint production of outputs  $m$  and  $n$  the product-specific economies of scale can be written as:

$$SL_{mn} = \frac{C(y) - C(y^{(-mn)})}{y^{(m)} * (\partial C / \partial y^{(m)}) + y^{(n)} * (\partial C / \partial y^{(n)})}, \quad (8)$$

where  $C(y^{(-mn)})$  is the costs of producing all the outputs except outputs  $m$  and  $n$ .

All the above definitions represent the ratio of the expansion rate in all or certain output(s) to the rate of the resulting increase in costs. For any one of these cases (global, output  $m$ , or output pair  $m$  and  $n$ ) the returns to scale are increasing, constant, or decreasing if the corresponding ratio ( $SL$ ,  $SL_m$  or  $SL_{mn}$ ) is greater, equal, or less than one.

Economies of scope are present when costs can be reduced by joint production of multiple outputs. Following Baumol *et al.* (1982) the degree of global economies of scope in the production of three products is defined as the ratio of excess costs of separate production to the costs of joint production of all outputs:

$$SC = \frac{C(y^{(1)}, 0, 0) + C(0, y^{(2)}, 0) + C(0, 0, y^{(3)}) - C(y)}{C(y)}. \quad (9)$$

A positive (negative) value for the above expression implies the existence of global economies (diseconomies) of scope.

In addition to the above measure, product-specific measures can be defined for any given output or output pair. The product-specific economies of scope for output  $m$  ( $SC_m$ ) measure the relative increase in costs resulting from separating the production of output  $m$  from all other outputs:

$$SC_m = \frac{C(y^{(m)}) + C(y^{(-m)}) - C(y)}{C(y)}. \quad (10)$$

In line with Fraquelli *et al.* (2004b) the degree of product-specific economies of scope for output pair  $m$  and  $n$  with the remaining output being

zero is defined as:

$$SC_{mn} = \frac{C(y^{(m)}) + C(y^{(n)}) - C(y^{(m)}, y^{(n)})}{C(y^{(m)}, y^{(n)})}. \quad (11)$$

Product-specific economies (diseconomies) of scope exist if  $SC_m$  or  $SC_{mn}$  is greater (smaller) than zero.

## 4.0 Data

The sample consists of sixteen public transport companies, which cover all the local public transit services within the urban centres in Switzerland.<sup>12</sup> Most of these companies participate in a transport association that ensures coordination with the regional public transport system.<sup>13</sup> There is no overlap between the offered transport services across companies. Therefore, all these companies can be considered as independent local monopolies.

For the years between 1985 through 1997 the data have been extracted from the annual statistics on public transport reported by the Swiss Federal Statistical Office (BFS (1985–97)). The data for the following years (1998–2003) have been collected from companies' annual reports.<sup>14</sup> Because of a merger with a regional transport company in 1999, one company was excluded from the sample after the merger. The available information in the data set includes costs, total number of employees, network length, total number of trolley-buses, motor-buses, and tramways, vehicle-kilometres, delivered passengers, and total number of seats in each transport mode.

The variables for the cost function specification were calculated as follows. Total costs ( $TC$ ) are calculated as the total expenditures of the local public transit firms in a given year. The output  $y$  is measured by the number of seat-kilometres provided by motor-buses, trolley-buses, and tramways, respectively. This is a pure supply output measure that has been used in previous studies for bus companies, such as Fazioli *et al.* (1993), Farsi *et al.* (2006). Filippini and Prioni (2003) compared a model

<sup>12</sup>Swiss Federal Statistical Office classifies local public transport into urban and rural categories (BFS (1985–97)). The sample used in this paper excludes rural transport companies. These companies are generally bus operators that cover relatively long distances with low frequencies in rural areas, which is considered a different transport operation compared to urban transport.

<sup>13</sup>These associations are created for setting the prices and organising the ticketing. They also ensure that passengers can use a single timetable and travel throughout the entire associated network with only one ticket. However, the participating companies operate independently.

<sup>14</sup>The Federal Statistical Office does not provide data on individual companies after 1997.

**Table 1**  
*Descriptive Statistics (300 Observations)*

	Min.	1st Quartile	Median	Mean	3rd Quartile	Max.	Std. dev.
Output [Mio seat-kilometres]							
Trolley-bus	0	79	176	249	368	861	212
Motor-bus	32	93	181	334	343	1,614	401
Tramway	0	0	0	365	335	2,926	745
Total cost [CHF]	$8.2 \times 10^6$	$18.2 \times 10^6$	$31.0 \times 10^6$	$79.3 \times 10^6$	$108.9 \times 10^6$	$430.4 \times 10^6$	$97.9 \times 10^6$
Labor price [CHF per employee]	39,888	85,585	93,330	90,942	99,321	123,861	12,317
Capital price [CHF per 100 seats]	49,128	111,706	135,654	141,276	161,151	312,774	41,034
Number of stops	64	141	186	246	278	772	163

with bus-kilometres with one with seat-kilometres as output. The bus-kilometre output variable has the disadvantage that the size of the bus is not taken into account. Alternatively some authors have used passenger revenue (as in Button and O'Donnell (1985)), or passenger trips (Berechman (1987), Bhattacharyya *et al.* (1995), and Windle (1988)).

Labour price ( $w_1$ ) is defined as the ratio of annual labour costs to the total number of full-time equivalent employees. The largest fraction of total costs is for labor costs (61 per cent on average). Following Friedlaender and Chiang (1983), the capital price ( $w_2$ ) is calculated as residual cost (where residual cost is total cost minus labour) divided by the total number of seats in the operator's fleet.<sup>15</sup> Capital price is therefore a measure of all non-labour inputs including materials and energy input.<sup>16</sup> Unfortunately no data were available that would allow us to calculate the capital stock using the capital inventory method. The use of a simple indicator for capital stock can be justified by the fact that the bus companies do not possess a significant stock of capital apart from the rolling stock.

Table 1 provides the sample's descriptive statistics. All the costs and prices are adjusted for inflation using consumer price index and are measured in year 2000 Swiss Francs (CHF). As can be seen in the table, the sample shows a considerable variation in all three outputs. All the companies in the sample provide motor-bus transport. As there were only seven companies (out of 16) with non-zero tramway services, we see from the table that the median output of the tramways is zero.

<sup>15</sup>For an application of this approach in the bus industry see Filippini and Prioni (2003) and Farsi *et al.* (2006).

<sup>16</sup>The energy price is not included directly because energy costs are only a small fraction of total costs (3.4 per cent on average and less than 6.3 per cent for 95 per cent of observations) and also because it does not vary much over time.

Among the sixteen companies in the sample, six offer all three modal transit services; nine provide motor-bus and trolley-bus services; and one firm offers motor-bus and tramway services. All the companies in the sample except one are multi-output operators.<sup>17</sup> Therefore the single-output cases can be considered as exceptions in Switzerland's urban transit system. This issue might create problems in estimating some of the product-specific scale and scope economies, which are based on extrapolation of costs for specific output combinations with zero values. However, this should be considered in the light of the fact that these cost values are second-order approximations at boundary points. These points, being far from the sample mean, might incur relatively high approximation errors in any case.

Moreover, a careful analysis of the sample shows that a considerable number of the companies are highly specialised in a single transport mode. For instance, there exist four two-output companies (about a quarter of the entire sample) whose motor-bus or tramway output consists of more than 80 per cent of their total output in terms of seat-kilometres. Therefore, the estimated scale and scope economies can be reasonably extended to such cases provided that the single-output and multi-output operators use a more or less similar production technology.

For the estimation of product-specific scope and scale economies we will focus on output combinations that are realistic in comparison to the observed cases in the sample. Therefore, we exclude the single-output case with trolley-bus and the two-output case with motor-bus/tram combination, because there is no case with strong specialisation that can be considered closely similar to these two cases.

## 5.0 Results

The estimation results are given in Table 2. As expected, the first-order output coefficients ( $\alpha^1$ ,  $\alpha^2$  and  $\alpha^3$ ) and that of the input price ( $\beta^2$ ) are positive and highly significant. The first-order coefficients suggest that a tramway system has the highest marginal cost, followed by trolley-bus and motor-bus. This order can be explained by the relatively high costs of tramway and trolley-bus systems that require an electricity grid and an additional railway network in the case of tramway. Both these elements have relatively high capital and labour costs that accrue the corresponding

<sup>17</sup>The exception is a bus company that has taken all its trolley-buses out of service in the last three years of the sample period.

**Table 2**  
*Regression Results*

Parameter	Estimate	Parameter	Estimate
$\alpha_0$ (Constant)	922,873.8*	$\alpha^{12}$	0.0011
	(31,080.1)		(0.5685)
$\alpha^1$ (Trolley-bus)	841.0*	$\alpha^{13}$	-0.3974***
	(90.1)		(0.2352)
$\alpha^2$ (Motor-bus)	775.6*	$\alpha^{23}$	0.3594*
	(75.1)		(0.1052)
$\alpha^3$ (Tramway)	898.2*	$\beta^2$ (Capital)	57,657.6*
	(65.3)		(8,735.9)
$\alpha^{11}$	0.2888	$\alpha^n$ Number of (stops)	775.2*
	(0.4404)		(154.8)
$\alpha^{22}$	-0.5466**	$\alpha^t$ (Time trend)	-6,692.2*
	(0.2524)		(1,404.3)
$\alpha^{33}$	-0.2936**	$\rho_i$ (median) (corr. coeff.)	0.71
	(0.1167)		

Note: \*, \*\* and \*\*\* refer to 1, 5 and 10 per cent level of significance respectively. Standard errors are given in parentheses. The measurement units are the same as those used in Table 1.

marginal costs. The quadratic output coefficients terms ( $\alpha^{11}$ ,  $\alpha^{22}$  and  $\alpha^{33}$ ) are negative (except  $\alpha^{11}$ , which is statistically insignificant), suggesting that the marginal cost of any given output is decreasing in that output.

As labour price is used for normalisation, the coefficient  $\beta^1$  is excluded from the normalised quadratic cost function. As expected, the sign of the coefficient  $\alpha_n$  is positive, showing that a higher number of stops increases costs. The negative coefficient  $\alpha_t$  show that companies have reduced their operating costs in the sample time period. The autocorrelation coefficient has also been estimated for all companies. The considerable variation of these values confirms the assumption that the correlation structure varies across firms. These coefficients are greater than 0.7 for half the companies, suggesting the importance of serial correlation in our sample.<sup>18</sup>

The results presented in Table 2 can be used to estimate the economies of scale and scope.

In order to study the variation of scale and scope economies in the sample, we considered several representative sample points regarding outputs. In particular, we estimated the scale economies respectively for output values at the sample mean, median, 1st and 3rd quartiles of non-zero output values. For all non-output variables that enter in the equations, we considered the sample mean values. For instance, the median point consists of the medians of outputs after excluding the zero values with all

<sup>18</sup>The estimated correlation coefficients range from 0.03 to 0.99 with an average value of 0.64 and with a value greater than 0.5 for 12 companies.

**Table 3**  
*Estimates of the Economies of Scale*

Output	SL (global)	SL <sub>2</sub> (motor-bus)	SL <sub>3</sub> (tramway)	SL <sub>12</sub> (trolley/motor-bus)	SL <sub>13</sub> (trolley/tram)
1st Quartile	1.29* (0.09)	1.03** (0.01)	1.03* (0.01)	1.01 (0.03)	1.05* (0.02)
Median	1.19* (0.05)	1.06** (0.02)	1.06* (0.02)	1.01 (0.07)	1.09** (0.04)
Mean	1.16* (0.04)	1.12** (0.05)	1.06* (0.02)	1.05 (0.09)	1.09** (0.04)
3rd Quartile	1.36* (0.11)	1.08** (0.03)	1.43*** (0.23)	1.02 (0.12)	1.58** (0.26)

Note: The estimates labelled with asterisks are significantly greater than 1, with \*, \*\* and \*\*\* referring to the 1, 5 and 10 per cent levels of significance, respectively. Standard errors are given in parentheses.

other variables kept at their mean values. As discussed in the data section, for the product-specific economies, only the realistic output combinations are estimated: that is, the single-output trolley bus and the two-output tram/motor-bus are excluded.

Table 3 shows the point estimates of scale economies along with their standard errors. The estimated global scale economies are significantly greater than one, suggesting increasing returns to scale at all the considered output levels. This implies that the scale economies are not fully exploited in a great majority of the companies. The results also indicate that most of the estimated product-specific coefficients are significantly different from one. Only for a joint production of trolley-bus and motor-bus can the hypothesis of constant product-specific returns to scale not be rejected.

Table 4 shows the point estimates for economies of scope. Similarly to the previous table, only the realistic output combinations are included. Most of the numbers in Table 4 are significantly greater than zero, indicating scope economies at all output levels and across all three output types. For instance the global scope economies of 0.25 at the sample median means that at the median output levels total costs are on average 25 per

**Table 4**  
*Estimates of the Economies of Scope*

Output	SC (global)	SC <sub>2</sub> (motor-bus)	SC <sub>3</sub> (tram)	SC <sub>12</sub> (trolley/motor-bus)	SC <sub>13</sub> (trolley/tram)
1st Quartile	0.41* (0.12)	0.19* (0.06)	0.21* (0.06)	0.37* (0.09)	0.27* (0.07)
Median	0.25* (0.07)	0.09** (0.04)	0.13* (0.05)	0.21* (0.06)	0.21* (0.07)
Mean	0.19* (0.06)	0.05 (0.05)	0.09** (0.04)	0.16** (0.08)	0.21* (0.07)
3rd Quartile	0.12** (0.06)	-0.05 (0.05)	0.07 (0.07)	0.13 (0.10)	0.23*** (0.12)

Note: \*, \*\* and \*\*\* refer to the 1, 5 and 10 per cent levels of significance, respectively. Standard errors are given in parentheses.

cent lower when offering all the three outputs by one company than produced by three specialised firms. In general economies of scope decrease with an increase in outputs. The computed values are statistically different from zero at the 1st quartile and median output levels as well as some of the mean output levels.

While global scope economies remain significant for all output levels, the product-specific economies of scope seem to be exhausted after a certain level of output, as indicated by mostly insignificant values at the 3rd quartile output level. The product-specific economies of scope in the single-output case — that is, when one output is produced by a company and the other two by another company — are in a similar range for both tram and motor-bus at the 1st quartile and median output levels (9–13 per cent for median and 19–21 per cent for the 1st quartile). The joint production of trolley-bus and tramway also yields economies of scope. Even higher are the cost savings from a joint production of trolley-bus and motor-bus (37 per cent at the 1st quartile output level).

It should be noted that the value of the global economies of scale depends upon both product specific economies of scale and economies of scope. The results listed in Table 3 and Table 4 suggest that the global scale economies are driven by strong economies of scope and to a lower extent by product-specific economies of scale. As pointed out by Baumol *et al.* (1982) decreasing average incremental costs of each product along with global scope economies imply subadditivity in costs. Therefore, the results of this paper provide suggestive evidence that the industry can be characterised as a natural monopoly.

## 6.0 Discussion

Several European countries have introduced a competitive tendering procedure in the assignment of a franchised monopoly in the local transport industry. In the case of multi-mode systems the regulator has to decide to open the competitive tendering procedure for supplying the entire transport services or to unbundle the multi-mode systems and open separate tenders for different modes of transport. In order to make the decision the regulator should have information on the economies of scope. Few studies have addressed the issue of scope economies in local transport systems.

The goal of this paper is to make a contribution to the ongoing debate about tendering local transport services. It is argued that the unbundling of transport modes in competitive tendering brings about efficiency benefits

since the level of potential bidders is high and thus competition is more intense. On the other hand, integrated companies benefit from the potential scope economies and reduce the total cost of service planning, since the local authority does not have to integrate the entire range of services provided by the different operators. Of course, in this case the potential number of bidders would be relatively low, since it is difficult for a small operator to provide services in a big city. Therefore, the potential benefits from competition for the market would be lower.

The tradeoff between these two efficiency gains lies at the core of the policy debate about unbundling. Using an empirical analysis of the cost structure of the urban transit companies in Switzerland this paper provides an assessment of scope and scale economies that would be compromised as a result of unbundling. The considered transport modes are motor-bus, trolley-bus, and tramway systems.

The estimation results indicate considerable economies of scope, suggesting that unbundling a multi-mode company into single-output companies might lead to higher costs as the synergies in the joint production can no longer be exploited. Moreover, the results indicate increasing returns to scale in almost all outputs, which combined with cost complementarity can be considered as a suggestive evidence for natural monopoly.

The results of this study provide some insight into the efficiency trade-off of unbundling between the loss of economies of scope and the gain of higher cost efficiency from the introduction of competition for market entry. The assessment of the efficiency gains of unbundling through greater competition remains an open question that needs further research. In particular, it is not clear that the unbundling can be effective in lowering barriers to market entry for some of the transport modes such as tramways that require relatively high infrastructure costs.

An alternative to competitive tendering procedures for the multi-mode transport system could be the introduction of incentive regulation schemes such as ‘yardstick competition’ in which cost-efficiency is induced by controlling each local monopolist based on average costs of similar firms (Shleifer (1985)). The advantage of such regulatory instruments is that they allow a complete exploitation of the economies of scale and scope while avoiding the implementation problems related to competitive tendering policies for urban transit systems.

Finally, it should be noted that unbundling might also have undesired consequences for quality of service. Namely, the integrated multi-mode operators have a better flexibility in minimising the disruptions and lowering the instability of their timetables by reallocating across different modes. Moreover, with lower transaction costs related to information and communication, such companies have a greater opportunity to create trust among

the consumers, thus reaching higher levels of quality as perceived by society.

## References

- Bailey, E. E. and A. F. Friedlaender (1982): 'Market Structure and Multiproduct Industries', *Journal of Economic Literature*, 20(3), 1024–48.
- Baltagi, B. H. (2001): *Econometric analysis of panel data*, Wiley, Chichester.
- Baumol, W. J., J. C. Panzar, and R. D. Willig (1982): *Contestable Markets and the Theory of Industry Structure*, Hartcourt Brace Jovanovich, New York.
- Berechman, J. (1987): 'Cost Structure and Production Technology in Transit: An Application to the Israeli Bus Transit Sector', *Regional Science and Urban Economics*, 17(4), 519–34.
- BFS (1985–97): Der öffentliche Verkehr, Bundesamt für Statistik, Bern.
- Bhattacharyya, A., S. C. Kumbhakar, and A. Bhattacharyya (1995): 'Ownership Structure and Cost Efficiency: A Study of Publicly Owned Passenger-Bus Transportation Companies in India', *Journal of Productivity Analysis*, 6(1), 47–61.
- Button, K. J. and K. J. O'Donnell (1985): 'An examination of the cost structures associated with providing urban bus services in Britain', *Scottish Journal of Political Economy*, 32(1), 67–81.
- Cambini, C. and A. Boitani (2006): 'To bid or not to bid, this is the question: the Italian experience in competitive tendering for local bus services', *European Transport*, 33, 41–53.
- Cambini, C. and M. Filippini (2003): 'Competitive Tendering and Optimal Size in the Regional Bus Transportation Industry: An Example from Italy', *Annals of Public and Cooperative Economics*, 74(1), 163–82.
- Caves, D. W., L. R. Christensen, and M. W. Tretheway (1980): 'Flexible Cost Functions for Multiproduct Firms', *Review of Economics and Statistics*, 62(3), 477–81.
- Caves, D. W., L. R. Christensen, and M. W. Tretheway (1984): 'Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ', *The RAND Journal of Economics*, 15(4).
- Cochrane, D. and G. H. Orcutt (1949): 'Application of Least Squares Regression to Relationships Containing Autocorrelated Error Terms', *Journal of the American Statistical Association*, 44, 32–61.
- Colburn, C. B. and W. K. Talley (1992): 'A firm specific analysis of economies of size in the U.S. urban multiservice transit industry', *Transportation Research*, Part B(3), 195–206.
- Farsi, M., M. Filippini, and M. Kuenzle (2006): 'Cost efficiency in regional bus companies: An application of new stochastic frontier models', *Journal of Transport Economics and Policy*, 40(1), 95–118.
- Fazioli, R., M. Filippini, and P. Prioni (1993): 'Cost-Structure and Efficiency of Local Public Transport: The Case of Emilia Romagna Bus Companies', *International Journal of Transport Economics*, 20(3), 305–24.
- Featherstone, A. M. and C. B. Moss (1994): 'Measuring Economies of Scale and Scope in Agricultural Banking', *American Journal of Agricultural Economics*, 76(3), 655–61.
- Filippini, M. and P. Prioni (1994): 'Is Scale and Cost Inefficiency in the Swiss Bus Industry a Regulatory Problem? Evidence from a Frontier Cost Approach', *Journal of the Economics of Business*, 1(2), 219–31.

- Filippini, M. and P. Prioni (2003): 'The Influence of Ownership on the Cost of Bus Service Provision in Switzerland — An Empirical Illustration', *Applied Economics*, 35(6), 683–90.
- Fraquelli, G., M. Piacenza, and G. Abrate (2004a): 'Regulating Public Transit Networks: How Do Urban-Intercity Diversification and Speed-Up Measures Affect Firms' Cost Performance?' *Annals of Public and Cooperative Economics*, 75(2), 193–225.
- Fraquelli, G., M. Piacenza, and D. Vannoni (2004b): 'Scope and Scale Economies in Multi-utilities: Evidence from Gas, Water and Electricity Combinations', *Applied Economics*, 36(18), 2045–57.
- Friedlaender, A. F. and W. Chiang (1983): 'Productivity Growth in the Regulated Trucking Industry', *Research in Transportation and Economics*, 1, 149–84.
- Gillen, D. W. and T.-H. Oum (1984): 'A Study of the Cost Structures of the Canadian Intercity Motor Coach Industry', *Canadian Journal of Economics*, 17, 369–85.
- Greene, W. H. (2003): *Econometric analysis*, Prentice-Hall Pearson Education International, Upper Saddle River.
- Jara-Diaz, S. R., E. Martinez-Budria, and F. J. Ramos-Real (2003): 'Adapting Productivity Theory to the Quadratic Cost Function: An Application to the Spanish Electric Sector', *Journal of Productivity Analysis*, 20(2), 213–29.
- Kmenta, J. (1986): *Elements of econometrics*, Macmillan, New York.
- Mayo, J. W. (1984): 'Multiproduct Monopoly, Regulation, and Firm Costs', *Southern Economic Journal*, 51(1), 208–18.
- Pulley, L. B. and D. B. Humphrey (1993): 'The Role of Fixed Costs and Cost Complementarities in Determining Scope Economies and the Cost of Narrow Banking Proposals', *Journal of Business*, 66(3), 437–62.
- Shaw-Er, J., W. Chiang, and Y.-W. Chen (2005): 'Cost Structure and Technological Change of Local Public Transport: The Kaohsiung City Bus Case', *Applied Economics*, 37(12), 1399–410.
- Shleifer, A. (1985): 'A Theory of Yardstick Competition', *RAND Journal of Economics*, 16(3), 319–27.
- Viton, P. A. (1992): 'Consolidations of Scale and Scope in Urban Transit', *Regional Science and Urban Economics*, 22(1), 25–49.
- Viton, P. A. (1993): 'How big should transit be? Evidence on the benefits of reorganization from the San Francisco Area', *Transportation*, 20, 35–57.
- Waldman, D. E. and E. J. Jensen (2001): *Industrial organization theory and practice*, Addison-Wesley, Boston.
- Windle, R. J. (1988): *Transit Policy and the Cost Structure of Urban Bus Transportation*, in Dogson, J. S. and N. Toppan (eds.), *Bus Deregulation and Privatisation*, Chapter 6, Brookfield.
- Wooldridge, J. M. (2002): *Econometric analysis of cross section and panel data*, MIT Press, Cambridge and London.