Assessing standard costs in local public bus transport: evidence from Italy

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Abstract

We present a regression model for estimating unit standard costs for the Italian local public bus transport services. We account for quantitative and qualitative characteristics, which contribute to explain the variability of the cost structure. Economic and transport data have been collected from companies producing more than 500 million of bus-kilometers. We find that commercial speed is the most important cost driver, while economies of scale are low and only present in small size services. Results prove a positive correlation between investments in bus fleet and the cost incurred in service provision. Finally, we show how the regression model can be augmented with policy targets in order to fairly allocate among Italian Regions the public funds yearly earmarked to the local public transport sector.

Keywords

standard costs, local public transport, fiscal federalism, cost proxy models

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1. Introduction

The principle of standard costs was introduced in the Italian legislation as far back as 1997 (legislative decree n. 422, art. 17, comma 1, 19 November 1997) to pursue the goal of a fairer distribution and a more efficient use of public resources devoted to local public transport (LPT). The standard cost should reflect the cost of a LPT service provided by an efficient operator and given a specified service quality (where the efficiency level are defined on the basis of the activities and costs of several operators and/or knowledge of the industrial process for the provision of LPT services). Actual unit costs varied in 1997 widely across regions and cities, presumably reflecting varying degrees of (in)efficiency. A history-dependent cost-plus allocation of public funds to LPT subsidies contributed to build up differential inefficiencies and to differently inflate costs. An inequitable distribution of public funds among regions and cities resulted.

The mentioned 1997 bill stated that non-tendered concessions were to be banned by 2004. The programming of the services and the management of the subsidies have been shifted from the national to the regional level. Later legislative interventions left discretion to local authorities whether tendering out concessions or making use of *in house* provision. Because of the fluctuations in the governance rules, competitive tendering did take place in just a few regions and in one large city (Milan), where only one bid (by the incumbent) was submitted in a largely tailor-made tendering procedure. Since 2009, all legislative interventions reaffirmed the crucial role played by standard costs in pursuing the goal of improving the allocative and productive efficiency of LPT operators[1]. The 2013 Budget (Law n.147/2013, art.1, clause 84) explicitly defines the unit standard cost as total cost per vehicle-kilometer, to be determined by taking into account commercial speed, economies of scales, production technologies, the rolling stock renewal and a reasonable profit. Local authorities and LPT firms are required to sign a *service contract*, whether tendering out concessions or making use of in house provision (Boitani and Cambini, 2006; Hensher and Wallis, 2005; Boitani, Ponti and Ramella, 2013), and, according to a bill passed in 2012 (L. 135/2012), related economic compensations to LPT firms should not generally exceed the standard cost of the service. This implies that standard costs should be used as reserve-prices in tendering procedures. However, to the present date, standard costs have not been applied, nor an appropriate methodology for their calculation has been adopted.

The kick-start to the present paper was the appointment of the authors in a ministerial committee in charge of collecting data and developing a workable model for gauging standard costs in the Italian local public *bus* transport sector. We do not use a frontier approach in order to define the minimal efficient cost for the provision of LPT services, because of the general will of the Minister of Infrastructures and Transport (MIT) and of the Italian Regions for a *gradual* financial reorganization of the LPT sector. Thus, the proposed standard cost reflects an achievable average-efficient cost of LPT services provided by an operator, given a specified service quality. The paper contributes to the literature and to the policy debate on three counts. First, at a macro-level, the model can be employed by policy makers to introduce regulatory constraints on the allocation of public funds among regions and local authorities. Second, similarly to the approach suggested in Hensher et al. (2013)[2], our results might be used at a

[1] Reference is to be made to: L. 42/2009; L. 216/2010; L. 228/2012; L. 147/2013.

[2] Hensher et al. (2013) introduce a simplified performance-linked payment (SPLP) model that can be used as a benchmark in assessing the subsidies that an Authority should recognize to a LPT operator. Similarly to ours, the

micro-level to define the upper bound on firms' compensation in competitive tendering procedures, by exploiting the favourable incentive properties of yardstick competition (Shleifer 1985). Indeed, local authorities have an incentive to design contracts to be auctioned in such a way that bidders have in turns an incentive to "beat" the standard which (by the law) must be available to potential competitors prior to any competitive tendering procedure. However, the yardstick competition principle is at work also were contracts are not tendered out, as local authorities may either increase the quantity/quality of the service or put resources to alternative uses if the local monopolistic LPT operator is able to reduce its actual cost below the standard level. Third, a detailed data set is used to estimate the model: economic and transport data have been collected from companies producing more than 500 million of bus-kilometers. In particular, detailed information has been gathered in order to fairly compute the total economic cost of the local bus transport services observed in 2011.

The paper is organized as follows. Section 2 contains the literature review. Section 3 identifies cost categories which define the standard cost model and the key aspects of the production process of local public bus transport services. Section 4 describes the data set and variables. Section 5 presents the model and the results, while Section 6 develops some test examples and policy implications. Section 7 concludes.

2. Literature Review

A burgeoning literature explores the cost structure of LPT bus companies. Most empirical studies make use of a parametric regression approach (for a critical review see Daraio et al. 2016): in most cases Ordinary Least Squares (Merewitz, 1977; Alexandersson et al., 1998); in other cases, Seemingly Unrelated Regressions such as Cambini et al. (2007). While earlier studies (such as Koshal, 1970; Miller, 1970; Pucher et al., 1983) mainly focus on input-output relations, more recent studies estimate variable and total costs (e.g., among others, Obeng and Sakano, 2002; Fraquelli et al. 2004; Cambini et al. 2007; Ottoz and Di Giacomo, 2012). Two different approaches have been used in order to measure output: supply-side indicators such as vehicle-kilometers (Cambini and Filippini 2003) or seat-kilometers (Farsi et al., 2007; Gagnepain and Ivaldi, 2002); demand-oriented measures, such as passenger-trips or passenger-kilometers (Bhattacharyya et al., 1995). Which of the two approaches is the most appropriate has been widely debated without achieving an agreement (see Berechman and Giuliano, 1985; De Borger and Kerstens, 2000; De Borger et al., 2002). However, when the focus is on costs, as in this paper, seat-kilometers or vehicle-kilometers are usually considered as appropriate output measures. Most papers include, among the explanatory variables, hedonic characteristics. Commercial speed, service size and the average fleet age are the most frequently employed (see Daraio et al. 2016). In the model presented in this work we consider size, commercial speed and the average fleet age as fundamental drivers in a standard cost function. In Section 3 we further discuss the role of each driver in defining quality (and thus cost) of a LPT service.

The focus of the above mentioned literature is on scale and density economies. Cambini et al. (2007) points towards the presence of economies of network density and scale economies,

cited model internalizes the effects of exogenous variables (not under the control of operators), such as commercial speed, on the cost of LPT services.

especially for urban LPT services. Fraquelli et al. (2004) finds evidence in support of both scale and scope economies. In the same vein, Filippini and Prioni (2003) finds the presence of considerable economies of scale for all size classes, comparing Italian and Swiss companies. Conversely, scale diseconomies are found in the studies by Bhattacharyya et al. (1995), Jha and Singh (2001), Levaggi (1994) and Matas and Raymond (1998). Diseconomies of scales are found also in Boitani et al. (2013). Finally, Fraquelli et al. (2001) finds that the average cost per seat-kilometers is U-shaped.

Another branch of the literature related to the present paper focuses on the impact of alternative contract schemes within one country, such as, for instance, Norway (Dalen and Gomez-Lobo, 1996; 2003), France (Kerstens, 1996; Gnagnepain and Ivaldi, 2002; Roy and Yvrande-Billon, 2007; Gautier and Yvrande-Billon, 2013), Italy (Piacenza, 2006; Buzzo Margari et al., 2007). These studies confirm that firms operating under high-powered incentive schemes, such as fixed-price contracts, are more efficient than firms operating under low-powered incentive schemes, such as cost-plus contracts. Dalen and Gomez-Lobo (2003) point out that by 1992-1993, the standard-cost model had become the most popular contract with 9 out of 19 Norwegian counties. They use a linear model that links driver costs, fuel costs, and maintenance costs (excluding the cost of capital) to the number of bus-kilometers produced for different categories of routes. Overall, their results suggest that firms regulated under the yardstick type contract exhibit less than half the cost inefficiency compared to those firms regulated under the individual contract or subsidy-cap contract[3]. Within individual contracts, counties bargain annually and individually with each company over both costs and transfers. Within subsidy-cap contracts, the companies and the county agree upon a reduction in the level of governmental transfers by X% per year, over a five years period (Dalen and Gomez-Lobo, 2003). In addition, the firms regulated with the yardstick type contract reduce cost inefficiency faster.

These studies mainly target the causes of inefficiencies and the cost structure of firms in order to identify the proper configuration of a network, or else they enquire to what extent the standard-cost model and different type of regulatory contracts affect the cost performance of LPT companies. However, they disregard the *ex-ante* definition of the standard cost of a service as an instrument either for the allocation of public funds to local authorities or the definition of the economic compensation earmarked to LPT firms in competitive tendering procedures. The present paper is aimed at filling this gap by developing a model for the estimation of unit standard costs for the Italian local public bus transport sector. For the sake of notation, we simply refer to LPT as to indicate the local public *bus* transport.

3. Cost categories and drivers

We first identify the items included in the cost basis (data from the sample are summarized in Table 3). They are: (i) operation and maintenance costs; (ii) administrative costs and other overheads; and (iii) the cost of capital (the effect of Regional Business Tax, IRAP, has also been taken into account). The cost of capital is based on an estimation of the pre-tax Weighted Average Cost of Capital (WACC) of the LPT sector, namely, the minimum return on the net invested capital that has to be generated to fully reward all providers of financial resources, that

[3] For an early theoretical assessment of the efficiency properties of a subsidy cap contract see Boitani and Cambini (2002).

is, debt and equity (Damodaran, 2012). Following the literature (Berechman, 1987; Cambini et al., 2007, Filippini and Prioni, 1994; Karlaftis and McCarthy, 1999; Piacenza, 2006; Viton, 1981; Williams, 1979), the number of vehicles owned by each firm has been used as a physical proxy of the invested capital, while the net value of those vehicles has been considered as a proxy of the net invested capital. It is not easy to verify the goodness of this approximation as many firms are typically multi-utilities and their balance sheet statements rarely report separate detailed data relating to invested capital exclusively devoted to LPT services. However, the net book value of vehicles appears to be a good approximation of the book value of the net invested capital as for many companies in our sample.

In order to calculate the economic cost for the provision of a specific transport service, the *total* number of owned vehicles should be considered (gross of non-repayable public funds), including those given to LPT firms free of charge by the local authority. The value of other inputs an operator obtains free of charge from the local authority, such as depots, should also be summed to the value of other inputs employed in the production process[4]. Since operators may use different depreciation period for fixed assets, the depreciation rate has been readjusted by considering a uniform depreciation period, so as to fairly compare the production costs of services. A technical group of transport experts, appointed by the MIT, provided an estimate of the average technical life of any fixed asset: (i) by taking into account the physical life of the asset and the expected technology enhancements, (ii) by assuming that ordinary maintenance is regularly carried out. Moreover, the depreciation period has been set equal to the technical life by assuming that the resale value of an asset at the end of its technical life is close to zero. Possible extraordinary maintenance of the assets is usually capitalized and thus it is considered as an additional asset. The depreciation life (inclusive of extraordinary maintenance) for buses and for depots has been set by the technical group equal to 15 years and 32.5 years, respectively.

Since most of the interviewed operators do not apply the international accounting standards, they are not able to provide fair values of the assets actually used. Depreciation reflects just a nominal amount of the assets value yearly consumed in the production process. Therefore, in order to assess the correct economic value of fixed assets, we deem appropriate to apply the current cost accounting method, where an estimate of the current market value of the assets can be obtained by multiplying the gross book value by a suitable deflation index (provided by the Italian National Institute of Statistics) depending on the age of the asset.

In order to have a clear understanding of the operational aspects of LPT services, first we follow the approach in Wunsch (1996) by estimating the average cost per bus-kilometer ($CSkm$) for each observed service, i.e., the ratio between total cost and the number of bus-kilometers in service. This is the dependent variable in a linear regression model. Second, we propose a simplified functional form focusing on the limited number of variables defined by Law n.147/2013, art.1, clause 84. Those variables actually turn out to explain most of the variability of costs in our sample. We do not use an ordinary frontier approach in order to define the minimal efficient cost for the provision of local public transport services. Our choice hinges on the general will of MIT and of the Italian Regions for a *gradual* financial reorganization of the LPT sector by means of yardstick competition. In fact, in the proposed approach, the stick to

[4]An appraisal and evaluation of free inputs has been only possible for vehicles. In fact, the design of the questionnaire was a compromise between the need for detailed information and the willingness of operators to provide data. Hence, data on free-loan depots were not collected.

be used is not the frontier-efficient cost but a within reach average-efficient cost. Thus, in this yardstick competition framework, the proposed standard cost approach provides similar incentives, although less severe punishments than those provided by a frontier approach. In this vein, the policy maker will periodically update unit standard costs.

3.1 Key aspects of the production process

In order to classify the main drivers of total cost and accordingly define the cost function to be estimated, it is necessary to analyze the technological features and the inputs entering the production process. To this purpose, interviews have been conducted with engineers and managers of LPT firms in our sample. The outcome of these interviews is summarized in the following observations.

Observation 1. Commercial speed is defined as the ratio between the total number of bus-kilometers supplied per year and the number of driving hours (from start to end of the line). Data may be derived through Automatic Vehicle Monitoring (AVM) systems, or through surveys conducted by the operating personnel. As there is only one driver per ride, the denominator is equal to the total number of *net* driving hours (i.e., excluding bus-kilometers driven out of service). Therefore, an effective estimation of commercial speed is obtained as the ratio between the number of bus-kilometers and the number of *net* driving hours per year. It is worth noting that in Italy *net* driving hours also include a short break of a few minutes at the end of each ride, and that the duration of a break depends on the ride type (e.g., at the end of any high-frequency service ride a break of three minutes is accounted as driving time). Commercial speed is perceived by users as a qualitative characteristic of the service and captures, at the same time, different aspects such as road congestion, the average distance between consecutive stops, the average slope of the road or the average level of road maintenance.

Observation 2. LPT services are mainly labor (rather than asset) intensive. Labor costs - of which driving personnel is the most significant part - determine, on average, more than half of the production cost. The number of bus-kilometers that each driver is able to provide depends, first, on commercial speed and, second, on the service type (i.e., urban or intercity).[5] Indeed, the provision of a urban service allows a more efficient organization of daily shifts compared to the provision of an intercity service. Since drivers take longer breaks between two intercity rides and the number of out of service kilometers is higher in intercity services compared to urban services, the number of *net* yearly intercity driving hours per driver is structurally lower. Thus, an increase in commercial speed as for urban services allows higher productivity gains compared to the case of intercity services. Moreover, a correlation exists between high commercial speed and intercity services, as well as low commercial speed and urban services. Thus, when commercial speed is low, the marginal effect of an increase in commercial speed on costs is expected to be high. The marginal effect of the commercial speed is expected to be moderate when commercial speed is high to start with.

[5] A urban service is defined as a service provided within high or low-density municipalities, typically, with high frequency and close stops. As opposite, an intercity service connects two or more municipalities either within a region or in two neighboring regions (typically, they are scheduled services and stops are sufficiently far removed).

Observation 3. There is a direct relation between commercial speed and the number of bus-kilometers per year per vehicle, i.e., the slower a vehicle runs the lower the number of bus-kilometers per year. However, the same vehicle may be used by several drivers in a day, that is it may be employed in several shifts. Therefore, even when commercial speed is low, the number of bus-kilometers per year may be increased by using the same vehicle for longer hours. In other words, services characterized by different commercial speed will differ in terms of the number of bus-kilometers yearly driven by each driver (Observation 2). However, the difference will be smaller when measured by the number of bus-kilometers yearly run by each vehicle. As already noted, drivers typically take a longer break between consecutive rides in intercity services, and this adversely affects the number of bus-kilometers driven yearly by each vehicle. Thus, it can be expected that the number of bus-kilometers yearly run by each vehicle with low commercial speed do not differ much from those with high commercial speed.

Observation 4. Fuel and energy consumption (with electric-wheel and hybrid buses) is higher when the service is provided at low commercial speed. Hence, the powertrain cost is higher the lower the commercial speed services. The relation between fuel consumption and commercial speed is moderately nonlinear.

Observation 5. A consortium of small LPT firms or a big LPT firm may display both economies and diseconomies of scales in input procurement. For instance, by means of well-designed tenders for the procurement of a sufficiently high number of buses, a firm may be able to pay a lower unit price and thus inducing pecuniary economies of scales. On the other hand, second-tier wage negotiation in large corporations may deliver higher wages and/or shorter working hours to union members, whereas in small to medium enterprises second-tier negotiations are often nonexistent or barely delivering. Some large firm lament the existence of cartels among fuel suppliers, which prevent them from obtaining quantity-discounts and from exploiting pecuniary economies of scale.

Observation 6. The average age of vehicles used by firms in our sample is very high (particularly as for intercity services) and, in most cases, they are diesel powered. In order to reduce a bus fleet average age and/or its environmental impact higher investment and thus a higher level of depreciation is required.

By taking into account Observations 1 to 4, we expect the impact of commercial speed to be significant and nonlinear, as a marginal increment of commercial speed would reduce the unit cost more as for low-speed services than as for high-speed services. Following Observation 5, the service size (the number of bus-kilometers) could positively influence the ability of a LPT operator to acquire inputs in imperfectly competitive markets, whilst it could negatively impact the levels of the daily drivers' productivity due to unions high bargaining power in second-tier wage negotiations. A nonlinear impact of size on the unit cost of service might then be expected. Finally, Observation 6 suggests that cost differences may arise due to different powertrain technologies and to varying fleet age.

4. Data and variables

Disaggregated information about costs (e.g., labor, energy, materials and services, capital) and about technical and environmental characteristics (e.g., average fleet age, average commercial speed, service size) have been collected by means of questionnaires sent to managers of 45

Italian private (20) and public-owned (25) companies, providing LPT services in 13 Italian Regions (see Table 1). The questionnaire has been later adopted by the national Observatory on Local Public Transport Policies, which is in charge of collecting economic and transport information from LPT firms and creating a complete, certified and constantly updated database for the monitoring of this industry.

Our dataset consists of a cross section of 54 instances, in the following referred to as *service bundles*. A *service bundle* is the set of one or more service contracts for which the firm is able to measure (only) jointly its direct and indirect costs. Indeed, Italian local authorities are allowed to design the geographical boundaries of the service areas to be assigned to firms through a single or multiple service contracts. 39 firms in our database operate 1 bundle only; 4 firms operate 2 service bundles (accounting for 8 instances); 1 firm operates 3 bundles (accounting for 3 instances); and 1 firms operates 4 bundles (accounting for 4 instances). As for the type of service, companies provide only urban transport service in 14 bundles; companies provide only an intercity transport service in 27 bundles and in the remaining ones companies provide both services. 27 service bundles are localized in the Northern Regions, while 15 and 12 service bundles are localized in Central and Southern Italy, respectively. Finally, as for size 13 service bundles are large (more than 10 million of bus-kilometers), 15 medium-sized (4 to 10 million) and 26 small (less than 4 million). We can maintain that firms in our sample are fairly representative of the universe of Italian LPT operators as the above figures are broadly consistent with the descriptive statistics on Italian firms, as for type and size of service (National Transport Statistics Factbook 2013-2014). For instance, in 2013, 53% of Italian LPT firms provided only intercity services and supplied 60% of the total number of bus kilometers. Official statistics also confirm that the majority of Italian LPT firms are small to medium enterprises.

== *Insert Table 1* ==

Table 2 contains the descriptive statistics for some variables characterizing the service bundles included in the sample (the coefficient of variation is calculated as the ratio between the standard deviation and the mean). The number of bus-kilometers provided in a bundle (excluding out-of-service kilometers) is a good proxy of the overall size of the service.

== *Insert Table 2* ==

Table 3 shows the average share of different cost items on the total cost per bus-kilometer. Labor cost (driving, depots and movement personnel - e.g., verifiers, personnel assigned to shifts organization) accounts for 40% of total cost per bus-kilometer, fuel for 13%, maintenance 15% and depreciation of the bus fleet 8%. The imputed costs of leased and free of charge vehicles, the depreciation of depots and the annual rent for leased depots are, respectively, 0.8%, 0.8% and 0.5% of the total cost per bus-kilometer. Finally, the share of administrative costs and other overheads is 16%, while the cost of capital (including the effect of the IRAP, Imposta Regionale sulle Attività Produttive – Regional Business Tax) is 6%.[6]

== *Insert Table 3* ==

Table 4 shows the average incidence of different components on the cost per bus-kilometer when different categories of service bundles are considered. The variable $\%kmIC$ stands for the percentage of bus-kilometers provided in the intercity segment of each service bundle. In particular, where companies provide jointly intercity and urban service, $\%kmIC$ is up to 60% in 6 service bundles, while it approaches 100% in the remaining 7. The total cost exhibits a slight cross-sectional variability. In 2011, the unit cost in the urban segment ($\%kmIC = 0\%$) is about 1.3 $€/km$ higher than the unit cost in the intercity segment ($\%kmIC = 100\%$). The largest gaps refer to labor cost, to the cost of maintenance as well as to the administrative costs and other overheads, which are, respectively, 0.88 $€/km$, 0.29 $€/km$ and 0.19 $€/km$ higher in the urban segment. In the joint-service bundles the cost per bus-kilometer is 21% lower compared to the urban segment, where the percentage of bus-kilometers provided in the urban segment falls in the range $0 < \%kmIC \leq 60\%$. Moreover, it is 9% lower compared to the intercity segment, when the percentage of bus service-kilometers provided in the intercity segment of the industrial basin is fairly large ($60 < \%kmIC < 100\%$).

== *Insert Table 4* ==

Based on observations presented in Section 3.1, in order to explain the variability of the unit costs of LPT services in 2011, we build a linear multiple regression model of the unit cost by employing the following explanatory variables:

- VC (km/h): commercial speed. This is a qualitative (hedonic) characteristic of a service, which can be barely controlled by the LPT firm.
- KM ($mln\ of\ km$): million of bus-kilometers.
- Akm ($€/km$): degree of renewal of the fleet. This variable is defined as the ratio between a monetary value and bus kilometers. The monetary value is the sum of all depreciations of owned vehicles (gross of non-repayable public contributions,

[6] Labor costs (driving, depots, movement, maintenance, and administrative) include health and social insurance and retirement funds. Maintenance costs include maintenance outsourced to third parties, the cost of spare parts, labor costs for in-house maintenance, the cost of equipment, machinery and other fixed assets used for in-house maintenance (net of extraordinary maintenance capitalized within the fiscal year). Administrative costs include, among others, labor costs of personnel employed in general activities. Other costs include costs related to the provision of LPT services within the service bundle which are not included in other cost elements, such as tolls, hardware and AVM software. The cost per bus-kilometer has been calculated taking into account an (equivalent) yearly rent for each vehicle handed over free of charge to the firm, determined as the minimum between a rent estimated on the basis of owned vehicles and the average rent of rented/leased vehicles. We remark that IRAP is a local tax levied on the value of production generated in each tax period in Italian Regions by, among others, corporations resident in Italy for tax purposes.

calculated by applying the current cost accounting method, and adjusted by assuming a 15 years depreciation life) and rents/leasing for non-owned vehicles. This variable identifies a qualitative characteristic, which can be controlled by the LPT firm.

Table 5 shows the descriptive statistics for all the variables included in the cost model.

== *Insert Table 5* ==

5. Methodology and empirical results

5.1 The econometric model

In order to take into account the nonlinear relationships, conjectured in Section 3.1, between cost per bus-kilometer and the commercial speed and service size, we propose three models. As regards the effect of service size (KM) we consider a piecewise linear function, whilst the relationship between the unit cost and the degree of renewal of the fleet (Akm) has been modeled as a linear function. As regards the effect of commercial speed (VC) we tested three non-linear functional forms. *Model (1)* consists of a least-squares estimation of a piecewise linear regression:

$$CSkm = \alpha_0 + \beta_{VC} \times VC + \beta_{VC1} \times D_{VC1} \times (VC - 17) + \beta_{VC2} \times D_{VC2} \times (VC - 32) + \gamma_{KM1} \times D_{KM1} \times KM + \gamma_{KM2} \times D_{KM2} \times KM + \sigma \times Akm \quad (1)$$

The dummy variables, $D_{VC1}, D_{VC2}, D_{KM1}, D_{KM2}$, model the nonlinear relationships between CS_{km} and both VC and KM:

$$D_{VC1} = \begin{cases} 1 & if\ VC \geq 17\ km/h \\ 0 & otherwise \end{cases}$$
$$D_{VC2} = \begin{cases} 1 & if\ VC \geq 32\ km/h \\ 0 & otherwise \end{cases}$$
$$D_{KM1} = \begin{cases} 1 & if\ KM \leq 4\ mln\ km \\ 0 & otherwise \end{cases} \quad (1.1)$$
$$D_{KM2} = \begin{cases} 1 & if\ KM > 4\ mln\ km \\ 0 & otherwise \end{cases}$$

The breakpoints for each dummy have been identified, on the one hand, in order to maximize the explained variance of cost and preserve the high statistical significance of the coefficients. On the other hand, interviews to policy makers and managers of LPT firms pointed to the existence of three different classes of services – urban, intercity and *suburban* – which correspond to three different classes of commercial speed[7]. Thus, the upper and the lower bounds of these breakpoints expected ranges have been chosen in order to mirror this distinction. This is consistent with Observation (1) to (4), according to which the impact of commercial speed would be significant and nonlinear, as a marginal increment of commercial

[7] A suburban bus service is a commuter passenger bus transport service that primarily operates between a city centre and its belt suburbs, which normally draw large numbers of commuters. Compared to an intercity service, suburban bus services normally exhibit lower commercial speed, close to that of urban bus services.

speed would reduce the unit cost more in the case of low-speed services than in the case of high-speed services.

Model (2) represents the impact of the commercial speed on the unit cost through a hyperbolic function:

$$CSkm = \alpha_0 + \frac{\beta_{VC}}{VC - 5} + \gamma_{KM1} \times D_{KM1} \times KM + \gamma_{KM2} \times D_{KM2} \times KM + \sigma \times Akm \qquad (2)$$

where the asymptote of the regressor $1/(VC - 5)$ has been selected in order to maximize the fitness of the regression and the significance of the parameters. Finally, *Model (3)* captures the impact of the commercial speed on the unit cost by means of a logarithmic form:

$$CSkm = \alpha_0 + \beta_{VC} \times \ln(VC - 11) + \gamma_{KM1} \times D_{KM1} \times KM + \gamma_{KM2} \times D_{KM2} \times KM + \sigma \times Akm. \qquad (3)$$

Again, the threshold value of the regressor $\ln(VC - 11)$ has been chosen to maximize the fitness of the regression and the statistical significance of the parameters.

All models deliver similar results. The estimated coefficients are all statistically significant and high R^2 and adjusted-R^2 prove the goodness of fit of the three models. For all three models, the hypothesis of heteroscedasticity in the errors can be rejected. In addition, multicollinearity is not an issue (obviously, variables VC, $D_{VC1} \times (VC - 17)$ and $D_{VC2} \times (VC - 32)$ in the piecewise model are inter-correlated by construction). In Table 6 the results of the estimated models are summarized.

== *Insert Table 6* ==

It is apparent the crucial role played by a limited number variables in explaining the cost differences amongst operators as well as mimicking the operational aspects characterizing LPT services. Several other regression models have been estimated. These alternative models comprised a larger set of explanatory variables, such as: (i) the number of driving hours, (ii) the number of drivers, (iii) the number of bus-kilometers per vehicle, (iv) a dummy for private/public ownership, (v) the number of driving hours per driver in the urban/intercity segment. However, the corresponding estimations did not prove to be statistically significant. Commercial speed strongly impacts on the number of driving hours and on the number of drivers and thus it captures the effects of the other two variables. The number of bus-kilometers per vehicle is a driver of the bus fleet size and thus it is already represented by the degree of renewal of the fleet. The difference between private and public ownership is not statistically significant. The covariate related to service size captures the possible cost of unionization in large firms mentioned above.

Robustness has been checked by carrying the analysis at the firm-level, i.e. after aggregating the services provided by the same firm in distinct bundles. Results are consistent with the analysis carried out at the bundle-level and the corresponding estimation of the model shows a high goodness of fit. In particular, economies of scale are only at work up to 5 million of bus-kilometers, which suggest the presence of weak synergies at a corporate-level. A "negotiation effect" related to firm size also survives leading to pecuniary diseconomies of scale, which can also be explained by greater slack in the management of drivers daily shifts.

5.2 Causes of variability in unit standard costs

In this sub-section (and in Section 6) we examine the impact of the explanatory variables on the unit standard cost and we focus on model (1) for two reasons. Firstly, as noted, *Model (1)* identifies three classes of services according to the commercial speed - urban, intercity and suburban - as commonly agreed amongst policy makers managers and engineers of LPT. Secondly, *Model (1)* provides more intuitive policy implications compared to the curvilinear *Model (2)* and *Model (3)*, whilst delivering similar qualitative results. Focusing on the effect of VC, for instance, the slope of the linear function, which measures the average variation of the standard cost per bus-kilometer when VC marginally increases (and KM and Akm do not vary), is constant in each segment. This means that, when commercial speed is low, raising the commercial speed by 1 km/h allows to save 0.58 €/km per bus-kilometer provided at a speed up to 17 km/h. In the curvilinear models, the marginal effect of VC on the standard cost varies with VC. In other words, the piecewise regression model allows the policy maker to straightforwardly appreciate the changes of the unit cost.

In fact, equation (1) can be rewritten as follows:

$$CSkm = \alpha + \beta \times VC + \gamma \times KM + \sigma \times Akm \tag{4}$$

where, as for the intercept α, it results:

$$\alpha = \begin{cases} \alpha_0 & VC < 17\ km/h \\ \alpha_0 - 17\beta_{VC1} & 17\ km/h \leq VC < 32\ km/h \\ \alpha_0 - 17\beta_{VC1} - 32\beta_{VC2} & VC \geq 32\ km/h \end{cases} \tag{5}$$

while, for the partial coefficients, it results:

$$\beta = \begin{cases} \beta_{VC} & VC < 17\ km/h \\ \beta_{VC} + \beta_{VC1} & 17\ km/h \leq VC < 32\ km/h \\ \beta_{VC} + \beta_{VC1} + \beta_{VC2} & VC \geq 32\ km/h \end{cases} \tag{6}$$

$$\gamma = \begin{cases} \gamma_{KM1} & KM \leq 4\ mln\ km \\ \gamma_{KM2} & KM > 4\ mln\ km \end{cases} \tag{7}$$

5.2.1 The effect of commercial speed

The dummy variables D_{VC1} and D_{VC2} affect both the intercept α and the coefficient β, which measures the average variation of the standard cost per bus-kilometer when VC marginally increases (and KM and Akm remain constant). Given equations (5) and (6), the nonlinear impact of the commercial speed on the standard cost per bus-kilometer may be identified for a fixed scale and renewal degree of the bus fleet by the following relationship:

$$\alpha + \beta \times VC = \begin{cases} 13.849 - 0.580 \times VC & VC \leq 17\ km/h \\ 5.417 - 0.084 \times VC & 17\ km/h \leq VC \leq 32\ km/h \\ 3.209 - 0.015 \times VC & VC \geq 32\ km/h \end{cases} \tag{8}$$

which is depicted in Figure 1.

== Insert Figure 1==

5.2.2 The effect of service size

The identified breakpoint implies that the response of $CSkm$ to changes in KM first decreases ($KM \leq KM^*$) and, then, after the critical threshold KM^* it increases when the bus-kilometers increase ($KM > KM^*$). According to equation (4), the coefficient γ, which measures (VC and Akm remaining constant) the average variation of the standard cost per bus-kilometer to a marginal increase of KM, determines a different impact of service size on $CSkm$:

$$\gamma \times KM = \begin{cases} -0.180 \times KM & KM \leq 4\ mln\ km \\ 0.016 \times KM & KM > 4\ mln\ km \end{cases} \tag{9}$$

Figure 2 depicts the case in point.

== Insert Figure 2==

Our analysis highlights the presence of weak economies or diseconomies of scales and that economies of scale turn into diseconomies when a service bundle is greater than 4 million bus-kilometers. We are not able to verify whether economies and diseconomies of scale are due to technological or pecuniary factors. However, on the basis of the observations in Section 3.1, we may guess that the pecuniary component plays a relevant role. The piecewise behavior of the unit standard cost with respect to service size points to some characteristics of the observed firms/bundles. On the one hand, the declining segment ($KM \leq 4\ mln\ km$) mainly corresponds to firms/bundles characterized by a productivity of the driving personnel (measured in terms of net yearly driving hours) 7.1% higher than that related to firms providing services of over 4 million of bus-kilometers. On the other hand, the average cost of the driving personnel is 10.4% lower. Once again, these differences may signal the absence of powerful labor unions and greater efficiency in the optimization of daily shifts in small firms/bundles. The discontinuity apparent in Figure 2 is also the result of the indivisibilities that characterize investments. For instance, this is the case of firms deciding on rolling stock investment according to peak-demand, which, in urban services, differs from off peak-demand more than in intercity services.

The presence of economies of scale is a heated topic in the literature on the subject. The results of the present paper are consistent with the findings of some papers focusing on the estimation of long-run cost function (Bhattacharyya et al., 1995; Jha and Singh, 2001; Levaggi 1994; Matas and Raymond, 1998). Diseconomies of scales have also been found in Boitani et al. (2013). The U-shaped cost per seat-kilometer found by Fraquelli et al. (2001) is also consistent with our findings.

5.2.3 The effect of the degree of renewal of the bus fleet

The variable Akm, which measures the degree of renewal of the bus fleet, may be considered as a proxy of service quality: the newer the bus, the higher the more comfortable the ride. The depreciation of owned vehicles (gross of non-repayable public funds) and rents/leasing for non-owned vehicles represent some of the heaviest quality related cost components of LPT services.

The coefficient σ, which measures the average variation of the standard cost per bus-kilometer when Akm marginally increases (and VC and KM remain constant), determines a linear impact of the degree of bus fleet renewal on the standard cost per bus-kilometer, identified by the following relationship:

$$\sigma \times Akm = 1.535 \times Akm \tag{10}$$

Therefore, as the degree of renewal of the fleet goes up by 1 the standard cost per bus-kilometer accordingly increases by more than 1.5.

6. Test examples and policy implications

In this section, we offer some examples of computable standard costs without and with policy constraints. For the reasons briefly highlighted in section 5.2, we focus on *Model (1)* in order to display its implementation.

Consider a bus urban service with the following characteristics: the commercial speed is 15 km/h, the size is equal to 3 million of bus-kilometers per year and the degree of renewal of the fleet is equal to 0.13€/km. The unit standard cost may be calculated as follows:

$$CSkm = \underbrace{13.849 - 0.580 \times 15}_{\substack{5.149\ €/km \\ Commercial \\ speed\ effect}} \quad \underbrace{-0.180 \times 3}_{\substack{-0.540\ €/km \\ Service\ size\ effect}} \quad \underbrace{+1.535 \times 0.13}_{\substack{+0.199\ €/km \\ Bus\ fleet \\ renewal\ effect}} = 4.808\ €/km \tag{A}$$

If the municipality, *ceteris paribus*, invests in bus lanes or busways, resulting in an increase of commercial speed - for instance from 15 km/h to 19 km/h - the standard cost per bus-kilometer goes down by 25%, from 4.808 €/km to 3.480 €/km:

$$CSkm = \underbrace{5.417 - 0.084 \times 19}_{\substack{3.821\ €/km \\ Commercial \\ speed\ effect}} \quad \underbrace{-0.180 \times 3}_{\substack{-0.540\ €/km \\ Service\ size\ effect}} \quad \underbrace{+1.535 \times 0.13}_{\substack{+0.199\ €/km \\ Bus\ fleet \\ renewal\ effect}} = 3.480\ €/km \tag{B}$$

(B) suggests that the local authority has an incentive to realize an investment in bus lanes whenever its future expected benefits (accruing from improved commercial speed) exceed the present cost of the investment. Our model does not encompass the costs of realizing and maintaining busways and/or bus lanes. Hence, we are not in the position to carry out a full-fledged cost-benefit analysis. However, any exogenous shock that improves commercial speed reduces the unit standard cost. We expect that, if these capital outlays were included in a more general model, tradeoffs would arise, as pointed out by Tirachini and Hensher (2011).

Along the same lines, a *ceteris paribus* investment aimed at accelerating the renewal of the bus fleet can be evaluated (C). Suppose that such an investment raises the degree of rolling stock renewal up to 0.20 €/km. The standard cost per bus-kilometer would have a 3% increase, from 3.480 €/km to 3.588 €/km:

$$CSkm = \underbrace{5.417 - 0.084 \times 19}_{\substack{3.821\ €/km \\ Commercial \\ speed\ effect}} \quad \underbrace{-0.180 \times 3}_{\substack{-0.540\ €/km \\ Service\ size\ effect}} \quad \underbrace{+1.535 \times 0.20}_{\substack{+0.307\ €/km \\ Bus\ fleet \\ renewal\ effect}} = 3.588\ €/km \tag{C}$$

(C) suggests that LPT firms have an incentive to invest in the quality of the rolling stock, as the financial cost of investments enters the standard cost and is fully refundable.

(D) shows the (limited) gains from expanding the service bundle. If this is expanded from 3 to 3.8 million kilometers, the unit standard cost would decrease by 4%, from 3.588 €/km to 3.444 €/km, as a results of moderate economies of scale:

$$CSkm = \underbrace{5{,}417 - 0{,}084 \times 19}_{\substack{3.821\,€/km \\ Commercial \\ speed\ effect}} \ \underbrace{-0.180 \times 3.8}_{\substack{-0.684\,€/km \\ Service\ size\ effect}} \ \underbrace{+1.535 \times 0.20}_{\substack{+0.307\,€/km \\ Bus\ fleet \\ renewal\ effect}} = 3.444\,€/km \qquad \text{(D)}$$

As already mentioned, in a standard cost framework firms have an incentive to increase their efficiency thanks to a yardstick competition mechanism, as companies able to produce at a unit cost lower than the standard are residual claimant of the piling up profits. Furthermore, we remark that *Model (1)* - as well as *Models (2)* or *(3)* - is based on variables which cannot be easily manipulated by LPT firms, which implies the model is quite robust with respect to opportunistic behavior of firms.

The model allows the introduction of some regulatory constraints in the allocation of public funds earmarked to the local public transport sector among Regions. First, it might be set a minimum commercial speed VC^{min}. In this case, the unit standard cost of a service provided at a commercial speed $VC < VC^{min}$, would be calculated by taking into account VC^{min}. By so doing the implementation of the model would provide strong incentives (mainly to local authorities) to carry out investments targeted at increasing the commercial speed at least up to the minimum threshold. For instance, if the actual commercial speed is VC=11 km/h and the minimum threshold is VC^{min}=13 km/h, the "regulation augmented" unit standard cost would decrease by 1.16 $€/km$.

Second, the government may not be willing to accept those extra-costs due to diseconomies of scale. If diseconomies of scale are not accounted for in the computed unit standard cost, Regions characterized by the presence of large service bundles would have an incentive to efficiently scale down the size of bundles. For instance (E), assume that a urban service has the following characteristics: commercial speed is 16 km/h, service size is equal to 41 million of bus-kilometers per year and the degree of fleet renewal is 0.373 $€/km$. The unit standard cost of the service may be computed by acknowledging economies of scale up to 4 million of bus-kilometers as follows:

$$CSkm = \underbrace{13.849 - 0.580 \times 16}_{\substack{+4.569\,€/km \\ Commercial \\ speed\ effect}} \ \underbrace{-0.180 \times 4}_{\substack{-0.720\,€/km \\ Service\ size\ effect}} \ \underbrace{+1.535 \times 0.373}_{\substack{+0.573\,€/km \\ Bus\ fleet \\ renewal\ effect}} = 4.422\,€/km \qquad \text{(E)}$$

As shown in (C), the firm has an incentive to invest in the quality of the rolling stock. However, the implementation of standard costs may spur distortions such as "gold plating" of the bus fleet; distorsions the policy maker may wish to correct. In order to prevent such distortions in the procurement of new buses, the regulator might establish random checks in order to verify that procurement procedures are correctly implemented. Furthermore, the model can be instrumented for the allocation of public funds among Regions in such a way that a maximum allowance for bus renewal is employed in the standard cost calculation. In this case (F), a region wanting to provide LPT services using expensive high-tech vehicles, such as hybrid or electric-wheel vehicles, should fund the excess-costs by increasing local taxes. If the roof to the degree of rolling stock renewal is set at 0.391 €/km (out of reasonable calculations[8]), the unit standard cost of the service identified in example (E) may be defined as:

$$CSkm = \underbrace{13.849 - 0.580 \times 16}_{\substack{+4.569\,€/km \\ Commercial \\ speed\ effect}} \quad \underbrace{-0.180 \times 4}_{\substack{-0.720\,€/km \\ Service\ size\ effect}} \quad \underbrace{+1.535 \times 0.391}_{\substack{+0.600\,€/km \\ Bus\ fleet \\ renewal\ effect}} = 4.449\,€/km \qquad \text{(F)}$$

with an increase of 0.027 €/km with respect to case under (E).

7. Concluding remarks

Standard costs were chosen by the Italian Parliament as an instrument for implementing yardstick competition in the LPT industry. Local authorities might then correspond to service providers a compensation that cover the costs of a (hypothetical but realistic) average-efficient operator (partly) disregarding the actual cost of the operating firm.

In this paper, we developed a model to estimate the unit standard costs for the Italian local bus transport services by considering selected quantitative and qualitative characteristics such as: commercial speed, service size and the renewal pace of the bus fleet. Economic and transport data have been collected from companies producing more than 500 million of bus-kilometers in 2011.

We find that commercial speed is the most important cost driver. In particular, the marginal effect of the commercial speed on the standard cost per bus-kilometers reduces when the commercial speed increases and the functional form of the standard cost per bus-kilometer assumes an L-shape. Furthermore, we find that economies of scale are weak: they run out when the service size is small and turn into diseconomies of scale when a 4 million of bus-kilometers threshold is trespassed. Finally, results point to a positive correlation between investments in bus fleet and the cost incurred for the provision of the service. The cost incurred by LPT firms for the modernization of the rolling stock and, thus, for the provision of a higher service quality is linearly rising.

Regulatory thresholds for specific characteristics of the service (e.g., minimum commercial speed or maximum "quality" of the bus fleet) may be defined. Similarly, diseconomies of scale may be dropped from the regulation-augmented standard cost. The proposed model, while identifying a relationship between unit costs and factors only partly influenced by the operators (such as commercial speed and size of the service bundle), favors policies aimed at improving the traffic conditions in which LPT services are provided, as well as at optimizing the bundle size.

Our findings are supportive of policies targeted at increasing the commercial speed (for instance, by increasing the number of bus lanes or busways) as that would lead to a substantial

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[8] The bus fleet of operators providing urban services in the Italian Regions is typically made of 12 meters-diesel vehicles (70%), 12 meters-hybrid vehicles (10%), 18 meters-diesel vehicles (10%), 18 meters-hybrid vehicles (10%). Prices per vehicle are, respectively, € 240,000, € 260,000, € 340,000 and € 360,000. The average price of a representative vehicle is € 264,000. The average productivity of any vehicle is 45,000 km per year and the depreciation life is 15 years. In such a scenario the depreciation per kilometer is $264{,}000/(15 \times 45{,}000) = 0.391\,€/km$.

reduction in unit costs. A recent study by Bain & Company (2014) shows that, in Italy, the commercial speed is on average 12% lower than in other European countries such as Germany, France, Spain and the United Kingdom. This gap largely explains why unit costs are in Italy 16% higher than in those countries. According to the mentioned study, the lower level of efficiency in Italy is due to productivity of drivers (measured as bus-kilometers per employee), which is 26% lower than in other European countries. The negative productivity gap is in turns the outcome of lower commercial speed (and for more than a half) and shorter hours driven.

It should be noted, however, that policy interventions aimed at increasing commercial speed must be tailored by taking into account the sloping characteristics of the service area and/or the presence of historical centers. Moreover, such policy measures must be assessed globally, accounting for the trade-offs related to the network effects of significant changes in the traffic system. For instance, in a urban setting, an excessive increase in the number of bus lanes, might, on the one hand, result in a faster service within the areas where the new lanes are located, and, on the other hand, increase congestion in surrounding areas up to the point that urban mobility as a whole turns out to be impaired. An in-depth analysis of the (social) costs and benefits of these public interventions should be carefully carried out prior to their adoption.

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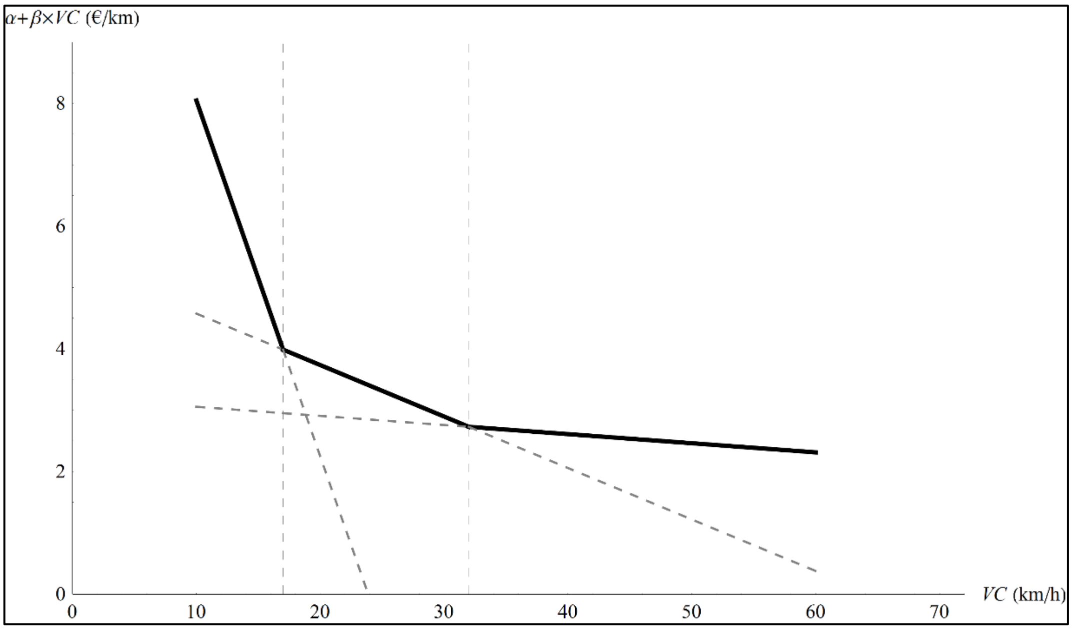

Figure 1. The effect of commercial speed

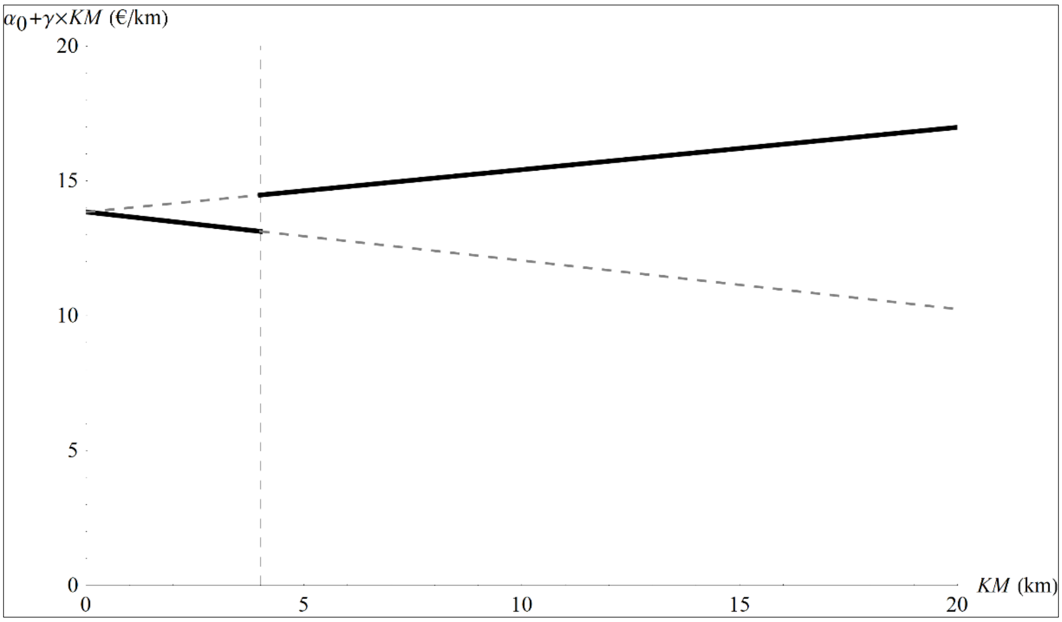

Figure 2. The effect of the size of the service

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Table 1. Number of bus-kilometers provided by firms included in the sample

Italian Regions	*Firms in our sample*	*Service bundles served by the firms in our sample*	*Bus-kilometers provided by firms in our sample (A)*	*Total number of bus-kilometers provided by firms located in the Region (B)*	*% (A/B)*
Abruzzo	1	1	1,710,017.00	48,314,533.50	3.54%
Basilicata	3	3	10,901,528.00	32,658,677.00	33.38%
Calabria	2	2	5,435,014.00	56,009,028.00	9.70%
Campania	4	4	37,140,951.60	119,361,776.00	31.12%
Emilia-Romagna*	-	-	-	124,694,171.85	0.00%
Friuli Venezia Giulia	2	3	32,196,191.00	42,113,700.00	76.45%
Lazio	4	4	189,593,532.00	230,991,734.00	82.08%
Liguria*	-	-	-	60,954,591.40	0.00%
Lombardia	4	4	19,549,511.80	280,000,000.00	6.98%
Marche	10	10	32,940,645.94	41,501,220.00	79.37%
Molise*	-	-	-	14,058,696.00	0.00%
Piemonte	7	8	100,431,005.10	122,670,000.00	81.87%
Puglia	1	1	1,965,000.00	98,720,000.00	1.99%
Sardegna	1	1	860,000.00	95,846,453.00	0.90%
Sicilia	1	1	2,489,477.00	98,863,167.00	2.52%
Toscana*	-	-	-	109,294,538.96	0.00%
Trentino-Alto Adige*	-	-	-	46,517,584.00	0.00%
Umbria*	-	-	-	27,571,779.00	0.00%
Valle d’Aosta*	-	-	-	7,500,000.00	0.00%
Veneto	5	12	76,782,217.12	129,437,614.00	59.32%
Total	*45*	*54*	*511,995,090.56*	*1,787,079,263.91*	*28.6%*

* *Our sample does not contain firms in this Region*

Table 2. Some descriptive statistics of firms included in the sample

	Mean	*Min*	*1° quartil*	*Median*	*3° quartil*	*Max*	*Coefficient of variation*
Number of bus-kilometers provided yearly within the service contract in the service bundle	9,481,391	153,431	1,668,153	4,224,841	9,344,301	101,000,000	1.86
Net driving hours per vehicle	1,213.36	717.38	1,073.81	1,182.92	1,349.71	1,972.16	0.23
Average age of used vehicle	10.14	3.70	8.88	10.28	11.89	13.50	0.21
Average productivity of used vehicles, including technical provision and standstills for planned maintenance (Total bus-kilometers provided/number of used vehicles)	41,693.29	18,304.65	37,733.16	41,180.60	48,121.05	57,113.63	0.20
Number of movement personnel/Number of driving personnel	4.9%	0.0%	3.1%	4.7%	6.7%	13.0%	0.66
Number of sales and marketing personnel/Number of driving personnel	12.2%	2.1%	8.5%	11.5%	15.0%	49.8%	0.59

Table 3. Cost components of firms in the sample

Cost per bus-kilometer							
€/km (€ per bus-kilometer)	*Mean*	*Min*	*1° quartil*	*Median*	*3° quartil*	*Max*	*Coefficient of variation*
Cost of driving, depots and movement personnel	1.451	0.566	1.062	1.333	1.753	3.360	0.382
Cost of fuel	0.462	0.260	0.404	0.444	0.499	0.699	0.211
Cost of maintenance	0.540	0.247	0.363	0.470	0.621	1.340	0.461
Depreciation of vehicles	0.283	0.045	0.213	0.260	0.336	0.797	0.413
Yearly rent for rented/leased	0.008	0.000	0.000	0.000	0.000	0.149	3.298
(Equivalent) yearly rent for vehicles handed over free of charge*	0.023	0.000	0.000	0.000	0.000	0.527	3.452
Depreciation of depots	0.030	0.000	0.000	0.010	0.048	0.229	1.468
Yearly rent for rented/leased depots	0.019	0.000	0.000	0.000	0.028	0.140	1.783
Administrative costs and other costs	0.565	0.037	0.381	0.476	0.586	2.176	0.690
IRAP	0.069	0.030	0.051	0.059	0.081	0.184	0.431
Cost of capital	0.161	0.016	0.073	0.147	0.223	0.641	0.725
Cost per bus-kilometer	3.612	2.114	2.918	3.280	3.968	7.877	0.294

* See Footnote 6 for details on the computation of the (Equivalent) yearly rent for vehicles handed over free of charge.

Table 4. Cost elements (average values) for different categories of service bundles, classified on the basis of the number of bus-kilometers provided in in each segment of the industry (urban or intercity)

€/km *(€ per bus-kilometer)*	$\%kmIC = 0\%$	$0 < \%kmIC \leq 60\%$	$60 < \%kmIC < 100\%$	$\%kmIC = 100\%$
Cost of driving, depots and movement personnel	2.058	1.507	1.228	1.183
Cost of fuel	0.456	0.452	0.454	0.470
Cost of maintenance	0.748	0.578	0.395	0.461
Depreciation of vehicles	0.274	0.328	0.272	0.282
Yearly rent for leased vehicles	0.017	0.009	0.000	0.006
(Equivalent) yearly rent for vehicles handed over free of charge*	0.004	0.000	0.036	0.035
Depreciation of depots	0.019	0.036	0.040	0.033
Yearly rent for rented/leased depots	0.020	0.003	0.015	0.023
Administrative costs and other costs	0.725	0.423	0.479	0.536
IRAP	0.100	0.070	0.057	0.056
Cost of capital	0.131	0.190	0.168	0.167
Cost per bus-kilometer	4.551	3.594	3.145	3.251

* See Footnote 6 for details on the computation of the (Equivalent) yearly rent for vehicles handed over free of charge.

Table 5. Summary statistics of the variables included in the cost function model

Sample: 54 observations	*Mean*	*St. Dev*	*Min*	*Max*
$VC(km/h)$	31.177	10.193	12.372	56.000
$KM(mln\ km)$	9.481	17.601	0.153	101.000
$Akm\ (€/km)$	0.315	0.121	0.135	0.797

Table 6. OLS estimate of standard cost per bus-kilometer

Model 1			*Model 2*			*Model 3*		
Regressor	*Coefficient*		*Regressor*	*Coefficient*		*Regressor*	*Coefficient*	
Constant	α_0	13.849*** (1.674)	Constant	α_0	1.538*** (0.232)	Constant	α_0	6.341*** (0.345)
VC	β_{VC}	-0.580*** (0.104)	$\frac{1}{VC-5}$	β_{VC}	34.183*** (2.903)	$\ln(VC-10)$	β_{VC}	-1.161*** (0.102)
$D_{VC1} \times (VC-17)$	β_{VC1}	0.496*** (0.113)						
$D_{VC2} \times (VC-32)$	β_{VC2}	0.069*** (0.026)						
$D_{KM1} \times KM$	γ_{KM1}	-0.180** (0.073)	$D_{KM1} \times KM$	γ_{KM1}	-0.186*** (0.067)	$D_{KM1} \times KM$	γ_{KM1}	-0.171** (0.069)
$D_{KM2} \times KM$	γ_{KM2}	0.016*** (0.004)	$D_{KM2} \times KM$	γ_{KM2}	0.015*** (0.004)	$D_{KM2} \times KM$	γ_{KM2}	0.015*** (0.004)
Akm	σ	1.535*** (0.529)	Akm	σ	1.651*** (0.528)	Akm	σ	1.771*** (0.543)
$R^2 = 0.84$ Adjusted-$R^2 = 0.82$			$R^2 = 0.83$ Adjusted-$R^2 = 0.81$			$R^2 = 0.82$ Adjusted-$R^2 = 0.80$		

Number of obs. = 54

***=Significant at 1% level

**=Significant at 5% level

*=Significant at 10% level