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genesDESIGN
published by [genesdesign.com] 11.2008
ISBN 978-88-96049-06-8
9 788896 049068

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5

Assessment of the subsidy to the municipal public transit minimum services

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Abstract

This research works out some tools to support the decision-makers in the allocation of the subsidies to the municipalities to run the public transit service up to them. By means of these tools we can quantify the municipality minimum service, as specified under the 1st paragraph of the article 16 of the Italian Decreto Legislativo 422/1997, and assess the reference unit cost. The implementation of these tools in a study case has allowed to verify its operation.

Keywords: Urban transit, transit cost, transit service need

1. Introduction

The subject of the paper is the local public transit planning that, as known, in Italy is regulated by the Decreto Legislativo (Italian Government Decree) 422/1997 and by the relative implementation regional rules.

The assessment of the minimum services[1] and their running unit cost are basic steps of the local transit planning process. The relevance of these operations lies in the fact that the allocation of the funds for the public transit running, up to the regions, the districts and the municipalities, results from the assessment of the minimum service haul and the admitted unit cost.

The funds allocation among the municipalities looks very difficult, because of their high amount in every region, their different sizes and the various functions that they play in the district and regional land and also the noticeable different costs following from different running schedules realized in differently infrastructured and settled areas.

In this framework, it is very important to have a tool suitable for the assess of the minimum services and its reference unit cost on the basis of synthetic parameters characterizing the requirement of public transit in every municipality and peculiarities of the supplied service.

As deepened further in the state-of-the-art section, there is no attempt of realizing such a tool in literature because probably the mechanism of subsidy to the local public transit is, in the countries inside and outside EU, different from Italy. The lack of scientific tools suitable to assess the real public transit requirement in each municipality and the related admitted costs forced the Italian Region to resort allocation methods favouring the recognition of the settled subsidy and eventually

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[1] The minimum services are defined, under the 1st paragraph of the article 16 of the Decreto Legislativo (Italian Government Decree) 422/1997, as those services enough, in quality and amount, to supply the mobility demand and whose costs are charged to the Regions accounts.

the bargaining among the involved authorities instead of decision tools based on impartial parameters.

The assessment of the maximum efficiency costs or target costs or at least reference costs is very useful in the deregulation of the local public transit market and in the efficiency raising as prescribed by the Decreto Legislativo 422/1997. Indeed the knowledge of reliable costs helps to set out the network ideal size and the amount to contract out and also the actions to rebuild the services taking into account the reduction of the unit cost too.

Nonetheless the difficulty in the assessment of the target or standard or maximum efficiency costs keeping count of the service production real conditions and of the environmental ones is known. In fact we cannot postulate the maximum efficiency as typical of a generic service nor of a generic company and so it is almost impossible to set parameters expressive of maximum efficiency conditions derived by real situations.

The reference unit cost for every municipal public transit service in the present research means a medium efficiency cost related to a real sample instead of a maximum efficiency or standard or target cost related to an ideal running realized in a particular real environment.

This work has faced the assessment of the minimum services, building a generally expendable model to quantify the municipal public transit minimum services. In parallel we have dealt with the assessment of a reference cost, tuning appraisal methodologies based on different settled approaches.

Then the topics discussed in the following sections of this paper are reported.

Section 2 summarizes an exhaustive analysis of the international bibliography about the relations between land settlement variables and public transit requirement and also about the cost and the efficiency of the local public transit services. Section 3 deals with the methodologies for the building of the haul model and for the assessment of the transport unit cost. A trial to verify the relevance of the tuned tools is showed in the fourth section. The fifth section gathers some considerations about the work results and the possible further research improvements.

2. State of the art

The critical analysis of the scientific international literature carries out two topics: the relation between land attributes and mobility requirement, and also the firms and the transport systems efficiency; the aim is to draw suggestions about the variables significantly affecting the urban public transit demand and the service production costs.

The relation between land and mobility is complex and difficult to formalize also because of the importance of the socio-economic factors on the first one (Stead et al., 2001); In addition the land use patterns are difficult to quantify and furthermore the detectable relations between land use and transportation are easily biased by the measurement method (Boarnet e Crane, 2001).

The impact of the settlement size in terms of population is discussed by ECOTEC (1993) and by Balcombe (2004). They both registered that, raising the settlement size, the amount of the rides by bus increases but their medium length decreases and the former found a more than linear relation; otherwise no specific trend is been observed for the rides by train.

Some researches (Department of Transport, 2002; Van Diepen, 2000; Frank e Pivo,

1994) indicated that, raising the settlement density, specially if not restricted only to residents but inclusive of employees and establishments, the amount of the daily rides per person by transit increases while their medium length decreases; also the travels on foot grow with the settlement density, while the car use drops. Naturally we take for granted that the areas in question are provided with an adequate public transit supply and that the road congestion do not increases. Unfortunately the assessment of the phenomenon is very difficult because, as highlighted by Fouchier (1997) and Breheny (1995), the density growth is usually concurrent with the raising of some socio-economic parameters (as income, public transit supply and fare, car ownership) itself affecting the mobility demand. A further problem rises because the relationship between the settlement density and the public transit use changes significantly with the size of the land on which the density is measured (Stead, 2001). The travel reason seems to affect the connection between density and land use as realized by Maat (1999) and by Boarnet and Greenwald (2000), but the travel starting/end time, mode, route and destination are not less important.

As emphasized by Simmonds and Combe (2001), Masnavi (2001) and Van and Senior (2001), a mixed land use affects favourably the public transit use more then a largely residential use, but more it reduces the travels by car in favour of the pedestrian ones. The employees and services centralization level affects the travel behaviour: a high centralization level promotes the public transit use while the services peripheral location induces the car use (Balcombe, 2004; Banister e Marshall, 2000).

Also the urban shape seems to impact on the attributes of the transport demand and to analyse its effects Newton (2001) has schematised the various possible shapes in a limited amount of typologies. Simmonds and Coombe (2001) and Murto (2000) have found that different urban development policies have a light consequence on the modal split.

Finally, even though the relation between city features and mobility is very complex and still not enough known, we can set out some aspects that are validated by the international research (Balcombe, 2004).

- The higher is the urban density, the higher is the public transit demand in terms of trips amount, but the shorter is the length of the trip. In addition, because the high density insediative typologies are mostly inhabited by people with low income and so with limited motorization rate, it is probable that a part of the effect of the density on the transport demand is due to the income and the car ownership.
- The settlement size, the urban shape and the uses mix affect the public transit demand, even though it is difficult to set out the type of these relationship
- The urban functions and services decentralization tends to reduce the demand of public transit for the private one.

Table 1 qualitatively schematises the relations between land and mobility validated by research, matching the attributes of the transport demand to the land features affecting the first one. However nowadays there is no quantitative model suitable to describe the effects of the land features on the transport demand.

Table 1: Impact of the urban land on the transport demand

Land features		Transport demand attributes
Settlement size	→	Trips length Modal split
Density of residents, activities and workers	→	Trips length and frequency
Use promiscuity	→	Trips length and frequency Modal split
Urban shape	→	Trips length

With respect to the topic of the costs of the road public transit services, it must to be highlighted, first of all, that the research in the last years was aimed mostly to point possible production inefficiencies and resource wastes in the public transit sector from where to draw fitted policies.

Italian researches on the topic of the public transit companies efficiency are various. The most important ones, mostly dated in the last fifteen years, join the efficiency analysis of a sample composed by some dozen of companies working in urban and interurban areas in a period of some years between the 80' and 90', realized by different cost function (largely translog). The factors of production are usually divided in work (amount of employees), assets (amount of vehicles) and other expenses; the output is measured, as the case may be, by the (seats x km), (vehicles x km) or (seats x vehicles x km). Despite the visible likeness, the mentioned works reach results sometimes contrasting among them, mostly about the existence, in the short and long term, of economies of scale, density (concentration of service on a surface or network unit) intensity (concentration of service on the network) and scope (different type of services, largely urban and interurban ones), probably due to the peculiarity of each work.

Particularly Fazioli et al. (1993), who took into account also some specific attributes of the supplied services as the network expansion, have observed appreciable scale economies, in the short and long term, decreasing with the raise of the company size, and also density economies. The results of Levaggi (1994) highlight scope, scale and density economies in the short term while, in the long term, draw a reduction of the intensity economies and light scale and density economies. Also Fabbri (1998), that like Levaggi used a variable cost function, has observed appreciable scale economies, both in the short and in the long term, reducing with the raise of the company size, in addition to cost inefficiency representative of not optimal size of the observed firms.

The impact on the production costs of firm factors (company size) and environment factors (commercial speed, users density per kilometre of network and network expansion) is pointed out by the analyses of Fraquelli et al. (2001). Leaving out the commercial speed whose impact on the service cost and appeal and also on the environment are well-known, the raise of the users density per kilometre of serviced network and the network extension (set in the environment attributes) favours the efficiency of the medium size companies; the firm size to reach the larger economies related to this last parameter is set in a supply between 600 million and 1.600 million of seats x km /year.

Piacenza (2006) fixed his attention to the effects, on the production efficiency, of the procedures for the allocation of the State subsidies to the public transport firms. He has drawn that the impact of the public regulation is less appreciable when the

structural inefficiency of the network is particularly stressed also through the adverse environment.

Interesting appraisals of the efficiency of Italian and Swiss small and medium passenger transport companies, working in urban or interurban area or both, have been developed by Fazioli et al.(2003) pointing out the presence of noticeable density and scale economies in all size groups included in the sample, with dominance of the density economies on the scale ones specially for small companies.

Fraquelli e Piacenza (2003), developing the same analysis, introduced in the model also the commercial speed, the network type (urban, interurban or mixed), the type of subsidy contract stipulated between committing authority and transport firm, with the aim to examine the causes of inefficiency. The results have underlined yet again the presence of scale and scope economies and also economies achievable by larger network and service density and by higher commercial speed.

The work of Cambini et al. (2007) differs from the formers because it analysed only the medium-large public transit firms associated with ASSTRA[2] and working in the big urban areas fairly placed in North, Centre and South Italy. It is aimed to set the ideal size of the network to contract out and the actions for the firms reorganization. The results, also in this study, have highlighted the presence of relevant scale and density economies for both the reference medium size firm and the big operators, independently from the type urban or interurban service, even through the work has not considered the quality of the services.

In the international literature the study of Matthew e McCarthy (2002) is very interesting also because of the size of the examined sample that includes 256 transport systems, in a 9 years period, divided in homogeneous groups for which they have tuned specific cost functions. This study generalizes the results arisen from the previous ones exceeding their limits lying in the use of cost models with different applicative features or in the analysis of different ownership firms or still in the set of disparate survey periods. The authors come to the conclusion that the system size affected the realized economies of the other studies, only because in these ones, different types of firms were analysed, and so the distinct costs are consequent to the different productive technologies; they indeed have drawn that production average and marginal costs are in direct proportion to the system size while this last variable is proportional to the use of the supplied capacity; nevertheless only in the short term the smallest firms record the greatest economies.

Fernandez et al (2005) criticize the previous studies drawing discordant results about the presence of scale economies and try to exceed their limits. The authors develope a microeconomic cost model for the production of bus services in a corridor that takes into account only the factors provided by the operators. It follows that, in the short term, the scale economies exist as a consequence of the investment fixed costs that have a greater impact on low overall production volumes. In the long term scale economies are consequence only of the sharing of the management fixed costs on a greater product amount.

Matthew (2004) tries to generalize the results of the previous studies using different measures for the output and taking into account the distinct product types. He examines a 256 urban road transport systems sample (data from the USA National Transit Database) by the data envelop analysis and the method of the efficiency frontier properly adjusted by a random parameter. The results are

[2] ASSTRA (Transport association) is the Italian association of the transport public firms

different for each of the six groups in which the sample is divided on the basis of the number of vehicles in the fleet; however, for all groups, a direct proportionality between the two performance efficiency and effectiveness exists, that is the efficient systems tend to be also effective. Further what arose from other studies about the reverse "U" trend of each one of the two performances, and also of their combination, with regard to the vehicles fleet size is confirmed. Specially the system size matching the maximum efficiency is in 550 vehicles, while the size matching the maximum effectiveness is about 150 vehicles.

A further validation of the cost "U" trend with respect to the production is given by Jorgensen et al. (1997): under two alternative hypotheses concerning the distribution of the inefficiency among the operators, a function of the stochastic cost frontier is appraised, based on the data of 170 among the 175 Norwegian public transit firms recipient the subsidy, whose size, measured in (vehicles x km / year) is included between 4.500 and 24,3 million, with an average of 1,6 million and so very close to the Italian overview. Besides in order to observe average costs lightly higher for the medium size firms, the authors have drawn that the efficiency is not related to the firm ownership (public or private), but to the subsidy mechanism that affects positively the costs reduction when it is based on criteria resorting a standard cost.

A research aimed to verify the efficiency of the contractual obligations has been developed by Dalen e Gomez-Lobo (2003). The authors examined a big amount of firms in a 11 years period (1136 observations) by a linear cost frontier model. With reference to the three types of contract possible in Norway in the considered period, they have realized a greater efficiency of those types that settle the clearance on the basis of reference parameters like the standard cost; in these contracts in fact the cost remains under the frontier at least for the 18%, against the 13,2% for the ones based on the subsidy-cup (consisting to agree a percent of yearly reduction for the subsidy in the five years of the relation validity) and the 7,6% for the ones regulated by a direct treaty between the committing authority and the service committed firm.

A synthesis of the analysed literature leads to recognize the linear or translog functions as the most used to describe the cost of the road public transit; it is also possible to group the variables affecting the efficiency, and so the costs, in three types reflecting the attributes of the producing firm, the supplied service and the operational environment, in accordance with the table 2.

Table 2: Variables affecting the public transit cost

Types	Variables	Units of measurement
Firm attributes	Frim size (product)	vehicles x km / year
	Firm size (fleet)	Amount of employed vehicles
	Scope concurrence	Amount of supplied services
Service attributes	Network extension	km of network
	Network density	km of network / km^2 of land
	Service density	vehicles x km / year km of network
	Service intensity	Vehicle x km in the peak period Vehicles x km in not peak
	Users density (use intensity) of the network	Users / year km of network
	Users density (use intensity) of the service	Users / year vehicle x km /year
Environment attributes	Average commercial speed	km / h
	Contract tipology (contract obligations regulating the public subsidy)	-----

3. Methodology

3.1 Minimum services dimensioning

The variables analysed to build the model for urban public transit services dimensioning are selected taking into account the type of service to quantify and the recurring conditions in which it is produced. In fact we studied the services up to the municipalities, supplied mostly in the urban centres by road collective vehicles and that usually meet, both demand inside the municipality, and the penetration one. Therefore we examined the variables that the international research developed to date has indicated to be revealing of the municipal mobility demand served by public transit. Among these variables, the urban density, that plays a key role, has been analysed in explicit form by the parameter composing it (inhabitants, services workers, urban extension) with the aim to observe the weight of each one on the phenomenon aggregate depiction.

The three independent variables regarded revealing, that are the municipal inhabitants, services workers (in the sectors ATECO G, H, J, L, M, N, O ISTAT[3] - addition of the companies and the local units workers) and the head urban centre extension, have been tested one by one, together with the independent variable represented by 2005 municipal public transit yearly haul, with the aim to catch helpful markers about the existence of a relationship and its nature (linear, quadratic, logarithmic, exponential, etc.). Furthermore we have carried out a statistical inference trial using the F (of Fisher) and T (of Student) tests by which we have extended, to the whole data population, the results of the sample.

In the building of the synthetic model, we have tried to minimize the amount of independent variables required to completely render the response of the dependent variable. This approach issues from the remark that multiple regressions with few

[3] ISTAT Italian National Statistics Institute

explanatory variables are clearer and less prone to the risk of multicollinearity that is of the presence of more independent variables with high grade of correlation not appreciably affecting the dependent variable and making more difficult to understand the incidence of each one. To measure this risk we have used the Variance Inflationary factor (VIF) making use of the Snee criterium, on the basis of which there will be multicollinearity if VIF > 5.

The methodology adopted to set the mathematical formulations of the model multiple regressions derives from the Best subset tecnique consisting in the working-out all regression models buildable by the set variables and in the identification of the best model on the basis of its predictive effectiveness, measured by the clean correlation coefficient R^2_{clean} and by the Mallows statistics making use of the statistic coefficient Cp appraising the difference between the assessed model and the real one. Particularly, when the regression model with p variables differs from the real model only as a consequence of casual errors, the average value of the Cp statistics is (p+1), therefore it comes to recognize those models with a Cp value less or equal to (p+1). The "best regression" among all ones drawn from the descriptive expressive variables, we have verified the statistic inference by the Fisher and Student tests and the residues analysis to check the type of relationship (linear quadratic, etc.).

3.2 Reference cost

The assessment of a transit service cost can be carried out in two ways:

- the synthetic or top-down method, consisting in the appraisal of the cost on the basis of the service attributes affecting it;
- the analytical or bottom-up one, consisting in the addition of the production factors costs.

In the first case we need to know the relations connecting the variables expressive of the service attributes to the cost variable. In the second case we have to know the cost of every activity taking part to the service production. Nevertheless the methods are both used on the basis of inputs expressing real situations that are certainly not always of maximum efficiency and producing an assessment cost value that is consequently a real cost but not automatically a maximum efficiency one and therefore it is not correct to adopt it as a target. We can get the standard or target cost by means of the same methods only as long as we manage to give maximum efficiency values to the parameters affecting it.

Unfortunately the disparate importance on the market of each municipal authority, on one side and of the firm producing the service, on the other side and the objective difficulty of the Italian Regions in fixing the standard cost of the urban transit services, following the Italian Act 151/1981, caused sometimes the recognition of costs to be very different from a municipality to another one against services equivalent for extent and attributes also environmental ones. This situation allows to suspect on not irrelevant inefficiencies and could clarify the frequently appreciable difference between assessed cost and real one.

The here advanced methodologies lead up to supply operational tools to assess reference values for the urban public transit unit cost considering, when possible, the peculiarities of the service and of the environment in which it is produced and, at the same time, efficiency medium levels, trying to draw information from the generalization of the supplied service in a given area rather then the particular service. Therefore it is manifest that the reference cost, estimated on a specified

sample of services, will consider, also if moderately, the possible inefficiency of some elements of it.

3.2.1 The sinthetic method

This method comprises to set the variables, describing the service and the environment, more affecting the cost and to draw this last one from the value of the first ones. The relationships linking these independent variables to the dependent variable represented by the service cost can be rendered by a particular model or can be established only implicitly defining, in the examined sample, correspondence between meaning interval of these variables and cost values.

The synthetic model of the urban public transit kilometric cost here developed is based on the manifestation of the relations between the unit cost and the variables representing some attributes of the service or of the environment in which it is produced.

The procedure founded on the split in clusters involves to recognize significant variation intervals for the variables and to link, to each interval, a value of the service unit cost drawn as an average of services costs included in that interval.

The cost model

The building of the model uses the statistical analysis and resorts the same procedure already specified about the model for the minimum services dimensioning with associated correlation verify (measure of the model predictive capability) and statistical inference (absence of casual predictions). The possible multicollinearity of each independent variables is verified by the Variance Inflationary Factor (VIF). The validation of the extracted model is realized by the F test (of Fisher) and T test (of Student) and the correlation verify by the coefficient of correlation R^2 or $R^2_{clean.}$

The independent variables to be included in the model are those which, according to the scientific literature about the topic, affect more heavily the service cost. They are the service dimension (busxkm/year), the number of lines, the number of rides, the network extension (km) and the commercial speed; the last one, as known, is strictly linked to the moving staff cost that is the most onerous producing factor for the firm. These variables allow to read the service dimension and complexity and so they are expressive of the possible scale, density and intensity economies.

The clusters split

A clustering based on significant intervals of the variables affecting the cost is an alternative to the synthetic model building.

The procedure uses the same variables included in the model formerly built, because they are enough expressive of the cost that we want to assess. This procedure involves the identification, from the available data-base, of significant intervals for each variable influencing the cost and then the inclusion of the services in a cluster on the basis of the values of every variable characterizing the same service. We associate, to each cluster, a medium unit cost of service drawn as the unit costs average weighted on the value of the variable linked to each service included in the cluster. Therefore, for every municipality, we get a value of unit cost on the basis of the cluster involving the same municipality in relation to each

expressive variable. Then it is possible to derive one only reference value for every service as an average of the aforesaid values related to each variable.

3.2.2 The analytical method

The analytical methodology below reported provides for the cost assessment of all direct and indirect factors employed in the production process.

The cost items by which we resolve the total cost are related to workers, traction, maintenance, fixtures, general expenses.

The whole workers cost consists in charge for running workers ($C_{Run.}$), for the office staff (C_{Off}), for the ancillary one (C_{Anc}) and for the running manager (provided for the greatest Italian companies) or the running person in charge (in the smallest companies) ($C_{RM./RP}$) and that is:

$C_W = C_{Run.} + C_{Off.} + C_{Anc.} + C_{RM/RP}$

We can calculate the cost of the running workers by the following expression:

$C_{Run.} = Hs / Re / H_W * Cu$ where:

Hs = hours of service supplied in one year (drawn from the running schedule);

Re = employment ratio = hours of service supplied to the service users in one year / working hours supplied in one year by the whole running workers;

H_W = working hours supplied in one year by each running worker (from the craft collective labour agreement, deducted holidays and various absences);

Cu = Average yearly cost per worker (from the craft collective labour agreement adding various charges).

So as to apply this formula we need to assess the employment ratio for the particular service and this is not easy. Otherwise the cost should be drawn directly from the service recording media, involving the limit lying to taking into account possible inefficiencies of the service shifts. However, in order to achieve a reference cost as more as possible closed to the target one, that is of maximum efficiency, it is better to apply the above mentioned formula for $C_{Run.}$, assessing specifically the employment ratio also as average value among equivalent for own and environmental attributes services.

We can assess the reference cost for the office workers and the ancillary one as a rate of the running workers cost, in case making use of what some Italian regions set about the calculation of the standard cost under the Italian Act 151/1981. As for the cost of the running manager or the running person in charge, it will be appropriate to refer to craft labour agreements.

The traction cost, sum of the fuel, oils and tyres costs, is to be calculated referring to the official price lists issued by the vehicles producers or to values set out by some Italian regions to assess the standard cost, taking care to make the possible updates.

The vehicles maintenance charges can be split in three parts referring respectively to the consumable stores, spare parts and work. Data are gathered from the maintenance schedules stated by the vehicles producers reporting also the working hours required for every operation; the spare parts cost can be gathered from the official price lists applying possible discounts. Some Italian regions, within the rules issued about the standard cost, fixed for the maintenance an all-inclusive cost per kilometer differing for type of vehicle and use.

The vehicle cost is composed by the depreciation and the moving costs (owner's tax and insurance). The first one is calculated on a standard depreciation schedule (usually 10 years) and on the basis of the net VAT and contributions list price.

The availability of installation for the vehicles depot and maintenance (sheds and garages) and also of properties for offices affect by a specific item on the service total cost. This item is only a depreciation cost because the managing charges of the same installations are included in the general expenses. These last ones can be assessed as a rate of the total cost according to what set by the most regions about the calculation of the standard cost for the local public transit services.

4. Experimentation and results

4.1 Minimum services dimensioning

The data-base built to verify the significance and to arrange and calibrate the model is composed by all municipalities, belonging to four Italian sample regions, receiving the regional running subsidy for the public transit up to them. The 157 examined municipalities are included for the 24% in Abruzzo (38), for the 30% in Basilicata (47), for the 18% in Marche (29) and for the residual 18% in Puglia (43). The choice of the regions is due to the need to consider different orographic and settlement areas so as to draw a generally suitable model and set acceptable intervals for the calibration constants. The following tables show a summary of the one variable regression results relating to the examined regions.

Table 3: statistic analysis, for the regions of the sample, of the variables affecting the needs of public transit

ABRUZZO REGION				
Variable	**R^2_{clean}**	**Correlation**	**Significance**	
			F	**T**
Total resident	0,828	Linear	YES	YES
Services workers	0,8655	Linear	YES	YES
Head centre area	0,6187	Linear	YES	YES

BASILICATA REGION				
Variable	**R^2_{clean}**	**Correlation**	**Significance**	
			F	**T**
Total resident	0,9386	Quadratic	YES	YES
Services workers	0,951	Linear	YES	YES
Head centre area	0,8756	Linear	YES	YES

MARCHE REGION				
Variable	**R^2_{clean}**	**Correlation**	**Significance**	
			F	**T**
Total resident	0,6374	Quadratic	YES	YES
Services workers	0,8042	Quadratic	YES	YES
Head centre area	0,583	Linear	YES	YES

PUGLIA REGION				
Variable	**R^2_{clean}**	**Correlation**	**Significance**	
			F	**T**
Total resident	0,862	Quadratic	YES	YES
Services workers	0,767	Linear	YES	YES
Head centre area	0,837	Linear	YES	YES

Table 4: results of the haul model statistic verify

OUTPUT SUMMARY								
Regression statistics		**Variance analysis**						
multiple R	0,9299		**Degree of freedom**	**SQ**	**MQ**	**F**	**Significat. F**	
R^2	0,8648	**Regression**	3	1,38E+14	4,6E+13	328,353	1,985E-66	
R^2_{clean}	0,8566	**Residue**	154	2,158E+13	1,401E+11			
Std. error	374301,502	**Total**	157	1,596E+14				
Observations	157,0000							
			Coeff.	**Standard error**	**Stat. t**	**Significat.**	**Less than 95%**	**More than 95%**
		Intercept	0					
		Head centre area (kmq)	72099,736	8642,7277	8,3422432	3,85277E-14	55026,14708	89173,325
		Services workers	7,1649	5,9365934	1,2069007	0,229320961	-4,56277918	18,892537
		Square Serv. workers	0,0002	4,072E-05	5,0308135	1,34524E-06	0,000124399	0,0002853

After setting the three independent variables (inhabitants, services workers and head urban centre extension) we have calculated the VIF to measure the collinearity of the inhabitants variable (VIF=12); consequently, after discarding this parameter, we have built the multiple regression by the two not collinear variables, drawing the following mathematical relationship:

P = 76858,76 X1 + 22,91 X2 where:

P = Yearly service haul or minimum service (vehicles x km / year);

X1 = Head urban centre extension (km^2);

X2 = Services workers (units)

The relationship has statistical significance and a noticeable correlation power with a value of R^2_{clean} = 0,835. Nevertheless the residues of the multiple linear regression showed aggregation underlining the need to study the higher order terms then the first one (quadratic, cubic). To that end we have searched for multiple regressions by linear and quadratic independent variables, and verified that they don't show residues aggregated. Particularly we have built one regression with four terms (linear and quadratic), two regression with three terms (two linear and one quadratic) and one regression with two terms (only quadratic) all of them having null intercept. The four and three terms regressions have an higher value of R^2_{clean} than the one of the above reported linear regression whereas the regression with two terms (only quadratic terms) doesn't have much lower correlation.

The regression mathematical formula with four terms (linear and quadratic), even though has the highest correlation value (R^2_{clean} = 0,901), is not generally suitable because of the presence of negative terms causing, for some smallest municipalities, simulated service haul less then zero; this regression however could be used if we fixed fit thresholds for the input variables and removed the lowest value from the data-base. In this research the current need of a more generalized model leaded to the following relationship:

$$\boxed{P = 72099{,}73\ X1 + 7{,}16\ X2 + 0{,}00020\ (X2)^2}$$ where:

P = Yearly service haul or minimum service (vehicles x km / year);

X1 = Head urban centre extension (km^2);

X2 = Services workers (units)

The drawn model has an high prevision power (R^2_{clean} = 0,856).

The framework of the last model shows itself effective also to represent the mobility need of each examined region; particularly the multiplicative coefficients of the significant variables take different values from a region to another one and the drawn correlations are all very high as summarized in table 5.

Table 5: summary of the haul models separated by region

	ABRUZZO	BASILICATA	MARCHE	PUGLIA
Moltiplicative coefficient of the X1 variabile	-12655,80	-8736,40	-73634,10	92104,98
Moltiplicative coefficient of the X2 variabile	63,82	72,04	62,44	-4,27
Moltiplicative coefficient of the $(X2)^2$ variable	-0,00023	$-3,70 \times 10^{-5}$	0,000352	0,000208
R^2_{clean}	0,867	0,949	0,829	0,861

Finally we have made two separate statistical analyses splitting the municipalities on the basis of their territorial role (district capital or not capital). For both categories we had the best prevision power by the same linear and quadratic terms and the same variable of the model adding a known term different from zero. For the not district capital municipalities the prevision power is low (R^2_{clean} = 0,520) but the relation is however not casual, as shown by the inference verify of Fisher and Student tests; the correlation raises considerably for the capital municipalities getting to R^2_{clean} = 0,800. This different attitude of the two categories set in the data sample is probably caused by the greater presence in the smallest municipalities, the not distinct capital one being prevalent amongst them, of the link services to the hamlets in regard to the whole haul of the municipal public transit. In fact the built model considers to be negligible the contribute of the land not included in the urban border (particularly when it assumes for the real service haul and for the services workers the value related to whole municipal land) while refers the land extension variable only to the head urban centre.

Table 6: summary of the haul models separated by the administrative function

	Municipalities not district capital	Municipalities district capital
Intercept	58901,4	786873,4
Moltiplicative coefficient of the X1 variabile	2284,7	93624,5
Moltiplicative coefficient of the X2 variabile	5,95	-18,04
Moltiplicative coefficient of the $(X2)^2$ variable	0,00083	0,00025
R^2_{clean}	0,520	0,800

Table 7: data-base and simulation by the haul model

Municipality	Pop. Tot.01	Head centre area (km2) 01	Services Workers 01	Real haul 2005	Simulated haul 2005	Municipality	Pop. Tot.01	Head centre area (km2) 01	Services Workers 01	Real haul 2005	Simulated haul 2005
Acerenza	3.010	0,347	509	38.300	28.709	Ostuni	32.901	1,980	6.741	232.653	200.364
Atella	3.726	0,882	591	46.939	67.898	Palo del colle	20.852	1,860	2.302	31.515	151.685
Avigliano	12.025	1,087	2.070	153.230	94.081	Putignano	28.176	2,650	9.111	94.545	273.347
Barile	3.229	0,610	314	15.000	46.251	S. Giovanni Rot.	26.106	3,270	11.815	73.134	349.013
Bella	5.440	0,540	595	38.110	43.269	San Severo	55.861	4,940	12.146	220.340	473.415
Castelluccio Inf.	2.344	0,397	373	79.300	31.325	Santeramo	26.050	3,450	3.804	69.677	278.963
Chiaromonte	2.148	0,340	484	89.174	28.030	Sava	16.163	3,240	2.277	35.754	250.980
Francavilla in S.	4.367	0,340	866	48.495	30.872	Spinazzola	7.362	1,110	1.217	21.710	89.054
Grumento Nova	1.839	0,348	344	31.200	27.580	Taranto	202.033	63,120	53.342	7.003.265	5.515.949
Lagonegro	6.146	0,876	2.711	84.258	84.089	Trani	53.139	10,140	11.795	215.000	844.098
Latronico	5.279	0,554	905	112.102	46.595	Chieti	52.486	12,999	24.675	1.469.700	1.238.763
Lauria	13.801	1,015	3.244	206.562	98.580	L'Aquila	68.503	16,695	28.687	2.133.390	1.577.813
Lavello	13.247	1,093	2.159	120.320	95.229	Pescara	116.286	26,051	50.521	2.135.345	2.763.070
Maratea	5.261	0,338	1.706	51.992	37.189	Teramo	51.023	5,478	21.958	1.039.725	651.031
Marsico Nuovo	5.134	0,338	734	84.751	29.739	Alba Adriatica	10.389	5,730	2.865	80.130	435.348
Marsicovetere	4.703	0,175	1.697	85.400	25.366	Atessa	10.338	0,911	2.998	119.810	89.005
Melfi	16.110	2,210	5.105	544.981	201.255	Avezzano	38.337	12,015	15.600	347.430	1.027.918
Moliterno	4.592	1,150	1.081	114.800	90.899	Francavilla mare	22.883	6,357	5.553	55.893	504.460
Muro Lucano	6.110	0,401	1.128	46.700	37.255	Giulianova	21.400	8,879	7.575	330.000	706.220
Picerno	6.186	1,213	897	100.360	94.049	Lanciano	35.798	8,956	12.807	431.511	771.104
Pignola	5.483	0,695	723	130.080	55.397	Ortona	22.694	3,984	5.125	445.076	329.345
Potenza	69.060	20,715	37.176	2.429.863	2.042.997	Penne	12.495	1,471	2.264	110.000	123.295
Rapolla	4.648	0,572	429	45.160	44.352	Pineto	13.095	1,258	5.125	70.850	132.799
Rionero in V.	13.441	1,997	3.211	72.149	169.102	San Salvo	17.254	2,191	3.379	103.516	184.513
Rotonda	3.888	0,568	626	103.580	45.504	Alanno	3.742	0,286	614	49.798	25.115
Ruoti	3.687	0,407	339	110.996	31.797	Altino	2.536	0,182	469	70.000	16.554
San Fele	3.832	0,317	476	46.870	26.313	Ateleta	1.232	0,298	125	37.825	22.358
San Severino L.	1.923	0,240	326	64.128	19.661	Balsorano	3.705	0,875	384	44.688	65.841
Sant'Arcangelo	6.637	0,314	1.256	60.700	31.962	Basciano	2.381	0,234	386	44.708	19.644
Senise	7.182	1,154	1.516	123.580	94.536	Castel di Sangro	5.626	3,431	2.241	97.313	264.424
Venosa	12.148	1,283	3.746	61.160	122.218	Castelli	1.391	0,110	250	33.996	9.726
Vietri di Potenza	3.096	0,187	610	48.288	17.929	Civitella Roveto	3.330	1,671	595	18.717	124.833
Viggianello	3.500	0,176	450	201.599	15.955	Crognaleto	1.549	0,046	201	61.486	4.746
Bernalda	11.958	2,104	1.801	124.709	165.266	Cupello	4.415	0,754	558	59.337	58.439
Ferrandina	9.358	1,090	1.456	91.767	89.455	Gissi	3.088	0,399	853	63.000	35.059
Matera	57.785	6,174	20.082	1.434.495	671.635	Guardiagrele	9.527	1,196	2.102	60.000	102.232
Montalbano	7.991	1,694	1.950	81.614	136.887	Isola G. Sasso	4.883	1,570	788	94.203	118.986
Montescaglioso	10.121	1,233	1.299	80.940	98.552	Mont. Vomano	8.048	1,890	1.372	133.712	146.493
Nova Siri	6.418	0,166	1.114	58.240	20.204	Mosciano	8.313	1,301	1.638	50.000	106.105
Pisticci	17.811	0,388	3.110	225.834	52.239	Paglieta	4.401	1,080	653	36.600	82.608
Policoro	15.096	2,539	3.790	208.237	213.158	Roccaspinalveti	1.671	0,799	173	19.324	58.848
Pomarico	4.482	0,558	569	46.332	44.375	San Vito chietino	4.901	0,778	853	80.000	62.381
Rotondella	3.233	0,144	394	33.550	13.237	S. Eusiano	2.451	0,390	189	20.000	29.475
Salandra	3.109	0,335	392	35.522	26.994	Scerni	3.704	1,678	586	50.153	125.245
Scanzano Jonico	6.711	0,691	1.199	68.165	58.706	Schiavi di Abruz.	1.403	0,144	120	37.491	11.248
Stigliano	5.616	1,083	1.229	66.490	87.199	Tagliacozzo	6.532	1,227	1.234	80.000	97.639
Tursi	5.510	0,570	878	63.240	47.546	Torrebruna	1.173	0,219	89	30.000	16.460
Altamura	64.167	5,093	12.178	46.086	484.835	Tortoreto	7.836	0,511	2.341	115.835	54.708
Bari	316.532	62,747	127.303	8.388.967	8.755.680	Orciano	2.268	0,447	553	1.399	36.238
Barletta	92.094	9,360	18.573	347.737	878.585	Fossombrone	9.591	2,000	2.962	2.779	167.246
Bitonto	56.929	3,760	8.853	120.926	350.580	Fano	57.329	9,590	19.858	780.113	914.500
Brindisi	89.081	13,267	26.043	2.074.483	1.282.067	Pesaro	91.086	19,408	36.933	934.692	1.943.357
Canosa	31.445	3,660	5.301	120.699	307.622	Urbino	15.270	3,008	7.412	1.279.332	281.247
Cassano Murge	11.958	2,266	2.289	16.146	180.852	Urbania	6.643	1,491	1.557	12.444	119.166
Cerignola	57.366	6,460	10.593	427.597	564.646	Senigallia	41.550	8,821	15.267	241.666	793.140
Conversano	24.071	2,660	4.616	60.176	229.223	Sassoferrato	7.419	2,257	1.232	157.611	171.840
Corato	44.971	10,745	8.847	43.140	854.131	Jesi	39.224	12,418	19.098	570.266	1.106.915
Fasano	38.667	2,770	7.702	379.623	267.051	Fabriano	30.019	6,419	9.014	332.882	544.015
Foggia	155.203	13,817	44.649	3.844.293	1.724.447	Castelfidardo	16.917	3,804	3.121	77.932	298.612
Francavilla Font.	36.274	2,718	6.917	78.382	255.327	Ancona	100.507	19,853	57.952	3.498.441	2.534.554
Galatina	28.081	2,917	6.861	80.052	269.115	Falconara M.	28.349	5,727	6.539	36.553	468.513
Gallipoli	20.266	2,307	4.708	60.270	204.607	Osimo	29.413	3,109	8.818	124.180	303.261
Gioia del Colle	27.655	2,396	5.993	78.870	223.047	Matelica	10.155	2,138	2.099	48.886	170.080
Giovinazzo	20.300	1,677	3.027	39.000	144.476	Civitanova M.	38.299	6,368	13.671	360.500	595.390
Gravina in Puglia	42.154	2,850	5.580	47.122	251.842	Recanati	20.050	2,592	4.570	125.758	223.874
Grottaglie	31.894	3,708	4.604	91.957	304.675	Tolentino	18.649	3,000	5.613	334.132	262.946
Lecce	83.303	17,600	44.661	192.224	1.997.506	Macerata	40.875	6,934	21.340	859.267	746.086
Locorotondo	13.928	1,537	2.437	8.766	129.495	Sarnano	3.375	1,246	987	9.173	97.105
Manduria	31.747	7,214	4.761	316.355	558.882	Camerino	6.858	2,068	4.226	66.008	183.020
Manfredonia	57.704	4,530	8.925	34.092	406.874	S.Severino M.	12.794	2,945	2.997	64.239	235.627
Martina Franca	48.756	3,017	9.154	187.622	300.276	Fermo	35.502	3,864	11.766	238.000	391.247
Massafra	30.923	2,737	4.394	115.473	232.774	Montegranaro	12.860	2,105	2.493	8.742	170.876
Mattinata	6.333	0,470	1.124	5.838	42.199	Acquasanta T.	3.346	0,206	539	17.954	18.752
Minervino Murge	10.213	1,081	1.344	45.000	87.939	Montefiore Aso	2.199	0,338	319	28.389	26.685
Modugno	35.980	9,130	9.698	98.043	747.020	S.Benedetto T.	45.054	9,617	18.333	421.276	893.599
Mola di Bari	25.919	1,928	3.282	39.276	164.730	Ascoli Piceno	51.375	6,568	21.068	1.117.581	715.389
Molfetta	62.546	3,640	9.921	237.843	353.687	Folignano	8.844	0,241	959	14.700	24.443
Monte S. Angelo	13.917	1,422	2.114	206.072	118.588						
Nardò	30.520	8,870	6.120	39.300	691.046						
Noci	19.564	2,064	4.261	112.129	183.062						

Municipalities in Basilicata region
Municipalities in Puglia region
Municipalities in Abruzzo region
Municipalities in Marche region

4.2 Reference cost

With the aim to highlight the applicative potential of the above mentioned methods for the assessment of the urban public transit cost, we have built and calibrated a cost synthetic model using a real sample and we have compared the results drawn by the cost model and by the cluster split procedure.

The data-base adopted (table 8) is composed by 38% of the public transit services up to the municipalities of Basilicata region receiving the regional running subsidy (18 on the amount of 47) reduced to 32% (15 on 47) including the only ones of which we have the through data (comprising the commercial speeds).The values of the independent and dependent variables are drawn from the sample and so the cost assessed by the exposed methods can result closer to the target cost (standard cost) or to the real cost depending on how much the services in the sample are efficient.

Table 8: Values of the independent variables adopted in the multiple regression for the cost model calibration

Municipality	Haul 2005 (busxkm/year)	Number of lines	Number of rides	Network extension (km)	Commercial speed (km/h)	Real cost (Eur/busxkm)
Francavilla sul Sinni	48.495	1	12	15	32,8	1,55
Latronico	112.102	10	35	92	27,0	1,65
Lauria	206.562	15	62	253	23,4	1,83
Lavello	120.320	3	26	65	26,0	2,08
Melfi	544.981	7	166	129	30,0	1,73
Pignola	130.080	8	26	266	36,0	0,91
Rapolla	45.160	2	14	42	35,8	1,21
S. Fele	46.870	1	2	136	27,2	1,88
Vietri di Potenza	53.160	2	32	87	25,2	1,10
Viggianello	201.599	11	39	258	26,0	1,23
Matera	1.434.495	34	288	336	25,0	2,83
Nova Siri	58.240	1	18	12	24,0	1,31
Pisticci	225.872	7	72	130	27,0	2,12
Scanzano Jonico	68.162	4	12	75	25,9	1,78
Stigliano	66.490	3	14	40	25,0	1,65
Average	**224.306**			**129**	**27,7**	

The understanding of the relations between cost and service attributes is, on the other hand, more difficult because of the sample unhomogeneity: in fact, whilst the main municipalities produce the public transit service up to them mostly inside the urban border, the smaller ones instead have an almost entirely municipal service linking the hamlets and the rural centres to the head urban centre. This unhomogeneity is highlighted largely by the commercial speeds, that are lower in the main municipalities, also if rather high for an urban transport (minimum value = 23 km/h), and certainly high for the smaller ones (maximum value = 36 km/h);

in some cases, however, an interurban road network with very low standards brings the commercial speed of the service produced in the municipal area closed to the lowest values.

4.1 The synthetic method

To recognize the independent variables mainly affecting the unit cost dependent variable with reference to the examined sample, we analysed all the possible combinations among the following independent variable already set before:

X1: yearly haul (bus x km / year);

X2: number of lines;

X3: number of rides;

X4: network extension (km);

X5: commercial speed (km/h).

The cost model

Among the models fulfilling the Mallow test, reported in table 9, the best one , that is the model getting to the highest correlation clean coefficient R^2_{clean} and having not multicollinearity, is expressed by the following relationship:

$$\mathbf{C = 2{,}662 + 1.076 \times 10^{-6}\, X1 - 0{,}00123\, X4 - 0{,}0391\, X5}$$

where:

C = service unit cost (Eur/busxkm)

X1 = real haul (busxkm/year),

X4 = network extension (km),

X5 = commercial speed (km/h).

Table 9: Summary of the cost models satisfying the Mallows verify, with grey painting of the better one

	Cp	p+1	R^2	$R^2_{corr.}$	Std. Error	Consider This Model?
X1X2X3X4X5	6	6	0,638369	0,437462793	0,361681	Yes
X1X2X3X5	4,790835	5	0,606592	0,449229075	0,357879	Yes
X1X2X4X5	4,190564	5	0,630712	0,482996573	0,346735	Yes
X1X2X5	3,053329	4	0,596045	0,485875317	0,345768	Yes
X1X3X4X5	4,044032	5	0,6366	0,491239524	0,343959	Yes
X1X3X5	3,188534	4	0,590612	0,478960949	0,348085	Yes
X1X4	2,894352	3	0,52207	0,442415358	0,360086	Yes
X1X4X5	2,300842	4	0,626281	0,524357297	0,332576	Yes
X1X5	1,309579	3	0,585748	0,516706522	0,33524	Yes
X2X3X4X5	4,891549	5	0,602545	0,443563575	0,359715	Yes
X2X4X5	3,969436	4	0,559235	0,439025825	0,361179	Yes
X3X4X5	3,713291	4	0,569527	0,452125041	0,356937	Yes
X3X5	2,20482	3	0,549777	0,474739334	0,349493	Yes

The chosen model shows an unit cost raising with the haul and so the existence of scale diseconomies. This phenomenon, usually confirmed by the research on the topic, can be explained in the increase of the organizational intricacy with the

growing of the service dimension. The unit cost appears inversely proportional instead to the network extension and commercial speed, highlighting the existence of intensity economies and other ones related to favourable environmental elements in the case in point of road traffic.

Table 10: results of the cost model statistic verify

OUTPUT SUMMARY							
Regression statistics		**Variance analysis**					
Multiple R	0,791379		**Degrre of freedom**	**SQ**	**MQ**	**F**	**Significat. F**
R^2	0,626281	**Regression**	3	2,038911	0,679637	6,144619	0,010393
R^2_{clean}	0,524357	**Residue**	11	1,216675	0,110607		
Std. error	0,332576	**Total**	14	3,255586			
Observations	15						
			Coeff.	**Standard error**	**Stat t**	**Significat.**	**Less then 95%**
		Intercept	2,662744	0,642436	4,144763	0,001631	1,248752
		Real haul	0,000001	0,000000	3,307703	0,006982	0,000000
		Network extension	-0,001234	0,001130	-1,092255	0,298066	-0,003721
		Commercial speed	-0,039180	0,022371	-1,751375	0,107677	-0,088418

The clusters split

Referring to table 8 of the set variables for the selected sample, we report the significant intervals recognized for each variable and the parallel cost medium value (table 11).

Table 11: Average cost for each network extension, commercial speed and haul cluster

Cluster	Number of municipalities in the cluster	Network extension (km)	Avg Cost/ km weighted on the cluster (Eur/busxkm)
A	**6**	**< 70**	**1,398**
B	**6**	**[70-130]**	**1,628**
C	**4**	**[130-270]**	**1,398**

Cluster	Number of municipalities in the cluster	Network extension (km)	Avg Cost/ km weighted on the cluster (Eur/busxkm)
A	**6**	**<26**	**1,534**
B	**6**	**[26-30]**	**1,782**
C	**3**	**>30**	**1,280**

Cluster	Number of municipalities in the cluster	Network extension (km)	Avg Cost/ km weighted on the cluster (Eur/busxkm)
A	**6**	**<= 60.000**	**1,383**
B	**6**	**[60.000-130.000]**	**1,757**
C	**6**	**>= 130.000**	**1,593**

The comparison between the costs assessed by the synthetic method and the real ones referred to the selected sample reported in table 12 shows expressive concurrences in some cases, big divergences in others, as expected because of the fact that the proposed methodologies are of value to generalize the kilometric cost at the regional scale balancing the extreme values by a more uniform trend of the phenomenon. Appraising the result on the whole by the variance calculated on the

per-cent difference between the costs assessed by each methodology and the real ones, we notice a better respondence of the synthetic model (4,50%) in regard to the clusters split (9,34%). This confirms the advisability to choose more refined methodologies that can better perform the phenomenon in its intricacy.

Table 12: Comparison among costs assessed by the model and by the cluster split and real costs

Municipalities	Haul 2005	Commercial speed cluster	Haul cluster	Network extension cluster	Cost from cluster split (Eur/busxkm) (A)	Cost from the model (Eur/busxkm) (B)	Real cost (Eur/busxkm) (C)	(A - C) / C (%)	(B - C) / C (%)
Francavilla in Sinni	48.495	C	A	A	0,825	1,414	1,554	-88,38%	-9,03%
Latronico	112.102	B	B	B	1,699	1,614	1,65	2,89%	-2,21%
Lauria	206.562	A	C	C	1,139	1,658	1,83	-60,70%	-9,39%
Lavello	120.320	B	B	A	1,459	1,695	2,08	-42,56%	-18,51%
Melfi	544.981	B	C	B	1,54	1,917	1,73	-12,30%	10,79%
Pignola	130.080	C	C	C	0,95	1,067	0,905	4,76%	17,92%
Rapolla	45.160	C	A	A	0,825	1,261	1,21	-46,68%	4,22%
Rotonda	103.580	nd	B	nd	nd	nd	nd	nd	nd
San Fele	46.870	B	A	C	1,148	1,482	1,88	-63,70%	-21,19%
Sant'Arcangelo	60.700	nd	A	nd	nd	nd	2,7	nd	nd
Vietri di Potenza	53.160	A	A	B	1,151	1,626	1,1	4,45%	47,78%
Viggianello	201.599	B	C	C	1,323	1,544	1,23	7,02%	25,57%
Nova Siri	58.240	A	A	A	0,989	1,772	1,31	-32,51%	34,82%
Pisticci	225.872	B	C	C	1,323	1,689	2,12	-60,26%	-20,31%
Policoro	208.237	nd	C	B	1,297	nd	1,21	6,69%	nd
Salandra	35.522	nd	A	A	0,967	nd	1	-3,44%	nd
Scanzano Jonico	68.162	A	B	B	1,463	1,631	1,78	-21,70%	-8,35%
Stigliano	66.490	A	B	A	1,256	1,707	1,65	-31,37%	3,45%
Average	*129.785*				*1,210*	*1,577*	*1,585*		
Variance	***1,49E+10***							***9,34%***	***4,50%***

4.2 The analytical method

We believed unnecessary to calculate the reference cost by this method because it does not show conceptual intricacy but it only requires some data and unit costs. Instead we have reported some helpful parameters for the calculation, set by the rules of some Italian regions about the standard cost. These parameters are supported by wide applicative studies and so, where they do not represent local particularities, they are easy to be generalized and, if necessary, to be updated. Specifically we referred to the Regione Basilicata rules, because very extensive (L.R.34/1988 e L.R.46/1993) and considering that the sample used in the trial is related to some municipalities of this region.

As for the workers cost, these rules peg the ancillary workers cost and the office workers one to the running workers cost, fixing for the first rate the only value of 0,04 and for the second one some values as a function of the service yearly haul, as reported in table 13. These values highlight that the need of office workers per product unit raises with the service dimension, associating to this production factor an important part in the scale diseconomies already realized also by the cost synthetic model calibrated on the sample in question and emphasized by the scientific literature of the sector.

Table 13: Multiplicative coefficient for the assessment of the office workers cost related to the running workers one (Law of the Basilicata Region 46/1993 art.2) for different haul cluster.

Haul (busxkm/year)	Multiplicative coefficient m_p
0 – 1.000.000	0,06
1.000.001 – 2.000.000	0,07
2.000.001 – 3.000.000	0,08
3.000.001 – 7.000.000	0,09
Over 7.000.000	0,10

Referring to the fuel and oil consumption the same rules specify the unit values for a long or regular bus, in urban service reported in the table 14.

Table 14: Unit consumptions of oil, fuel and antifreeze

Fuel (lt/km)	Motor oil (g /km)	Gear oil (g/ km)	Axle oil (g/ km)	Power steering oil (g/ km)	Antifreeze (g/ km)
0,555	3,3	2,2	0,38	0,09	0,60

These consumptions, with particular reference to the fuel are probably decreased, from the date of the rules enactment (1988) to the present, through the higher degree of efficiency (about 15 – 20 %) of the present diesel engines in regard to that time ones. Therefore it is possible to adopt, at least for the fuel, an unit consumption of 15 – 20% lower than the tabled value.

With the respect to the tyres, the formula to be used is reported as following with the specified values:

$C_{Ty.} = C_{Tn} + C_{Bl.} + (C_{Co} \times R')$

$C_{Ty.}$ Must be divided for ($P_{nik} + P_{nik} \times R'$) and then multiplying by 6 (number of tyres on every vehicles;

C_{Tn}= cost of the tyre;

C_{Bl}= cost of the bladder;

C_{Co}= cost of the covering;

P_T= haul of the new tyres (50.000 km);

R'= % of covering (60%).

The unit cost of the tyres is recognized applying a suitable discount to the list prices.

The before adduced Regione Basilicata rules for the standard cost calculation provided, in the 1990, with reference to an average yearly haul of 60.000 km per vehicle, for a maintenance specific cost of 0,1747 Eur/busxkm (338,39 ITL) inclusive of spare parts, consumable stores and work. This value is to be upvalued by the average bus list price increase elapsed in the period between the 1990 (100.709 Eur, the bus standard price at the 1987) and today and it should be also expanded or reduced as the vehicles average haul if this last one will differ notably from the reference value.

The vehicles cost (depreciation, owner's tax and insurance) has to be calculated on the basis of the amount of the vehicles strictly required to execute the running schedule and increased by 10% to take into account the necessary safety stock.

The assessment of standard values for the depreciation cost of fixtures is certainly more difficult; this operation, in fact, requires the quantification of the standard surfaces for the admitted fixtures and of the depreciation period and also the assessment of the market value for these estates. Evidently it is not possible to give general leads about the fixtures value suffering certainly from the soil prices on which they stand; instead, as for the standard surfaces admitted to the depreciation, we can refer to the above cited regional rules providing 50 m^2 of garage surface for each bus used in the service, and 45 m^2 of office one for each standard office worker, with a depreciation period respectively of 30 and 20 years.

Also with regard to the general expenses, as already highlighted for the office workers charges, the cited rules admit the existence of scale diseconomies because they fix, for this factor, cost rates raising with the product (service haul), as in table 15.

Table 15: Relationship between general expenses and total ones with relation to the haul

Haul (busxkm/year)	General expenses / / total expenses
0 – 1.000.000	0,025
1.000.001 – 2.000.000	0,030
2.000.001 – 3.000.000	0,040
3.000.001 – 7.000.000	0,060
Over 7.000.000	0,090

5. Conclusions

The research presented so far has achieved theoretical-methodological and applicative results summarized as following:

- validation and quantification of the relation between the public transit needs and the municipality geographic and settlement sizes, and also between the service cost and some attributes of the supply, of the producer company and of the environment in which the supply is produced;
- verify of a methodology, based on statistical techniques, for the building of a synthetic model;
- tuning of general use tools for the quantification of the municipal public transit services and the assessment of their reference cost.

As for the model for the determination of the minimum services haul, on the theoretical-methodological level, we found that the municipal services workers is the only settlement variable notably affecting the needs of the public transit measured by transport service haul; other variables, as the inhabitants or the other workers, impact minimally on the public transit needs. The other variable

significantly affecting the analysed phenomenon is the area of the serviced land. This last parameter is referred to the head urban centre of the municipality because the remaining part of the municipal area weights irrelevantly on the haul of a service that is supplied mostly inside the urban border. The services workers are referred to the whole municipality since their presence is quite prevailing in the head urban centre. The haul is instead that of the whole public transit service up to the municipality subsidized by the regions. Then the calibrated model reproduces the haul of the public transit service up to the municipalities under the hypothesis that the service is developed entirely inside the urban border and that the municipal services workers are located in this area. As obvious, the prevision power of the model decreases as more as the real conditions are different from the schematised ones.

The tuned haul model is of prompt use and, also if it is still further perfectible by a calibration availing itself of a larger data-base, for general use because it is been already verified on the municipalities included in region different for orography and settlement features, either as a whole or divided for region. It is possible however to adjust the model to specific regional conditions fitting minimum or maximum limit values, both for the independent variables and for the dependent one, with the aim to restrict their range. The haul developed by each municipality and used for the calibration of the models is referred to the only road transit and so we will need a new calibration if we want to use the model to calculate the running subsidy for the public transit of the municipalities that have also other transport systems than bus.

As regards to the calculation of the reference cost, the built and calibrated model validates the results of the international research about the efficiency of the public transit services and gives practical leads to assessment of the unit cost. The peculiarity of the adopted data-base, concerning the public transit of the small settlement size municipalities, is emphasized by the haul of the considered services that are almost always very small, limited between about 45.000 and 1,4 million of busxkm/year (average value of 224.000 busxkm/year. The unit cost of this size services is influenced by the haul, network extension and commercial speed variables. Particularly the calibrated model shows a direct proportionality between haul and cost, validating the existence of scale economies and inverse proportionality between network extension and cost as a confirmation of the possibility to obtain density economies; naturally the cost raises as the commercial speed is been reduced.

The values of the cost obtained by the synthetic method (implemented in the model and in the clusters split methodology) reported in table 12 show an assessed cost essentially equal or not much different from the real cost for many municipalities of the selected sample. The much more noticeable differences comparable in some cases does not invalidate the method effectiveness that, generalizeing the relation between cost and service attributes, trends to reduce the extreme values reproducing the phenomenon with a more uniform trend.

The size and the reliability of the examined data sample affect the effectiveness of the tuned tools. On the topic it is to highlight that the sample used to build and calibrate the cost model, besides to be small, presents some limits associated to the typology of the data that it includes. In fact all the represented municipalities are small: only 5 of them exceed the 10.000 residents and only three of this are ranked above the 15.000; among the all others only five of them exceed the 5.000 inhabitants. Therefore the transit services present in them are characterized, besides for the low haul, also for sometimes appreciable network extension in regard to the haul and so they emerge often as municipal services rather than properly urban ones. This overtone can produce diseconomies associated to a low

network density and a low service intensity (the daily rides amount is mostly very low) and economies or diseconomies resultant from some environmental favourable factors (scant traffic) and from some unfavourable ones (road network with particularly limited standards) able to thwart the first ones. Doubtless the sample is not representative of medium and large municipalities where the public transit service is characterized by a dense network and by high frequencies.

Another limit of the sample concerns the services unit cost. This last one, also if extracted from official documents, raises some doubts the moment that services with similar features, produced in municipalities with the same size and the same land and settlement features, have very different costs. We should wonder how much the authorities of the smallest municipalities achieve to schedule public transit services that are efficient and effective with reference to the mobility needs, and how much the market power of the running companies has weighed to fix the cost, also in order to set out the auction amount in the competitive tender, particularly when the companies in question are deep-rooted in the municipality where they supply the service or in the surrounding areas.

On the other hand it is possible that the lowest values of the service unit cost can be accepted only by some minimal size companies with personal or family management, in presence of peculiar running schedules involving a minimum amount of workers and capital, or just to implement market strategies aimed to retain virtual monopolies in a specific area.

From all these considerations on the adopted sample we realize that we need to expand the research on the topic of the urban public transit service costs and to extend the verify of the proposed methodologies to a wider range. The purpose is to tune global and reliable operational tools as much as possible, by which assess the reference unit cost for the municipal public transit services. These tools should consider effectiveness conditions and, at the same time, the peculiarity of the service and of the environment in which it is supplied.

The analytical method can give better results as long as we are able to produce reliable assessment for the cost of each production factors. A part from the possibility, for this purpose, to avail ourselves of regional rules and specific studies, it remains difficult to tune assessment tools of global use that are suited to give values for the cost of each production factor on the basis of the own and employment features of the same factor so that these values can be not the real ones but those ones achievable in maximum efficiency conditions and so adoptable as target or standard values.

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