Infrastructure Local Expenditure Needs: a proposal for Italian municipalities

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Abstract

The Italian legislation on fiscal federalism provides that a comparison of the infrastructure service levels with the corresponding service standards shall be effected using appropriate indicators to measure any deviations. Actually, it is easy to find in literature several contributes about current expenditure connected to local services, but it is hard to find significant proposals for public capital expenditure estimation.
The present paper is aimed to propose a quantitative procedure concerning two objectives: i) the evaluation of the gap between the effective infrastructural endowment and the infrastructure needs deduced from the factors of demand generation; ii) the conversion in monetary terms of this gap.
In this first and experimental work we have focused the model and its application on the local transport infrastructure at the level of the Italian provincial capitals (about 100 municipalities). The most interesting result concerns the situation of the largest municipalities, different according as their location in the center and the north of Italy (endowment of local public transport essentially fulfilled against the corresponding needs) or in the south (more or less considerable deficit in the considered infrastructure).

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1. Motivation and overview

For EU countries the need of meeting monetary obligations and abiding by the budgetary constraints of the Growth and Stability Pact has imposed a new emphasis on the need for stricter control of government finances. This has "*affected local and regional authorities and their capacity to provide public services*" (Bloomfield, 2006).

The focus of public national account systems is, therefore, shifting to the need, in the short term, but especially in the medium-long term, to build stable, flexible and proactive control spending systems, both at central level and, mainly, at local level.

Given these constraints, for governments the real challenge is to build spending perequation and account control systems that allow maintaining the levels of public service, as much as possible, unchanged, by minimizing the overspending due to inefficiency, incorrect allocations of production factors or chronic misalignment in optimal Local Authorities sizing.

In Italy an innovative autonomy path for Local Authorities has started in 2009, linked to a fundamental change in the criteria for funding of local public services; the statutory law on fiscal federalism (Law No. 42 of 5 May 2009) and the provisions implemented regarding the determination of standard requirements for Local Authorities (Municipalities, Provinces and Metropolitan cities) issued through Legislative Decree No. 216 of 26 November 2010, allows Italy to modernize intergovernmental financial relations and to make efficient the Local Authorities costs.

In particular, Article 2 establishes that "*the infrastructural survey [] shall be conducted by means of a comparison, for each sector of intervention, of the service levels provided at 31 December 2010 with the corresponding service standards at the same date. The comparison shall be effected using appropriate indicators to measure any deviations, both quantitative and qualitative*".

Estimating standard requirements is a first necessary step towards building a new mechanism for the distribution of equalization transfers as provided for in Article 13 of Law 42/09 regarding the essential functions funding for Municipalities and Provinces.

In literature (see Dafflon and Mischler, 2007 for a complete survey) several allocation techniques have been proposed in recent years which differ for their complexity and the informative setting size they needed.

The most used methods, namely those based on the cost function - in the full or reduced form - focus, however, on Local Authorities current expenditure part and do not propose any solution for the capital part.

This theoretical lack is even more pressing in Italy, where, as found by Vidoli and Mazziotta (2012), exist a "*considerable [...] mismatch between the demand and the supply for infrastructure expressed by the territory and [...] the territorial distribution of the infrastructural endowment of transport is not in line with the theoretic factors of generation that are present in the Italian provinces*".

The objective of the present paper is to propose a theoretical model aimed to evaluate the infrastructure local expenditure needs at local level considering the supply and demand factors of generation and taking into account the existing infrastructural gap.

In this first and experimental proposal we will focus our application on the local transport infrastructure for the Italian provincial capitals.

The paper is organized as follows: Chapter 2 briefly recalls the two ways generally used to obtain the reconstruction of public capital: on one hand, construction of a composite indicator, synthesis of single indicators expressed in physical terms; on the other hand, recourse to the prevailing Perpetual Inventory Method (PIM), operating on data expressed in monetary terms. In chapter 3 a theoretical model for capital local expenditure needs is presented, wherein a specific estimation of public transport infrastructure considering the demand generation factors joins the previous evaluations, in order to determine the capital expenditure needs for Italian provincial capitals. Chapter 4 describes the various steps necessary to the model implementation and presents the relative results, the most important of which is the estimation of the capital expenditure needs consistent with the infrastructural equalization considered in the Italian legislation. Chapter 5 finally contains some conclusions and a summary of the work.

2. Two alternative approaches to measuring infrastructural endowment

There are two main approaches to measuring public capital: estimating it in physical terms or using the monetary yardstick to estimate it in terms of value (a critical survey of both applications is in Mazziotta, 2005).

Public capital in monetary terms is normally estimated by means of Perpetual Inventory Method, suggested by Goldsmith, 1951 and now used by most national statistics institutes. This method reconstructs capital endowment as the sum of gross fixed investment in the years prior to that in which the valuation is made, the number of years chosen to coincide with the average useful life of the various categories of capital goods included.

The greater simplicity and directness of the perpetual inventory is evident, which is why this is the method of choice for the majority of statistical institutes. This preference has essentially two reasons: i) the perpetual inventory dispenses with the need for supplementary inquiry, as one can use the time series on investment for major categories of public works that are calculated and published by the statistical institutes; ii) it circumvents the problem of assigning a price to each type of capital good (which is complicated indeed, both conceptually and practically), as the estimates of investment already available in the national accounts can be used.

Drawbacks linked to Perpetual Inventory Method consists in: i) the arbitrary assumptions on the rate of depreciation and the life cycle of durable goods, ii) the need to have sufficiently long time series and comparable especially for capital goods with long half-life; iii) the estimate reflect the monetary value of public spending in capital account not taking into account the quantity and quality of work actually performed or cost differences due to environmental circumstances.

The monetary measurement of public capital certainly has advantages in its tested estimation methodology and the features of the indicators obtained (great uniformity and flexibility, properties of additivity, etc.). Nevertheless, regional disparities in infrastructural endowment can probably be better grasped by estimates expressed in physical terms. This is above all because sometimes radically diverse topography (chiefly, mountainous terrain in some places) means that equal investment in money amounts is actually not equivalent. Hence the value of estimating infrastructural endowment based on physical indicators.

The standard procedure used for constructing composite indicators of infrastructure endowment based on physical data is as follows: i) data collection and construction of elementary indicators; ii) normalization of the indicators with respect to size of the geographical units examined; iii) standardization of the normalized indices to adjust the normalized indicators for the units of measurement relating to the various categories; iv) aggregation of the standardized indicators into composite indicators for the main categories and, lastly, into an overall composite indicator for the various categories. The last step is the most objectionable, overall in the matter of the aggregation function to adopt: simple, weighted, linear or non-linear, compensative or non-compensative, and so on (for a specific solution adopted in this work, see following section 3.1).

The two mentioned approaches are usually alternative, as already affirmed. But in this work both have been used, in order to pursue two different objectives. The construction of composite indicator in physical terms is aimed to obtain a more realistic vision of the effective local transport capital endowment in the

Italian municipalities. The application of perpetual inventory is aimed to have an estimation of effective capital expenditure for the local transport. The comparison between expenditure and physical endowment allows to obtain an estimated price/cost of the considered infrastructure.

3. Model

3.1. Composite indicators

Composite indicators (CI) techniques has been deeply enhanced during the last few years enabling to compare different dimensions effectively and making easier to interpret complex phenomena.

In the present paper we propose to use a particular generalization of the Benefit of the Doubt[1] (BoD) method suggested in Vidoli and Mazziotta (2013) with the aim to reduce the visible size of a set of basic infrastructural indicators without dropping the underlying information base.

More specifically, in our previous paper we have enhanced frontier approach in two directions: i) incorporating the DeMuro et al. (2010)'s idea assuming that each indicator may not be replaced by the others or is so only in part to overcome the "compensatory" BoD drawback, and ii) reducing the influence of extreme values and outliers choosing order-m approach (Daraio and Simar, 2005) as a more robust estimator in the field of nonparametric frontier technique.

More precisely, we can calculate the CI for the unit i such as:

$$CI_i = Order_i(1 - cv_i^2), \forall i = 1, \ldots, N \tag{1}$$

where $Order_i$ is the order-m score, that is the expected value of minimum input efficiency score of the unit i when compared to m units randomly drawn from the population of units with greater indicators values, and cv_i^2 represents the coefficient of variation for the unit i between all indicators.

3.2. Capital local expenditure needs

As described in the last paragraph, we are able to calculate the historical physical level of infrastructure, named I_h.

Starting from infrastructural CI, therefore, similarly to the reduced form of the structural model of demand and supply of public services (see *e.g.* Reschovsky,

[1] *"The Benefit of the Doubt approach is formally tantamount to the original input-oriented CCR-DEA model of Charnes et al. (1978), with all questionnaire items considered as outputs and a dummy input equal to one for all observations"*, Witte and Rogge (2009).

2007 for the standard public current expenditure model), we can hypothesize the standard level of infrastructure needs I_e as:

$$I_e = f(D, S, p, R) \tag{2}$$

where D are demographic and socio-economic contextual variables which mimic the infrastructure demand, R is the average local income, p the input price vector and S the supply variables that represent morphological and socio-economic constraints changing the unitary service costs.

Considering $\widehat{I_e}$ as the estimated infrastructural composite level linked to the local demand and supply, we can calculate the difference between the estimated and the historical index, even in physical terms, to derive a composite gap indicator.

$$\Delta I = \widehat{I_e} - I_h \tag{3}$$

Once the physical gap ΔI has been founded, the second step has the aim to determine a price level in order to derive a monetary infrastructural gap estimation; the transition to monetary values is surely the most difficult part since the standard price (here noted as p_{I_h}) is influenced by many factors (see previous paragraph).

In a classical PIM framework, the standard price p_{I_h}, linked to a unitary part of I_h, can be expressed[2] as:

$$p_{I_h} = \frac{MV}{I_h} \tag{4}$$

where the actual monetary value MV is:

$$MV = \sum_{t}^{T} CE_t P_{t,t-j} \tag{5}$$

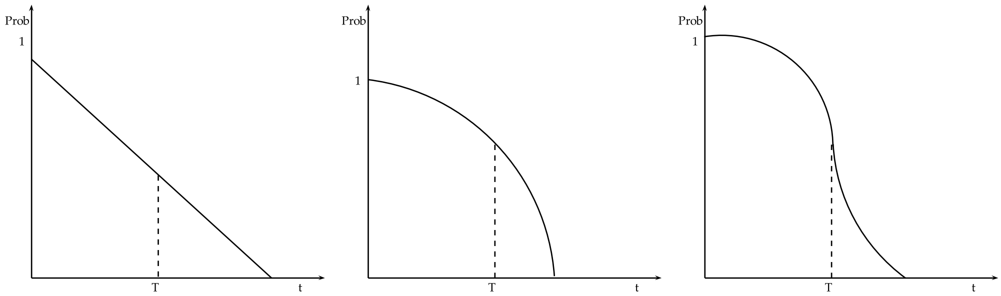
and CE_t is the capital expenditure at time t for unit i, $P_{t,t-j}$ the price index of year t with base year $t-j$ and T the expected service life.

In a standard PIM application the main assumption is that the total investment of a particular asset does not deteriorate during the expected service life of that asset and is discarded as a whole after that period of time. For this purpose, a simple uniform function is used for the survival function of a certain asset.

[2]For seek of simplicity we omit the subscript of the unit i.

Using a probabilistic setting, instead, a survival function $S(t) = 1 - F(t)$ is used where $S(t)$ is the survival function and $F(t)$ the probability distribution of the service life of the asset, that is the probability that the service life of an asset is less than or equal to T.

In Figure 1 the shapes of three survival functions are shown; T denotes the expected (mean) service life.



(a) Linear (b) Hyperbolic (c) Logistic

Figure 1: PIM survival functions

Starting from the equations (4) and (5), we propose to enhance standard PIM calculation method using survival framework; the actual monetary value MV can be more usefully expressed as:

$$MV = S(CE_t)P_{t,t-j} \tag{6}$$

This more general formulation lets to study the estimates robustness varying the survival function.

Starting from the equation (6), we propose to integrate survival PIM formulation with an optimum frontier production approach in order to estimate an efficient price p_{eff} considering the actual monetary value of the capital good (MV) as input and the infrastructural composite indicator (I_h) as output; the frontier approach, in fact, lets us to overcome the main PIM shortcoming concerning the non-coincidence between the historical expenditures and the actual infrastructural level differences due to cost inefficiencies[3].

Note also that, in a efficiency production framework, the optimal I_{eff} and consequently the optimal unitary price p_{eff} is not a theoretical value for each

[3]Contextual factors can also usefully included in a frontier framework, allowing to take into account cost differences due to exogenous supply factors.

level of capital expenditure, but it is a linear combination of best historical expenditure values with decreasing marginal returns (see Figure 2).

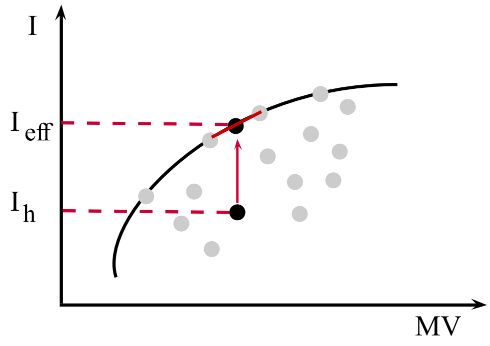


Figure 2: Efficient price

Finally, p_{eff} can be used to estimate the total capital financial needs ($TCFN$) useful to fill the local infrastructure gap.

$$TCFN = p_{eff} \cdot \Delta I \tag{7}$$

4. Application

4.1. Data

Responding to the need to estimate the capital standard needs has been really an *hard job*; it has been necessary to build a very complete dataset both from a temporal point of view (through a time series as long as possible in order to grasp the cumulative effect of annual investment) both from the extension of the sectors analyzed describing the provincial capitals expenditures and explaining the local supply and demand differences.

The information set, therefore, has been collected as the union of several official information sources, even in a panel (year 2000-2010) framework: the accounting data called *Municipal final account certificates* from the Italian Ministry of Interior (http://finanzalocale.interno.it/), the socioeconomic data through a multitude of ISTAT dataset covering population (http://demo.istat.it/), lifestyle (see e.g. https://indata.istat.it/musei/) and territory (http://sitis.istat.it/sitis/html/), and the ISTAT transportation supply and demand information (http://www.istat.it/it/archivio/trasporti).

Finally we have chosen capital goods sector (local public transport) with a relative short life cycle in order to bypass the need for capital expenditures time series too long and not very homogeneous.

4.2. Results

The estimation procedure of the capital expenditure needs has been very long and complex; for the sake of simplicity and clarity, we'll illustrate it, therefore, as a series of sequential steps.

Step 1: Calculation of physical infrastructure simple indicators.

Capital expenditure in local public transport sector are intended to finance the public transport network, to acquire buses, trolleybuses, trams and subways and to improve the public car parks. For this reason, we have considered four simple indicators covering all areas of expenditure.

$$Network = \sum(Dens_{net\_BUS}, Dens_{net\_TRAM}, Dens_{net\_FILO}, Dens_{net\_METRO}) \cdot KMQ_{area}/100$$

$$Vehicles = \sum(Dens_{veh\_BUS}, Dens_{veh\_TRAM}, Dens_{veh\_FILO}, Dens_{veh\_METRO}) \cdot Population/10000$$

$$Paid\_parking = Paid\_parkings \cdot car/1000$$

$$Stops = Dens_{Stops} \cdot KMQ_{area}$$

where, in particular, the subway density ($Dens_{net\_METRO}$) is corrected by a factor[4] of 25/15, the $Paid\_parking$ is the number of paid parking stalls on the road and the $Stops$ are the buses, trams, trolley buses and metro stops.

All simple indicators have been, finally, normalized to 1 by dividing each indicator to its maximum.

Step 2: Composite historical indicator (I_h) estimation.

As proposed in section 3.1 we have, therefore, used frontier methods to calculate, in a exogenous and robust way, the physical capital synthetic indicator (I_h).

This indicator has been calculated using either the BoD classic method both the robust version[5] (Order-*m* BoD); the correlation between the two rankings has been highly significant (equal to 0.97) bringing out a great concurrence between the composite indicator and the elementary ones.

[4]This factor is the ratio between the metro minimum commercial speed equal to 25 km/h and the average of the buses commercial speed in urban areas (16.3 km/h) and the trams commercial speed (14.5 km/h).

[5]Please see Vidoli and Mazziotta (2013) for a comprehensive explanation of these techniques.

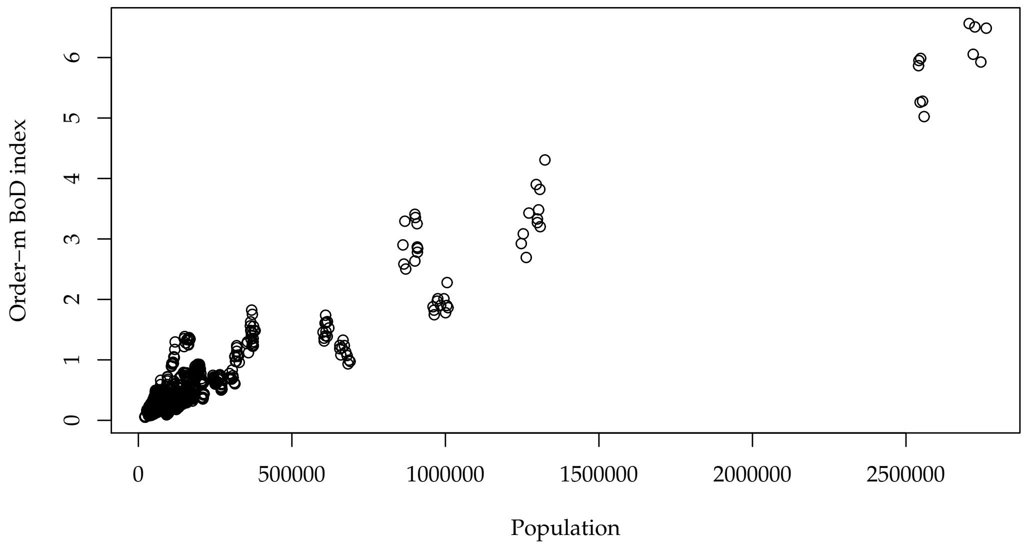


Figure 3: Historical Order-m BoD CI by population

Figures 3 and 4 show that the physical level is properly correlated with the size of the municipality (in terms of population) and highlight the noticeable differences between metropolitan cities (themselves very different) and other ones.

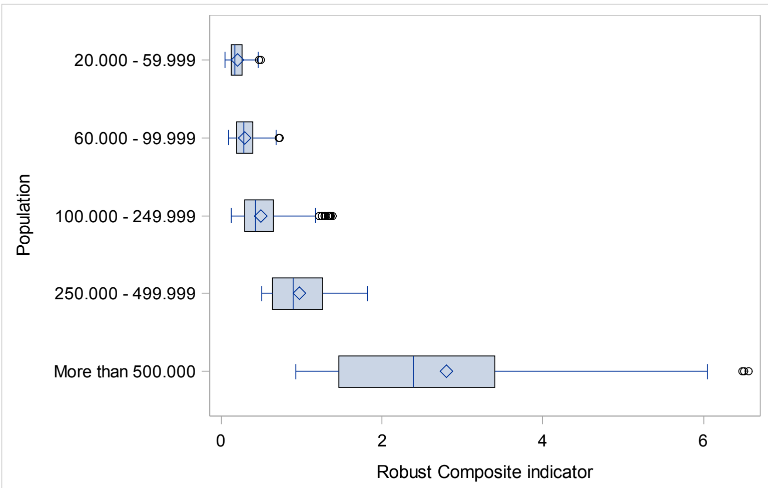


Figure 4: Historical Order-m BoD CI by class of population

Step 3: Supply and demand composite indicator (I_e) estimation.

The aim of this step is to estimate the composite indicator (I_e) level linked to the local supply and demand factors in order to assess the capital needs in physical terms (ΔI).

The explicative factors (in a ten years panel) and the estimation model chosen (independent variables in logs, regional and year dummies) have allowed us to get a very good fit ($R^2 = 0.9373$), but, above all, they have allowed to explain the physical endowment in terms of covariates economically very significant and consistent with I_e.

Results are shown in Table 1; in particular, please note the negative sign of two variables related to private transport (*N. of vehicles for urban surface* and *Average travel time*, average travel time of commuters within the city of residence), thus showing the trade-off between public and private supply.

Covariates related to the day-time population (*Commuters*, Incoming less outgoing diary commuters), the extension of the physical territory (*Roads*, *Urban surface*) and the annual passengers transported by public transport (*Demand for public transport*) are also significant.

Covariates	Coef.	Robust Std. Err.	t	$P > t$	[95% Conf.	Interval]
Roads (km)	0.0731322	0.0386793	1.89	0.059	-0.0027731	0.1490376
Urban surface	0.0767658	0.0172393	4.45	0	0.0429348	0.1105968
N. of vehicles for urban surface	-0.1952825	0.0279444	-6.99	0	-0.2501213	-0.1404437
Average travel time	-0.1015437	0.0480093	-2.12	0.035	-0.1957584	-0.007329
Museums visitors	0.0206594	0.0057872	3.57	0	0.0093024	0.0320164
Commuters	0.0154019	0.0038163	4.04	0	0.0079126	0.0228911
Population	-2.856251	0.1242179	-22.99	0	-3.10002	-2.612483
Population Squared	0.3392782	0.0139062	24.4	0	0.3119884	0.366568
Demand for public transport	0.073111	0.0086439	8.46	0	0.0561479	0.0900741
Capital transfers from Central gov.	0.0002865	0.0043777	0.07	0.948	-0.0083043	0.0088774
Year_2001	0.0062474	0.027448	0.23	0.82	-0.0476173	0.060112
Year_2002	0.028559	0.0274087	1.04	0.298	-0.0252287	0.0823467
Year_2003	0.0365798	0.0296121	1.24	0.217	-0.0215317	0.0946914
Year_2004	0.0373403	0.0279402	1.34	0.182	-0.0174903	0.0921709
Year_2005	0.0379248	0.0285366	1.33	0.184	-0.0180762	0.0939259
Year_2006	0.0493197	0.0286526	1.72	0.086	-0.006909	0.1055484
Year_2007	0.046011	0.0268126	1.72	0.086	-0.0066067	0.0986287
Year_2008	0.0627294	0.0298487	2.1	0.036	0.0041535	0.1213054
Year_2009	0.0665061	0.0279503	2.38	0.018	0.0116557	0.1213565
Year_2010	0.0586241	0.0325204	1.8	0.072	-0.0051949	0.1224431
Dummy_reg1	-0.0063167	0.0381912	-0.17	0.869	-0.0812642	0.0686308
Dummy_reg2	(omitted)					
Dummy_reg3	-0.0238805	0.0370957	-0.64	0.52	-0.0966781	0.0489171
Dummy_reg4	0.2432769	0.0656372	3.71	0	0.1144687	0.3720852
Dummy_reg5	-0.2476401	0.0404118	-6.13	0	-0.3269452	-0.1683349
Dummy_reg6	0.0619218	0.0654929	0.95	0.345	-0.0666033	0.1904469
Dummy_reg7	-0.1241705	0.0709729	-1.75	0.081	-0.2634496	0.0151087
Dummy_reg8	-0.2166396	0.036076	-6.01	0	-0.2874361	-0.145843
Dummy_reg9	-0.0583515	0.0417212	-1.4	0.162	-0.1402263	0.0235233
Dummy_reg10	0.073036	0.0752553	0.97	0.332	-0.0746471	0.2207191
Dummy_reg11	0.0105486	0.0232773	0.45	0.651	-0.0351314	0.0562286
Dummy_reg12	0.115758	0.0585866	1.98	0.048	0.0007861	0.2307299
Dummy_reg13	-0.0258293	0.0240219	-1.08	0.283	-0.0729705	0.021312
Dummy_reg15	-0.186938	0.0450334	-4.15	0	-0.2753129	-0.0985631
Dummy_reg16	0.0147737	0.0327141	0.45	0.652	-0.0494253	0.0789728
Dummy_reg17	0.0563434	0.0378995	1.49	0.137	-0.0180317	0.1307185
Dummy_reg18	-0.0721749	0.036812	-1.96	0.05	-0.1444157	0.000066
Dummy_reg19	-0.0794673	0.0592531	-1.34	0.18	-0.1957473	0.0368127
Dummy_reg20	0.1032654	0.0683862	1.51	0.131	-0.0309376	0.2374684
Constant	6.509016	0.5003055	13.01	0	5.527202	7.490829

Table 1: Demand and supply physical capital index estimation

Panel data, therefore, have been useful for the robust estimation of the indicator; however, only the gap between the estimated and historical level in the last year, namely 2010, is of interest to us, from this point onwards.

Figures 5, 6 and 7 show the difference, for year 2010, between estimated (I_e) and historical index (I_h) by population and regions; please note that differences increase with the city size although in the higher population class results are very heterogeneous.

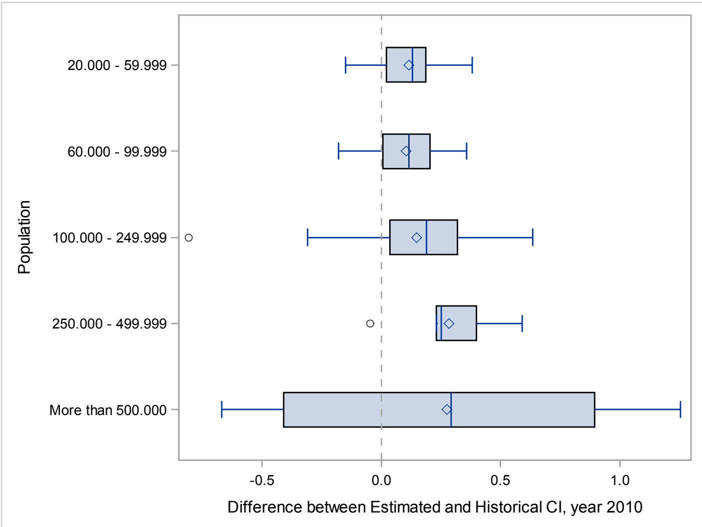


Figure 5: Difference between estimated and historical index by population

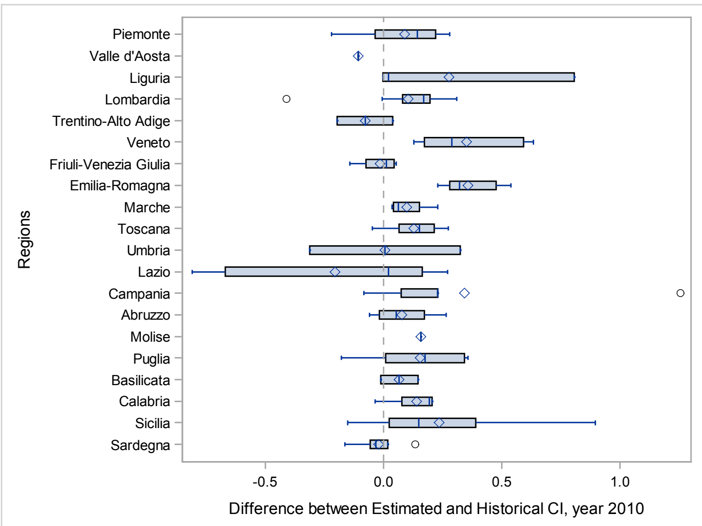


Figure 6: Difference between estimated and historical index by regions

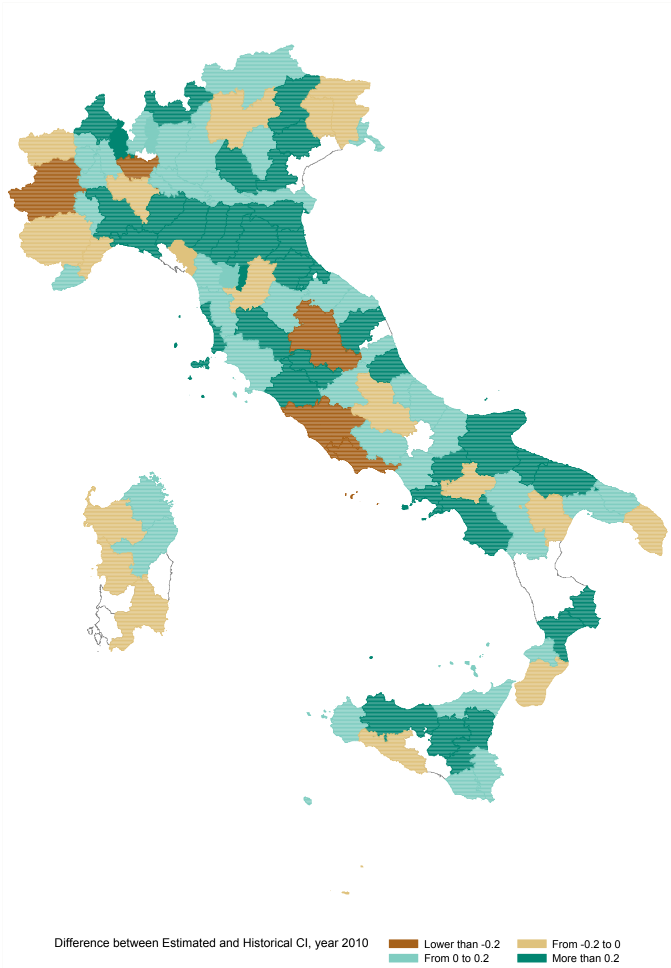


Figure 7: Difference between estimated and historical index, year 2010

Step 4: Actual monetary value capital stock (MV) estimation, year 2010.

Starting from the Public Administration accounting data related to the capital expenditures[6] (Traffic and transport function net of Public lighting and related services), we have calculated the actual monetary value of the capital stock (following equation 6) as the sum of the expenditures from 2000 to 2010 multiplied by the probability of survival of the capital itself (see Table 2).

[6]For the presence of missing data in the cost time series, it has been necessary to reconstruct some values; the estimation has been done by assuming, for each municipality, a single trend fitted on the other existing values.

Year	Linear	Hyperbolic	Logit
2000	0.05	0.05	0.05
2001	0.1	0.1	0.1
2002	0.2	0.29	0.15
2003	0.3	0.43	0.23
2004	0.4	0.56	0.35
2005	0.5	0.7	0.52
2006	0.6	0.79	0.73
2007	0.7	0.87	0.85
2008	0.8	0.94	0.92
2009	0.9	0.98	0.96
2010	1	1	1

Table 2: PIM Survival functions coefficients

As initial analysis, we used the hyperbolic function given that it maintains, most of the other, the capital stock value in time; other functions will be used to test the robustness of the results.

Step 5: Efficient prices (p_{eff}) and total capital financial needs ($TCFN$) estimation

The aim of the last step is to estimate the efficient price (p_{eff}) linking the capital stock (year 2010) to the historical physical level I_h for the efficient municipalities, namely for those that have obtained higher level of physical infrastructure with a minimum stock of expenditures.

Figure 8 show clearly the estimation problem[7]: we have to find the convex frontier of the data and, for efficient points, calculate the mean ratio between spending and physical indicator.

[7]For graphical reason, we have plotted only units with I_h less than 4 and stock of Capital stock less than 60,000,000 Euro.

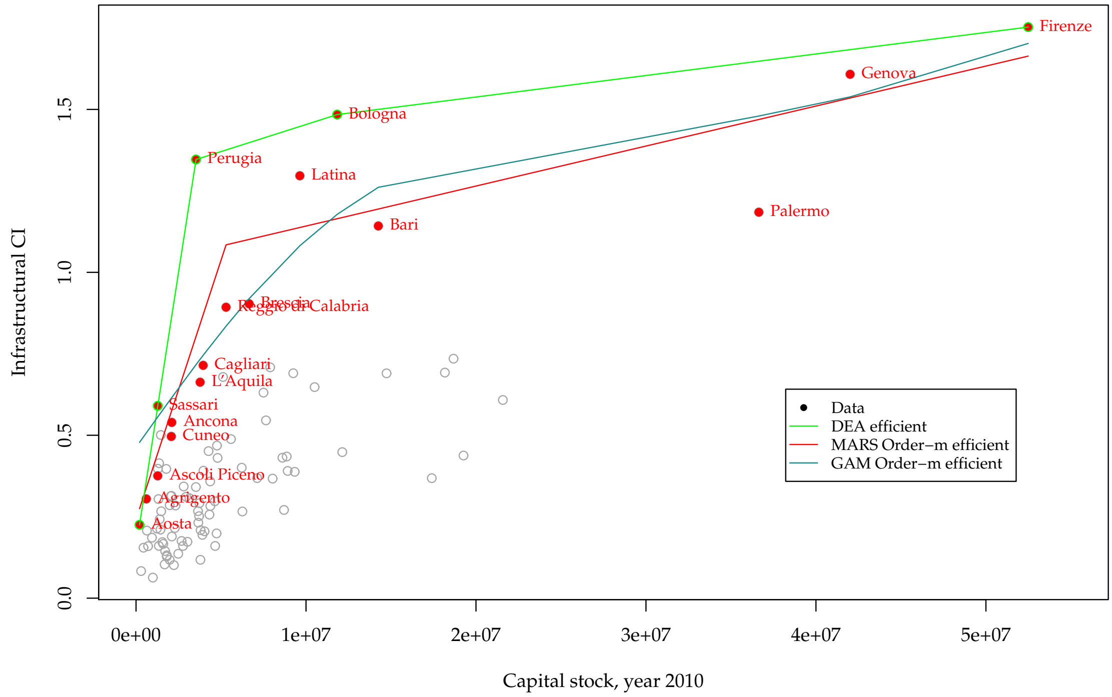


Figure 8: Capital stock (year 2010) and historical CI

The estimation has been carried out with a particular two-stage procedure that in the first step estimate the frontier in a robust non-parametric form (red points in Figure 8) and then, in a second step, use a MARS model (Friedman, 1991) in order to derive the parametric form of the function that fit (red line in Figure 8) the efficient units (for more information on this two-step procedure, please see Vidoli, 2011).

Therefore, we have obtained the parametric form of the piecewise linear function (equation 8) with a discontinuity value equal to 5296530 Euro and a very good fitting ($R^2 = 0.78$).

$$I_h = 1 + 1.4e^{-08} \cdot max(0; MV - 5296530) - 1.5e^{-07} \cdot max(0; 5296530 - MV) \tag{8}$$

Finally, once estimated the function linking I_h and MV, through the inverse function, we were able to reconstruct from a physical measure the capital financial needs, even taking into account the expenditures best practices.

Figure 9 and Table 3 show the total capital financial needs $TCFN$ estimation for each provincial capital.

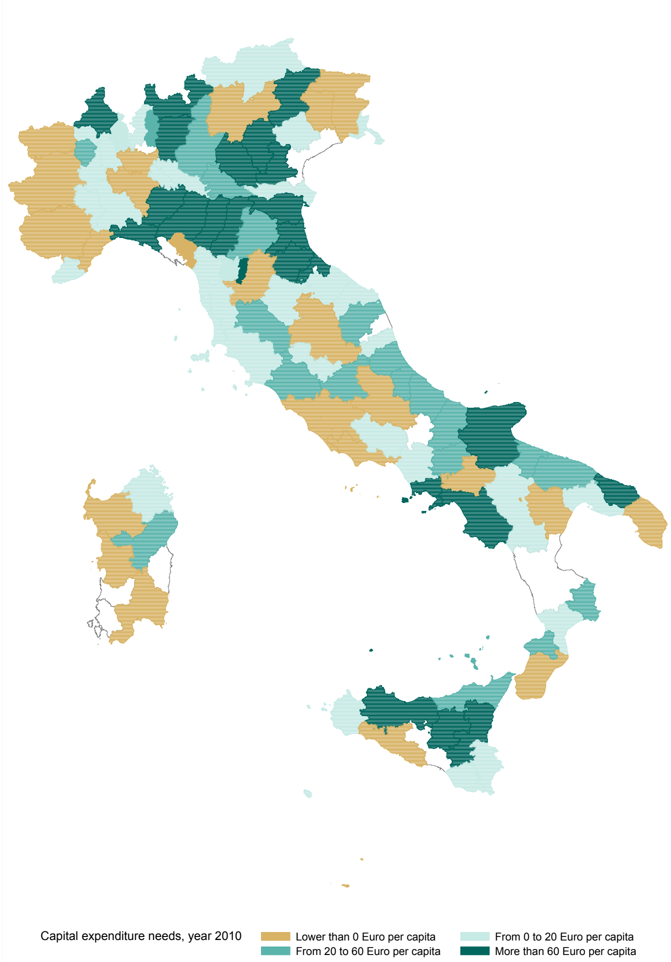


Figure 9: Total capital financial needs, year 2010

5. Summary and conclusions

5.1. Objectives

The starting point of this work is the Italian legislative provision on fiscal federalism. Particularly, we intend to lay stress on the point that a comparison of the infrastructure service levels with the corresponding service standards should be effected using appropriate indicators to measure any deviations, both quantitative and qualitative ones. In regard to this, it is easy to find in literature several contributes about current expenditure connected to local services, but it is hard

to find significant proposals for public capital expenditure (local infrastructure endowment).

In this framework, the present paper intends to put forward a quantitative procedure concerning two objectives: i) the evaluation of the gap between the effective infrastructural endowment and the infrastructure needs, deduced from the factors of demand generation; ii) the conversion of such a gap in monetary terms. In this first and experimental work we have focused the theoretical model and its application on the local transport infrastructure at the level of Italian provincial capitals (about 100 municipalities).

5.2. Methodology

The logical sequence of the work is the following:

1. Construction of a historical composite indicator of the local transport infrastructure, based on the official data about single indicators (vehicles, network, paid parking, bus stops);
2. Construction of an estimated indicator of the local transport infrastructure, as the result of a regression considering the principal factors of demand generation (population, road extension, urban surface, density of vehicles, average travel time, number of commuters);
3. Evaluation of the gap (in physical terms) between theoretical needs and effective endowment for each provincial capital;
4. Estimation of the capital expenditure in local transport infrastructure, corresponding to the public capital endowment in monetary terms;
5. Comparison between the historical composite indicator and the monetary estimation of local transport infrastructure, consecutive derivation of the unit price/cost for the infrastructural gap, determination of capital expenditure needs at the considered territorial level.

From a methodological point of view the main problems concern the above mentioned points 1, 2 and 4. As for the first one (the construction of historical composite indicator of the local transport infrastructure), the main difficulty concerns the aggregation of the single indicators, particularly the decision on which formula to use, what weights, what non compensatory technique. Therein we adopted the Benefit of the Doubt technique (which belongs to the family of DEA methods), integrated by non-compensatory approach between the single indicators, as it has already been done in previous works concerning the construction of composite indicators of infrastructure endowment. As for the construction of an estimated indicator of the local transport infrastructure, we used a panel

log regression (about 1000 observations), whose results are statistically efficient and robust. Eventually, as for the estimation of the capital expenditure in local transport infrastructure, we used the classical approach of Perpetual Inventory Method, which we applied to each considered category of transport capital. The relative survival function has been estimated using a hyperbolic function, which seems fitter to the relatively short life of the considered infrastructure.

5.3. Results

In general, the obtained results can be considered satisfactory. Actually they are highly satisfying, if one considers the experimental nature of our work. The most relevant results can be summarized as follows:

- The infrastructural gap between effective capital (historical composite indicator) and estimated capital (representative of the local needs) - both calculated in physical terms - shows a sharp difference among the major urban centers and the others considered provinces;

- The comparison (with reference to year 2010) between capital stock (in monetary terms) and historical composite indicator (in physical terms) allows the estimation of the unit cost for the considered infrastructure: the observed difference of this cost at the territorial level can be considered as a proxy for the efficient capital expenditure;

- The estimation of capital expenditure needs - calculated for overall population and per capita - produces some very interesting results, even if in a few cases (in particular, some provinces located in Lazio and Emilia-Romagna) it will be necessary a further in-depth analysis. Two results seem clearly evident: on the one hand, the largest municipalities located in the center and the north of Italy (Roma, Milano, Torino, Firenze) as well as some municipalities belonging to ”special statute” regions (Valle d’Aosta, Friuli, Sardinia) present an endowment of local public transport essentially fulfilled against the corresponding needs; on the other hand, the majority of the largest municipalities located in the south of Italy (Napoli, Palermo, Catania, Bari, Messina) presents a more or less considerable deficit in the considered infrastructure.

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Region	**Municipality**	**Population**	I_h	$\widehat{I_e}$	ΔI	MV	$TCFN$	$TCFN$ **per capita**
Abruzzo	Chieti	53.937	0,39	0,41	0,02	9.335.026,00	1.687.314,90	31,28
Abruzzo	L'Aquila	72.511	0,66	0,60	-0,06	3.771.860,60	-405.245,20	-5,59
Abruzzo	Pescara	123.077	0,39	0,47	0,08	8.921.375,80	5.877.113,00	47,75
Abruzzo	Teramo	54.957	0,14	0,40	0,26	2.484.050,70	1.791.355,20	32,60
Basilicata	Matera	60.818	0,50	0,49	-0,01	1.457.924,20	-82.461,05	-1,36
Basilicata	Potenza	68.297	0,25	0,40	0,15	3.710.681,20	984.100,42	14,41
Calabria	Catanzaro	93.124	0,22	0,42	0,21	2.283.442,60	1.402.703,00	15,06
Calabria	Crotone	61.798	0,16	0,36	0,20	709.381,03	1.375.167,60	22,25
Calabria	Reggio di Calabria	186.547	0,89	0,86	-0,03	5.296.529,70	-2.372.014,00	-12,72
Calabria	Vibo Valentia	33.853	0,08	0,27	0,19	298.099,57	1.266.842,10	37,42
Campania	Avellino	56.339	0,27	0,18	-0,08	3.646.186,80	-567.369,50	-10,07
Campania	Benevento	62.035	0,21	0,44	0,23	3.797.997,60	1.554.941,50	25,07
Campania	Caserta	78.693	0,31	0,38	0,08	3.141.814,20	510.345,81	6,49
Campania	Napoli	959.574	1,88	3,13	1,25	157.944.367,00	88.075.961,00	91,79
Campania	Salerno	139.019	0,37	0,60	0,23	17.399.585,00	16.205.195,00	116,57
Emilia-Romagna	Bologna	380.181	1,48	1,72	0,23	11.836.164,00	16.203.940,00	42,62
Emilia-Romagna	Ferrara	135.369	0,27	0,80	0,54	6.256.759,70	37.724.883,00	278,68
Emilia-Romagna	Forli	118.167	0,27	0,60	0,32	8.704.472,00	22.813.294,00	193,06
Emilia-Romagna	Modena	184.663	0,43	0,91	0,48	8.611.716,70	33.389.170,00	180,81
Emilia-Romagna	Parma	186.690	0,69	1,01	0,32	18.169.781,00	22.385.869,00	119,91
Emilia-Romagna	Piacenza	103.206	0,21	0,49	0,28	56.489.882,00	19.556.329,00	189,49
Emilia-Romagna	Ravenna	158.739	0,63	0,95	0,32	7.498.036,20	22.498.296,00	141,73
Emilia-Romagna	Reggio nell'Emilia	170.086	0,37	0,85	0,49	8.036.101,30	34.072.930,00	200,33
Emilia-Romagna	Rimini	143.321	0,45	0,70	0,25	12.133.403,00	17.840.249,00	124,48
Friuli-Venezia Giulia	Gorizia	35.798	0,10	0,13	0,03	2.225.614,20	223.831,70	6,25
Friuli-Venezia Giulia	Pordenone	51.723	0,12	0,11	-0,01	3.786.686,70	-51.220,55	-0,99
Friuli-Venezia Giulia	Trieste	205.535	0,69	0,74	0,05	14.737.743,00	3.846.947,40	18,72
Friuli-Venezia Giulia	Udine	99.627	0,39	0,25	-0,14	3.964.550,70	-965.112,40	-9,69
Lazio	Frosinone	48.122	0,16	0,18	0,02	4.656.137,20	148.681,55	3,09
Lazio	Latina	119.804	1,30	0,49	-0,81	9.638.023,90	-56.753.298,00	-473,72
Lazio	Rieti	47.774	0,31	0,48	0,16	2.087.320,70	1.104.259,00	23,11
Lazio	Roma	2.761.477	6,49	5,82	-0,67	499.089.234,00	-46.890.494,00	-16,98
Lazio	Viterbo	63.597	0,30	0,57	0,27	1.319.048,10	1.827.695,70	28,74
Liguria	Genova	607.906	1,61	2,41	0,81	42.011.904,00	56.651.680,00	93,19
Liguria	Imperia	42.667	0,28	0,31	0,02	2.323.601,60	149.180,52	3,50
Liguria	Savona	62.553	0,34	0,34	0,00	2.804.759,70	-17.720,78	-0,28

Table 3: Capital expenditure needs and physical gap (year 2010)

Region	**Municipality**	**Population**	I_h	$\widehat{I_e}$	ΔI	MV	$TCFN$	$TCFN$ **per capita**
Lombardia	Bergamo	119.551	0,43	0,61	0,17	8.864.582,20	12.033.239,00	100,65
Lombardia	Brescia	193.879	0,90	0,99	0,08	6.654.088,50	5.767.363,10	29,75
Lombardia	Como	85.263	0,19	0,39	0,20	2.106.626,10	1.329.868,00	15,60
Lombardia	Cremona	72.147	0,19	0,31	0,11	3.905.022,80	763.105,05	10,58
Lombardia	Lecco	48.114	0,17	0,35	0,18	1.602.849,60	1.210.655,70	25,16
Lombardia	Lodi	44.401	0,10	0,23	0,13	1.683.743,60	847.661,88	19,09
Lombardia	Mantova	48.612	0,31	0,49	0,18	2.043.361,00	1.202.244,10	24,73
Lombardia	Milano	1.324.110	4,31	3,90	-0,41	295.674.563,00	-28.786.469,00	-21,74
Lombardia	Pavia	71.142	0,40	0,39	0,00	1.777.895,70	-32.054,60	-0,45
Lombardia	Sondrio	22.365	0,06	0,37	0,31	989.606,06	2.106.240,20	94,18
Lombardia	Varese	81.579	0,17	0,39	0,22	3.023.762,80	1.467.256,80	17,99
Marche	Ancona	102.997	0,54	0,58	0,04	2.103.217,00	253.745,72	2,46
Marche	Ascoli P.	51.168	0,38	0,42	0,05	1.277.359,70	335.790,27	6,56
Marche	Macerata	43.019	0,21	0,44	0,23	1.437.769,90	1.545.703,90	35,93
Marche	Pesaro	95.011	0,36	0,43	0,07	4.363.924,90	503.928,99	5,30
Molise	Campobasso	50.916	0,23	0,39	0,16	3.663.352,20	1.070.774,40	21,03
Piemonte	Alessandria	94.974	0,28	0,52	0,24	4.371.014,00	1.639.602,20	17,26
Piemonte	Asti	76.534	0,41	0,42	0,01	1.358.692,60	52.839,95	0,69
Piemonte	Biella	45.589	0,12	0,27	0,16	1.978.429,30	1.054.106,30	23,12
Piemonte	Cuneo	55.714	0,50	0,42	-0,08	2.076.411,40	-530.017,20	-9,51
Piemonte	Novara	105.024	0,29	0,49	0,20	3.730.233,10	1.334.392,50	12,71
Piemonte	Torino	907.563	3,25	3,03	-0,22	71.650.101,00	-15.381.116,00	-16,95
Piemonte	Verbania	31.243	0,14	0,42	0,28	1.711.735,60	1.889.172,90	60,47
Piemonte	Vercelli	46.979	0,13	0,26	0,13	1.805.762,70	875.444,20	18,63
Puglia	Andria	100.086	0,16	0,52	0,36	2.764.262,90	2.424.922,20	24,23
Puglia	Bari	320.475	1,14	1,39	0,25	14.254.646,00	17.560.583,00	54,80
Puglia	Barletta	94.459	0,13	0,31	0,18	1.810.607,60	1.199.515,50	12,70
Puglia	Brindisi	89.780	0,40	0,52	0,12	6.217.460,70	8.283.473,60	92,26
Puglia	Foggia	152.747	0,49	0,83	0,34	5.585.529,80	24.115.207,00	157,88
Puglia	Lecce	95.520	0,68	0,50	-0,18	5.118.000,00	-1.208.247,00	-12,65
Puglia	Taranto	191.810	0,90	0,91	0,01	97.849,27	70.422,64	0,37

Table 3: Capital expenditure needs and physical gap (year 2010)

Region	**Municipality**	**Population**	I_h	$\widehat{I}_e$	ΔI	MV	$TCFN$	$TCFN$ **per capita**
Sardegna	Cagliari	156.488	0,71	0,55	-0,16	3.950.956,40	-1.099.142,00	-7,02
Sardegna	Nuoro	36.347	0,16	0,29	0,13	1.342.815,50	909.330,04	25,02
Sardegna	Olbia	56.066	0,27	0,28	0,02	1.479.089,50	120.710,86	2,15
Sardegna	Oristano	32.015	0,19	0,15	-0,03	937.337,57	-218.819,70	-6,83
Sardegna	Sassari	130.658	0,59	0,53	-0,06	1.279.844,60	-376.258,40	-2,88
Sicilia	Agrigento	59.175	0,30	0,16	-0,15	607.527,86	-1.012.898,00	-17,12
Sicilia	Catania	293.458	0,71	1,11	0,40	7.891.110,00	27.942.478,00	95,22
Sicilia	Enna	27.850	0,15	0,54	0,38	439.927,62	2.581.498,20	92,69
Sicilia	Messina	242.503	0,69	0,88	0,19	9.247.936,00	13.208.127,00	54,47
Sicilia	Palermo	655.875	1,18	2,08	0,89	36.641.250,00	62.813.618,00	95,77
Sicilia	Ragusa	73.743	0,21	0,22	0,02	638.686,35	116.221,35	1,58
Sicilia	Siracusa	123.850	0,24	0,35	0,11	1.391.757,80	750.048,42	6,06
Sicilia	Trapani	70.622	0,21	0,25	0,03	1.227.038,00	217.508,08	3,08
Toscana	Arezzo	100.212	0,43	0,59	0,16	4.798.401,10	1.101.740,20	10,99
Toscana	Firenze	371.282	1,75	1,71	-0,05	52.488.095,00	-3.216.699,00	-8,66
Toscana	Grosseto	81.928	0,40	0,47	0,08	1.284.689,00	525.286,63	6,41
Toscana	Livorno	161.131	0,31	0,57	0,25	2.946.653,20	1.727.108,90	10,72
Toscana	Lucca	84.939	0,30	0,44	0,14	4.635.790,10	976.792,66	11,50
Toscana	Massa	70.973	0,29	0,24	-0,04	1.981.574,60	-299.303,20	-4,22
Toscana	Pisa	88.217	0,47	0,65	0,19	4.761.468,30	1.262.526,50	14,31
Toscana	Pistoia	90.288	0,45	0,52	0,07	4.266.256,00	442.294,80	4,90
Toscana	Prato	188.011	0,55	0,76	0,22	7.644.359,20	15.129.392,00	80,47
Toscana	Siena	54.543	0,34	0,62	0,27	3.521.086,20	1.860.604,20	34,11
Trentino-AA	Bolzano	104.029	0,20	0,24	0,04	4.738.162,10	270.621,00	2,60
Trentino-AA	Trento	116.298	0,65	0,45	-0,20	10.506.719,00	-13.697.783,00	-117,78
Umbria	Perugia	168.169	1,35	1,04	-0,31	3.530.063,10	-2.102.906,00	-12,50
Umbria	Terni	113.324	0,26	0,58	0,32	4.318.128,30	2.195.297,30	19,37
Valle d'Aosta	Aosta	35.049	0,23	0,12	-0,11	204.857,21	-720.533,80	-20,56
Veneto	Belluno	36.599	0,17	0,54	0,37	1.547.022,00	2.505.235,60	68,45
Veneto	Padova	214.198	0,44	1,07	0,63	19.265.859,00	44.537.655,00	207,93
Veneto	Rovigo	52.793	0,18	0,31	0,13	2.677.377,20	879.186,51	16,65
Veneto	Treviso	82.807	0,21	0,41	0,21	4.031.430,10	1.411.734,10	17,05
Veneto	Venezia	270.884	0,61	.	.	21.580.080,00	.	.
Veneto	Verona	263.964	0,73	1,33	0,59	18.677.749,00	41.511.469,00	157,26
Veneto	Vicenza	115.927	0,37	0,54	0,17	7.125.280,70	12.109.485,00	104,46

Table 3: Capital expenditure needs and physical gap (year 2010)