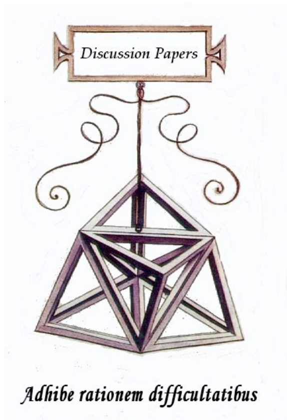
Discussion Papers
Collana di
E-papers del Dipartimento di Economia e Management – Università di Pisa



Laura Carosi, Giovanna D'Inverno, Letizia Ravagli

Global public spending efficiency in Tuscan municipalities

Discussion Paper n. 175
2014

Discussion Paper
n. 175

Laura Carosi, Giovanna D'Inverno, Letizia Ravagli

Global public spending efficiency in Tuscan municipalities

Abstract

The aim of this paper is the study of Tuscan municipalities public expenditure efficiency, with particular attention on the effect of the municipal size, through a DEA analysis. In line with the existing literature, the study includes a second stage analysis to explain municipal inefficiencies through a Tobit regression. The results obtained through the DEA analysis and explained by the Tobit regression appear consistent and could represent a sound suggestion to correct the expenditure of the inefficient municipalities. The new evidences related to the efficiency analysis of local government described in the paper provide an important contribution to the current debate, being this the first study carried out on Tuscan municipalities and introducing a new indicator for the computation of the efficiency scores which offer a new way of procedure. Moreover, the study addresses the long debated issue on municipal size proving that the municipal size really affects the efficiency of the public expenditure (i.e. the bigger is a municipality, the greater is its level of public spending efficiency).

Classificazione JEL: C24, C61, D78, H11, H72
Classificazione AMS: 90B50, 90C05
Keywords: Spending efficiency, Municipalities, Data Envelopment Analysis, Tobit regression

Contents

I. Introduction

The efficient use of resources has always been a very debated issue in the economic literature. The empirical analysis of production efficiency has been applied over time to many business areas, both in the private sector and in sectors with a significant public relevance. In this vast area, the evaluation of the efficiency performance achieved by the municipalities has assumed increasing importance. In particular, beyond the widespread view that local governments that have higher level of expenditure are the inefficient ones, the empirical efficiency analysis of local governments answer the question whether a given quantity of a public output is actually produced in a technically and allocatively efficient way.

Certainly, the interest for the public expenditure efficiency analysis stems from different reasons: on the one hand, the economic and financial crisis of recent years has led to a growing emphasis on the containment of public spending and on the rationalized use of scarce and limited resources, through legislative measures at both national and local level. Even the Tuscan legislator has promoted institutional and administrative reforms to overcome the presence of inefficiency in the municipalities expenditure, in particular in relation to their size. In fact, evidences show that with regards to the smallest municipalities the expenditure inefficiency is mostly related to the not reached scale economies in the provision of public goods and services: for this reason the issue of the local governments optimal size to settle these diseconomies has long been and still is the center of academic and political debate. On the other hand, in the scientific literature there is growing attention to the study of efficiency in the public expenditure municipalities and the use of quantitative tools turns out to be useful to analyze municipal spending and possibly to have suggestion to do it in a better way. The most common way to do an efficiency analysis is through the estimation of the Efficiency Frontier, even if other different approaches to face this topic exist. In particular, in this field there are two alternative techniques: parametric and non-parametric techniques. Among non-parametric techniques, the DEA approach results suitable to an efficiency analysis of the public sector: in fact, DEA avoids assuming specific functional forms of the production frontier and gives intuitive ideas to correct the found inefficiencies.

Given the highly topical feature undoubtedly linked to these topics, the aim of this paper is to analyze the global public expenditure efficiency of Tuscan municipalities through a Data Envelopment Analysis (DEA) approach , with particular attention on the effect of the municipal size. Furthermore, in compliance with the existing literature, also a second stage analysis has been applied: in fact, the explanation of the efficiency results considering some municipal features can be useful to understand the sources of potential inefficiency in a municipality. In particular, a Tobit regression has been employed.

The paper contributes to the literature by supplying new evidences concerning the efficiency analysis of local government in two different ways. First of all, studies of municipal expenditure efficiency are still not abundant in the economic literature and, as far as the authors know, are not available for the Tuscan region.

The other contribution regards the use of a new indicator for the computation of the efficiency scores. With respect to the existing indicators, this new one presents three main advantages: firstly, the municipal inefficiency is computed separately for each municipal area, so to run a non-aggregate analysis; then, it's possible to compute an average level of inefficiency considering the weight that each municipal area has in the total expenditure, so to have the average overspending for each municipality. Finally, comparing the composite indicator obtained by the municipal weight with the indicator obtained by the Tuscan mean weight, there are possible suggestions as room for improvement for the inefficient municipalities: in some cases, just a change in the composition of the expenditure could bring to an increase of the efficiency composite indicator.

This paper is structured as follows. In section II., there is a short review of several papers so to show the state-of-art of the global municipal efficiency literature. First of all, since public efficiency analysis can be done in very different municipal offered services, a reach variety of observed samples, methodologies and other additional features are presented. Then, the main quantitative techniques for the efficiency analysis are described, pointing out the peculiarities of the public analysis applications. Furthermore, the main contribution of the literature is presented with regards to the choice of the decision variables, both for the computation of the municipal efficiency scores and for the explanation of its determinants. In section III., the main choices regarding the definition of the Tuscan municipalities spending efficiency analysis are described, focusing on the faced critical aspects, step by step: the most relevant decisions concern the definition of the dataset and the inputs and outputs choice. Also the choices of the DEA model to be used and the explanatory variables to use in the Tobit regression are presented. Section IV. is dedicated to the explanation of the obtained DEA and Tobit results: the main peculiar aspects are presented and some elements to improve the municipal efficiency are put in evidence.

II. The literature state-of-art

The literature about the measurement of efficiency is relatively recent and starts with the seminal contribution of Farrel (1957). The first applications have concerned the analysis of enterprises in productive private sectors: in these fields, the identification of appropriate indicators of input and output and the collection of information on input and final product prices is much smoother than in the context of the public sector. In fact, the evaluation of local spending efficiency derives from the microeconomic theory of production and it's based on the interpretation of local sector activities as production processes, which transform inputs into outputs/outcomes: however, it's very complicated to identify variables that can accurately measure the quantitative and qualitative aspects of the provided services, as well as to find the market price. For these reasons, the literature on the local governments efficiency has been developed just since the

Nineties, often stimulated by a perceived need at the institutional level of public finances rebalancing.

The existing literature on municipal efficiency analysis can be divided into two-branches. On the one hand, there are numerous studies on individual public services, as reviewed by Bönisch et al. (2011): solid waste and sewage disposal (Worthington and Dollery, 2001), water (Picazo et al., 2009; Byrnes et al., 2010) and energy provision (von Hirschhausen et al., 2006), hospitals (e.g. Aksezer and Benneyan, 2010; Blank and Valdmanis, 2010), municipal savings banks (Conrad et al. 2009), public libraries (De Witte and Geys, 2009), road maintenance (Kalb, 2009), fire protection (Lan et al., 2009), care for the elderly sector (Borge and Haraldsvik, 2009), local police services (García-Sánchez 2009), public transportation (Walter and Cullmann 2008) or pre-school education (Montén and Thater 2010). De Borger and Kerstens (2000) or Worthington and Dollery (2000) can be considered as a reference for a survey of earlier studies.

On the other hand, there are studies that analyze global municipal efficiency for various countries: Belgium (De Borger and Kerstens, 1996), Finland (Loikkanen and Susiluoto, 2005), Brazil (Sampaio de Sousa et al., 2005), Spain (Balaguer-Coll and Prior 2009; Prieto and Zofio, 2001), Portugal (Afonso and Fernandes, 2008), Japan (Nijkamp and Suzuki, 2009), Germany (Kalb et al., 2011; Geys et al., 2010) and Italy (Boetti et al., 2010; Boetti et al., 2011; Bollino et al., 2012). De Borger and Kerstens (2000) or Worthington and Dollery (2000) again can be considered as a reference for a survey of earlier studies. In particular, this second type of studies sometimes attempts to analyze the relationship between municipal performances and some important topics, like the relevance of the municipal size, the effect of public function decentralization to the municipalities, the impact of fiscal decentralization, the influence of the effects of spatial closeness between municipalities and other aspects. According to many authors, there is an advantage in the use of a comprehensive approach, compared to studies focused on specific functions: it is the ability to take into account the opportunity cost perceived by the municipality in deciding the allocation of resources to different services, the possible synergies of expenditure and the quantification of the total savings of resources.

In the table below (Table 1), some relevant contributions of this second group are listed in chronological order of publication. In particular, looking at the used samples, it's worth noting that they often regard municipalities belonging to the same region: this avoids the presence of a higher heterogeneity among units, stemming from different information data at national level.

Table 1: Contributions in the municipal global efficiency studies

Author/s	Year	Sample
Vanden Eeckhaut, Tulkens and Jamar	1993	235 Belgian municipalities
De Borger and Kerstens	1996	589 Belgian municipalities
Athanassopoulos and Triantis	1998	172 Greek municiplaities
Worthington	2000	177 municipalities of New South Wales
Prieto and Zofio	2001	209 Spanish municipalities of less of 20.000 inhabitants
Lokkainen and Susiluoto	2005	353 Finnish municipalities
Balaguer-Coll, Prior and Tortosa-Ausina	2007	414 Valencian municipalities
Afonso and Fernandes	2008	51 Lisbon area municipalities
Boetti, Piacenza and Turati	2010-11	262 Italian municipalities from the Italian province of Turin
Bönisch, Haug, Illy and Schreier	2011	46 independent municipalities and 157 municipal associations in Saxony-Anhalt
Bollino, Di Vaio and Polinori	2012	341 municipalities from the Italian region Emilia-Romagna

II.A. Methodologies

The alternative methods available for the efficiency analysis of production processes differ in the way the so-called "efficiency frontier" (that is unknown and unobservable) is inferred from data about inputs and outputs of a sample of firms. In fact, measures of efficiency are based on the ratio of observed output levels to the maximum level that could have been obtained for a given input level. This maximum level constitutes the efficient frontier that will be the benchmark for measuring the relative efficiency of observations. There are multiple techniques to estimate this frontier, surveyed recently by Murillo-Zamorano (2004), and these methods have recently been applied to examine the efficiency of public spending.

The main distinction regards two separate, though conceptually similar, theoretical approaches: on the one hand, there is the econometric approach, while on the other hand the mathematical programming approach. These approaches use different techniques to envelop the observed data and therefore make different accommodations for random noise and for flexibility in the structure of the production technology.

The econometric approach specifies a production function and normally recognises that deviation away from this given technology (as measured by the error term) is composed of two parts, one representing randomness (or statistical noise) and the other inefficiency. The usual assumption with the two-component error structure is that the inefficiencies follow an asymmetric half-normal distribution and the random errors are normally distributed. The random error term is generally thought to encompass all events outside the control of the organisation, including both uncontrollable factors directly concerned with the "actual" production function (such as differences in operating environments) and econometric errors (such as misspecification of the production function and measurement error). This type of reasoning has primarily led to the development of the "stochastic frontier approach" (SFA), introduced by Aigner et al. (1977): SFA seeks to take these external factors into account when estimating the efficiency of real world organisations. Following Worthington (2000), the first studies of local government cost efficiency by Deller et al. (1988), Hayes and Chang (1990) and De Borger and Kerstens (1996) have used this approach. The main problem associated with this approach is that considerable structure is imposed upon data from stringent parametric form and distributional assumption.

On the other hand, and in contrast to the econometric approaches which attempt to determine the absolute economic efficiency of organisations against some imposed benchmark, the mathematical programming approach seeks to evaluate the efficiency of an organisation relatively to other organisations in the same industry. The most commonly employed version of this approach is a linear programming tool referred to as "data envelopment analysis", DEA, introduced by Charnes et al. (1978) and by Banker et al. (1984)[1]. DEA essentially calculates the economic efficiency of a given organisation with respect to the performance of other organisations producing the same good or service, rather than against an idealised standard of performance. DEA is a nonstochastic method as it likewise assumes all deviations from the frontier are the result of inefficiency[2]: so, the entire deviation from the frontier is assessed as being the result of inefficiency, since it's both non-parametric and non-stochastic; thus, no accommodation is made for the types of bias resulting from environmental heterogeneity, external shocks, measurement error, omitted variables and so on. However, given its non-parametric basis, it is possible to considerably vary the specification of inputs and outputs and not to specify a particular form. Still following Worthington (ibidem), Vanden Eeckaut et al. (1993) and De Borger and Kerstens (1996) have firstly undertaken work in this area. A less-constrained alternative to DEA often employed in the analysis of economic efficiency in the public sector is known as "free-disposal hull" (FDH), introduced by Deprins et al. (1984). This approach has been applied to local governments for the first time by De Borger et al. (1994) and De Borger and Kerstens (1996).

The methodological literature to date provides inconclusive evidence concerning the sensitivity of local government efficiency rankings to these alternative technologies. It should be emphasised that the stochastic frontier and DEA approaches address different questions, serve different purposes and have different informational requirements: for these reasons, DEA and stochastic frontier should be thought of as a complementary tools in the analysis of local public sector efficiency; for example, in the first istance, the frontier adheres closely to the notion of best-practice efficiency, whereas in the second it refers to an absolute measure of efficiency.

In general, these approaches allow for ignoring the question about how a certain quantity of municipal output results from the political process and if it

[1] Based on the concept of efficiency proposed by Farrell (1957) .

[2] In the recent literature, to encompass uncertainty and data variability, some authors combine the classical DEA models with other probability-based ones. For a survey on this issue, see for example Cook and Seiford (2009).

represents a welfare-maximizing optimum from the perspective of a benevolent social planner: they simply analyze whether either a given output quantity is produced with minimum input (input-oriented approach) or the maximum output is produced with a given input quantity (output-orientation). In particular, DEA allows for both input- and output-oriented models that identify the same set of efficient/inefficient Decision Making Units: these methods provide the same ranking results under constant returns to scale (CRS), but give different values under variable returns to scale (VRS).

In the table below (Table 2), the methodologies used in the global efficiency studies are listed in chronological order of publication.

Table 2: Methodologies in the municipal global efficiency studies

Author/s	Year	Methodologies
Vanden Eeckhaut, Tulkens and Jamar	1993	FDH and DEA
De Borger and Kerstens	1996	DEA, FDH and 3 parametric frontiers
Athanassopoulos and Triantis	1998	DEA, FDH and SFA
Worthington	2000	DEA, FDH and SFA
Prieto and Zofio	2001	DEA
Lokkainen and Susiluoto	2005	DEA
Balaguer-Coll, Prior and Tortosa-Ausina	2007	DEA and FDH
Afonso and Fernandes	2008	DEA
Boetti, Piacenza and Turati	2010-11	DEA and SFA
Bönisch, Haug, Illy and Schreier	2011	DEA
Bollino, Di Vaio and Polinori	2012	DEA

Often, the authors of the aforementioned studies on global municipal efficiency try to understand what are the underlying causes of estimated efficiency gaps and potential determinants of inefficiency.

Regarding the non-parametric approach, in particular DEA, when exogenous variables are taken into account, a two-stage approach is preferred: firstly, efficiency scores are computed; then a regression of that resulting scores on potential exogenous variables is run. Among the studies that regress estimates of efficiency on some explanatory variables in a second stage, several ones have estimated a linear model by ordinary least squares (OLS), but most have specified a censored (Tobit) model: in fact, Tobit specification is motivated by the observation that efficiency estimates can assume values between zero and one in a given application. However, a possible critique that is made to the use of these regression models is linked to the fact that the efficiency scores may be serially correlated: the correlation arises in finite samples from the fact that perturbations of observations lying on the estimate frontier will, in many cases, cause changes in the efficiency estimated for other observation (for more details, Simar and Wilson, 2007).

With regards to the econometric approach, it's possible to use a one-step Stochastic Frontier Analysis to estimate global efficiency and, possibly together, the effect of the exogenous variables.

Moreover, it's worth mentioning that there are few studies that use alternative way to explain the impact of the environmental variable: this is the case of the fuzzy K-means clustering approach used by Athanassopoulos and Triantis (1998), the non-parametric regression and, as a complementary approach, non-parametric density estimation used by Balaguer-Coll et al. (2007) and the Exploratory Spatial Data Analysis (ESDA) used by Bollino et al. (2012).

In the table below (Table 3), the ways to explain the underlying causes of estimated efficiency gaps considered in the global efficiency studies are listed in chronological order of publication.

Table 3: Ways to explain efficiency gaps in the municipal global efficiency studies

Author/s	Year	Ways to find explanation
Vanden Eeckhaut, Tulkens and Jamar	1993	-
De Borger and Kerstens	1996	Tobit regression for DEA, FDH and SF-mode scores OLS regression for DF and SF-mean scores
Athanassopoulos and Triantis	1998	Fuzzy K-means clustering approach Tobit regression for DEA scores
Worthington	2000	Tobit regression
Prieto and Zofio	2001	-
Lokkainen and Susiluoto	2005	OLS regression
Balaguer-Coll, Prior and Tortosa-Ausina	2007	Nonparametric smoothing techniques
Afonso and Fernandes	2008	-
Boetti, Piacenza and Turati	2010-11	Tobit regression for DEA scores The Battese and Coelli (1995) specification
Bönisch, Haug, Illy and Schreier	2011	Second bootstrap procedure applied to a truncated regression
Bollino, Di Vaio and Polinori	2012	Exploratory Spatial Data Analysis

In this paper, Data envelopment analysis will be used to analyze global municipal expenditure efficiency and Tobit regression to explain its potential determinants.

II.B. Decision variables

Certainly, in literature, a fundamental step in the definition of the municipal efficiency analysis regards the choice of the decision variables, both for the computation of the efficiency scores (inputs and outputs) and for the explanation of its determinants.

Considering the input side, there are just few different decisional possibilities: in fact, usually municipal current expenditure is used, but it can be taken in aggregate or non-aggregate way according to the different services and it can be expressed in absolute value or in per capita terms.

Considering the output side, the measurement of local government performance poses difficult issues. In fact, the performance indicators are typically difficult to construct and may not coincide with the assessment that the user has about the same service. Moreover, in general, just quantitative variables are considered, since qualitative indicators are difficult to be identified.

In addition, in many studies, there is the difficulty to directly measure some of the municipal production results, so that some performance indicators are surrogate measures of municipal demand and, in other words, often proxies for the relative service are selected: for example, the "total population" is used as a proxy for the various administrative tasks undertaken by municipalities, but it's clearly not a direct output of local production.

In general, in the literature concerning the global efficiency analysis of municipalities, the following outputs are present, listed by the different area of involved services and, in particular, by the functions considered in the following.

General administration:

- TOTAL POPULATION

Local police:

- N. OF CRIMES REGISTERED IN THE MUNICIPALITY

Educational services:

- N. OF STUDENTS enrolled in local primary schools.
- EDUCATION ATTAINMENT
- N. OF TEACHING HOURS.

Social services:

- N. OF SENIOR CITIZENS (aged 65 and more)
- N. OF BENEFICIARIES OF MINIMAL SUBSISTENCE GRANTS.
- N. OF PEOPLE IN NEEDS OF CARE, that are those under 14 years old - enrolled in nursery, primary and secondary school - and those over 75 years old; or, alternatively, those under 5 and over 65 years old.

Road maintenance and local mobility:

- LENGTH OF ROAD to be maintained by the municipality

- N. OF LIGHTING POINTS
- STREET INFRASTRUCTURE SURFACE AREA
- REGISTERED SURFACE AREA OF PUBLIC PARKS.

Finally, as mentioned above, the efficiency scores are regressed on a set of explanatory variables, such as financial, political and social, economic and structural indicators, which are considered some of the main environmental factors that can influence the local government efficiency.

Among all, the economic variables appear to play the most important role. In particular, the transfers received from higher levels of governments and the local taxes represent the most significant variables. All studies show an inverse relationship between the levels of estimated efficiency and the degree of municipal dependence from the central government transfers. Regarding the impact of local taxation, instead, the empirical evidence does not lead to unequivocal conclusions. In fact, in some studies (see e.g. in De Borger and Kerstens, 1996; Vanden et al., 1993) there is a positive relationship between efficiency scores and level of taxation: from this, it can be deduced that the government's ability to maintain public spending at efficient levels depends on the composition of municipal revenues, in line with the modern literature on fiscal federalism. On the other side (see e.g. in Balaguer-Coll et al., 2007), however, there is an opposite result: the result is explained by the fact that a wider availability of public resources tends to make soft the municipal budget constraint, thus local politicians perceive less the importance of control of expenditure. Moreover, also a variable that proxies the idea of deficit is taken into account and in particular the possible financial vulnerability, defined as the inability of a municipality to face its present and future financial commitments: thus, a negative relationship is supposed.

Regarding socio-economic factors, the per capita income is considered and it negatively affects the efficiency scores: citizens with a higher income may be less motivated to commit themselves in monitoring the spending of the local government, due to a higher opportunity cost of time. However, the level of education gives opposite reasoning: a higher degree of education should motivate a higher participation of the population in the process of collective decision. Also the municipal dimension is used as a possible explanation of the differences in the efficiency scores: in particular, with the increase of the population size the efficiency score increases.

With regards to the geographical variable, a high population density has a positive influence on the efficiency, in the majority of the studies; instead, the municipal distance from its capital province negatively affects efficiency, because the provision of services becomes harder, and also the mountain feature of a municipality affects the efficiency scores, as explained for example in Boetti et al. (2011). Moreover, in this last mentioned study, also the effect of the tourism aspect on the efficiency analysis is pointed out. Finally, even political variables can be useful to understand the efficiency scores gap. In fact, in some studies (see e.g. in Vanden et al., 1993; Athanassopoulos and Triantis, 1998) there is a negative relationship between efficiency and the number of parties; also a negative relationship is related to the proximity of new elections. In addition, in some works the effect of the political colour is considered, however opposite results are obtained.

III. The empirical application I: Preliminary considerations

III.A. Choice of data for DEA analysis

In compliance with the existing literature, the first step in the global efficiency analysis is to define the data to be used. In particular, the first decision regards the areas of municipal expenditure to be considered. Obviously, it's necessary to say that this choice is strongly influenced by the Italian institutional framework. In fact, in Italy, municipal expenditure is classified into twelve macro-functions. However, since the fundamental functions (i.e. "General administration", "Environmental management", "Social Services", "Educational services", "Road maintenance and local mobility" and "Local police") cover about the 90% of the total current expenditure in 2011 (reference year), just the six fundamental functions are taken into account : moreover, they represent not only the most fundamental competencies for the municipal budget, but also for the services provided to the citizens. With regards to the function for "Environmental management", it should be observed that it presents very heterogeneous expenditure items (e.g. the urban services, the environmental conservation services, the waste disposal service), that heavily differ among municipalities according to their own characteristics. Even just taking into account the waste disposal service (that covers in average the 60% of the total expenditure in this function), another source of heterogeneity is present in the sample. In fact, at 2011[3] in some municipalities the TARSU system (that is, the "Tassa Rifiuti Solidi Urbani") is still applied, while in others TIA system (that is, the "Tariffa Igiene Ambientale")[4] is already operative. The choice between TIA or TARSU tax system heavily affects the municipal expenditure and cannot be ignored: for example, the municipality that applies TIA has always a lower expenditure. Since DEA requires homogeneous units to be compared, the authors have preferred excluding this function from the current analysis, so that it could be possible to consider the whole Tuscan region and to study the relationship between the expenditure efficiency and the municipal size, without excluding any municipality. Nevertheless, due to the importance of this function, the authors have performed a second analysis which includes also the environmental expenditures but it is limited to a smaller sample of more homogeneous municipalities: this is the content of a forthcoming working paper written by the same authors.

[3]In January 2013 both systems have been superseded by the new tax TARES, that is the "Tassa Rifiuti E Servizi". In January 2014 TARES has been in turn superseded by the so-called "Service Tax".

[4]Introduced with the Legislative Decree No. 22/1997, the so-called "Ronchi" Decree.

Then, the choice of the inputs and the outputs of the model is determinant. As evident to the researchers that have worked on this topic, the definition of these elements is one of the most critical aspect to implement a municipal efficiency analysis. Certainly, on the input side, there are few discretionary items: so, in this context, just municipal current expenditure is used as input indicator, taken in non-aggregate way and expressed in absolute value. Data come from the available municipal balance sheets, referred to year 2011, published by the Home office Ministry (Ministero degli Interni): since for that year there aren't data for two municipalities (Castiglion Fiorentino and Monterotondo Marittimo), the following analysis will consider just 285 municipalities, instead of the effectively present 287.

Regarding the output choice, first of all, the outputs presented in the literature have been considered and function by function the variables have been selected. In addition, in order to relate services/output consistent with the expenditures, there is the attempt to look for data of 2011. As in literature, it has been difficult to find data that directly measure municipal production results: so, just surrogate measures of municipal demand are considered for performance indicators, often used as proxies for the relative services provided to the citizens. In addition, there is no information about qualitative results of the municipal activities: so, just quantitative data have been employed in the analysis. Moreover, the data available for some performance indicators sometimes have missing data with respect to some municipalities and certainly they become useless to be used in the analysis.

Going into details, for the "General administration" function, the resident population has been considered, taken from DEMO ISTAT and referred to 2011: the resident population is used as a proxy for the various administrative tasks undertaken by each municipality.

Regarding the function for "Local police", the kilometers of roads and the sum of population and average annual tourist presence have been considered. The kilometers of roads are used as proxy of the area that the municipal police has to supervise and data of 2011 are taken from the Regional Observatory; instead, the resident population and the average annual tourist presence are considered as proxy of the potential users of this service: data for resident population are again taken from DEMO ISTAT and referred to 2011, while, for tourist presence, annual data of 2011 contained in a survey of Tuscany Region are used and then divided by 365 days, in order to have the average annual presence.

For the "Educational services" function, the big internal heterogeneity in the expenditure components of this function has to be taken into account: so, despite different outputs are present in the literature, the school-age population (i.e. the population from 3 to 13 years old) is considered, as the catchment area of the services supplied by the municipality in this field; data referred to 2011 are taken from DEMO ISTAT.

With regards to the function for "Social Services", the potential users of this services have been considered, that is the population from 0 to 5 years old to proxy the services for kindergarten and school canteens, the population over 65 years old to proxy the provisions for the elderly and the immigrant population to proxy the serviced to meet the needs of these people: these data are taken from DEMO ISTAT, referred to 2011.

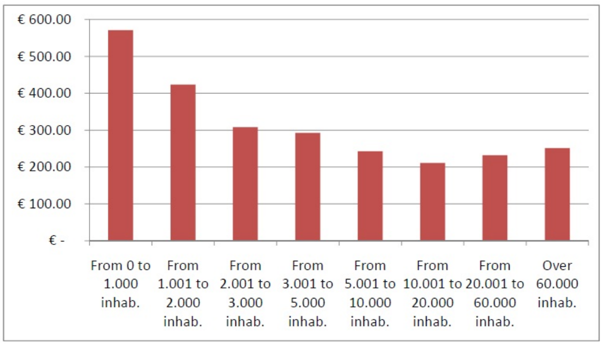
For the "Road maintenance and local mobility" function, the kilometers of roads and the sum of population and average annual tourist presence have been considered, as proxies for maintenance work and number of interventions on the road.

For the determination of the dataset, the critical aspects don't concern only the previous considerations about the input/output choice, but also involve the units under analysis: in fact, it's important to have in the dataset information that makes coherent the DEA analysis with the statistical description inferred from the sample. In other words, it's necessary to identify, and possibly to eliminate, the heterogeneous units in the dataset to which DEA can be sensitive and that can alter its results: this is the problem of the "outliers". According to Wilson (1993), "outliers are atypical observation. Some outliers are the result of recording or measurement errors and should be corrected (if possible) or deleted from data". The presence of outliers in the used sample of data is a problem that can significantly affect the outcome of the analysis based on nonparametric procedures. For these reasons, in the literature, different procedures are used to detect the presence of outliers and to manage them in the best way: from one hand, some authors prefer to identify possible unusual observations through particular procedures *ex ante*, that is before to run DEA, and after to check the results[5]; on the other hand, there are *ex post* measures, i.e. DEA is immediately implemented and then the sample is adjusted until DEA gives consistent results. In this case, in order to evaluate the presence of outliers in the municipalities sample, the second way is preferred. In this context, just the "General administration" function has been considered, in fact it's enough to have an idea of the coherence of the found results. In order to do this, first of all the per capita expenditure distribution according to the dimensional classes has been considered for this function: as evident, the distribution has an"U-shaped form". Then, this distribution is compared with the Constant Return to Scale DEA scores[6] distributed according to the same dimensional classes: if DEA results were consistent, the DEA scores would have the reverse form. The idea behind this hypothesis implies that the higher is the per capita level of expenditure among municipalities, the lower is the relative level of efficiency; in particular, in this comparison there is the temporary idea that all the municipalities under analysis are performing at an optimal scale. Considering the largest sample, that is constituted by 285 municipalities, there is not the expected "U-shaped reverse form" (Figure 1). Dropping just Firenze from the sample, the expected form of the distribution immediately appears (Figure 2): certainly, Firenze is absolutely out of scale in comparison with all the other municipalities and clearly can alter the DEA results.

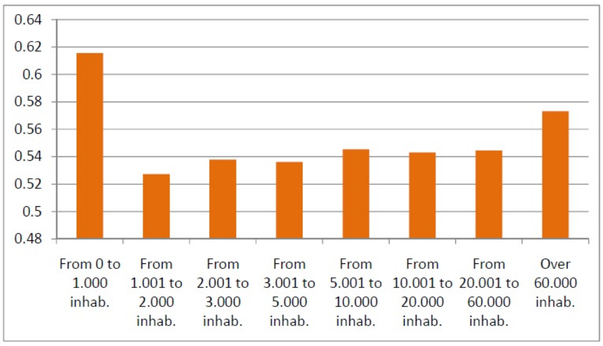
[5]For more details, see Bollino et al. (2012).

[6]For a complete discussion on the DEA software choice, see the next section III.B..

Figure 1: Comparison between per capita current expenditures and CRS DEA scores. 285 municipalities

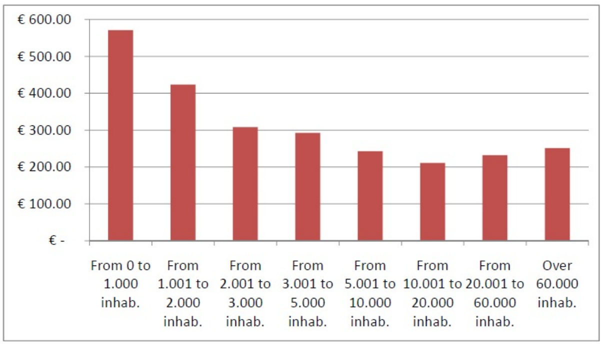


Per capita current expenditures
for "General administration" by dimensional class

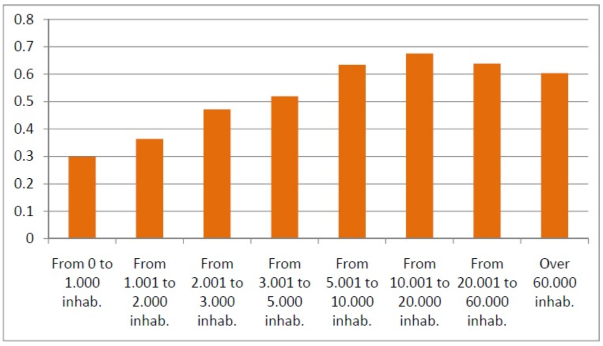


CRS DEA scores by dimensional classes
for "General administration". 285 municipalities

Figure 2: Comparison between per capita current expenditures and CRS DEA scores. 284 municipalities



Per capita current expenditures
for "General administration" by dimensional class



CRS DEA scores by dimensional classes
for "General administration". 284 municipalities

In order to detect other potential outliers, different reasonable alternatives have been considered. For example, in order to eliminate the extreme observations, the first and the last percentile have been excluded from the largest sample, so to have 279 municipalities ; also all the provincial capitals have been dropped from the largest sample, so to have 275 municipalities ; finally, also the second and the second last percentile have been excluded, so to have 273 municipalities. However, all these attempts show the same expected "U-shaped reverse form": so, in order to get consistent results, it's enough to drop Firenze from the widest sample.

In conclusion, the data used in the empirical investigation are all referred to 2011 and DEA is used to compute the efficiency scores for 284 municipalities of Tuscany (all but Firenze, Castiglion Fiorentino and Monterotondo Marittimo).

In addition, just to summarize, the chosen variables are:

- Expenditure for the "General administration" function ⟹Total resident population;
- Expenditure for the "Educational services" function⟹Population from 3 to 13 years old;
- Expenditure for the "Social Services"⟹Population from 0 to 5 years old + Population over 65 + Immigrants;
- Expenditure for the "Road maintenance and local mobility" function⟹Resident population + Tourist presence and Length of roads;
- Expenditure for the "Local police" function⟹Resident population + Tourist presence and Length of roads.

In the table below (Table 4) the dataset descriptive statistics for the relevant input and output variables are presented.

Table 4: Descriptive statistics for DEA dataset

INPUT (million euro)	Mean	Min	Max	Std. dev.
General administration	28.32	1.43	414.58	47.75
Local police	5.64	0.003	106.96	12.08
Educational services	11.70	0.10	185.81	21.41
Road maintenance and local mobility	8.54	0.16	187.52	19.31
Social services	16.58	0.05	354.14	37.22
OUTPUT	Mean	Min	Max	Std. dev.
Total population	11605.16	327.00	184885.00	20175.39
Population 3-13	1103.33	20	19640	1949.05
Tourist presence	346.15	0.10	5036.29	722.68
Population 0-5	612.36	11.00	11183.00	1087.58
Population over 65	2740.17	96.00	38702.00	4708.25
Immigrants	979.18	8.00	28405.00	2133.45
Length of roads	138846.12	0.00	1353082.12	156644.01

III.B. Choice of DEA model

In the determination of the DEA model that has to be used in the analysis, it's necessary to specify some elements: the orientation (i.e. input or output oriented), the returns to scale and the number of inputs and outputs considered together.

First of all, regarding the orientation, in compliance with the existing literature an *input-oriented* approach is preferred: in fact, even in this context, the specification of the output makes the expenditures the only discretionary variables of the problem.

With regards to the returns to scale, the difference between Variable Return to Scale (VRS) and Constant Return to Scale (CRS) affects the municipal expenditure efficiency analysis. In fact, measuring the degree of inefficiency of a certain municipality, the VRS DEA model takes into account the possibility that each unit is characterized by technological returns of any nature; the CRS DEA model assumes, instead, that all units in the sample satisfy the property of constant returns, providing a mix of technical and scale inefficiency (i.e., overspending due to missing economies of scale or to the presence of diseconomies of scale). For these reasons, it seems to be more reasonable that the main analysis will use a VRS DEA model. However, it's worth mentioning that also a CRS DEA analysis will be run since it is possible to quantify the inefficiency of scale computing the ratio between the CRS and the VRS efficiency scores, so that to assess the impact of returns in the functioning of the municipalities (affected by the municipal size).

Finally, another critical issue to be solved regards the number of input and output put simultaneously in the DEA computation. However, before reasoning whether to use one-input/one-output model or a multi-input/multi output model or whatever, it's worth going into details with regards to the software used to compute DEA scores: in fact, in the literature different software packages are used. In this context, Coelli program, that is "DEAP Version 2.1: A Data Envelopment Analysis (Computer Program)" is the chosen software to compute the DEA efficiency scores referred to Tuscan municipalities.

Back to the above introduced problem, the practical application of DEA presents a procedural issue to be examined and solved that regards the number of used inputs and outputs, that is the pitfall to include variables indiscriminately, as presented by Dyson et al. (2001). As DEA allows flexibility in the choice of weights on the inputs and outputs, the greater the number of factors included the lower the level of discrimination between efficient and inefficient units: so, discrimination can be increased by being parsimonious in the number of the variables. In other words, by increasing the number of inputs and/or outputs, there is automatically, by construction, an increase of the efficient DMUs. This reasoning becomes very evident looking at the DEA results stemming from the municipal analysis: gradually adding in the VRS model a function, the number of efficient municipalities increases more and more. In fact, just considering the "General administration" function there are only 5 efficient municipalities. Considering also the function for "Educational services" the number of efficient municipalities increases at 16. Then, adding the function for "Social Services" 51 municipalities result to be efficient. Finally, the number of efficient municipalities becomes very big introducing the "Road maintenance and local mobility" function, i.e. 116 efficient municipalities, and then the "Local police" function, i.e. 109 efficient municipalities: obviously, it's quite unreasonable that so much municipalities are efficient.

In the literature, there is an open theoretical debate on this issue. From one hand, different suggested "rules of thumb" are proposed in order to achieve reasonable level of discrimination; for example, there are proposed rules in Bowlin (1998), i.e. there should be at least three DMUs for each input and output variable so to have sufficient degrees of freedom, or in Dyson et al. (ibidem), i.e. the number of units should be at least twice the product of the number of inputs and outputs. On the other hand, the definition of a stringent rule is considered not so necessary: in fact, this reasoning seems to be too rigid and useless in relation to the needs of research (see e.g. Cooper et al., 2011). However, from an application point of view, still other solutions have been proposed in the municipal expenditure efficiency analysis. For example, according to Bönisch et al. (2011), the bootstrap procedure is preferred in the general multi-input/multi-output framework, since it is the only means of inferring statistical properties essential for the interpretation of the estimated efficiency measures and the DEA-efficiency estimator is corrected for bias. In particular, taking into account bias, authors notice no efficient observations: in fact, by definition, the bias-corrected convex hull constructed by the DEA program is further away from the observed data than the initial DEA frontier. Another way to solve this problem is also proposed by Afonso et al. (2008): they use a Total Municipal Output Indicator (TMOI) to put together different outputs, following the reasoning of other studies, e.g. Afonso et al. (2005). They assume that TMOI depends on the $k\in \{1, 2, ..., l\}$ values of certain economic and social indicators. If there are $i\in \{1, 2, ..., n\}$ municipalities and $j\in \{1, 2, ..., m\}$ policy areas, the TMOI is defined as the sum of each total municipal total sub-indicators, TMSOI, that is:

$$TMOI_i = \sum_{j=1}^{m} TMOSI_{ij}.$$

So, previously all values of each sub-indicator must be computed: this indicator is calculated by centering each variable around the mean of all observations and then using an unweighted average of all variables for policy area.

$$TMOSI_{ij} = \frac{\sum_{k=1}^{l} \frac{x_{ijk}}{\bar{x}_{jk}}}{l}$$

where

$$\bar{x}_{jk} = \frac{\sum_{i=1}^{n} x_{ijk}}{n}.$$

The DEA analysis is then performed both with the composite TMOI and alternatively using the several sub-indicators directly as output: obviously, going from the "one input/one output" to the "one input/multi output" model, it's possible to observe the increase of the overall efficiency scores and the increase of the efficient DMUs.

In this paper, a different way to solve this issue has been proposed: a composite indicator has been used, but not in the sense of the aforementioned TMOI. In fact, the use of the TMOI cannot identify the inputs in which there is the most waste, since it considers all the functions together; on the contrary, in this context it's possible to find the main waste areas. In fact, first of all, each function is considered separately: DEA scores are obtained for each function and it's possible to identify the level of overspending focusing on each area. Then, all these DEA scores have been put together through a weighted average, according to the weight of each function expenditure on the total. So, DEA efficiency scores have been computed five times: each time for a different function proposed in this analysis; then these scores have been put together. There are three main advantages in this proposed approach:

1. there is a non-aggregate analysis for each function that makes possible to find the municipal inefficiencies separately, considering just a "one input-one output" model or at most "one input-two output" model, so to limit the number of efficient municipalities;

2. it's possible to compute an average level of inefficiency considering the weight that each function has in the total expenditure, so to have the average overspending for each municipality;

3. comparing the composite indicator obtained by the municipal weight with the indicator obtained by the Tuscan mean weight, there are possible suggestions as room for improvement for the inefficient municipalities: in some cases, just a change in the composition of the expenditure could bring to an increase of the efficiency composite indicator.

In conclusion, in this paper an input-oriented VRS DEA model will be implemented: a "one input-one output" model or at most "one input-two output" model will be used for each municipal function and then these efficiency scores will be put together as an efficiency composite indicator.

III.C. Choice of the determinants for the Tobit regression

In compliance with the existing literature, as already said, also a second stage analysis have been applied: in fact, the explanation of the efficiency results considering some municipal features can be useful to understand the sources of potential inefficiency in a municipality. In particular, a Tobit regression will be employed and implemented by the software "Stata".

Certainly, in order to choose the explanatory variables in the municipal context, the literature has been taken into account. So, in this context some financial, socio-economic, geographical and political variables have been considered in order to consider some of the main environmental factors that can influence the local government efficiency.

First of all, economic variables are considered, in particular those variables that focus on the accountability degree of local governments with respect to the citizens and soft budget constraint[7]. The first aspect is reached by the continuous variable "AUTONOMY", that is the ratio between local taxes over the total expenditures in the functions involved in the analysis; local taxes data are taken from the municipal balance sheets referred to 2011. According to the literature, this variable should have a positive effect on the level of the efficiency: the higher is the revenues stemming from the citizens contribution, the higher is the responsibility of the local government, that will spend in a more efficient way these resources. The other aspect is reached by the continuous variable "REVENUES": it is the ratio of total revenues over total resident population, so it's a normalized variable: total revenues data are taken from the municipal balance sheets referred to 2011 and total resident population data are taken, as the same, from DEMO ISTAT and are referred to 2011. Actually, as already presented, the expected effect of this variable is uncertain.

Regarding to the socio-economic factors, there is the attempt to understand how the level of tourism and the municipal size affect the efficiency of the municipalities. At first glance, the tourism presence seems to negatively affects the municipal performance, in the sense that it implies more per capita costs: in fact, the per capita expenditure according to the tourism classes increases as the level of tourism increases, even taken into account the tourism presence in addition to the population. For the continuous variable "TOURISM", the annual tourist presence data of 2011 contained in a survey of Tuscany Region are used and then divided by 365 days, in order to have the average annual presence. Going to the other element, the effect of the municipal size is a long debated issue in the literature and also in the normative context. In this case, the variable "DIMENSION" is a categorical variable, that takes on a finite number of values, each denoting membership in one of the subclasses listed as follows:

1. from 0 to 5.000 inhabitants;
2. from 5.000 to 10.000 inhabitants;
3. from 10.000 to 20.000 inhabitants;
4. from 20.000 to 60.000 inhabitants;
5. over 60.000 inhabitants.

The information contained in the 5-valued categorical variable can be, and it is, well represented by 5 dummy variables: these dummies denote the truth or falseness of "the municipality has from 0 to 5.000 inhabitants", "the municipality has from 5.000 to 10.000 inhabitants" and so on. For a practical reason, these dummies are named Dim1, Dim2, Dim3, Dim4 and Dim5. It's worth mentioning that the difference between Dim4 and Dim3 is significant as the difference between Dim5 and Dim4: this has been checked by Wald tests performed by

[7] See e.g. in Kornai et al. (2003) and Boetti et al. (2010).

“Stata”. These dimensional classes are obtained grouping the non-significant different classes already considered in section III.A..

Since also the geographical factors affect the level of municipal efficiency, also the dummy variable “SEA” and the dummy “MOUNTAIN” are considered. Certainly, the sea places can be subject to seasonality and this could suggest a negative impact on the municipal efficiency. In addition, it’s worth mentioning that, as a limit of the dataset, there are not into account the vacation properties: this could reduce the potential output as services provided by sea municipalities. For the “SEA” variable, data are taken from the ISTAT classification regarding the capacity of accommodation establishments; the dummy is equal to one when the municipality is a sea place. In addition, the interaction of the sea municipalities with the variable “tourism” is also considered and the variable is “SEA*TOURISM”: so it’s possible to distinguish the effect of turisticity when the municipality is a sea place or not. With respects to the mountain feature, the distinction between mountain and non-mountain municipalities is taken from the Italian legislation: the dummy is equal to one when the municipality is a mountain place. Obviously, the negative effect of the mountain feature on the municipal efficiency is expected: the more impervious is the municipal territory, the more high costs this municipality has to pay, affecting the efficiency. Moreover, also the continuous variable “DENSITY” is considered: it is the ratio of total resident population over the municipal surface: total resident population data are taken from DEMO ISTAT and referred to 2011 and the municipal surface data are taken from ISTAT and referred to 2011. In this case, a positive effect of the degree of density is expected: the more densely populated is a municipality, the less dispersion of resources is present.

Finally, as a political variable the dummy variable “SECOND MANDATE” is considered: the dummy is equal to one when a municipality has its major at the second mandate. For “SECOND MANDATE”, data are taken from the election timetable data provided by ANCI TOSCANA. Certainly, the effect of this variable on the municipal efficiency is not so obvious and different explanation could be given: on one hand, it can positively affect the efficiency because at the second mandate the major and its staff has become more competent on the local issues; on the other hand, however, there is no room to be re-elected after the second mandate, so the local government can decide to spend in a less prudent manner. In addition, the interaction of the municipalities at the second mandate with the variable “revenues” is also considered and the variable is “SECOND*REVENUES”: so it’s possible to go into details in the effect of the revenues when the municipality is at the second mandate of its major or not.

IV. The empirical application II: Results

In this section the efficiency analysis results are presented: in section IV.A. and IV.B. DEA results respectively for the non-aggregate and average analysis are described and in the last IV.C. the explanation of the expenditure efficiency through the comparison of the Tobit regression results are commented.

As a preliminary consideration, it's worth explaining that DEA results are mainly presented in inefficiency terms: in this way, it's immediately possible to get the municipalities that behave worse. The assessment of expenditure performance expressed in terms of DEA scores is represented by values between 0 and 1, where the municipalities with a score equal to one are those that are fully efficient: computing the complement to one of that scores, there is the assessment in terms of inefficiency. Moreover, from a theoretical point of view, these inefficiency scores denote the percentage of expenditure in excess in comparison with the level that would allow municipalities to operate on the efficiency frontier. However, since DEA is a non-parametric technique, in this context it's preferable to focus more on the ordering, among municipalities and different classes of municipalities, that DEA analysis provides and to understand which are the municipalities that behave better and worse: the task of waste resources computation is delegated to the slack variables associated with the DEA model.

IV.A. Non-aggregate analysis for each function

As already presented, first of all DEA efficiency scores have been computed for each different municipal function considered in this paper and commented in a critical way, through different municipal classifications: in other words, the results are presented taking into account the dimensional, mountain, tourism and local labour system classes, so to consider the distribution of the efficiency scores according to the municipal size, the geo-morphological feature, the tourism aspect and the socio-economic structure.
As introduced in section III.B., for each function a VRS analysis has been done. However, for the General Administration function also a CRS DEA analysis has been considered in order to quantify the inefficiency of scale, so to understand how the mismanagement and the presence of economies/diseconomies of scale affect the overall technical efficiency. In fact, since this function has the total resident population as output, this inefficiency decomposition could be useful to face the issue of the municipal size.

Since going through all the functions results details would take too long, in the next two sections firstly, by way of example, the function for general administration is presented in a very detailed manner and then some more significant results of the other functions are presented in short (For a more detailed analysis, the interested reader can see D'Inverno (2013)).

IV.A.i. General Administration

First of all, in order to give a consistent interpretation of the obtained efficiency results for this function, it's useful to take in mind what are the main services provided to the citizens by this area: the function for general administration provides services regarding the institutional bodies, the administrative office, the management of tax revenue, the technical office, military services, civil registration and electoral services, vital records and statistics, according to the municipal balance sheet items of expenditure.

Table 5 presents the overall technical inefficiency scores of the CRS analysis. The mean of the inefficiency scores is equal to 0.45 and implies that theoretically the 45 % of the expenditure spent for this function could be reduced. In addition, the distribution of the estimated level of inefficiency is quite symmetric: in fact, the mean and the median (i.e. the 50° percentile) are the same. However, as already said, this level of inefficiency could be affected by the constant return to scale assumption: for this reason, municipal inefficiency is estimated just taking into account the mismanagement component, so in other words just considering the variable returns to scale.

So, Table 6 presents the inefficiency scores of the VRS analysis. The mean of the inefficiency scores is equal to 0.40, so it's a lower value than in the CRS case: certainly this implies that among some municipalities there is the presence of economies/diseconomies of scale. In addition, also in this case, the distribution of the estimated level of inefficiency is quite symmetric: in fact, the mean and the median (i.e. the 50 ° percentile) are very similar. However, looking at the min and max values, it's possible to see how the extreme values are very distant from each other.

Table 5: Descriptive statistics of CRS inefficiency scores in general administration. 2011

Mean	St. Dev.	Min	Max	Percentiles				
				10°	25°	50°	75°	90°
0.45	0.19	0.00	0.89	0.21	0.32	0.45	0.60	0.70

Table 6: Descriptive statistics of VRS inefficiency scores in general administration. 2011

Mean	St. Dev.	Min	Max	Percentiles				
				10°	25°	50°	75°	90°
0.40	0.19	0.00	0.85	0.16	0.27	0.42	0.54	0.63

By construction, in the CRS analysis, just a municipality is completely efficient: Lamporecchio. Table 7 instead describes the municipalities that results to be efficient according to the VRS analysis. It becomes immediately evident that the non-mountain feature represents a common element of these municipalities. In addition, three out of five municipalities belong to the highest dimensional classes and four out of five have a low level of tourism. It's worth noting the number of times each efficient municipality is a peer for the others [8]: the two smallest efficient municipalities are the peer for the greatest part of the municipalities and this is a relevant information. In fact, the presence of the biggest municipalities (except Firenze) could be criticized to represent potential outliers; however, in the detection of the potential outliers, some authors consider precisely

[8]Information provided directly by Coelli software.

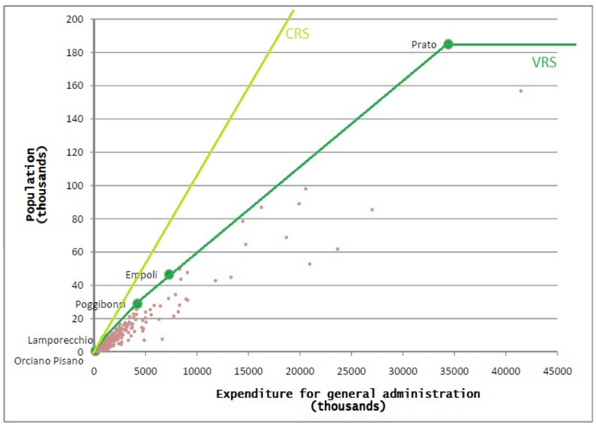
the high number of times each unit is a peer for other units under analysis (see e.g. in Tran et al., 2010) and this reasoning could exclude potential critique.

Table 7: Details of efficient municipalities in **general administration**. 2011

Municipality	Dimensional class	Mountain class	Tourism class	N°of times considered as a PEER	
				Absolute value	Percentage value
Orciano Pisano	From 0 to 1.000 inhab.	Non-mountain	Very low tourism	166	30%
Lamporecchio	From 5.001 to 10.000 inhab.	Non-mountain	High tourism	252	46%
Empoli	From 20.001 to 60.000 inhab.	Non-mountain	Very low tourism	19	3%
Poggibonsi	From 20.001 to 60.000 inhab.	Non-mountain	Low tourism	101	18%
Prato	Over 60.000 inhab.	Non-mountain	Low tourism	12	2%
				550	100%

Moreover, Figure 3 presents the theoretical production possibility frontier associated with the aforementioned sets of efficient municipalities: also from a graphical point of view it's possible to observe how the two smallest efficient municipalities are the peer for the greatest part of the municipalities in the VRS case. The horizontal distance of a municipality from the CRS frontier indicates whether it is globally inefficient, while the horizontal distance from the VRS frontier shows whether it is inefficient because it uses the available input in a bad manner. It follows that the horizontal distance between the two frontiers indicates the scale efficiency score : a value less than unity indicates inefficiency.

Figure 3: Theoretical production possibility frontier for general administration. 2011



In order to disentangle the causes that affect the overall technical inefficiency, the level of inefficiency depending on the dimensional classes is observed. Table 8 and Table 9 present the descriptive statistics of the inefficiency scores respectively for the CRS and the VRS case and the related graph (Figure 4) gives a graphical intuition of the two inefficiency distributions.

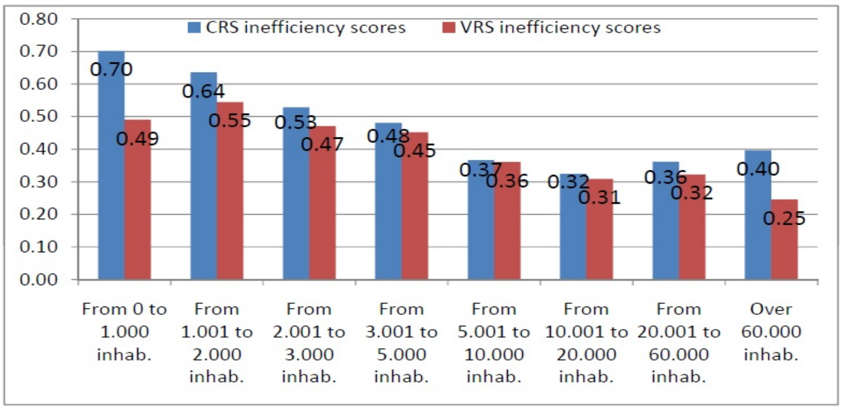
Table 8: Descriptive statistics of CRS inefficiency scores in general administration by dimensional classes. 2011

Dimensional classes	Mean	Std. dev.	Min	Max
From 0 to 1.000 inhab.	0.70	0.15	0.38	0.89
From 1.001 to 2.000 inhab.	0.64	0.11	0.37	0.86
From 2.001 to 3.000 inhab.	0.53	0.12	0.21	0.78
From 3.001 to 5.000 inhab.	0.48	0.15	0.13	0.76
From 5.001 to 10.000 inhab.	0.37	0.18	0.00	0.84
From 10.001 to 20.000 inhab.	0.32	0.13	0.06	0.63
From 20.001 to 60.000 inhab.	0.36	0.17	0.04	0.65
Over 60.000 inhab.	0.40	0.14	0.24	0.63

Table 9: Descriptive statistics of VRS inefficiency scores in general administration by dimensional classes. 2011

Dimensional classes	Mean	Std. dev.	Min	Max
From 0 to 1.000 inhab.	0.49	0.23	0.00	0.85
From 1.001 to 2.000 inhab.	0.55	0.14	0.21	0.82
From 2.001 to 3.000 inhab.	0.47	0.13	0.11	0.75
From 3.001 to 5.000 inhab.	0.45	0.16	0.10	0.75
From 5.001 to 10.000 inhab.	0.36	0.18	0.00	0.84
From 10.001 to 20.000 inhab.	0.31	0.14	0.03	0.62
From 20.001 to 60.000 inhab.	0.32	0.18	0.00	0.60
Over 60.000 inhab.	0.25	0.18	0.00	0.57

Figure 4: Inefficiency scores in general administration by dimensional classes. 2011

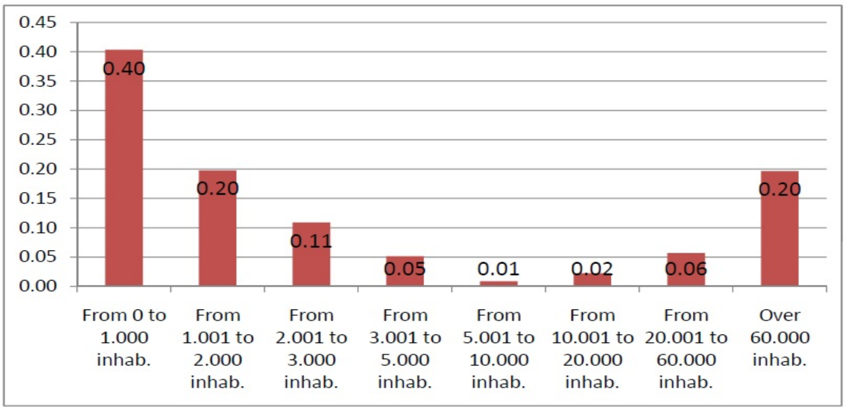


From the comparison between CRS and VRS inefficiency scores, it's possible to observe that in the extreme classes the gap between CRS and VRS scores is higher than in the central classes: the differences between CRS and VRS is to be attributed to the scale inefficiency. For the same reason, the scale inefficiency scores presented graphically (Figure 5) also denotes higher scores at the extreme demographical classes. In addition, as described in Table 10, the scale inefficiencies for the smallest dimensional classes are related to missing economies of scale, in fact there are observed increasing returns to scale; while for the biggest municipalities the scale inefficiency is due to the presence of diseconomies of scale, as the prevalent presence of decreasing returns to scale shows.

Table 10: Descriptive statistics of scale inefficiency scores in general administration by dimensional classes. 2011

Dimensional class	Mean	Std. dev.	Prevalent RTS
From 0 to 1.000 inhab.	0.40	0.12	irts
From 1.001 to 2.000 inhab.	0.20	0.04	irts
From 2.001 to 3.000 inhab.	0.11	0.02	irts
From 3.001 to 5.000 inhab.	0.05	0.02	irts
From 5.001 to 10.000 inhab.	0.01	0.01	mixed
From 10.001 to 20.000 inhab.	0.02	0.01	drts
From 20.001 to 60.000 inhab.	0.06	0.03	drts
Over 60.000 inhab.	0.20	0.03	drts

Figure 5: Scale inefficiency scores in general administration by dimensional classes. 2011



However, there is a very relevant aspect to underline: even taken into account the presence of scale inefficiencies, the smallest municipalities result to be the most technically inefficient ones. In others words, this implies that these small dimensional classes show technical inefficiency even taking into account that they can produce under variable returns to scale and this inefficiency can be attributed entirely to a bad municipal management. This does not hold for the biggest municipalities. In fact, these municipalities result to be technically inefficient under the global point of view. However, if they are evaluated under variable returns to scale, they result to be the most efficient class: so the main inefficiency problem in their case is related with their too big dimension and actually not to their municipal management. These considerations suggest that at least under 5.000 thousands of inhabitants an aggregation among the smallest municipalities should be promoted in order to reach the missing economies of scale and so to improve the level of efficiency at least under this aspect. So, at least in relation to the general administration function, it is clear that it is not entirely correct to impute all the inefficiency to the municipal management, certainly not responsible for a wrong municipal size. Especially with regard to the small municipalities, the cause of the inefficiency results from the presence of too much small fragmented municipalities: this evidence is therefore in line with the legislative measures already undertaken by the Tuscany Region in order to overcome this problematic aspect.

Furthermore, it can be said that the municipal inefficiency is strongly influenced by the characteristics of the municipalities themselves, as already seen in the main features of the found efficient municipalities. For this reason, a more detailed analysis of the inefficiency results is presented, considering the aforementioned municipal classifications (i.e. by mountain, tourism and local labour system classes), and in particular just the VRS inefficiency scores are considered for the already explained reasons: so, the level of municipal mismanagement is under attention.

Regarding the mountain classification considered in Table 11, the highest level of inefficiency is present in the totally mountain classes, while the opposite holds for the non-mountain classes. Moreover, it's worth noting that going from non-mountain to totally mountain municipalities the level of inefficiency increases: certainly, the local governments of the totally mountain places have to face more difficulties to accomplish their services for all the citizens and can be influenced in their municipal management.

Table 11: Descriptive statistics of inefficiency scores in general administration by mountain classes. 2011

Mountain class	Mean	Std. dev.	Min	Max
Non-mountain	0.36	0.20	0.00	0.84
Partially mountain	0.38	0.16	0.06	0.69
Totally mountain	0.47	0.16	0.11	0.85

Table 12 presents the results about the tourism classes: the highest level of inefficiency is present in the municipalities with high level of tourism, while the opposite holds for those municipalities with very low level of tourism. In particular, it's possible to observe that considering an increasing level of tourism, the level of inefficiency systematically increases. Certainly, a clarification is necessary: probably, this high score of inefficiency for the municipalities subject to high tourism level should be lower if the average annual tourism presence and also vacancy properties (and its residents) would be taken into account. In fact, the general administration services are addressed to all these users, that are the resident population, but also the tourists and the owners of vacancy properties: probably, this level of inefficiency would be mitigated.

Table 12: Descriptive statistics of inefficiency scores in general administration by tourism classes. 2011

Tourism class	Mean	Std. dev.	Min	Max
Very low tourism	0.31	0.16	0.00	0.79
Low tourism	0.35	0.17	0.00	0.73
Medium tourism	0.40	0.15	0.06	0.74
High tourism	0.55	0.16	0.00	0.85

Finally, Table 13 presents the descriptive statistics of the inefficiency scores in relation to the local labour system classes. The highest level of inefficiency is present, consistently with what said earlier, in the tourism and agricultural vocation systems, while the opposite holds for the manufacturing systems in the textile, leather and clothing. Moreover, it's worth noting that in general all the manufacturing systems have the minimum value of inefficiency equal to zero (so among them there are the efficient municipalities), even if they also have the highest value of maximum inefficiency: it is not surprising that for these classes there is the highest value of standard deviation, meaning high level of variability within each class.

Table 13: Descriptive statistics of inefficiency scores in general administration by local labour system classes. 2011

Local labour system class	Mean	Std. dev.	Min	Max
Systems without specialization	0.44	0.15	0.11	0.74
Urban systems	0.40	0.16	0.05	0.80
Tourism and agricultural vocation systems	0.55	0.14	0.19	0.82
Manufacturing systems in the textile, leather and clothing	0.29	0.16	0.00	0.79
Other manufacturing systems made in Italy	0.36	0.19	0.00	0.85
Heavy manufacturing systems	0.47	0.18	0.00	0.84

IV.A.ii. Other municipal areas results

Showing briefly the results of the other four considered functions, firstly it's necessary to point out that the main findings of the general administration function are confirmed. In fact, for all the functions the highest inefficiencies are present in the smallest dimensional classes, while the opposite holds for the biggest dimensional classes. Furthermore, the biggest dimensional class has the lowest inefficient score. In particular, for both the educational and the social services

functions the inefficiency results suggest that in the provision of both these services a municipality works better with a larger catchment area than a smaller.
Moreover, all the functions have the highest level of inefficiency in the mountain municipalities: certainly, the difficulties related to the territory make more inefficient the provision of the services, in particular those related to the road maintenance and local mobility and to the local police function. Even the evidence for the tourism municipal classification confirms that the municipalities with the highest level of tourism have the highest level of inefficiency (except for the case of the road maintenance and local mobility function, whose higher presence of inefficient municipalities is represented by those with a medium level).
Regarding the local labour system municipalities, there is not univocally a typology of inefficient municipalities, but for sure the lowest level of inefficiency is present in the urban system municipalities.
However, even if there are mostly common features in relation to the source of inefficiency among all the functions under analysis, it must be said that the efficient municipalities considered as peer for all the other inefficient municipalities vary according to each function, both in terms of number of efficient units and in terms of municipal typology. The tables below shortly show this reasoning.

Table 14: Details of efficient municipalities in **social services**. 2011

Municipality	Dimensional class	Mountain class	Tourism class	N°of times considered as a PEER	
				Absolute value	Percentage value
Capraia Isola	From 0 to 1.000 inhab.	Totally mountain	High tourism	47	9%
Sambuca Pistoiese	From 1.001 to 2.000 inhab.	Totally mountain	Low tourism	123	22%
Fosdinovo	From 3.001 to 5.000 inhab.	Totally mountain	Very low tourism	130	24%
Manciano	From 5.001 to 10.000 inhab.	Totally mountain	High tourism	78	14%
Barga	From 10.001 to 20.000 inhab.	Totally mountain	Medium tourism	68	12%
Campi Bisenzio	From 20.001 to 60.000 inhab.	Non-mountain	Low tourism	29	5%
Colle di Val d'Elsa	From 20.001 to 60.000 inhab.	Non-mountain	Low tourism	61	11%
Arezzo	Over 60.000 inhab.	Partially mountain	Low tourism	12	2%
Prato	Over 60.000 inhab.	Non-mountain	Low tourism	1	0%
				549	100%

Table 15: Details of efficient municipalities in **educational services**. 2011

Municipality	Dimensional class	Mountain class	Tourism class	N°of times considered as a PEER	
				Absolute value	Percentage value
Vergemoli	From 0 to 1.000 inhab.	Totally mountain	Very low tourism	199	36%
Bucine	From 10.001 to 20.000 inhab.	Non-mountain	Medium tourism	270	48%
Campi Bisenzio	From 20.001 to 60.000 inhab. .	Non-mountain	Low tourism	80	14%
Prato	Over 60.000 inhab.	Non-mountain	Low tourism	9	2%
				558	100%

Table 16: Details of efficient municipalities in **road maintenance and local mobility**. 2011

Municipality	Dimensional class	Mountain class	Tourism class	N°of times considered as a PEER	
				Absolute value	Percentage value
Capraia Isola	From 0 to 1.000 inhab.	Totally mountain	High tourism	26	4%
Monteverdi Marittimo	From 0 to 1.000 inhab.	Totally mountain	High tourism	96	14%
Casale Marittimo	From 1.001 to 2.000 inhab.	Non-mountain	High tourism	209	31%
Riparbella	From 1.001 to 2.000 inhab.	Non-mountain	High tourism	47	7%
Greve in Chianti	From 10.001 to 20.000 inhab.	Partially mountain	Medium tourism	34	5%
Capannori	From 20.001 to 60.000 inhab.	Partially mountain	Very low tourism	1	0%
Cascina	From 20.001 to 60.000 inhab.	Non-mountain	Very low tourism	242	36%
Arezzo	Over 60.000 inhab.	Partially mountain	Low tourism	12	2%
Prato	Over 60.000 inhab.	Non-mountain	Low tourism	1	0%
				668	100%

Table 17: Details of efficient municipalities in **local police**. 2011

Municipality	Dimensional class	Mountain class	Tourism class	N°of times considered as a PEER	
				Absolute value	Percentage value
Fosciandora	From 0 to 1.000 inhab.	Totally mountain	Low tourism	38	5%
Vergemoli	From 0 to 1.000 inhab.	Totally mountain	Very low tourism	20	3%
San Godenzo	From 1.001 to 2.000 inhab.	Totally mountain	Medium tourism	35	5%
Chiusdino	From 2.001 to 3.000 inhab.	Partially mountain	High tourism	172	24%
Murlo	From 2.001 to 3.000 inhab.	Non-mountain	High tourism	65	9%
Capraia e Limite	From 5.001 to 10.000 inhab.	Non-mountain	Low tourism	127	18%
Civitella in Val di Chiana	From 5.001 to 10.000 inhab.	Non-mountain	Low tourism	73	10%
Greve in Chianti	From 10.001 to 20.000 inhab.	Partially mountain	Medium tourism	4	1%
Capannori	From 20.001 to 60.000 inhab.	Partially mountain	Very low tourism	161	23%
Massa	Over 60.000 inhab.	Partially mountain	Medium tourism	10	1%
Arezzo	Over 60.000 inhab.	Partially mountain	Low tourism	4	1%
Prato	Over 60.000 inhab.	Non-mountain	Low tourism	4	1%
				713	100%

IV.B. Average inefficiency among functions

In this part, the average inefficiency results among Tuscan municipalities is described, considering the average municipal behaviour among the different functions. Just to recall it, these average inefficiency scores are obtained as the weighted average among each function efficiency scores according to the different weight they cover in the total expenditure (see section III.B.).

Obviously, the VRS DEA scores are used to compute the average inefficiency: so, in this context, the average waste of resources per function due to municipal mismanagement is evaluated.

Table 18 presents the statistics of the average inefficiency scores of the VRS analysis. The mean of the average inefficiency scores is equal to 0.57. This implies that considering the weight of each function expenditure, in average a Tuscan municipality could not waste the 57% of the resources. In this case, the distribution of the level of inefficiencies is symmetric: in fact, the mean and the median are quite similar. Moreover, looking at the min and max values and especially to the percentiles, it's possible to see that the inefficiency scores are more concentrated than in the singular case. This could be explained by the fact that taking into consideration all the functions together, the difference among municipality efficiency scores becomes smaller rather than function by function.

Table 18: Descriptive statistics of average inefficiency scores among functions. 2011

Mean	St. Dev.	Min	Max	Percentiles				
				10°	25°	50°	75°	90°
0.57	0.14	0.00	0.89	0.39	0.47	0.58	0.66	0.73

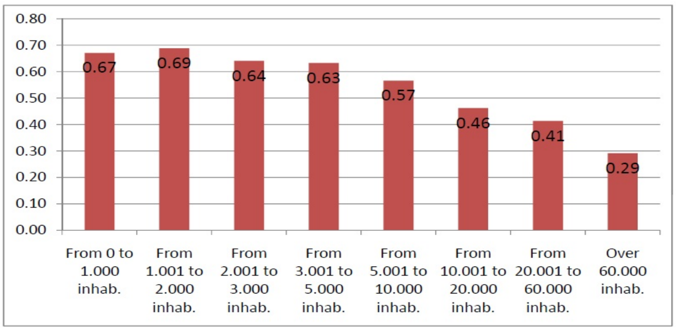
Since, the municipal inefficiency is strongly influenced by the characteristics of the municipalities themselves, a more detailed analysis of the inefficiency results is presented, considering the aforementioned municipal classifications (i.e. by dimensional, mountain, tourism and local labour system classes).

Table 19 presents the descriptive statistics of the average inefficiency scores by dimensional classes and the related graph (Figure 6) gives a graphical intuition of the inefficiency distribution. The highest inefficiencies are present in the smallest dimensional classes, while the opposite holds for the biggest ones. In this average analysis, it's possible to observe a "quite decreasing form" of the inefficiency scores distribution. Moreover, it's worth noting that the biggest dimensional class has the lowest maximum value of inefficiency. More important, just in the biggest dimensional class there is zero as a minimum value of inefficiency: just in this class there is a complete efficient municipality, according to this analysis and it is Prato. The inefficiency results suggest that in the provision of the services a municipality works better with a larger catchment area than a smaller.

Table 19: Descriptive statistics of average inefficiency scores among functions by dimensional classes. 2011

Dimensional classes	Mean	Std. dev.	Min	Max
From 0 to 1.000 inhab.	0.67	0.10	0.49	0.88
From 1.001 to 2.000 inhab.	0.69	0.07	0.57	0.82
From 2.001 to 3.000 inhab.	0.64	0.06	0.49	0.80
From 3.001 to 5.000 inhab.	0.63	0.09	0.46	0.89
From 5.001 to 10.000 inhab.	0.57	0.10	0.33	0.86
From 10.001 to 20.000 inhab.	0.46	0.09	0.29	0.68
From 20.001 to 60.000 inhab.	0.41	0.12	0.21	0.61
Over 60.000 inhab.	0.29	0.16	0.00	0.55

Figure 6: Average inefficiency scores among functions by dimensional classes. 2011



Considering also the municipal classification by mountain features, Table 20 presents the descriptive statistics of the average inefficiency scores and show that the highest inefficiencies are present in the mountain municipalities: certainly, the difficult territory and the smallest presence of resident population make more inefficient the provision of the services.

Table 20: Descriptive statistics of average inefficiency scores among functions by mountain classes. 2011

Mountain class	Mean	Std. dev.	Min	Max
Non-mountain	0.52	0.15	0.00	0.89
Partially mountain	0.52	0.14	0.10	0.78
Totally mountain	0.64	0.09	0.39	0.88

Regarding the municipal classification by tourism classes, Table 21 presents the descriptive statistics of the inefficiency scores .The highest level of inefficiency is present in the municipalities with high level of tourism, while the opposite holds for those municipalities with very low level of tourism. In general, it's possible to observe that considering an increasing level of tourism, the average level of inefficiency systematically increases. Certainly, a clarification must be recalled. Considering the tourism presence there is no account of the vacancy properties owners, that certainly represent a non-negligible part of the catchment area of the municipal services in general that surely would lower the inefficiency scores. Anyhow, especially the tourist municipalities subject to strong seasonality certainly face higher costs than others (e.g. this is the case of the sea places).

Table 21: Descriptive statistics of average inefficiency scores among functions by tourism classes. 2011

Tourism class	Mean	Std. dev.	Min	Max
Very low tourism	0.51	0.13	0.21	0.81
Low tourism	0.54	0.15	0.00	0.80
Medium tourism	0.56	0.12	0.23	0.78
High tourism	0.65	0.11	0.39	0.89

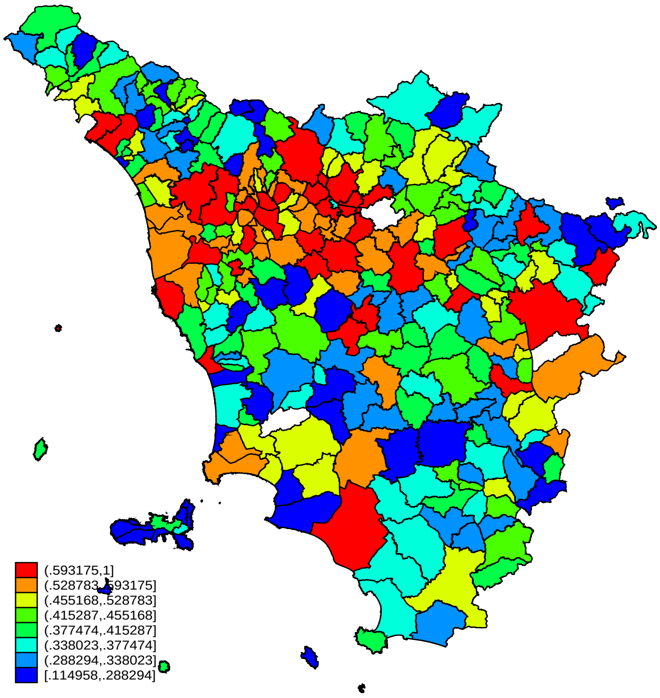
To understand the effect of the municipal economic features, Table 22 presents the descriptive statistics of the average inefficiency scores with respect to the municipal classification by local labour system classes. Consistently with what already said, the highest level of inefficiency is present in the tourism and agricultural vocation systems, while the opposite holds for the manufacturing systems in the textile, leather and clothing. In relation to this last mentioned class, it's worth noting that the obtained most efficient municipality, Prato, belongs precisely to it. Moreover, almost all the other provincial capitals result to be the most efficient municipalities: this can be seen also graphically from Figure 7 [9]. This evidence makes stronger the reasoning about the municipal size: the bigger is the municipal catchment area, the lower the average cost in the provision of municipal services; moreover, it's worth pointing out that this lower cost makes possible to provide more differentiated and complex services.
In addition, it's possible to see also that the main municipal efficient areas correspond to those areas with the lowest per capita expenditure (and the opposite holds for the areas with the highest per capita expenditure): so, for example, the red area corresponding to the Firenze plain in the efficiency level picture coincides to the area with a very low level of per capita expenditure. So, without loss of generalization, from the obtained evidences, it can be said that the average efficiency behavior of a municipality can be inferred in a preliminary way by the total per capita expenditure trend.

Table 22: Descriptive statistics of average inefficiency scores among functions by local labour system classes. 2011

Local labour system class	Mean	Std. dev.	Min	Max
Systems without specialization	0.62	0.07	0.49	0.77
Urban systems	0.53	0.13	0.23	0.81
Tourism and agricultural vocation systems	0.63	0.14	0.21	0.88
Manufacturing systems in the textile, leather and clothing	0.51	0.15	0.00	0.89
Other manufacturing systems made in Italy	0.55	0.15	0.10	0.86
Heavy manufacturing systems	0.60	0.12	0.29	0.86

[9] Figure 7 is obtained by "Stata" program.

Figure 7: Geographical distribution of the average efficiency scores. 2011



In order to conclude this section, it's interesting to go into details about a last aspect: the comparison between the average inefficiency scores computed for each municipality considering its own expenditure composition and the average inefficiency scores computed considering the average Tuscan expenditure composition. From this comparisons, it could be possible to make some considerations about the effect on the average inefficiency of the municipal expenditure allocation among the different functions.

So, firstly the descriptive statistics of these new average inefficiency scores are presented in Table 23. As evident, the average inefficiency computed through these different weights is lower than in the previous case: this should suggest that in average, if the expenditure composition was different and in line with the Tuscan average, the level of average efficiency would be higher. Of course, also the percentiles denotes these lower scores.

Table 23: Descriptive statistics of average inefficiency scores among functions (Tuscan weights). 2011

Mean	St. Dev.	Min	Max	Percentiles				
				10°	25°	50°	75°	90°
0.54	0.14	0.00	0.86	0.36	0.45	0.56	0.64	0.70

Finally, in order to go deeply in the differences among municipal performances, municipalities have been divided according with two features. The first regards the relative level of efficiency: the difference between each average inefficiency score (computed considering its own expenditure composition) and its median (that, as already said, quite coincides to the mean) is computed, so to have the relative efficiency of each municipality in comparison to all the others. The second feature regards the expenditure composition: the difference between each average inefficiency score computed considering its own expenditure composition and that one computed considering the Tuscan expenditure composition is calculated. If this difference is positive, this means that the municipality has chosen a composition that allows it to achieve a better level of average efficiency rather than in the other composition; in the other case (i.e. if the difference is negative), this means that the municipality has chosen a composition that brings it to achieve a worse level of efficiency.

These two features are put in relationship in a graphical and intuitive way (Figure 8), so to distinguish four groups of municipalities: on the vertical axis there is the relative efficiency, while on the horizontal axis the expenditure composition aspect is considered. So, municipalities are laid out into four quadrants. In the North-East quadrant, there are the municipalities that result more efficient than the median and that have an expenditure composition that allows them to achieve a better level of average efficiency (in the following, this quadrant will be named Efficient-Better quadrant or shortly E-B quadrant). In the North-West quadrant, there are municipalities that result more efficient than the median, but have an expenditure composition that brings them to achieve a worse level of efficiency (in the following, this quadrant will be named Efficient-Worse quadrant or shortly E-W quadrant). In the South-East quadrant, there are the municipalities that result less efficient than the median but that have an expenditure composition that allows them to achieve a better level of average efficiency (in the following, this quadrant will be named Inefficient-Better quadrant or shortly I-B quadrant). In the South-West quadrant, there are municipalities that result less efficient than the median and also have an expenditure composition that brings them to achieve a worse level of efficiency (in the following, this quadrant will be named Efficient-Worse quadrant or shortly E-W quadrant).

So shortly it can be said that the municipalities in the Efficient-Worse and Inefficient-Worse quadrant have possible room of improvement in the efficiency level just changing a little the composition of the expenditure. Certainly, this suggestion should be handle carefully, especially for two reasons: the change in the expenditure brings to a change in the DEA model input, so to modify endogenously the level of the efficiency; secondly, especially for the smallest municipalities there are some binding thresholds of expenditure that cannot be avoided.

Furthermore, the municipalities in the Inefficient-Worse and Inefficient-Better quadrant certainly could improve their level of efficiency at least solving the present mismanagement problems and their causes. So, in conclusion, the Efficient-Better quadrant seems to collect the municipalities that behave better, according to this analysis.

In a synthetic way, Table 24 shows the main features of each quadrant according to the dimensional, mountain, tourism and local labour system classes and referring the number of present municipalities (shortly, DMUs).

In the Efficient-Better quadrant, there is the prevalence of municipalities belonging to the class ranging from twenty thousands to sixty thousands of inhabitants; these municipalities are non-mountain places and subject to very low level of tourism. Moreover, the manufacturing systems in the textile, leather and clothing system represents the main class of these municipalities. As evident, these features recall those already presented in the description of the average inefficiency results; so, results are again confirmed.

In the Efficient-Worse quadrant municipalities ranging from five thousands to twenty thousands are prevalent and again the non-mountain feature represents the main characteristic of these municipalities. Moreover, they also belong to the very low tourism class and to the manufacturing systems in the textile, leather and clothing system.

In the Inefficient-Better quadrant, there is the prevalence of a lower dimensional class, that is from one to two thousands of inhabitants. Furthermore, these municipalities are totally-mountain places and are subject to a high level of tourism; related to this, there is the prevalence of municipalities that belong to the tourism and agricultural vocation system.

In the end, in the Inefficient-Worse quadrant there are municipalities that belong to the dimensional class ranging from three thousands to five thousands; they are totally mountain places, with high level of tourism and are prevalently heavy manufacturing systems.

Figure 8: Municipalities representation by relative efficiency and expenditure composition. 2011

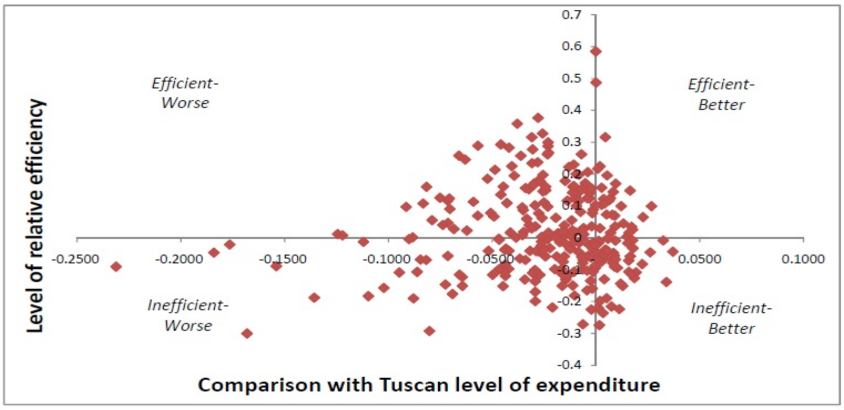


Table 24: Descriptive statistics of each quadrant. 2011

	Efficient-Better quadrant		Efficient-Worse quadrant		Inefficient-Better quadrant		Inefficient-Worse quadrant		
Dimensional class	DMUs	%	DMUs	%	DMUs	%	DMUs	%	TOTAL
From 0 to 1.000 inhab.	2	7%	1	1%	5	11%	10	10%	18
From 1.001 to 2.000 inhab.	1	3%	3	3%	14	32%	22	22%	40
From 2.001 to 3.000 inhab.	2	7%	3	3%	6	14%	17	17%	28
From 3.001 to 5.000 inhab.	5	17%	10	9%	9	20%	24	24%	48
From 5.001 to 10.000 inhab.	4	14%	34	30%	6	14%	19	19%	63
From 10.001 to 20.000 inhab.	9	31%	34	30%	3	7%	4	4%	50
From 20.001 to 60.000 inhab .	4	14%	20	18%	1	2%	2	2%	27
Over 60.000 inhab.	2	7%	8	7%	0	0%	0	0%	10
TOTAL	29	100%	113	100%	44	100%	98	100%	284
Mountain class	DMUs	%	DMUs	%	DMUs	%	DMUs	%	TOTAL
Non-mountain	16	55%	67	59%	15	34%	31	32%	129
Partially mountain	5	17%	23	20%	4	9%	10	10%	42
Totally mountain	8	28%	23	20%	25	57%	57	58%	113
TOTAL	29	100%	113	100%	44	100%	98	100%	284
Tourism class	DMUs	%	DMUs	%	DMUs	%	DMUs	%	TOTAL
Very low tourism	14	48%	36	32%	4	9%	17	17%	71
Low tourism	6	21%	33	29%	12	27%	20	20%	71
Medium tourism	7	24%	31	27%	7	16%	26	27%	71
High tourism	2	7%	13	12%	21	48%	35	36%	71
TOTAL	29	100%	113	100%	44	100%	98	100%	284
Local labour system class	DMUs	%	DMUs	%	DMUs	%	DMUs	%	TOTAL
Systems without specialization	4	14%	9	8%	4	9%	16	16%	33
Urban systems	2	7%	25	22%	4	9%	12	12%	43
Tourism and agricultural vocation systems	3	10%	8	7%	15	34%	17	17%	43
Manufacturing systems in the textile, leather and clothing	9	31%	41	36%	5	11%	20	20%	75
Other manufacturing systems made in Italy	4	14%	19	17%	5	11%	12	12%	40
Heavy manufacturing systems	7	24%	11	10%	11	25%	21	21%	50
TOTAL	29	100%	113	100%	44	100%	98	100%	284

IV.C. TOBIT results

In this last section, the results of the Tobit regression are presented, so to better understand the possible municipal spending inefficiency causes.

Table 25 contains the findings of this analysis. In particular, DEA efficiency scores are regressed: if an explanatory variable has a positive sign, it positively affects the efficiency and if it has a negative sign, the opposite holds.

Table 25: Tobit results. 2011

	Tobit results
AUTONOMY	.14703811***
REVENUES	-.00006794***
TOURISM	-.38844573***
DIM2	.0411038***
DIM3	.12657757***
DIM4	.19000678***
DIM5	.32902227***
DENSITY	.00004106*
MOUNTAIN	-.03615654***
SEA	-.10823416***
SECOND MANDATE	-.0393868*
SEA*TOURISM	.35181239**
SECOND*REVENUES	.00003669***
constant	.34677515***
σ	.06418401***
R^2	0.7893
Adjusted R^2	0.7792
N°observations	284

* denotes 5% significance level.

** denotes 1% significance level.

*** denotes 0.1% significance level.

First of all, it's worth noting that more or less all the explanatory variables are really very significant from a statistical point of view. Moreover, the R^2 and the Adjusted R^2 referred to the relative OLS regression are presented: it's possible to see that a quite good specification of the models is reached.

In general, the Tobit results confirm the supposed inefficiency sources.

The variable AUTONOMY has a positive effect on the efficiency score: for the same tax revenue, lower expenditure brings the municipality to be logically more efficient; considering another aspect, it's possible to say that this result makes look better those municipalities that try to spend in the better way the citizens contribution, because they are responsible of this.

It's interesting the outcome of the variable DIMENSION: DIM1 is the dropped variable and it's possible to observe that as the municipal size increases, the efficiency increases (as the increasing value of the intercept shows). So, as already evident from the DEA results comments, higher municipal size is preferable: certainly, the idea is linked to the discussed presence of missing increasing returns to scale. Moreover, a higher municipal dimension could make possible to offer more differentiated services to the population. Furthermore, another consideration must be presented: dropping the DENSITY from the TOBIT regression model, the R^2 and the Adjusted R^2 still remains quite high. The same also applies for the variable DENSITY: dropping the variable DIMENSION, the R^2 and the Adjusted R^2 still remains quite high and in addition the variable becomes more statistically significant. So, for these two variables a correlation problem is present in a certain way.

However, the variable DENSITY shows as expected a positive effect on the municipal expenditure efficiency: this element is reached for example in the lower per capita expenditure present in the most densely populated municipalities.

With regards to the mountain features, it's evident that it negatively affects the level of efficiency: this is also the evidence stemming from the analysis of the DEA results. The more impervious is the territory, the higher are the costs a municipality faces.

Another factor that negatively affects the municipal expenditure efficiency is the variable SEA: the sea features negatively affects the efficiency. Certainly, these sea places are subject to a greater seasonality and the resident population is lower than the effectively present. However, even if the variable TOURISM also has a negative effect on the efficiency, the interaction coefficient between TOURISM and SEA shows that the sea feature reduces the tourism negative effect: in this case such a phenomenon is justified by the highest variability in the non-sea municipality features. Furthermore it's worth noting that probably the greater tourist presence tends to increase the level of inefficiency because it brings more revenues in the municipal cash: so, there is a less felt need not to waste resources. This "wealth-effect" can be seen from the composition of the expenditure type among the different tourism classes: in the municipalities with high degree of tourism, actually there is a higher staff expenditure (the 35% vs the 31% in the other classes) necessary to maintain a heavier bureaucracy.

Finally, the variable SECOND MANDATE has a negative sign: probably, administrations that are at the second mandate tend to spend in a less prudent manner, since they have no possibility to be elected again. However, even if the variable REVENUES also has a negative effect on the efficiency, the interaction coefficient between REVENUES and SECOND MANDATE shows that second mandate makes lower the negative effect of the variable revenues: for this reason, it could be possible to say that the source of second mandate administration inefficiency is not related to a mismanagement of the municipal revenues, that instead is present in the first mandate administration, that can be unable to immediately manage in the most efficient way these resources. The overall meaning of a negative effect of the revenues could be related to an already expressed idea: the more resources are available for a municipality, the greater is the possibility to waste resources.

V. Conclusion

In this paper the global efficiency of Tuscan municipal spending has been under analysis by means of Data Envelopment Analysis. The data referred to municipal expenditure have been taken from the available municipal balance sheets (the so-called "Certificati consuntivi di bilancio") and the following functions have been considered: "General administration", "Educational services", "Social services", "Road maintenance and local mobility" and "Local police"). The city of Firenze has been considered as an outlier because it is absolutely out of scale in comparison with all other municipalities. Therefore it has not been included in the analysis.
Once the variables have been chosen, a separate DEA model has been run for each function and at the end a global index has been constructed through a weighted average, according to the weight that each function has in the total expenditure. As a further step, this paper has regarded the application of Tobit regression in order to have econometric interpretation of the synthetic DEA scores. Coelli program, that is "DEAP Version 2.1: A Data Envelopment Analysis (Computer Program)" has been the chosen software to compute DEA scores while for Tobit regression, Stata program has been used. The explanatory variables have been chosen starting from the existing literature: the municipal financial autonomy through the ratio between total tax revenues and total expenditures; the overall municipal resources, as the ratio between total revenues and the total population; the population density, as the ratio of total resident population over the municipal surface; the level of tourism through the ratio between the average annual tourist presence and the total population; as a categorical variable, 5 dimensional classes; as a dichotomous variable, the feature to be or not sea municipalities, the feature to be or not mountain municipalities and the possibility to be or not at the second mandate of municipal government. The results of the Tobit regression confirm what one can expect in terms of positive or negative impact on the municipal efficiency, that is: the ratio between total tax revenues over total expenditures positively affects the efficiency, while the ratio between total revenues and the total population does not. Moreover, as municipal size increases, the positive impact on efficiency is always greater. The mountain municipalities turn out to have a lower level of efficiency and the same applies for municipalities whose government is at the second mandate.
The obtained results through a DEA analysis and explained by a Tobit regression appear consistent and could be a starting point to have suggestions to correct the expenditure of the inefficient municipalities. Moreover, some expected evidences come out, especially regarding the long debated issue of the municipal size. In this analysis, the municipal size really affects the efficiency of the public expenditure: the bigger is a municipality, the greater is its level of public spending efficiency and the measures at regional level to reduce the present fragmentation of the Tuscan territory should actually bring to reduce waste. Certainly, through this paper, strengths and limitations of the DEA analysis have been tested: as it is suggested in the related literature, to test the robustness and the confidence of

the obtained results it could be preferable to further investigate this issue even with other methods, like Stochastic Frontier Analysis, and to make a comparison among results.

References

Afonso, A., Schuknecht, L., Tanzi, V., (2005), "Public Sector Efficiency: An International Comparison", Public Choice, 123 (3-4), pp. 321-347.

Afonso, A., Fernandes, S., (2008), "Assessing and explaining the relative efficiency of local government", Journal of Socio-Economics, 37 (5), pp. 1946-1979.

Aigner, D. J., Lovell, C. A. K., Schmidt, P., (1977), "Formulation and estimation of stochastic frontier production function models", Journal of Econometrics, 6 (1), pp. 21-37.

Aksezer, C. S., Benneyan, J. C., (2010), "Assessing the efficiency of hospitals operating under a unique owner: a DEA application in the presence of missing data", International Journal of Services and Operations Management, 7 (1), pp. 53-75.

Athanassopoulos, A. D., Triantis, K., (1998),"Assessing aggregate cost efficiency and the policy implications for Greek local authorities", INFOR: Information Systems and Operational Research, 36 (3), pp. 66-84.

Balaguer-Coll, M. T., Prior, D., Tortosa-Ausina, E., (2007), "On the determinants of local government performance: a two-stage nonparametric approach", European Economic Review, 51 (2), pp. 425-451.

Banker, R. D., Charnes, A., Cooper, W. W., (1984), "Models for the estimation of technical and scale inefficiencies in Data Envelopment Analysis", Management Science, 30 (9), pp. 1078-1092.

Battese, G. E., Coelli, T. J., (1995), "A model for technical inefficiency effects in a stochastic frontier production function for panel data", Empirical Economics, 20, pp. 325-232.

Blank, J. L. T., Valdmanis, V. G., (2010), "Environmental factors and productivity on Dutch hospitals: a semi-parametric approach", Health Care Management Science, 13 (1), pp. 27-34.

Boetti, L., Piacenza, M., Turati, G., (2010), "Decentralization and local government's performance: how does fiscal autonomy affect spending efficiency?", Department of Economics and Public Finance "G. Prato", University of Turin, Working Paper Series, No. 11/2010, March.

Boetti, L., Piacenza, M., Turati, G., (2011), "La valutazione dell'efficienza globale dell'attività dei governi locali", Working Paper n.1/2011, HERMES, Centro di Ricerca sull'Economia e il Diritto dei Servizi Regolamentati, Fondazione Collegio Carlo Alberto.

Bollino, C. A., Di Vaio, G., Polinori, P., (2012), "Spillover ed eterogeneità spaziali nei livelli di efficienza delle amministrazioni locali: un'applicazione ai comuni dell'Emilia-Romagna", Dipartimento di economia, finanza e statistica, Università degli studi di Perugia, Quaderno n.101, Febbraio 2012.

Bönisch, P., Haug, P., Illy, A., Schreier, L., (2011), "Municipality size and efficiency of local public services: Does size matter?", IWH-Diskussionpapiere, n.2011, 18.

Borge, L.-E., Haraldsvik, M., (2009), "Efficiency potential and determinants of efficiency: an analysis of the care for the elderly sector in Norway", International Tax and Public Finance, 16 (4), pp. 468-486.

Bowlin, W., (1998), "Measuring performance: An introduction to data envelopment analysis (DEA)", Journal of Cost Analysis, Fall 1998, pp. 3-27.

Byrnes, J., Crase, L., Dollery, B., Villano, R., (2010), "The relative economic efficiency of urban water utilities in regional New South Wales and Victoria", Resource and Energy Economics, 32 (3), pp. 439-455.

Charnes, A., Cooper, W., Rhodes, E., (1978) "Measuring the efficiency of decision making units", European Journal of Operations Research, 2 (6), pp. 429-444.

Coelli, T., (1996), "A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program", CEPA Working Paper 96/08, Departments of Econometrics, University of New England, Armidale, Australia.

Conrad, A., Neuberger, D., Trigo Gamarra, L., (2009), "The impact of regional and demographic factors on the efficiency of German savings banks", Thünen-series of applied economic theory, 111.

Conti, E., (2012) "Il turismo in toscana nel 2011". In IRPET, Regione Toscana (Eds.), (2012), "Rapporto sul turismo in Toscana. La congiuntura 2012".

Cook, W. D., Seiford, L.M., (2009), "Data envelopment analysis (DEA)-Thirty years on". European Journal of Operational Research, 192 (1), pp. 1-17.

Cooper, W. W., Li, S., Seiford, L. M., Zhu, J., (2011), "Sensitivity analysis in DEA". In Cooper, W. W., Seiford, L. M., Zhu, J. (Eds.) "Handbook on data envelopment analysis", pp. 41-70, Springer US.

D'Inverno, G., (2013), "Public Spending Efficiency: Evidence from Tuscan municipalities", Master's thesis, Master in Science in Economics, Department of Economics and Management, University of Pisa and Sant' Anna School of Advanced Studies, available on line at: http://etd.adm.unipi.it/theses/available/etd-09172013-124950/

De Borger, B., Kerstens, K., (1996), "Cost efficiency of Belgian local governments: a comparative analysis of FDH, DEA, and econometric approaches", Regional Science and Urban Economics, 26 (2), pp. 145-170.

De Borger, B., Kerstens, K., (2000), "What is known about municipal efficiency? The Belgian case and beyond", in Blank, J.L.T. (ed.), Public provision and performance - contributions from efficiency and productivity measurement, Elsevier, Amsterdam et al., pp. 299-330.

De Borger, B., Kerstens, K. Moesen, W., Vanneste, J. (1994), "Explaining Differences in Productive Efficiency: An Application to Belgian Municipalities", Public Choice, 80, pp. 339-358.

De Witte, K., Geys, B., (2009), "The political economy of efficient public good provision: evidence from Flemish libraries using a generalised conditional efficiency framework", Leuven: Center for Economic Studies, Discussion Paper Series 9.10.

Deller, S. C., Chicoine, D. L., Walzer, N., (1988), "Economies of Size and Scope in Rural Low-Volume Roads", Review of Economics and Statistics, 70 (3), pp. 459-465.

Deprins, D. L., Simar, L., Tulkens, H., (1984), "Measuring labor-efficiency in post offices", in: Marchand, M., Pestieau, P., Tulkens, H., (eds) The performance of public enterprises: Concepts and measurement, North-Holland, Amsterdam, pp. 243-268.

Dyson, R. G., Allen, R., Camanho, A. S., Podinovski, V. V., Sarrico, C.S., Shale, E. A., (2001), "Pitfalls and protocols in DEA", European Journal of Operational Research, 132, pp. 245-59.

Färe, R., Grosskopf, S., Lovell, C. A. K., (1994), "Production Frontiers", Cambridge University Press, Cambridge.

Farrell, M., (1957), "The measurement of productive efficiency", Journal of the Royal Statistical Society Series A (General) 120, pp. 253-281.

García-Sánchez, I.-M., (2009), "Measuring the efficiency of local police force", European Journal of Law and Economics, 27 (1), pp. 59-77.

Geys, B., Heinemann, F., Kalb, A. (2010), "Voter involvement, fiscal autonomy and public sector efficiency: evidence from German municipalities", European Journal of Political Economy, 26 (2), pp. 265-278.

Greene, W., (2003), "Econometric Analysis", New Jersey: Prentice Hall.

Hayes, K., Chang, S., (1990), "The Relative Efficiency of City Manager and Mayor-Council Forms of Government", Southern Economic Journal, 57 (1), pp. 167-77.

Kalb, A., (2009), "What determines local governments' technical efficiency?: The case of road maintenance", ZEW Discussion paper 09-047.

Kalb, A., Geys, B., Heinemann, F., (2011), "Value for Money? German Local Government Efficiency in a Comparative Perspective", Applied Economics, 44 (2), pp. 201-218.

Lan, C.-H., Chuang, L.-L., Chen, Y.-F., (2009), "Performance efficiency and resource allocation strategy for fire department with the stochastic consideration", International Journal of Technology, Policy and Management, 9 (3), pp. 296-315.

Loikkanen, H. A., Susiluoto, I., (2005), "Cost efficiency of Finnish municipalities in basic service provision 1994-2002", Urban Public Economics Review, 4, pp. 39-64.

Montén, A., Thater, C., (2010), "Determinants of efficiency in child care provision", IFO Working paper No. 83.

Murillo-Zamorano, L., (2004), "Economic efficiency and frontier techniques", Journal of Economic Surveys, 18 (1), pp. 33-77.

Nijkamp, P., Suzuki, S., (2009), "A generalized goals-achievement model in data envelopment analysis: an application to efficiency improvement in local government finance in Japan", Spatial Economic Analysis, 4 (3), pp. 249-274.

Prieto, A. M., Zofío, J. L., (2001), "Evaluating effectiveness in public provision of infrastructure and equipment: the case of Spanish municipalities", Journal of Productivity Analysis, 15 (1), pp. 41-58.

Picazo, T. A. J., González, G. F., Sáez, F. F. J., (2009), "Accounting for operating environments in measuring water utilities' managerial efficiency", The Service Industries Journal, 29 (5-6), pp. 761-773.

Sampaio de Sousa, M., Stosic, B., (2005), "Technical efficiency of the Brazilian municipalities: Correcting nonparametric frontier measurements for outliers", Journal of Productivity Analysis, 24, pp. 157-181.

Simar, L., Wilson, P. W., (2007), "Estimation and inference in two-stage, semiparametric models of production processes", Journal of Econometrics, 136 (1), pp. 31-64.

Tran, N. A., Shively, G., Preckel, P., (2010), "A new method for detecting outliers in Data Envelopment Analysis", Applied Economics Letters, 17 (4), pp. 313-316.

Vanden Eeckhaut, P., Tulkens, H., Jamar, M.-A., (1993), "Cost-efficiency in Belgian municipalities". In Fried, H., Lovell, C., Schmidt, S. (Eds.), "The measurement of productive efficiency: Techniques and applications". New York: Oxford University Press.

Von Hirschhausen, C., Cullman, A., Kappeler, A., (2006), "Efficiency analysis of German electricity distribution utilities - non-parametric and parametric tests", Applied Economics, 38, pp. 2553-2566.

Walter, M., Cullmann, A., (2008), "Potential gains from mergers in local public transport: an efficiency analysis applied to Germany", DIW discussion paper 832.

Wilson, P. W., (1993), "Detecting outliers in deterministic nonparametric frontier models with multiple outputs", Journal of Business and Economic Statistics, 11 (3), pp. 319-323.

Worthington, A. C., (2000), "Cost efficiency in Australian local government: a comparative analysis of mathematical programming and econometric approaches", Financial Accountability & Management, 16 (3), pp. 201-223.

Worthington, A. C., Dollery, B., (2000), "Efficiency measurement in the local public sector: Econometric and mathematical programming frontier techniques", School of Economics and Finance Discussion Papers and Working Papers Series 078, School of Economics and Finance, Queensland University of Technology.

Worthington, A. C., Dollery, B., (2001), "Measuring Efficiency in Local Government: An Analysis of New South Wales Municipalities' Domestic Waste Management Function", Policy Studies Journal, 29 (2), pp. 232-250.

Discussion Papers – Collana del Dipartimento di Economia e Management
Universitá di Pisa

Discussion Paper n.175, presentato: **gennaio 2014**

Corresponding Author:

Giovanna D'Inverno
Department of Economics & Management
University of Pisa
Via Ridolfi 10 - 56124
Pisa, Italy
Tel. 050-2216256
Fax. 050 2210603
Email: giodinve@tiscali.it

Laura Carosi: Department of Economics and Management, University of Pisa, Italy

Letizia Ravagli: IRPET - Istituto Regionale per la Programmazione Economica della Toscana, Firenze, Italy.

La presente pubblicazione ottempera agli obblighi previsti dall'art. 1 del decreto legislativo luogotenenziale 31 agosto 1945, n. 660.

Acknowledgements
The research has been performed while Giovanna D'Inverno was doing her internships at the IRPET Institute. The authors are very grateful to the IRPET researcher for their support, helpful suggestions and productive comments.

Please quote as follows:
Laura Carosi, Giovanna D'Inverno, Letizia Ravagli (2014), "Global Public spending efficiency in Tuscan municipalities", Discussion Papers del Dipartimento di Economia e Management – Università di Pisa, n. 175 (http://www.dse.ec.unipi.it/index.php?id=52).