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Abstract

Measuring local government efficiency is a complex task that has to take into account that they usually operate in a heterogeneous context. Therefore, the estimation of relative efficiency measures of their performance needs to account for the effect of contextual and exogenous variables on the production process. This should assure that the respective measures adequately reflect the portion of inefficiency that may be attributable to local authorities. In this paper, we apply time-dependent conditional frontier estimators to assess the performance of the 278 Portuguese mainland municipalities for the 2009-2014 period. By applying this nonparametric approach, we can avoid the strong assumptions on the specification of the estimated production function required by traditional two-stage methods. Furthermore, we examine the effect of contextual and exogenous variables on municipal efficiency levels and technological change. The results reveal that the recent local reforms introduced after the bailout agreement have slightly enhanced the performance of local authorities, but only for small and medium-sized municipalities.

Keywords: Efficiency, Local governments, Operational environment, Nonparametric estimation, Conditional approach

JEL codes: H71, H83, D24.

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1. Introduction

Irrespective of the level of decentralization, local governments play an important role in providing public goods and services to citizens in many developed countries. Local authorities are increasingly under a lot of pressure to conform to the standards demanded by the general public in terms of both quantity and quality. In the wake of the economic and financial crisis, they have to deal with growing resource constraints. Thus, one of their main challenges is to further improve their performance. In this context, the assessment of municipal efficiency has become a very important factor in providing additional guidance for policy makers.

This paper focuses on the measurement of local government efficiency in Portugal. This country is an interesting case study because municipalities are all subject to the same political and administrative rules and laws and have the same policy instruments and resources at their disposal. Besides, local politicians have substantial decision-making autonomy (Costa et al., 2015). In addition, a comprehensive and detailed dataset is available on local public finances covering the entire country, including electoral results, municipal economic, demographic and social conditions (Veiga and Veiga, 2014).

The current global economic and financial crisis hit Portugal hard. Following the banking collapse in the US and shortly after the beginning of the Greek debt crisis in the first quarter of 2010, Portugal was considered as a high-risk investment. Thus the demand for government bonds decreased, and the interest rate shot up. By 2011, the accumulation of private and public debt was so high that the Portuguese authorities were forced to ask for financial assistance[1]. The bailout agreement negotiated with the international lenders (the European Commission, the European Central Bank and the International Monetary Fund) obliged the Portuguese government to reform the structure of the local governments to enhance service delivery, reduce costs and improve efficiency. The key commitments were to reduce State grants to municipalities, decrease the local debt limit and cut back staffing levels in municipalities, as well as to reorganize the administrative map by reducing the number of local government units (Teles, 2014).

[1] In 2011, private sector and public debt represented 326% and 108% of the GPD, respectively.

The government's *Green Paper on Local Administration Reform* set a number of challenges that needed to be accomplished by 2012. Apart from the reduction of the number of local council representatives, the plan also established criteria for reducing, amalgamating or abolishing various civil parishes (*freguesias*). A civil parish is a subdivision of a municipality with its own elected bodies, possibly a neighborhood or city district, a group of hamlets, a village, a town or an entire city, which has limited powers. Finally, the reform was implemented according to Law 11-A/2013 of 28 January 2013, which defined the reorganization of the civil parishes. This reorganization of municipalities by size generated popular concern because of the recognition that identity often overlaps with individual relations to territory and the emotional attachment of Portuguese population to their civil parishes (Stoker, 2011).

The aim of this research is to assess the efficiency of Portuguese local governments during this transformation process. For this purpose, we adapt the time-dependent conditional frontier models recently developed by Mastromarco and Simar (2015) to the analysis of a panel of the 278 Portuguese mainland municipalities for the 2009-2014 period, most of which coincides with the term of local authorities elected in 2009[2]. This nonparametric approach allows us to take into account the heterogeneous context in which the above municipalities operate by including the effect of environmental factors in the estimation of production frontiers. Thus the resulting performance measures reflect the portion of inefficiency that may be attributable to local authorities. Furthermore, it enables us to examine the effect of the selected exogenous variables and time on the production process using second-stage nonparametric regressions.

The main contributions of this study to the existing literature are three-fold. Firstly, this is the first study to consider the effect of a set of exogenous variables in the estimation of efficiency measures of municipal performance. In this respect, the adopted nonparametric approach allows us to avoid the restrictive separability assumptions on the specification of the estimated production function required by traditional methods (see Badin et al., 2014 for details). Secondly, our analysis covers a six-year period. On this ground, we need to adapt our model to a dynamic framework by incorporating the time dimension as an additional conditional variable in order to investigate the evolution of the production process over time. This approach has not been applied in

[2] The 2013 Portuguese local election took place on September and the previous one was in October 2009.

previous studies analyzing the performance of municipalities, most of which are based on data about a single year. Finally, we assess the performance of Portuguese municipalities for the first time since the implementation of the reforms in the structure of the local governments required by the bailout agreement, thus we can provide an initial evaluation about their impact on efficiency levels.

The remainder of this paper is structured as follows. Section 2 reviews the previous literature on measuring local government performance and describes the methodology applied. Section 3 provides a brief description of the Portuguese local administration and explains the main characteristics of the dataset and the variables selected for the empirical analysis. Section 4 presents and discusses the main results and relates them to the existing literature. Finally, the paper ends with some concluding remarks in Section 5.

2. Measuring municipal efficiency

2.1. Literature review

The literature about local government efficiency is relatively recent, since the pioneering works did not emerge until the early 1990s (Van Den Eeckaut et al., 1993; De Borger et al. 1994; De Borger and Kerstens, 1996a, 1996b). Since then, a wide range of studies has analyzed the efficiency of municipalities from multiple perspectives, although they can be divided into two main groups. On the one hand, some works focused on a single local public service, such as refuse collection (Bosch et al. 2000), water provision (Picazo et al. 2009, Byrnes et al. 2010), police services (Garcia-Sanchez 2009), street lighting (Lorenzo and García-Sánchez, 2007) or public libraries (De Witte and Geys, 2013). On the other hand, many articles take a global perspective, since local authorities provide a wide variety of services and facilities from the same municipal budget.

A major drawback of the first type of studies is that it is difficult to sort out which parts of the municipal inputs are assigned to each specific service. In this paper, therefore, we focus on the literature addressing global local government efficiency. This approach has been applied to assess the performance of municipalities in many different countries such as Greece (Athanassopoulos & Triantis, 1998), Brazil (Sousa & Ramos, 1999;

Sousa & Stosic, 2005), Australia (Worthington, 2000; Worthington & Dollery, 2000), Spain (Giménez & Prior, 2007; Balaguer-Coll et al., 2007; 2010; 2013; Zafra & Muñiz, 2010; Benito et al., 2014), Finland (Loikkanen & Susiluoto, 2005), Germany (Geys et al., 2010; Kalb et al., 2012), Japan (Nijkamp & Suzuki, 2009; Otsuka et al. 2014), Italy (Storto, 2013; Settimi et al, 2014) or Turkey (Kutlar et al., 2012).

The global efficiency of Portuguese local governments has also been analyzed in previous studies[3]. Afonso and Fernandes (2006) assessed the expenditure efficiency of a sample of 51 municipalities located in the region of Lisbon and Vale do Tejo for 2001. In a later work (Afonso and Fernandes, 2008), they extended the empirical study to include all the Portuguese mainland municipalities (278) for the same year. More recently, Cruz and Marques (2014) evaluated the performance of all the municipalities in Portugal (308), also including the thirty located on the islands, using data for the year 2009.

Most studies estimate the global efficiency of units using non-parametric techniques like data envelopment analysis (DEA) or free disposal hull (FDH), since the flexibility of these methods is well adapted to the characteristics of public service provision[4]. Input selection in the above empirical analyses is usually based on staff and local expenditures (total or distinguishing between current and capital expenses). On the other hand, the indicators representing outputs are usually related to the services and facilities provided by local governments in each country. Subsequently, researchers are primarily concerned with exploring how a set of socioeconomic and political variables potentially influence the distribution of the estimated efficiency scores. For that purpose, the common practice is to apply a second-stage analysis where scores are regressed on a set of covariates that are viewed as representing the main characteristics of the external environment in which the local governments are operating. This model has been traditionally estimated using conventional inference methods such as Tobit or OLS (e.g. Loikkanen & Susiluoto 2005, Gimenez & Prior, 2007, Afonso & Fernandes 2008 or Balaguer-Coll & Prior 2009). However, the results yielded by the above

[3] These studies also provide systematic reviews of the existing literature related to this topic of research. Afonso and Fernandes (2008) covered the most representatives studies published until 2006, while Cruz and Marques (2014) extended the review until 2012.

[4] Nevertheless, various studies (Worthington, 2000; Kalb et al., 2012; Otsuka et al., 2014) have applied stochastic frontier methods (SFA).

approaches are biased and inconsistent due to the existence of serial correlation among the estimated efficiencies obtained with nonparametric methods (see Simar & Wilson, 2007, 2011 for details).

In order to avoid this problem, Simar and Wilson (2007) proposed two different algorithms based on truncated (and not censored) regression models and bootstrap methods where maximum likelihood estimation produces consistent estimates of the parameters. Therefore, some of the most recent papers interested in measuring global municipal efficiency have started to use this approach. For instance, Bonisch et al. (2011) apply this bootstrap-DEA procedure to control for the influence of a set of institutional and fiscal variables in German municipalities. Bosch et al. (2012) use the same approach to analyze the possible effect of the socioeconomic characteristics of the population, as well as fiscal and political variables in Catalonia (Spain). Doumpos and Koen (2014) employ a similar methodology to test the potential influence of external variables related to fiscal and economic aspects in Greek municipalities. Finally, Cruz and Marques (2014) also adopt the double-bootstrap algorithm to account for a total number of 25 exogenous variables representing natural, demographic, economic and political factors that may have an influence of the global efficiency of Portuguese local governments.

Although the use of the algorithms developed by Simar and Wilson (2007) mitigates some of the theoretical limitations of traditional regression methods, the validity of the estimates obtained with this approach rely on the assumption that environmental factors only affect the shape of the distribution of inefficiencies (i.e., mean, variance, etc.), but not the attainable set or the estimated frontier. This restrictive separability condition implies to assume that the exogenous variables included in the second stage cannot affect the support of the input and output variables included in the first stage. This is often unrealistic in the context of global municipal efficiency, since the socio-demographic and economic characteristics of the municipalities can be presumed to determine the level and type of outputs provided, as well as the resources employed. Although Simar and Wilson (2007) advised that the input–output space and the space of external variables should be tested for separability in advance, none of the above empirical studies examined whether this assumption holds before applying this method.

This verification could have been done using the statistical tool developed by Dariao et al. (2010) and based on a nonparametric test employing sub-sampling methods.

In cases where the two-stage approach is found to be inappropriate, the alternative option is to use conditional measures of efficiency (Daraio and Simar, 2005, 2007a, 2007b). Such measures provide for the direct inclusion of the external or environmental factors in the production process without imposing this restrictive separability condition between external factor values and the input–output space. To the best of our knowledge, this methodology has not been applied to assess the efficiency of municipalities so far. Therefore, this is the first paper to apply this method to directly account for the effect of external variables on the estimation of efficiency measures of local government performance. Moreover, we adopt the time dimension as an additional conditioning variable in our empirical analysis. In this manner, we can adapt our model to a dynamic framework.

2.2. Methodology

It is not easy to define the production technology that local governments use to convert inputs into outputs. In the context of our study, we define a set of inputs $x(x \in \Re_+^p)$ that are used to provide services to the population, which will be the output y ($y \in \Re_+^q$). Then, the feasible combinations of *(x, y)* can be defined as

$$\psi = \left\{(x, y) \in \Re_+^{p+q} \;\middle|\; x \text{ can produce } y \right\}. \qquad (1)$$

In an input-oriented case, the Farrell's efficiency measure of efficiency for a unit operating at level *(x, y)* can be defined as follows:

$$\theta(x, y) = \inf\left\{\theta \middle| (\theta x, y) \in \psi\right\} \qquad (2)$$

Within this framework, nonparametric models are the most popular in the literature since they do not rely on restrictive hypotheses on the data-generating process. In this paper we use a DEA estimator of the frontier (which relies on the convexity assumption of ψ). Following the notation provided by Daraio and Simar (2007a), this estimator

$\hat{\psi}_{DEA}$ can be calculated as the smallest free disposal convex set covering all the data[5]:

$$\hat{\psi}_{DEA} = \left\{ (x,y) \in \Re_{+}^{p+q} \middle| y \le \sum_{i=1}^{n} \gamma_i y_i ; x \ge \sum_{i=1}^{n} \gamma_i x_i, \text{for } (\gamma_1,....,\gamma_n) \right.$$
$$\left. \text{s.t.} \sum_{i=1}^{n} \gamma_i = 1; y_i \ge 0, i = 1,....,n \right\} \quad (3)$$

This production process can be defined using an alternative probabilistic formulation. Following the notation introduced by Cazals et al. (2002) and Daraio and Simar (2005), the production process can be described by the joint probability function denoted by $H_{XY}(x, y)$, which represents the probability of dominating a unit operating at level (x, y):

$$H_{XY}(x,y) = \Pr(X \le x, Y \ge y) \quad (4)$$

This probability function can be further decomposed as follows:

$$H_{XY}(x,y) = \Pr(X \le x | Y \ge y) \Pr(Y \ge y) = F_{X|Y}(x,y) S_Y(y) \quad (5)$$

Therefore, the efficiency scores can be defined in terms of the support of these probabilities:

$$\theta(x,y) = \inf \left\{ \theta \middle| F_{X|Y}(\theta x | y) > 0 \right\} = \inf \left\{ \theta \middle| H_{XY}(\theta x, y) > 0 \right\} \quad (6)$$

Using the plug-in rule, the conditional DEA estimator for the input-oriented efficiency score can be obtained by solving the following linear program:

$$\hat{\theta}_{DEA}(x,y) = \inf \left\{ \theta \middle| (\theta x, y) \in \hat{\psi}_{DEA} \right\} \quad (7)$$

[5] This definition represents the case of variable returns to scale (VRS) according to the model introduced by Banker et al. (1984). The constant returns to scale model developed by Charnes et al. (1978) can also be applied when the equality constraint ($\sum_{i=1}^{n} \gamma_i = 1$) is omitted from the equation.

As our analysis aims to assess efficiency over a period, we need to extend this model to a dynamic framework including the time dimension. Following Mastromarco and Simar (2015), we consider the time T as a conditional variable, defining, for each time period t, $\psi_t \in \Re_+^{p+q}$, whose distribution is

$$H_{X,Y}^t(x,y) = \Pr(X \le x, Y \ge y | T = t) \tag{8}$$

which is the probability of being dominated for a production plan (x, y) at time t. Additionally, in the probabilistic formulation of the production process, we can also consider considering potential contextual or environmental factors Z which might have influence on the production process and the resulting efficiency measures by conditioning the production process to a given value of $Z = z$ (Cazals et al., 2002; Daraio and Simar 2005; 2007b), thus the distribution can be determined by

$$H_{X,Y|Z}^t(x,y|z) = \Pr(X \le x, Y \ge y | Z = z, T = t) \tag{9}$$

For an input conditional measure of efficiency, the decomposition of this joint distribution is given by

$$H_{X,Y|Z}^t(x,y|z) = F_{X|Y,Z}(x|y,z) S_{Y|Z}(y,z) \tag{10}$$

Therefore, the conditional input-oriented technical efficiency measure of the production plan *(x, y)* at time *t* facing conditions z can be defined as:

$$\theta_t(x,y|z) = \inf\{\theta | F_{X|Y,Z}^t(\theta x | y,z) > 0\} \tag{11}$$

Following Dario and Simar (2007b), the DEA estimators at time t and facing the condition Z = z can be written as

$$\theta_{DEA}^t(x,y|z) = \inf\left\{\theta \middle| y \le \sum_{j \in \Im(z,t)} \gamma_j y_j ; x \ge \sum_{j=(i,t)} \gamma_j x_j ; \gamma \ge 0 \quad \text{s.t.} \quad \sum_{j \in \Im(z,t)} \gamma_j = 1\right\} \tag{12}$$

where $\Im(z,t) = \left\{ j = (i,v) \middle| z - h_z < z_{i,v} < z + h_z ; t - h_t < v < t + h_t \right.$; h_z and h_t are bandwidths of appropriate size selected by data-driven methods. Bandwidth selection is a key issue in this complex framework since the estimation of the conditional frontier will depend on this parameter (Jeong et al., 2010). In our case, optimal bandwidths are selected, as suggested by Badin et al. (2010), using the least squares cross-validation (LSCV) procedure developed in Hall et al. (2004) and Li and Racine (2007). This approach has the appealing feature of detecting the irrelevant factors and smoothing them out by providing them with large bandwidth parameters. Likewise, it is noteworthy that the time variable is discrete, thus discrete kernels could be used for this variable. However, the most common alternative is to smooth all the components of Z using the standard continuous kernels proposed by Racine and Li (2004) and Li and Racine (2007) (see Badin and Dario, 2011 for details).

Following Badin et al. (2012), we can also disentangle the potential effects of conditional variables (*t, z*) to identify the impact on the boundary (shift of the frontier) and the effects on the distribution of the inefficiencies. The first effect can be investigated by considering the ratio of conditional to unconditional efficiency measures:

$$Q(x, y|z,t) = \frac{\theta_t(x, y|z)}{\theta(x, y)} \tag{13}$$

The effect of time and exogenous variables on the distribution of the inefficiencies can be calculated by looking instead at the robust partial order-α quantile efficiency measures developed by Daouia and Simar (2007). Those measures are based on the idea that there is, for each unit in the comparison set, a quantile frontier on which the organization is efficient. Thus the conditional order-α input efficiency score can be defined by

$$\theta_{\alpha,t}(x, y|z) = \inf \left\{ \theta \middle| F^t_{X|Y,Z}(\theta x|y, z) > 1 - \alpha \right\} \tag{14}$$

For our purpose of analyzing the impact of t and z on the distribution of efficiencies, we are interested here in the median quantile (α = 0.5), thus the ratio to be analyzed will be

$$Q_{\alpha}(x, y|z, t) = \frac{\theta_{\alpha,t}(x, y|z)}{\theta(x, y)} \tag{15}$$

In an input-oriented conditional model, a global tendency of the ratios to increase with the conditional variables indicates an unfavorable effect on efficiency (the conditional efficient boundary moves away from the marginal boundary when the variables increase, i.e., the variables act as undesirable outputs), whereas a tendency to decrease will denote a favorable effect. If the effect when considering full frontiers and partial frontiers is similar, we can conclude that when the conditional variables change, there is a shift in the frontier, whereas the distribution of the efficiencies is unchanged. In contrast, if the effect with the medians is greater than for the full frontier, we also have an effect on the distribution of the efficiencies.

Finally, there should also be a procedure for testing the effect of time and exogenous variables on the estimated efficiency scores using nonparametric estimators. Indeed, some authors like De Witte and Kortelainen (2013) have suggested that the bootstrap procedure proposed by Racine (1997) could be used to test whether or not this effect is significant. However, this procedure cannot be used in our case because the estimates are not equal to the true values used for defining the ratios in Equations 12 and 14. Thus our results would be biased by the noise introduced by the first estimation of the nonparametric regression estimates (see Kneip et al, 2013 for details). Nevertheless, Daraio and Simar (2014) explain that this problem can be avoided by using partial quantile frontiers and order-α efficiency because these nonparametric estimators have rates of convergence that are independent of the number of inputs and outputs. In particular, our empirical analysis tests the significance of Z on the average efficiency estimated for a large value of α (α = 0.95). Thus, the analysis could be viewed as a robust version of the analysis for full efficiency scores. Therefore, the use of the bootstrap algorithm suggested by Racine (1997) will be appropriate.

3. Empirical analysis

3.1. Portuguese local governments

Local governments in Portugal were formally established in the 1976 Constitution, two years after the institution of democracy in the country. Apart from defining the status of the two autonomous regions (the archipelagos of Azores and Madeira), the Constitution established that the local administration is composed of administrative regions, municipalities and civil parishes, although the administrative regions have yet to be developed[6]. The municipalities have autonomy to manage their resources, which include their own personnel, property, finance and administration, as well as to choose their governance structures for the provision of local public services. Their main activities focus on providing services to the population that live in their territories and attempting to satisfy their basic needs. Thus, they are responsible for the provision of local public goods and services such as water, transport, housing, education, sports, energy, social action, civil protection, culture or healthcare. Municipalities collect their own taxes and user charges, receive income from the sale of goods and services, receive intergovernmental transfers, benefit from the sale of assets, receive donations and inheritances, receive dividends and obtain loans (Silva, 2008). On the other hand, civil parishes are small jurisdictions with limited powers, performing duties that are delegated by the respective municipalities.

Despite the growing importance of local governments, the level of expenditure decentralization is still small in Portugal (according to the OECD Fiscal Decentralization Database, only 11.7% of total government expenditure was generated by municipalities in 2014). Moreover, local taxes only account for about 40% of their current revenues, thus they are heavily dependent on transfers from the central government and the European Union (EU). The growing debt size has also been an important feature observed in municipal financing, especially after the global economic and financial crisis started in 2008. The debt of Portuguese local authorities increased notably during the 2008-2010 period up to a total volume of over 8 billion euros, although this amount decreased in the following years thanks to the subsidies and special loans received from the central government (Ribeiro and Jorge, 2015).

[6] The recent Law 75/2013 defined two types of administrative regions (metropolitan areas and intermunicipal communities) and specified their powers and duties.

The number of municipalities has remained fairly stable over the last four decades (only three new municipalities were created). There are currently 308 municipalities, 278 of which are located in mainland Portugal and the remaining 30 are on the islands. A controversial issue in Portugal is municipal size, since many municipalities are sparsely populated despite the large size of their jurisdictions. Before the 2013 local government reforms, the 308 municipalities were subdivided into 4,259 civil parishes, but the recent reform of the structure of local governments implemented according to Law 11-A/2013 reduced this number to 3,091 (2881 on the mainland and 210 on the islands). This amalgamation strategy cannot be justified by the reduction of public expenditure, but requires changes to the local public management paradigm in response to the economic and financial situation in order to guarantee the sustainability of local governments without neglecting the provision of public goods and services for citizens.

Municipalities can be grouped according to their geographical distribution. Districts and autonomous regions constitute the most relevant and historically significant subdivision of the territory. They serve as the basis for a series of administrative divisions, such as electoral constituencies, and are a socially recognizable territorial division of the country. For statistical purposes, however, they are more often clustered into the five NUTS-II regions (Alentejo, Algarve, Centro, Lisbon and Norte)[7]. Another possible size-based classification is (Carvalho et al., 2014): small (less than 20,000 inhabitants), medium (from 20,000 to 100,000 inhabitants) and large (more than 100,000 inhabitants). Table 1 reports the distribution of municipalities across NUTS-II regions considering their population size. We use these classifications in Section 4 to facilitate the interpretation of results according to municipality location and size.

(Table 1 around here)
(Table 2 around here)

3.2. Data and variables

In our empirical analysis, we assess the relative efficiency of the 278 municipalities located in mainland Portugal. The island municipalities were omitted because they have

[7] The nomenclature of territorial units for statistics (NUTS) is the classification used by Eurostat for sub-national spatial units.

some specific financial and fiscal benefits that could cause comparability problems with other mainland local governments[8]. Our empirical analysis covers a six-year period (2009-2014), and therefore our dataset has a total of 1,668 observations. This dynamic framework allows us to assess the performance of local governments elected in 2009 throughout a whole term in which they had to face the effects of the financial crisis as well as the first year of the new governments elected in 2013 which are responsible for implementing the reforms derived from the bailout agreement.

The output indicators selected to estimate the efficiency levels of Portuguese municipalities are related to their responsibilities in providing services to the population. In particular, we consider the water supplied, the urban waste collected and the building permits issued, as well as the total resident population as an approximate variable for the other outputs[9]. The variables used as inputs represent the resources consumed by local governments in the provision of the above services. Specifically, we separate personnel expenditures from all other spending, including operational and capital (non-financial investment and capital grants) expenditures. All these data were gathered from municipality annual reports and the National Statistics Institute (INE in its Portuguese acronym).

We have also selected several indicators representing the environment in which the municipalities operate in order to take into account the effects of external factors on efficiency levels. In an attempt to account for geographical or demographic characteristics that might affect the costs of municipal service provision, we consider population density, which might indicate the presence of scale diseconomies, and the number of civil parishes. By including civil parishes, we can determine, firstly, whether municipality subdivision might affect economic performance and, secondly, if the reduction in the number of such entities undertaken in 2013 might have a real impact in terms of efficiency. In addition, we have retrieved data about two indicators representing the socioeconomic characteristics of the population of the municipality:

[8] Afonso and Fernandes (2008) provide similar arguments to support their decision to exclude the island municipalities from their analysis of Portuguese local governments.

[9] Although this variable is not a direct output, most studies consider it to be representative of services provided (e.g. Afonso and Fernandez, 2006; Balaguer et al, 2007; Balaguer and Prior, 2009; De Borger and Kerstens, 1996a; Geys et al, 2010; Gimenez and Prior, 2007; Worthington and Dollery, 2000).

average monthly salary and unemployment rate[10]. The information about these four variables was gathered from online INE databases. Another economic indicator included in our empirical analysis was the level of net debt, since this issue was a major concern for local authorities during the studied period. In our empirical analysis, the net debt was defined as a proportion of the total expenditure of the municipality. We computed this percentage using data provided by the Directorate General of Local Administration.

Another concern is to investigate whether the local government ideology (left-wing or right-wing) might affect the level of efficiency. Since the first municipal elections in Portugal in 1976, most of the municipalities have been governed by either PS or PPD/PSD[11], thus we include two dummy variables representing the ruling political party according to the results of the 2009 and 2013 elections. This information about the ruling party was gathered from the National Elections Commission. Likewise, we also include a dummy variable representing the location of the municipality, i.e., if it is located along the coast, because they are more economically attractive municipalities, and have more prospects of increasing their tax revenues. Finally, we adopt a categorical variable that represents each of the six years considered in order to take into account time as an additional exogenous variable in our empirical analysis[12]. Table 2 provides the definition of all the variables included in the analysis and the main statistics for the whole dataset.

Table 3 reports the descriptive statistics of all the variables in each year. According to this information, we find that the average trend for all the output indicators included in our model is downward, although population remains more stable. The most noteworthy drop is the rate of construction observed from the number of building permits, which nearly halved in six years. The volume of the inputs also declined throughout most of the period, although there was a slight increase in 2013. The evolution of the exogenous variables was mixed. There was an upward trend in the average monthly salary and the

[10] Poorer residents are likely to be more interested in better and more efficient local services. Actually, several authors suggest that the demand for local public services may vary with income (De Borger et al., 1994, Hayes et al., 1998).
[11] PS (Partido Socialista) is the main center-left party in Portugal. PSD (Partido Social Democrata) or PPD (Partido Popular Democrata) is the main center-right party in Portugal.
[12] Tzeremes (2014) also uses this approach in his empirical analysis of the effect of human capital on countries´ economic efficiency.

unemployment rate until 2012 followed by a small decrease, whereas the net debt declined since 2010 and, more remarkably, in 2013. The population density was also unchanged, as was the number of parishes until the implementation of the local reform that involved the reduction discussed above. Finally, note that most of the exogenous variables varied widely over the period as a whole, thus an empirical analysis assuming similar contextual circumstances for all municipalities would not reflect their real situation.

4. Results

Since the main purpose of this study is to evaluate how the consideration of time and the environment under which local authorities operate might affect the estimation of efficiency measures of municipal performance, we report the efficiency scores for two alternative models in this section. Firstly, we apply the DEA model considering only data about inputs and outputs (unconditional model) in different periods and then we estimate a conditional efficiency model including time and exogenous variables. In both models we assume the more flexible option of variable returns to scale (VRS) and adopt an input orientation because the output levels are more or less externally imposed, and thus they only have control over their expenditures.

Table 4 summarizes the efficiency scores estimated for both unconditional and conditional models for the full frontiers. We find that the average efficiency scores are higher (0.762) in the unconditional model where we do not account for contextual or exogenous variables, although the number of efficient units is almost the same in both models. The value of the correlation coefficient between both measures (0.703) indicates that there are sizeable differences depending on whether or not exogenous variables are considered. However, we focus primarily on analyzing the evolution of efficiency scores over the considered period. In this respect, the content of Table 5 and Figure 1 reveals that, in the case of the unconditional model, the level of mean efficiency was similar, whereas, after some ups (2010 and 2012) and downs (2011 and 2013), the average efficiency for the conditional model at the end of the period was slightly higher than in 2009. Therefore, if we do not take into account the external variables, the local reforms do not seem to have achieved the pursued objective of improving the efficiency of local government performance. Nevertheless, the

consideration of the heterogeneous context in which local authorities are operating allows us to identify a significant drop in 2013 followed by a certain improvement in the first year of the mandate of new elected local governments.

More interesting results can be derived by exploring the distribution of the efficiency scores across local governments of different sizes. The average efficiency scores reported in Table 6 denote that, on average, large municipalities are more efficient in both the unconditional and the conditional models, i.e., irrespective of whether or not the model considers exogenous variables[13]. Actually, average efficiency is quite similar in both models for large municipalities. Nevertheless, there are considerable differences between the mean efficiency score of the unconditional and conditional models for medium-sized and, especially, for small local authorities. Therefore, the consideration of external variables in the model widens the gap between municipalities of different sizes (the gap between large and small municipalities increases from 5% to 15%). This result suggests that the implicit assumption of the unconditional model about the existence of a similar environment for all units was more unrealistic for the smaller muncipalities which appear to be facing the most difficult environment[14].

By observing the evolution of mean efficiency levels for municipalities of different sizes over the period (Figure 2), we find some degree of convergence among different groups of municipalities in the unconditional model (Figure 2a). However, when the model includes exogenous variables (Figure 2b) the existing differences among different groups persist until 2013. In 2014 we can notice a certain convergence in both figures, thus we can interpret that the reforms implemented in the local sector have enhanced the performance of medium-sized and small municipalities more substantially.

If municipalities are clustered according to NUTS-II regions, Lisbon shows up as being the most efficient region in general terms independently of the model considered, although the existing divergences with respect to the other regions are larger in the conditional model (Table 7). The Norte and Centro regions are placed second and third in the ranking, while municipalities belonging to Algarve and Alentejo are the worst

[13] Jorge et al. (2008) obtained similar results using an unconditional DEA approach with data about Portuguese municipalities in 2004.
[14] Small municipalities are more dependent on government funding, while the larger ones are better able to increase their resources.

performers. Nevertheless, if we observe the evolution of efficiency levels over the period, it is worth noting that the average efficiency of municipalities belonging to Lisboa has decreased since 2011 in both models, while the rest of regions have maintained similar levels of efficiency or even higher (e.g. Centro), thus there appears to be some convergence among regions over the years (Figure 3). In the case of the conditional model (Figure 3b), this convergence is more pronounced in 2014, when almost all regions improve their performance with the exception of Lisbon and Algarve.

In order to examine the significance of the effect of the contextual variables on efficiency estimates, we re-estimated both models using a partial order-α estimator with a large value of α ($\alpha = 0.95$)[15]. The resulting analysis could be viewed as a robust version of the analysis for full efficiency scores. These new estimates were found to be highly correlated with the values obtained for full frontiers (the Spearman correlation coefficient is 0.96). We then regressed the ratio between conditional and unconditional efficiency scores on exogenous variables using the local linear estimator described in Section 2.2. Table 8 reports the influence of these variables and the p-values of the significance test proposed by Racine (1997) yielded after performing the bootstrap with 1,000 bootstrap samples. We also specify whether a variable has a favorable or unfavorable correlation with efficiency as illustrated by the partial regression scatter plots (Daraio and Simar (2005, 2007a)[16].

The results suggest that the inclusion of population density and socioeconomic variables in the model does not have a significant impact on municipal performance. Afonso and Fernandes (2008) already identified population density as being irrelevant in their analysis of the Portuguese municipalities by regions. Neither were average salary and unemployment rate expected to play a significant role, taking into account that, in previous studies, the effect of a similar variable, the purchasing power of citizens, was found to have an opposite impact as a potential explanatory factor of efficiency (see Afonso and Fernandes, 2008; Cruz and Marques, 2014). In addition, the results show that the ideological orientation of ruling parties does not play a key role in municipal efficiency levels. This is actually a common finding in empirical studies analyzing the performance of Portuguese municipalities focused on different aspects, such as the

[15] We tested three alternative values of α (0.9, 0.95 and 0.99) leading to very similar results.
[16] These figures are available upon request.

establishment of local tax rates (Silva et al (2011), the amount of spending (Costa et al., 2015) or debt management (Ribeiro and Jorge, 2015). Lastly, the variable representing time does not have a significant impact either. This suggests that efficiency levels have not experienced meaningful changes over the evaluated period, confirming our presentiment that the reforms implemented to improve the efficiency of municipalities were unsuccessful.

In contrast, some other variables considered in the conditional model such as the number of civil parishes and the net debt had a significant and negative effect on the estimation of efficiency measures. The above results are in line with findings from previous research using data about the year 2009 (Cruz and Marques, 2014), although the analysis reported in that study focused on identifying the determinants of performance using a two-stage approach rather than through inclusion in the production function. The results also suggest that there is a positive and significant relation between coastal location and municipal efficiency. This implies that coastal municipalities are better able to achieve higher levels of economic efficiency due mainly to their higher levels of development and their greater ability to increase tax receipts.

Finally, we examine the effect of the two factors identified as significant variables (the number of civil parishes and the net debt) over time using the three-dimensional pictures shown in Figure 4[17], which illustrate their effects on technological change and the efficiency level. With regard to the interpretation of those graphs, note that higher values in an input-oriented model denote a negative effect, whereas lower levels are associated with a favorable effect. Specifically, Figure 4a examines the effect of time and civil parishes on the ratio of conditional and unconditional efficiency measures relative to the full frontier (shifts in the frontier). It indicates that the number of civil parishes has a greater effect in accelerating technological change compare to time. In fact the effect of time is not clear for the case of technological change, while the number of civil parishes has a U-shape relationship to the efficiency level with a positive effect up to a value of around 30 and a negative effect for higher values. Similarly, Figure 4c shows that the effect of time is almost inexistent compared to the level of net debt,

[17] We do not explore the influence of coastal location because this variable takes the same value every year.

which has a major negative influence on technological change throughout the whole period.

The forms in Figure 4b and 4d report the effect of the same variables on the distribution of efficiencies represented by the ratio of the measures relative to the robust partial frontier estimated by applying the median quantile ($\alpha = 0.5$). In particular, Figure 4b reveals a clear positive effect of time in the last year of the period, especially for municipalities with a higher number of civil parishes. This suggests that the process of amalgamation implemented in 2013 has enhanced more substantially the efficiency of more divided municipalities, i.e., those with a higher number of civil parishes. Finally, the form of Figure 4d indicates that the net debt has a greater and positive effect on the distribution of efficiency than time, which has very little influence.

5. Conclusions

This paper uses a recently developed time-dependent conditional nonparametric approach to estimate efficiency measures for the 278 Portuguese mainland municipalities in the 2009-2014 period, incorporating the effect of time and different types of exogenous and contextual factors that might affect their performance. This method allows us to avoid the restrictive separability assumptions required by traditional two-stage approaches and thereby provide meaningful results. In addition, this methodology makes it possible to examine the impact of exogenous variables and time on the production process, distinguishing between the boundary and the distribution of the inefficiencies. To the best of our knowledge, this is the first empirical study using this method to measure the efficiency of local governments.

This methodology has been applied to evaluate the impact of the recently implemented structural reforms of local governments required by the bailout agreement negotiated with the troika (the European Commission, the European Central Bank and the International Monetary Fund) with the aim of reducing costs and improving efficiency. The above initiatives included reducing the local debt and municipal staffing levels and reorganizing the administrative map by reducing the number civil parishes. Our empirical analysis considers all these variables, and thus we can determine whether the pursued objective has been achieved.

The results suggest that the average efficiency of local governments has remained almost the same over the period, although it is possible to identify a certain improvement in the performance of municipalities in the last year in the model that includes data about exogenous variables, thus it is possible that the reforms implemented in 2013 might have a certain impact in the short-term. Moreover, we can identify differences across municipalities. For instance, when they are classified by size, we find that large municipalities have higher average levels of efficiency, although the gap between these and small municipalities narrowed notably after the local reforms were implemented. Thus the reforms might possibly have enhanced the performance of small and medium-sized municipalities more substantially. Likewise, from the division by NUTS-II regions, we found that municipalities belonging to Lisbon were clearly the most efficient local governments. However, their efficiency levels declined over the period, so there has been some convergence among regions over the years.

With regard to the exogenous variables incorporated into the production function, the results suggest that population density and socioeconomic factors do not have a significant impact on the municipal performance, whereas a coastal location, the level of net debt and the number of civil parishes are significantly related to the efficiency of municipalities. Moreover, from the analysis of the effect of the net debt and number of parishes over the period, we found that the process of amalgamation implemented in 2013 contributed to an improvement in the distribution of efficiencies, especially for municipalities with a higher number of civil parishes., while the effect of the level of net debt was almost unchanged across the whole period.

Finally, note that these results should be interpreted with caution for two main reasons. Firstly, they largely depend on the variables selected as inputs and outputs to estimate efficiency. Therefore, researchers who consider other variables to be more appropriate might question our findings. Secondly, it may be that not enough time has elapsed for us to get the full picture with respect to the effect of local reforms on the efficiency levels of Portuguese local governments. Hence, it will be necessary to evaluate performance again in the near future in order to test how the municipalities have adapted and responded to challenges like the problem of rural desertification, the need to manage urban development without increasing financial debt, the obligation to increase

intermunicipal cooperation or the necessity to achieve greater regional balance in a country that is highly dependent on the European market.

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TABLES

Table 1. Distribution of municipalities (depending on size) across NUTS-2

NUTS	Small	Medium	Large	Total
Algarve	7	9	0	16
Alentejo	45	13	0	58
Centro	63	35	2	100
Lisboa	1	6	11	18
Norte	46	30	10	86
Azores	15	4	0	19
Madeira	7	3	1	11
Portugal	**184**	**100**	**24**	**308**
Mainland	**162**	**93**	**23**	**278**

Table 2. Descriptive statistics of variables included in the analysis (whole sample)

Variable	Type	Form	Mean	Std. Dev.	Min	Max
Resident population	Output	Continuous	36,020	57,502	1,634	546,825
Buildings permits issued	Output	Continuous	77	84	1	919
Urban waste collected (tons.)	Output	Continuous	17,153	30,475	652	357,033
Drinking water supplied (1000 m^3)	Output	Continuous	8,253	16,055	193	220,000
Personnel expenditure	Input	Continuous	7,885	15,631	973	256,441
Total expenditure (capital + operational- personnel)	Input	Continuous	16,376	23,428	1,545	336,696
Population Density	Exogenous	Continuous	308.45	841.53	4.40	7,397.70
Average monthly salary	Exogenous	Continuous	870	157	617	1,883
Unemployment rate	Exogenous	Continuous	5.34	1.77	1.22	12.26
Civil parishes	Exogenous	Continuous	13.17	11.74	1	89
Net debt (% total expenditure)	Exogenous	Continuous	74.83	72.55	-111.33	740.02
Ruling party PS	Exogenous	Dummy	0.44	0.50	0	1
Ruling party PPD/PSD	Exogenous	Dummy	0.34	0.48	0	1
Coastal area	Exogenous	Dummy	0.39	0.49	0	1

Table 3. Descriptive statistics of variables included in the analysis per year

	2009		2010		2011		2012		2013		2014	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Resident population	36,493	57,886	36,488	57,888	36,073	58,220	35,887	57,538	35,678	57,159	35,503	56,926
Buildings permits issued	104	109	94	93	71	79	71	79	55	50	53	60
Urban waste collected (tons.)	18,719	34,694	18,713	34,082	17,617	32,168	16,340	29,561	15,751	28,041	16,091	27,934
Water	8,589	17,267	8,327	16,341	8,377	16,312	8,310	16,236	8,042	15,468	7,806	14,712
Personnel expenditures	8,233	16,834	8,421	16,888	8,129	16,127	7,169	13,966	7,732	15,239	7,625	14,636
Total expenditure (capital + operational- personnel)	18,660	27,377	16,434	24,346	16,150	21,518	15,855	22,216	16,454	21,431	14,704	23,207
Population Density	311	838	310	833	311	866	310	857	305	832	304	831
Average monthly salary	832	146	854	151	877	159	886	165	901	173	884	158
Unemployment rate	4.46	1.57	4.69	1.64	5.23	1.59	6.24	1.71	6.02	1.72	5.40	1.68
Civil parishes	14.57	12.78	14.57	12.78	14.57	12.78	14.57	12.78	10.37	8.74	10.37	8.74
Net debt (% total expenditure)	76.79	60.75	81.92	62.56	79.92	70.54	76.26	80.77	66.51	75.89	67.57	81.26
Ruling party PS	0.43	0.50	0.43	0.50	0.43	0.50	0.43	0.50	0.43	0.50	0.48	0.50
Ruling party PPD/PSD	0.36	0.48	0.36	0.48	0.36	0.48	0.36	0.48	0.36	0.48	0.28	0.45
Coastal area	0.39	0.49	0.39	0.49	0.39	0.49	0.39	0.49	0.39	0.49	0.39	0.49

Table 4. Descriptive statistics of the efficiency scores in both models

	Mean efficiency	**Standard Deviation**	**Min**	**Max**	**Efficient units**	**Correlation coefficient**
Unconditional DEA	0.7618	0.0969	0.4802	1.0000	59 (3,5%)	0.703
Conditional DEA	0.6730	0.1497	0.3002	1.0000	58 (3,5%)	

Table 5. Summary of main results over the period

	2009		**2010**		**2011**		**2012**		**2013**		**2014**	
	Uncond. DEA	**Cond. DEA**	**Uncond. DEA**	**Cond. DEA**	**Uncond. DEA**	**Cond. DEA**	**Uncond. DEA**	**Cond. DEA**	**Uncond. DEA**	**Cond. DEA**	**Uncond. DEA**	**Cond. DEA**
Mean efficiency	0.7631	0.6651	0.7730	0.6858	0.7598	0.6694	0.7654	0.6877	0.7493	0.6457	0.7603	0.6844
Efficient units	13	13	19	19	6	6	12	11	2	2	7	7
Correlation Coefficient	0.6707		0.7315		0.6523		0.7417		0.6503		0.7613	

Table 6. Average efficiency scores of municipalities of different sizes

Type of municipality (size)	**UNCONDITIONAL DEA**	**CONDITIONAL DEA**
Large (> 100.000 inhabitants)	0.8059	0.7927
Medium (20.000-100.000 inhabitants)	0.7547	0.6914
Small (<20.000 inhabitants)	0.7596	0.6447
TOTAL	**0.7618**	**0.6730**

Table 7. Average efficiency scores of municipalities in different NUTS II

NUTS	UNCONDITIONAL	NUTS	CONDITIONAL
LISBON	0.7969	LISBON	0.7694
CENTRO	0.7786	CENTRO	0.7070
NORTE	0.7545	NORTE	0.6547
ALENTEJO	0.7469	ALGARVE	0.6382
ALGARVE	0.7108	ALENTEJO	0.6213
TOTAL	**0.7618**	**TOTAL**	**0.6730**

Table 8. Influence of different exogenous factors on efficiency scores

(Estimation of nonparametric significance tests)

Exogenous variables	p-value	Influence
Population Density	0.49	Favorable
Average monthly salary	0.75	Favorable
Unemployment rate	0.36	Unfavorable
Civil parishes	0.00***	Unfavorable
Net debt (% total expenditure)	0.00***	Unfavorable
Ruling party PS	0.62	Favorable
Ruling party PPD/PSD	0.13	Favorable
Coastal area	0.00***	Favorable

*** denotes statistical significance at 1%

FIGURES

Figure 1. Evolution of average efficiency scores (2009-2013)

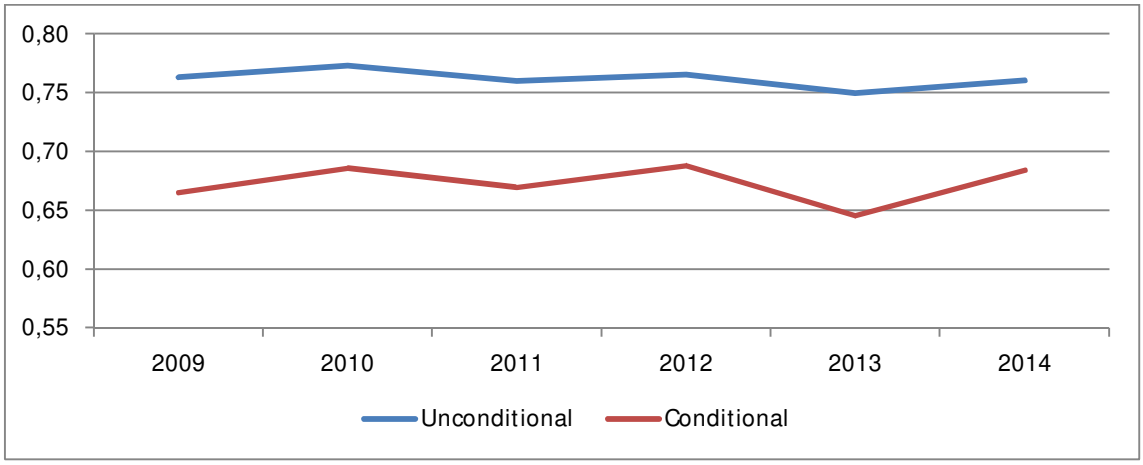
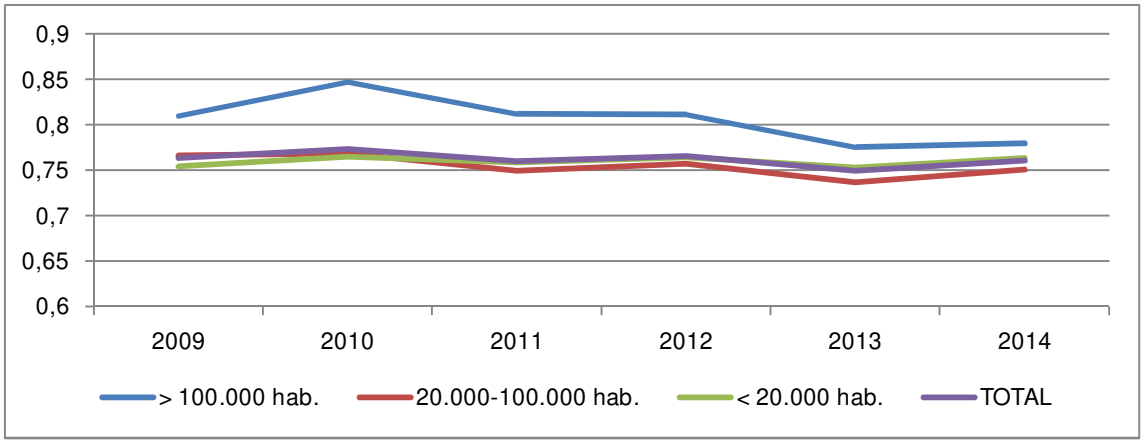


Figure 2. Evolution of average efficiency scores for municipalities with different size

a. Unconditional model



b. Conditional model

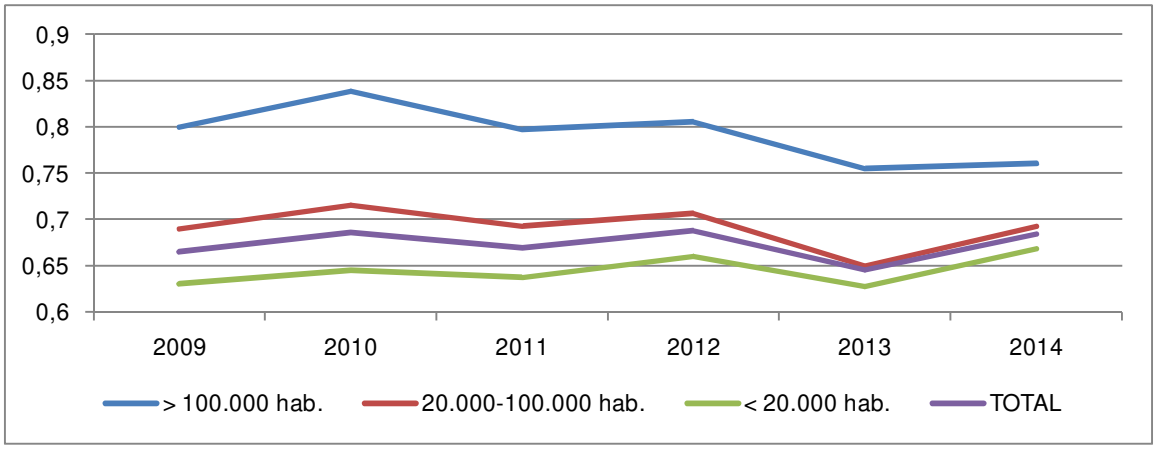
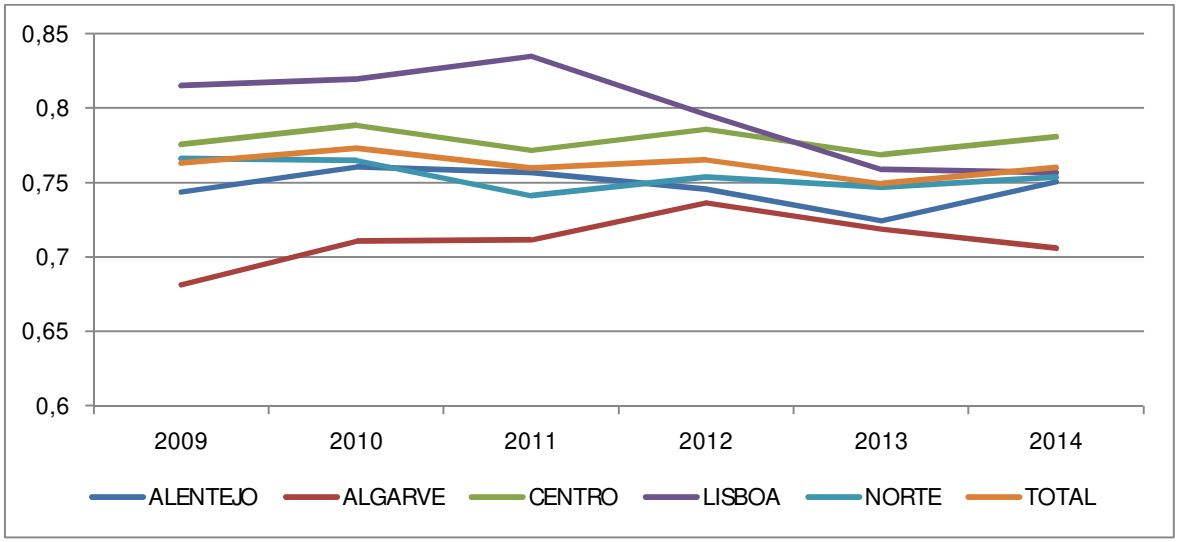


Figure 3. Evolution of average efficiency scores for municipalities in different NUTS II

a. Unconditional model



b. Conditional model

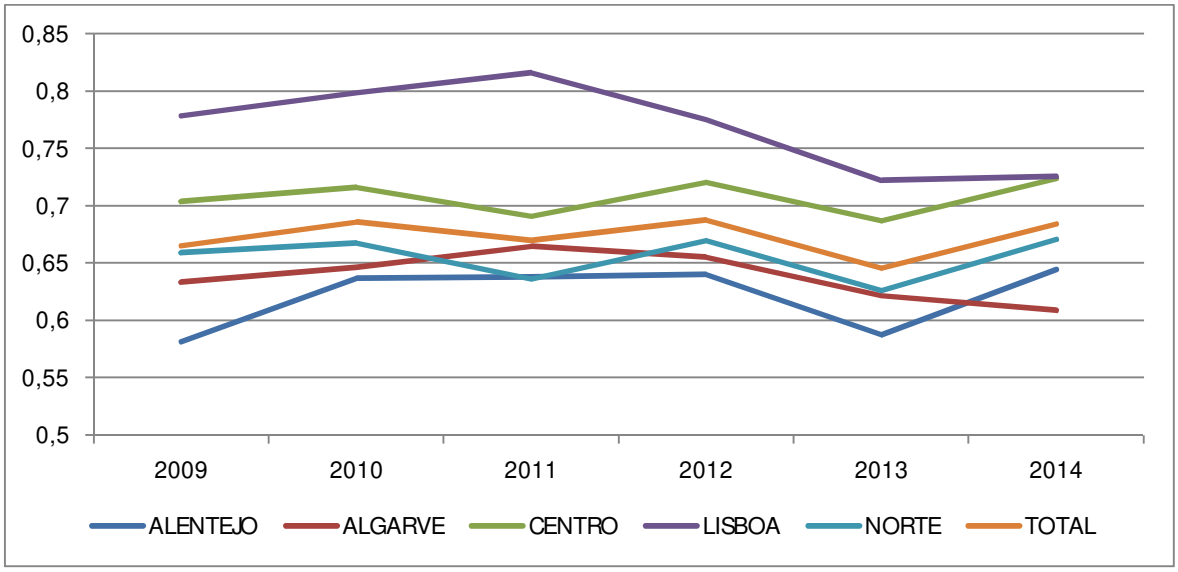
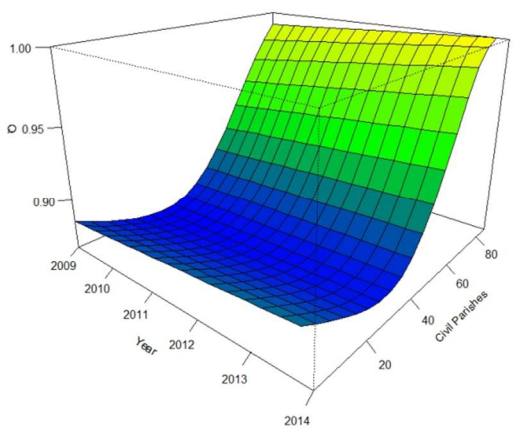
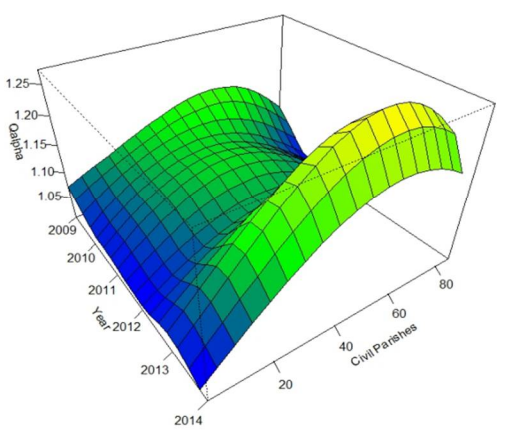


Figure 4. The effect of significant exogenous variables on efficiency

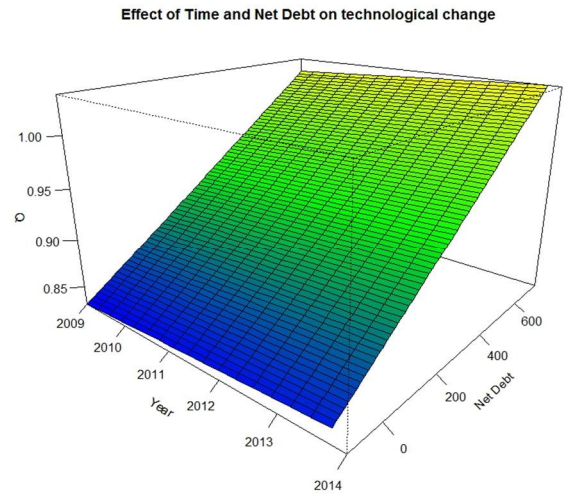
(a)



(b)



(c)



(d)