Decentralization and efficiency in Spanish local government*

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Abstract

This study analyzes the links between efficiency and the decentralization of competencies among Spanish local governments for years 1995 and 2000. The aim is pursued by considering a two-stage activity analysis model in which the performance of each municipality is first evaluated against other municipalities with a similar level of competencies and, in a second stage, it is compared with that of other municipalities for which decentralization remains at a more preliminary stage. The model also considers an index aimed at measuring whether tendencies towards higher (or lower) benefits from decentralization might exist over time. Results suggest that the type of technique considered plays a relevant role, since gains from higher decentralization are more apparent under the FDH (Free Disposable Hull) reference technology. However, regardless of the technique considered, on average, the gains from enhanced decentralization are improving over time.

Keywords: activity analysis, decentralization, efficiency, local government

JEL Classification: D24, D60, H71, H72

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1. Introduction

Since Tiebout's 1956, or Oates' 1972 classic studies, a growing stem of the literature on public economics has been devoted to emphasize the benefits of political decentralization and the federal state—and the competition among regional or local governments that it makes possible—to the detriment of centralized systems in which resource allocation and spending decisions are made by central governments (Cai and Treisman, 2004). Some authors consider it has already become a *classic* problem in public finance and public economics, in which the question as to how should authority provide the public goods to be allocated, and how should the costs of provision be shared, requests appropriate answers (Besley and Coate, 2003).

A deeper scrutiny would show that the benefits attributable to decentralization deal primarily with the enhanced responsiveness of governments to local needs by 'tailoring levels of consumption to the preferences of smaller, more homogeneous groups' (Wallis and Oates, 1988, p. 5) or, according to Tiebout (1956), Oates (1972), and others, it is better able to accommodate differences in tastes for public goods and services and, therefore, decentralization would be justified from an economic efficiency perspective. On the other hand, opponents to decentralization such as Crook and Sverrisson (1999), or Smith (1985), argue that power should remain in the hands of central governments since local authorities lack of human, financial and technical resources will prevent them from providing appropriate public services under a decentralized scenario (Faguet, 2004).

The topic is relevant for both developing and developed economies. In the world of development it is at the center of reform efforts not only throughout Latin America and many parts of Asia and Africa but also throughout several formerly planned economies. On the other hand, the guises of subsidiarity, devolution and federalism have prompted its analysis as a central policy issue in United States and several European Union countries. Some recent empirical studies have sought responses as to whether decentralization increase government responsiveness in developing countries (see Faguet, 2004), yielding affirmative answers. However, although the theoretical literature is enormous, empirical applications focusing on developed countries are few, and hence new contributions would be welcome.

This study focuses in Spain, one of the European Union countries where decentralization has been relentless since the establishment of the 1978 Constitution which, indeed, defined a decentralized organization of the state by featuring autonomous communities or regions (NUTS2 in European terminology), reviving local governments (NUTS5 in European terminology), and redefining central government positions, whose relationships were newly framed. Since then, regional governments have been gaining competencies to the detriment of central governments, and their share of total public spending in Spain has been growing at a remarkable pace.

However, the *second* decentralization, from either regional or central government to municipalities, has been far more modest, and local governments' share of total public spending has remained relatively stable—at least compared to public regional spending. Proponents for the second decentralization in Spain argue that decentralizing towards lower (local) layers of government not only would increase the size of local public sector but also, as suggested by other proponents for decentralization, would enhance their capabilities for managing *efficiently* both their financial needs and financial resources.

However, the literature on the efficiency of local governments is not abundant, and the Spanish case is not an exception. Some previous studies focusing on the efficiency of Spanish municipalities are those by Prieto and Zofío (2001) and Giménez and Prior (2003), or Balaguer-Coll *et al.* (2003), which differ from ours in several aspects, including the regions studied.[1] In particular, they focus on Castilla-León, Catalunya, and Comunitat Valenciana municipalities, whereas our study is focused on a sample of all Spanish regions.[2] A related branch of the literature attempts to evaluate Spanish local services, yet concentrating on the analysis of single services: garbage collection, urban public transport, water supply, local police, fire service, etc. For instance, Bosch *et al.* (2000) deal with the measurement of efficiency in Spanish municipal garbage collection services. In contrast, our analysis focuses on the evaluation of local organizations as a whole, such as decision-making units that organize the production process of multiple services. Therefore, this global analysis is more closely related to research studies focusing in the efficiency of local governments in other European Union countries, such as those by Vanden Eeckaut *et al.* (1993) and De Borger and Kerstens (1996)—although the set of techniques considered here have been specifically designed to our setting.

The literature on decentralization in Spain is far more abundant, since it is directly related to the literature on federalism and spending responsibilities among different government levels. A good prospect is provided by Molero (2001). However, the debate has traditionally leaned towards the allotment of responsibilities between central and regional governments whereas, as suggested above, local governments have played a minor role. It has also dealt more prone to the analysis of *fiscal* decentralization, in general, and other fiscal policy issues, in particular, rather than decentralizing competencies towards lower levels of government. However, as mentioned earlier, most studies are more deeply focused on decentralization from central government to regional governments, mirroring the process that has been taking place.

However, if the intention is to analyze the hypothetical links between (enhanced) decentralization and efficiency, the empirical evidence is entirely yet to come—not only in Spain, but also the scope is widened so as to encompass other countries.[3] This gap could be related to the difficulties in linking both issues. Our approach considers that benefits from decentralization might be detected because of the differing competencies among Spanish municipalities based on their population size. Therefore, if

[1] Other studies focusing on Spanish local government issues include those by Bosch and Suárez-Pandiello (1993, 1995), Gil Jiménez (2001), Pérez Blanco (1995), Pérez García (1995), Solé-Ollé and Bosch (2002), Solé-Ollé (1997, 2001), or Vela (1996), amongst others.

[2] All those for which information is available so far.

[3] The only published study related to our research interest is Agúndez García and Pedraja Chaparro (2003), yet the analysis is confined to fiscal decentralization.

a positive relationship between efficiency and population size emerged (since large municipalities are endowed with more competencies), it could be argued that benefits from enhanced decentralization might exist.

Yet, since competencies depend on the size (population) of each municipality, it is not an easy task to disentangle whether benefits accrue due to a wider range or competencies or simply because agglomeration economies might exist. However, considering both expenditures and revenues for each municipality may be more directly linked to the amount of services and facilities they must provide, and considering also that the inclusion of each observation on each size category depends on a thin line,[4], we argue that should performance differences exist, it is more likely that they were related to the decentralization issue.

Another related branch of literature comes from the study of scope economies among municipalities. Accordingly, as suggested by Grosskopf and Yaisawarng (1990), some cost benefits could accrue due to a broader range of services and facilities being provided. For instance, billing for garbage services could utilize existing computer files from the property tax department. Therefore, those municipalities with less competencies could not benefit from this type of economies. The linkage to our specific decentralization setting is also clear, since the existing comparison in the scope economies literature between *diversified* and *specialized* municipalities is paralleled by comparing here municipalities with more competencies to municipalities with less competencies or, in other words, municipalities benefitted in differing degrees from decentralization.

Yet the relationships under analysis are not easy to model. Our analysis considers a set of activity analysis techniques (see Färe *et al.*, 1994) which yields the specific decentralization gains that might occur.

The plan of the paper is as follows. The ensuing Section presents some brief features of the decentralization process in Spain. Section 3 is devoted to present the model aimed to estimate whether *decentralization* economies might exist. Section 4 presents data, inputs and outputs. Section 5 presents and comments on the most relevant results, whereas Section 6 sums up some concluding remarks.

2. Decentralization of public spending and responsibilities in Spain

As suggested by Molero (2001), the handing over of competencies from the central to the regional and local governments in Spain has been mainly spurred by political motives. However, local corporations have not benefited as much as regional governments (autonomous communities) from the decentralization process. Regardless of the source being considered, their share of public administrations' spending has remained fairly constant since the establishment of the Spanish Constitution in 1978. In contrast, the expenditures of both "high level of competencies" and "low level of competencies" regio-

[4]For instance, there might exist municipalities very similar in size yet they fall under different competencies' categories just because of a tiny difference in the number of inhabitants.

nal governments have increased dramatically, to the point that their current share of public spending more than doubles what they had in the early eighties.

Figure 1 displays the evolution of public spending shares for the three levels of government considered. It upholds the trends put forward earlier, i.e., regional governments' share of spending has been increasing steadily to the detriment of central government, whereas local governments' share increase has been far more modest. A great deal of regional governments' increase is due to more competencies for social goods, basically non-university education. Indeed, as suggested by Monasterio Escudero and Suárez Pandiello (1998), the joint category of non-university education and medical care accounts for nearly 80% of public spending in some "high speed" autonomous communities (see Suárez Pandiello, 1999).

Competencies to regional governments have been transferred according to the group they are affiliated to—either the "low level of responsibilities" group, or the "high level of responsibilities" group (see Monasterio Escudero and Suárez Pandiello, 1998). Accordingly, the Spanish State cannot be labeled as a purely federal nor a centralized state, but rather as as "cooperative federalism" state (López Guerra, 1987).

Local corporations' competencies are established by the *Ley Reguladora de Bases del Régimen Local* ("Regulating Local Regime Law"), as well as the Article 25.1 of the Spanish Constitution. These competencies depend on each municipality's population, and their specifics are provided in Section 4. One of the most marked differences consists in their inability to issue laws for self-government, in contrast to regional governments. These corporations are made up not only by municipalities but also provinces, islands, metropolitan areas, districts, and autonomous cities (Molero, 2001). However, our study is entirely confined to the efficiency of municipalities, since they constitute, along with regional governments, the most important players in the decentralization process.

3. The model

3.1. The DEA convex evaluation

To specify the model aimed at establishing the likely linkages between efficiency and (enhanced) decentralization, we first describe the variables needed. We assume that for each of the S production units to be evaluated, we know both the vector $\mathbf{x}^s$ of inputs consumed, $\mathbf{x}^s = (x_1^s, \dots, x_J^s)$ and the $\mathbf{y}^s$ vector of outputs, $\mathbf{y}^s = (y_1^s, \dots, y_I^s)$. We also assume that the production technology describing the process to translate inputs into outputs is known and can be epitomized through the input requirement set:

$$L(\mathbf{y}^s) = \{\mathbf{x} | (\mathbf{x}, \mathbf{y}^s) \text{ is feasible}\}. \tag{1}$$

The input set $L(\mathbf{y}^s)$ denotes the collection of input vectors $\mathbf{x} \in \mathbb{R}_+^J$ able to generate, at least, the output vector $\mathbf{y}^s \in \mathbb{R}_+^I$. It provides a general representation of the technology in terms of input and output quantities. No prices are involved, and no behavioral assumptions are required.

When input prices are available, and cost minimization is a reasonable behavioral assumption, it is possible to develop a price-dependent characterization of technology. Assuming prices for each s observation, $\mathbf{p}^s = (p_1^s, \ldots, p_J^s)$, are known, we denote the observed cost vector as $\mathbf{c}^s = (p_1^s x_1^s, \ldots, p_J^s x_J^s) = (c_1^s, \ldots, c_J^s) \in \mathbb{R}_+^J$, and the observed total costs as $TC(\mathbf{y}^s) = \vec{\mathbf{1}}\mathbf{c}^s = \mathbf{p}^s\mathbf{x}^s$. Treating outputs $\mathbf{y}^s$ as given, we can define a price-dependent characterization of the technology:

$$TC^*(\mathbf{y}^s) = \min\{\vec{\mathbf{1}}\mathbf{c} = \mathbf{p}^s\mathbf{x}^* | \mathbf{x}^* \in L(\mathbf{y}^s)\} \tag{2}$$

where $\mathbf{p}^s = (p_1^s, \ldots, p_J^s) \in \mathbb{R}_+^J$ is vector of input prices for unit s and $\mathbf{x}^* = (x_1^s, \ldots, x_J^s) \in \mathbb{R}_+^J$ is the input vector minimizing total costs. $TC^*(\mathbf{y}^s)$ shows the minimum total expenditure to produce output vector $\mathbf{y}^s$ at input prices $\mathbf{p}^s$.

Now we can define an overall cost frontier coefficient $OE(\mathbf{y}^s)$ for each s unit as the ratio between the minimum total cost $TC^*(\mathbf{y}^s)$ and its total observed cost $TC^s(\mathbf{y}^s)$:

$$OE(\mathbf{y}^s) = \frac{TC^*(\mathbf{y}^s)}{TC^s(\mathbf{y}^s)} = \frac{\mathbf{p}^s\mathbf{x}^*}{\mathbf{p}^s\mathbf{x}^s} \leq 1. \tag{3}$$

If $OE(\mathbf{y}^s) = 1$, then the evaluated observation is operating at the best practice costs, given the outputs and the input prices. However, when $OE(\mathbf{y}^s) < 1$, the observation is not part of the cost frontier; akin to this, $[1 - OE(\mathbf{y}^s)]$ would indicate the proportional reduction in costs that could be obtained if unit s operated on the cost-efficient frontier.

According to Färe *et al.* (1994), the overall cost efficiency coefficient, $OE(\mathbf{y}^s)$, is obtained by solving a Data Envelopment Analysis (DEA) (activity analysis) linear programming problem for each unit as follows:

$$\begin{aligned} OE^s(\mathbf{y}^s) &= \min_{\alpha,\lambda} \alpha^s \\ s.t.\quad TC^s\alpha - \lambda\mathbf{TC} &\geq 0, \\ -\mathbf{y}^s + \lambda\mathbf{M} &\geq 0, \\ \lambda &\geq 0, \end{aligned} \tag{4}$$

where $\mathbf{TC}$ is a vector containing the observed total costs for all S units, $\mathbf{M}$ is a matrix containing the observed S output vectors and λ is the activity vector denoting the intensity levels at which the S observations are conducted. The solution of the linear programming problem (4) yields for each s observation optimal values for OE^s (i.e., the cost efficiency coefficient) and λ^*, the activity vector. As mentioned above, when information on input prices and input quantities is not available, all units are assumed to face the same input prices, and we operate with input costs variables.

In the standard application of the linear programming problem (4) we do not *a priori* introduce any restriction so as to consider simultaneously large or small observations. Obviously, there is no restriction as to computing the best-practice frontier by combining observations with highly differing sizes—large and small. So, the benchmark can be constructed by the convex combination of municipalities having different levels of decentralization.

In order to address this caveat, we evaluate the possible existence of what urban economists define as 'economies of agglomeration', by classifying the S units into two sub-samples. The first one, with S_1 units, would encompass observations with the smallest size (in our current setting, municipalities with populations of under 5,000). In the second sub-sample there are the S_2 units with larger size. Therefore, the total sample is partitioned into two sub-samples just as described, i.e., $S = S_1 + S_2$.

We now adopt a two-stage procedure, similar to that in Prior and Solà (2000). In the first stage, the largest observations are taken separately, and the traditional cost frontier evaluation is applied. Thus, the following linear programming problem evaluates exclusively those units affiliated to group S_2:

$$\begin{aligned} OE^{s_2}(\mathbf{y}^{s_2}) &= \min_{\beta^{s_2},\lambda} \beta^{s_2} \\ s.t. \quad TC^{s_2}\beta^{s_2} - \lambda\mathbf{TC}^{s_2} &\geq 0, \\ -\mathbf{y}^{s_2} + \lambda\mathbf{M}^{s_2} &\geq 0, \\ \lambda &\geq 0, \end{aligned} \tag{5}$$

where the s_2 subscript indicates that the unit being evaluated is affiliated to group 2. Therefore, program (5) is the standard nonparametric cost frontier evaluation, yet it only includes a specific sub-sample of observations, namely, the largest ones.

In the second stage, the efficiency level of the S_2 sub-sample is evaluated again, yet exclusively with reference to the frontier that includes only units affiliated to S_1:

$$\begin{aligned} OE^{s_2}(\mathbf{y}^{s_2}) &= \min_{\gamma^{s_2},\lambda} \gamma^{s_2} \\ s.t. \quad TC^{s_2}\gamma^{s_2} - \lambda\mathbf{TC}^{s_1} &\geq 0, \\ -\mathbf{y}^{s_2} + \lambda\mathbf{M}^{s_1} &\geq 0, \\ \lambda &\geq 0, \end{aligned} \tag{6}$$

Programs (4), (5) and (6) differ in that, when evaluating the same s unit, the reference frontier is alternatively constructed with an uncontrolled mix of observations (program (4)), with only observations of the same characteristics (program (5)) and, finally, with the observations with lower level of decentralized services (program (6)). Therefore, in the first-stage analysis, when solving program (4), we are combining observations with different levels of decentralized services. On the other hand, in the second-stage, since the units we are interested in do not present the required level of homogeneity in their operational conditions, it is better to establish these frontiers separately, as defined in programs (5) and (6). In so doing, we obtain results that are more reliable, and easier to translate into policy proposals.

This two-stage evaluation process holds an additional advantage. As we obtain a *double* frontier reference, comparing these two groups of coefficients allows disentangling whether substantial efficiency differences might exist. Accordingly, considering that the β^{s_2} coefficient indicates the proportion in costs ($0 < \beta^{s_2} \leq 1$) that unit s_2 requires to reach the frontier corresponding to the same group, and γ^{s_2} indicates the proportion in total costs ($0 < \gamma^{s_2} \leq 1$) that unit s_2 requires to achieve the frontier defined by the sub-sample S_1 (the less decentralized municipalities), the relationship between β^{s_2} and γ^{s_2} would indicate either the presence of agglomeration economies or output complexity. Specifically, when $\beta^{s_2} < \gamma^{s_2}$, it would indicate the case where municipalities with more decentralized services (S_2) make the most of their size and operate with lower total costs than municipalities with lower levels of decentralization (S_1). On the other hand, when $\beta^{s_2} > \gamma^{s_2}$, then municipalities with more decentralized services (i.e., those affiliated to sub-sample S_2) provide more complex—and more costly—services than municipalities with lower levels of decentralization (affiliated to sub-sample S_1).

This evaluation process is summarized in Figure 2 and Figure 3. Let us assume that observations A, B and G are drawn from the sub-sample of less decentralized municipalities (S_1), and observations C, D, E and F are drawn from the sub-sample of more decentralized municipalities (S_2). Figure 2 shows how the linear programming problem (5) establishes the reference frontier taking into account only the observations affiliated to the group of more decentralized municipalities. Unit D is the only cost efficient observation, whereas the remainder (observations C, E and F) show overall cost inefficiency.

When we compare the units referred to in the paragraph above with the frontier of small, or less decentralized municipalities (Figure 3), linear programming problem (6) indicates that the benchmark is now that corresponding to the frontier of municipalities affiliated to group S_1. Graphically, the benchmark would then be constructed by taking observation B, compared to which units C, E and F become inefficient, yet leaving aside observation D.

In the particular setting being described, when analyzing unit s_2, it is possible to measure the agglomeration economies achievable when mingling these two frontiers by means of the γ^{s_2}/β^{s_2} ratio. If the ratio were above unity, it would indicate that economies of agglomeration exist, i.e., large municipalities make the most of a sort of scale economies. On the other hand, if the ratio γ^{s_2}/β^{s_2} were below unity it would suggest that the range of services and facilities provided by these municipalities is by far more complex, and more costly, than the services provided by smaller municipalities—which are bound to provide their population with fewer services and facilities.

3.2. The FDH nonconvex evaluation

Programs (4), (5), and (6) assume a convex technology, under which the frontier is composed by real observations and linear combinations of them. The problem is that it is not *a priori* granted whether the convexity postulate were the most suitable assumption in any circumstance, and it may be worth contemplating other technological references. In this case, if convexity is not postulated, we can adopt the so-called nonconvex reference technology defined by the FDH (Free Disposable Hull) frontier (Deprins *et al.*, 1984). Among other advantages with respect to convex formulations of the technology, it has been demonstrated that when the true technology is convex, the FDH estimator converges to the true estimator. In contrast, when the true technology is nonconvex, the convex estimator causes specification error (see Park *et al.*, 2000; Simar and Wilson, 2000).

In order to evaluate the nonconvex efficiency, Tulkens (1993) and Tulkens and Vanden Eeckaut (1995) proposed an integer linear programming model. The adaptation to the cost efficiency evaluation, using the notation previously defined is as follows:

$$\begin{aligned} OE^s(\mathbf{y}^s) = \min_{\alpha,\lambda} \; & \alpha^s \\ s.t. \quad TC^s\alpha - \lambda\mathbf{TC} &\geq 0, \\ -\mathbf{y}^s + \lambda\mathbf{M} &\geq 0, \\ \overrightarrow{\mathbf{1}}\lambda &= 1, \\ \lambda^s &= \{0,1\}. \end{aligned} \tag{7}$$

This program is the nonconvex version of the variable returns to scale nonparametric cost frontier evaluation. For us, however, Program (7) is not applicable provided that, as mentioned earlier, programs (5) and (6) required the comparison of observations with different sizes. In order to solve this problem, we put forward a new version of the FDH programs that, while keeping the nonconvexity technological assumption, allows the comparison of observations with different dimensions by 'cloning' the efficient smaller observations. Therefore, we can corroborate what the more efficient way to provide services to 100,000 inhabitants is: i) in five municipalities with populations of 20,000 each; ii) in two municipalities with populations of 50,000 each; or iii) in one municipality with population of 100,000 inhabitants. Strictly speaking, this is not a constant returns to scale comparison, as no comparison among large and small municipalities (or, more generally, municipalities of different population sizes) is performed, yet we can explore what the most efficient population size as to provide public services is. The modifications to introduce in Program (7) so as to make possible the 'cloning process' are presented in the following linear programming problem:

$$\begin{aligned} OE^s(\mathbf{y}^s) = \min_{\alpha,\lambda} \; & \alpha^s \\ s.t. \quad TC^s\alpha - \lambda\mathbf{TC} &\geq 0, \\ -\mathbf{y}^s + \lambda\mathbf{M} &\geq 0, \\ \mathbf{zM} &\geq \lambda^s, \\ \overrightarrow{\mathbf{1}}\lambda &= 1, \\ \lambda^s &= \{0,1\}, \\ \mathbf{z}^s &= \{0,1\}, \\ \mathbf{M} &\rightarrow \infty. \end{aligned} \tag{8}$$

Program (8) accepts every integer value for the λ^s components of the activity vector, yet restricting λ^s not to be larger than a binary variable, $\mathbf{z}^s$, multiplied by a parameter which tends to infinity. These new restrictions allow λ^s to take any integer value, precisely for the component of $\mathbf{z}^s$ with unitary value.[5]

3.3. Temporal analysis

Let us assume now that we have data corresponding to two time periods (t and $t+1$). It is feasible to define an index indicating the time evolution of the coefficients presented in Section 3.1 as follows:

$$\frac{\gamma^{s_2,t+1}/\beta^{s_2,t+1}}{\gamma^{s_2,t}/\beta^{s_2,t}} = \frac{\gamma^{s_2,t+1}/\gamma^{s_2,t}}{\beta^{s_2,t+1}/\beta^{s_2,t}} \tag{9}$$

Its value will be above or below unity depending on whether agglomeration economies or the output complexity increase between periods t and $t+1$, respectively. If nothing changes the index equals to one.

This temporal index can be decomposed in a similar way to the Malmquist indices (see Caves *et al.*, 1982; Grosskopf, 2003). In so doing, we are capable of determining the importance of technical change (shifts of the frontier between t and $t+1$), and efficiency change (taking into account the movements in the distance separating the observation under analysis from their respective frontiers). Allowing for this decomposition involves defining two additional linear programming problems mixing information corresponding to periods t and $t+1$:

$$\begin{aligned} OE^{s_2}(\mathbf{y}^{s_2,t+1}) &= \min_{\tilde{\beta}^{s_2},\lambda} \; \tilde{\beta}^{s_2,t+1} \\ s.t. \quad TC^{s_2,t+1}\tilde{\beta}^{s_2,t+1} - \lambda\mathbf{TC}^{s_2,t} &\geq 0, \\ -\mathbf{y}^{s_2,t+1} + \lambda\mathbf{M}^{s_2,t} &\geq 0, \\ \lambda &\geq 0, \end{aligned} \tag{10}$$

and

$$\begin{aligned} OE^{s_2}(\mathbf{y}^{s_2,t+1}) &= \min_{\tilde{\gamma}^{s_2},\lambda} \; \tilde{\gamma}^{s_2,t+1} \\ s.t. \quad TC^{s_2,t+1}\tilde{\gamma}^{s_2,t+1} - \lambda\mathbf{TC}^{s_1,t} &\geq 0, \\ -\mathbf{y}^{s_2,t+1} + \lambda\mathbf{M}^{s_1,t} &\geq 0, \\ \lambda &\geq 0, \end{aligned} \tag{11}$$

Finally, having these new cost efficiency coefficients, it is straightforward to decompose the index

[5]Program (8) holds similarities with the proposal made by Giménez García (2004), yet restricting the activity vector to be always an integer.

in order to define the technical change and efficiency change components:

$$\underbrace{\frac{\gamma^{s_2,t+1}/\beta^{s_2,t+1}}{\gamma^{s_2,t}/\beta^{s_2,t}}}_{\text{Agglomeration economies index}} = \underbrace{\frac{\gamma^{s_2,t+1}/\tilde{\gamma}^{s_2,t+1}}{\beta^{s_2,t+1}/\tilde{\beta}^{s_2,t+1}}}_{\text{Technical change index}} \cdot \underbrace{\frac{\tilde{\gamma}^{s_2,t+1}/\gamma^{s_2,t}}{\tilde{\beta}^{s_2,t+1}/\beta^{s_2,t}}}_{\text{Efficiency change index}} \tag{12}$$

The technical change index quantifies the observed changes in the frontier of the larger municipalities with respect to the change in the frontier made up by smaller municipalities. This index encompasses the relative shifts in best-practice technology, corresponding to the two samples (S_1 and S_2) under analysis, between periods t and $t+1$. A deeper scrutiny of its components corroborates that the cost efficiency coefficients 'benchmark' the same observation with the cost frontiers corresponding to periods t a and $t+1$. A technical change index larger than the unity indicates that the frontier of the sub-sample S_2 improves more rapidly than the frontier corresponding to the sub-sample S_1 (i.e., larger municipalities go through faster technical progress, or more sluggish technical regress). When the technical change index is below unity, then the technical progress of the S_1 sub-sample is superior to the technical progress corresponding to the sub-sample S_2 (i.e. small municipalities experience faster technical progress, or a lower technical regress).

In contrast, the efficiency change index (or catching up effect), shows what the changes in the relative cost efficiency levels are, corresponding to the two samples—S_1 and S_2—under analysis, between periods t and $t+1$. This index defines the distance of the observed costs for periods t and $t+1$ with respect to the frontier in period t. It indicates whether or not observations in $t+1$ are closer to the frontier than what they are in period t. When the efficiency change index is larger than unity, the cost efficiency change between periods t and $t+1$ improves more for the S_2 sub-sample than for the S_1 sub-sample. On the other hand, when the efficiency change index is below unity, the distance with respect to the frontier of the sub-sample S_1 has increased more than the distance respect to the sub-sample S_2.

3.4. Testing the closeness between efficiency distributions

Since the analysis considered above is based on comparing those results yielded by different linear programming problems which fall under the broad category of nonparametric techniques to measure efficiency, we may also resort to nonparametric techniques to test formally whether efficiency scores differ *significantly*. Specifically, following Fan and Ullah (1999), we may test whether two unknown distributions, which in our specific setting would be related to those for β^{s_2} and γ^{s_2} scores, differ significantly. Therefore, if f and g are the distributions corresponding to, say, β^{s_2} and γ^{s_2} for year 1995 under the convex DEA evaluation, the null hypothesis being tested would be $H_0 : f(\beta^{s_2}) = g(\gamma^{s_2})$ against the alternative, $H_1 : f(\beta^{s_2}) \neq g(\gamma^{s_2})$.

Although one might consider a two-sample t-test for the comparison of both distributions, there are some assumptions such as the independence of observations which efficiency scores do not meet—given they are the result of linear programming problems and, therefore, are dependent in the statistical sense. This caveat might be overcome by considering some nonparametric alternatives to the two-sample t-test such as the Kruskal-Wallis test. However, we consider it is far more luring exploiting nonparametric statistical methods aimed at exploring statistical differences between our efficiency indicators since they focus on the *entire* distributions instead of confining the comparison to summary statistics—such as the mean, in the case of the two-sample t-test, or the median, in the case of the Kruskal-Wallis test.

The test is based on the generally accepted idea of measuring the global distance (closeness) between two densities $f(x)$ and $g(x)$ by the integrated squared error (Pagan and Ullah, 1999), namely:

$$I = I\big(f(x), g(x)\big) = \int_x \big(f(x) - g(x)\big)^2 dx = \int_x \big(f^2(x) + g^2(x) - 2f(x)g(x)\big)dx$$
$$= \int_x \big(f(x)dF(x) + g(x)dG(x) - 2g(x)dF(x)\big) \quad (13)$$

where F and G would be two candidates for the distribution of X, with probability density functions $f(x)$ and $g(x)$. However, we may turn to kernel smoothing methods (Silverman, 1986) to estimate f, and therefore $\hat{f}$ would be the nonparametric kernel estimator of f. In such a case, since $\hat{f} = \big(1/(Sh)\big)\sum_{s=1}^{S} K\big((x_s - x)/h\big)$, a suitable estimator for I would be:

$$\tilde{I} = \int_x \big(\hat{f}(x) - \hat{g}(x)\big)^2 dx$$
$$= \frac{1}{S^2 h}\sum_{s=1}^{S}\sum_{t=1}^{S}\Big[K\Big(\frac{x_s - x_t}{h}\Big) + K\Big(\frac{y_s - y_t}{h}\Big) - 2K\Big(\frac{y_s - x_t}{h}\Big) - K\Big(\frac{x_s - y_t}{h}\Big)\Big]$$
$$+ \frac{1}{S^2 h}\sum_{s=1}^{S}\Big[2K(0) - 2K\Big(\frac{x_s - y_s}{h}\Big)\Big] \quad (14)$$

The integrated square error constitutes the basis to build the statistic on which the test is based (see Fan, 1994; Li, 1996; Pagan and Ullah, 1999), whose general form is:

$$T = \frac{Sh^{1/2}\tilde{I}}{\hat{\sigma}} \quad (15)$$

where

$$\hat{\sigma} = \frac{1}{S^2 h}\sum_{s=1}^{S}\sum_{t=1}^{S}\Big[K\Big(\frac{x_s - x_t}{h}\Big) + K\Big(\frac{y_s - y_t}{h}\Big) + 2K\Big(\frac{x_s - y_t}{h}\Big)\Big]\int K^2(\Psi)d\psi. \quad (16)$$

and h would be the bandwidth, window width or smoothing parameter, which we estimate using the plug-in method suggested by Sheather and Jones (1991).

4. Data, inputs, and outputs

Our analysis is performed for a sample of Spanish municipalities with a population over 1,000 inhabitants for years 1995 and 2000. Input and output data come from the same institution, although from different sources. The latter are provided by the Spanish Ministry for Public Administration, through the information gathered in the survey on local infrastructures and facilities (*Encuesta de Infraestructuras y Equipamientos Locales*). The focus of our analysis is confined to years 1995 and 2000, since these are the only years on which available information exist so far. On the other hand, local governments' budgetary data have been used to construct inputs. In this case frequency is much higher, since these data are available for every year; however, we are bound by the available information in the output side. Those regions meeting our criteria (data for years 1995 and 2000, data for both inputs and outputs, etc.) were Andalucía, Aragón, Asturias, Canarias, Cantabria, Castilla-León, Castilla-La Mancha, Extremadura, Murcia, La Rioja, and Comunitat Valenciana. After removing all those municipalities for which information was not available for both years 1995 and 2000, the sample was made up by 1,315 municipalities for each sample year. Unfortunately, there was no information for the remaining regions for several reasons. By the time of conducting this study, Madrid had not presented yet the information on outputs. Information on outputs is neither available for Catalunya, the Basque Country and Navarra.

The translation of the production process at municipal level in terms of the standard notion of transforming inputs into outputs very often presents a huge problem. In the case of municipalities it is quite common to distinguish three stages in this production process (Bradford *et al.*, 1969). First, there is the transformation of primary inputs (labor, equipment and external services) into intermediate outputs (e.g., hours of traffic control or the extension of police services). Second, these intermediate outputs are transformed into direct outputs (*D-outputs* as termed by Bradford *et al.*, 1969) ready for "consumption" (e.g., the number of urban streets controlled or the number of cases treated). Third, these direct outputs ultimately have welfare effects on consumers (e.g., increasing perceptions and feelings of safety and welfare). This final process is captured by outcome indicators (labeled *C-outputs* by Bradford *et al.*, 1969) that reflect the degree to which the direct outputs of municipal activities translate into welfare improvements as perceived by consumers. Theoretically, efficiency can be measured at each stage of this production process. Yet in practice, data availability problems typically do not allow us to distinguish between primary inputs, intermediate outputs, direct outputs, and final welfare effects. For this reason the analysis is very often limited to the study of the first and second phases of this process: relations between primary inputs or activities and direct outputs.

The selection of outputs is based on the services provided by each municipality.[6] Specifically, all

[6]See *Ley* 7/1985, April, 2$^{\text{nd}}$, Reguladora de Bases de Régimen Local (LBRL). The distribution of responsibilities among central, regional, and local administrations may be found at the URL

local authorities must provide public street lighting, cemeteries, waste collection and street cleaning services, drinking water to households, access to population centers, surfacing of public roads, and regulation of food and drink. In some cases we have to select proxies for these services. For instance, as pointed out by De Borger and Kerstens (1996), population is assumed to proxy for the various administrative tasks undertaken by municipalities, but it is clearly not a direct output of local production.[7] It also may constitute a proxy for measuring those services that a particular municipality could provide at its own expense, going beyond the legal minimum. Other important outputs, such as provision of primary and secondary education, do not fall within the responsibilities of Spanish municipalities.

Spanish municipalities are bound by law to provide minimum services depending on their population. Specifically, there are minimum services that all municipalities must provide, yet there are some additional ones that only larger municipalities (with populations of over 5,000, 20,000, and 50,000, which are the boundaries that define the different categories) are bound to furnish. Table 1 presents this type of information. The minimum services that each category of municipalities must provide appear in the second column, whereas the third column column shows the different output indicators aimed to measure, or to proxy, the different services.

The minimum services have led our output choice. Specifically, they are the list of outputs for years 1995 and 2000, along with summary statistics, is presented in Table 3. Therefore, we are measuring eight services (listed in the first column of Table 1) by means of the proxy indicators (listed in the second column of Table 1). The choice has also been led by previous studies focusing on the efficiency of other European local governments, since they are mostly endowed with the same competencies, and differences are basically confined to the education realm—which, in Spain, rely on regional and central governments. The publicly available information does not go much further from the outputs in Table 3. In addition to this, although the list of mandatory services to be provided varies according to municipalities' size, and therefore smaller municipalities could just be sticking to the legal minimum, we include all outputs when modeling their production since the case could happen that some of them might be going beyond the legal minimum.

Our selection of inputs is based on budgetary variables that reflect municipality costs. Specifically, our definition of inputs reflects the economic structure of Spanish local government expenditures, whose specifics are reported by Spanish legislation,[8] which considers three basic categories: current, or ordinary expenditures, capital expenditures, and financial expenditures. Among them, current expenditures are further divided into four chapters, or categories, which account for: i) personnel expenditure; ii) current goods and services expenditures; iii) financial expenditures; iv) current transfers. Capital expenditures are also decomposed, falling into either real investments, or capital transfers.

`http://www.igsap.map.es/cia/dispo/ce_ingles_index.htm`.

[7]See also Ladd (1994), who addresses the fiscal impact of population growth.

[8]See *Orden Ministerial*, September 20$^{\text{th}}$, 1989.

The former is what Table 2 refers to as capital expenditures (X_4), i.e., all expenditures local governments implement either: i) to produce or acquire capital goods; ii) to acquire necessary goods to provide local services in good condition; iii) financial expenditures that are suitable for amortization. On the other hand, capital transfers (X_5) refer to the payments to institutions to finance certain investments. Descriptive statistics for the year 1995 are provided in Table 3. Since our analysis is entirely confined to overall cost efficiency, the fact that some local government departments may be actually sharing some costs does not raise any particular issue. Table 2 provides further details on the contents of the economic budgetary classification for local governments.

Apart from that corresponding to inputs and outputs, we also defined another variable, representative of the operative level of quality of service, which describes the condition of public infrastructures. In so doing, it is granted that, in every evaluation made, the benchmark in the frontier would offer the public services with a non-inferior level in the quality of the service than the observation under analysis.

5. Results

Results for the β^{s_2} coefficient are provided in Table 4. It provides summary statistics for both types of activity models considered (the convex DEA and the nonconvex FDH), as well as the decomposition into the different population classes, or categories—which we must bear in mind have been devised according to the different levels of competencies. For convenience, the three groups of municipalities according to their competencies will be labeled as small (municipalities with a population under 5,000), medium (municipalities with a population between 5,000 and 20,000), and large (municipalities with a population over 20,000).

We must also recall what the precise interpretation of β^{s_2} is, namely, the proportion of costs unit s_2 requires to reach the frontier corresponding to the *same* group S_2, where same group refers to the group of municipalities with equal level of competencies. Therefore, the closer the β^{s_2} index is to one, the lesser the differences between s_2 municipality and those other ones bound to provide the same amount of services and facilities are. In other words, if β^{s_2} approaches unity, it should be interpreted as evidence suggesting that the unit being evaluated is not far from the best-practice units *in their competencies' group*, i.e., those bound to provide the same services and facilities.

Results show that average efficiency is higher for large- and medium-sized municipalities. This result is robust for both convex DEA and nonconvex FDH technologies, as well as both years 1995 and 2000. However, under the FDH evaluation efficiency is substantially higher since, by construction, it is more difficult to find dominating units. Divergences are more apparent when analyzing the disparities (standard deviation), which do not differ much for the three competencies' groups under DEA, yet they vary more according to FDH, due to the large amount of efficient municipalities found here.

The second component of our the second stage analysis, i.e., the γ^{s_2} coefficient, indicates the proportion of costs that unit s_2, affiliated to the group with higher level of competencies (S_2), requires to reach the frontier made up by those municipalities with lower competencies, i.e., to reach the frontier made up by the observations in group S_1. Therefore, if γ^{s_2} value were close to one, it would suggest s_2 municipality is not far from the frontier made up by other municipalities with lower levels of competencies or, in other words, less decentralized municipalities. However, in this case we may also expect values larger than unity, since the unit being evaluated is excluded from the reference set.[9]

Results are displayed in Table 5. They are, as expected, the same for small municipalities, since this group cannot be compared to any other group with less competencies. However, results vary for both medium and large municipalities, and in both cases efficiency worsens. However, the result does not hold under FDH, for which the pattern is reversed. In this case, both medium and large municipalities exhibit larger efficiency values. This result, however, should be assessed cautiously, since DEA methodology is extremely dependent on the number of units being evaluated. It is a well-known DEA phenomenon that as the number of units being evaluated increases, average efficiency decreases because it is easier to find units, or linear combination of units, whose performance is better than that of the firm being evaluated. However, this phenomenon is more lessened under FDH since, by construction, even if number of units is large it is more difficult to be *dominated* since linear combinations (i.e., convexity) are not permitted.

Following Section 3, the existence of agglomeration/decentralization economies is better assessed when analyzing how the γ^{s_2}/β^{s_2} behaves. The relationship between both components is presented in Table 6. It shows that, as suggested earlier, the dominance of agglomeration/decentralization economies is far more apparent under the FDH nonconvex technology. In this case, for both years 1995 and 2000, agglomeration economies are found to be substantial (45%). Therefore, there was a considerable number of municipalities whose performance improved when comparing them with a frontier made up by other municipalities with less competencies. Although a non-negligible 55% of units showed agglomeration/decentralization diseconomies, their distance to the unity is not as high as that of those units for which economies exist (0.762 and 0.769 for years 1995 and 2000, respectively, compared to 1.876 and 1.436 for the same periods). However, agglomeration economies are virtually nonexistent under DEA, since in year 2000, 96.67% of observations (totalling 495 observations) presented agglomeration diseconomies.

Table 7 reveals whether results for β^{s_2} and γ^{s_2} densities differ significantly, according to Li (1996) test. Results are provided for both years 1995 and 2000, and DEA and FDH models. This may be also thought of a way of finding out whether the existence of either agglomeration economies or diseconomies is significant or not. The test reveals significant differences for both indicators at the 1% significance level, regardless of the convexity assumption and the time period. We also perform the test for comparing the agglomeration economies ratio for years 1995 and 2000. In this case, the

[9] In a similar fashion of what may occur in a *super-efficiency* setting (Andersen and Petersen, 1993).

test reveals differences between years 1995 and 2000 are only significant under the DEA evaluation.

The third component of the second stage analysis is our agglomeration or, again, more adjacent to our setting, *decentralization* economies indicator. The indicator should be interpreted as the gains that municipalities obtain over time (between periods t and $t+1$) from focusing on a wider range of services and facilities. Results suggest that, over time (from 1995 to 2000), benefits from a broader range have accrued for municipalities with higher levels of competencies. In this case, results reconcile for both convex DEA and nonconvex FDH, yet the effect is, as expected, more tempered according to DEA. However, the result is interesting since it suggests that, even in the convex case for which agglomeration economies were virtually nonexistent, there is a tendency for this type of economies to increase between years 1995 and 2000. Therefore, although our *static* results were somewhat conflictive when attempting to reconcile DEA and FDH results, tendencies are more similar for our agglomeration economies index.

However, differences emerge again when delving into the sources of change. Whereas the nonconvex FDH suggest improvements over time are mostly brought about by technical change, and efficiency change contributing negatively to the time evolution of the agglomeration index, the relative contributions are much more balanced under DEA. Yet in this case technical change is also the component that contributes the most to the improvement of the agglomeration economies index.

6. Concluding remarks

This article has analyzed the links between overall cost efficiency in Spanish local government and the likely gains from empowering them with larger shares of self-government, by increasing their current competencies. The issue is relevant since it is related to the hypothetical *second* decentralization which could have followed the *first* decentralization yet actually never took place. Therefore, one may conclude this constitutes a relentlessly debated issue but remains largely unsolved. Our article attempts to shed some light by pointing out what the likely gains from enhanced decentralization could be in terms of overall cost efficiency.

The aims are achieved by initially dividing our sample of Spanish municipalities into different groups of units according to their competencies. Then, we consider an activity analysis model which proceeds in two stages. Firstly, it conducts an evaluation of each municipality's performance against all other municipalities affiliated to the same group of competencies. Secondly, the efficiency of each unit is evaluated against those municipalities empowered with lower levels of competencies or, put it differently, which are bound to provide their populations with narrower ranges of services and facilities. A direct comparison of the indicators obtained in both stages provides us with a measure of agglomeration or decentralization economies, as opposed to output complexity or centralization economies—i.e., the case could occur that providing populations with wider output bundles results into disproportionate cost increases. The DEA convex technology results do not show substantial improvements from enhanced decentralization, yet this finding may be related to the DEA well-known phenomenon of being highly sensitive to the number of units being evaluated. In contrast, the phenomenon is far more lessened under FDH, and in this case benefits from enhanced decentralization accrue for almost 50% of our sample.

According to the DEA convex frontier, it is not possible to recognize those units making up the reference set. Thus, it could be the case that the municipality under analysis were evaluated against a composite observation, made up by starking differences. Such a problem vanishes by removing the convexity technological assumption, since the benchmark is built using an observation only, assuming it is feasible to clone it and obtain other observations with identical features. Summing up, by attaching greater importance to the convex frontier results we are assuming linear combinations among observations which could be way too dissimilar. In contrast, the nonconvex reference frontier guarantees total agreement in the features of the reference frontier and, therefore, it allows efficiency scores to be fully representative of the results.

Since we have information for two periods (years 1995 and 2000), we may also attempt to weigh in whether the likely decentralization gains improve over time. This aimed is achieved by devising a Malmquist-type dynamic agglomeration economies index which, in addition, provides as with information as to the likely sources of change—whether it is due to technical change or a catching-up effect. In this case, results are robust for both methodologies, suggesting that, over time, benefits for larger municipalities (with more competencies) are increasing. This finding could be related to the trend underwent in most public sector areas before Spain's economy adhered to the Euro, following the stipulations of the Maastricht Treaty on the sustainability of the government financial position.

As far as we are aware, the relevance of the study is also related to the units under analysis, since there is no empirical evidence to date on the efficiency of Spanish municipalities when considering the majority of Spanish regions (at least those for which information was available). Previous studies have analyzed the efficiency of Spanish local governments of different regions, yet a more comprehensive study was missing. In this line, our future research agenda comprises an analysis of the differences in the performance of municipalities according to their home region, so as to accommodate differences in taste for independence, autonomy, or fiscal authority (Garcia-Milà and McGuire, 2002).

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Table 1: Output indicators based on the minimum services provided

	Minimum services provided	Output indicators
All local governments	Public street lighting.	Number of lighting points
	Cemetery	Total population
	Waste collection	Waste collected
	Street cleaning	Street infrastructure surface area
	Supply of drinking water to households	Population, street infrastructure surface area
	Access to population centres	Street infrastructure surface area
	Surfacing of public roads	Street infrastructure surface area
	Regulation of food and drink	Total population
In local governments with populations of over 5,000, in addition	Public parks	Surface of public parks
	Public library	Total population, public buildings surface area
	Market	*Lonjas* surface area
	Treatment of collected waste	Waste collected
In local governments with population of over 20,000, in addition	Civil protection	Total population
	Provision of social services	Total population, public buildings surface area, assistance centers surface area
	Fire prevention and extinction	Street infrastructure surface area
	Public sports facilities	Total population, public buildings surface area
	Abattoir	Total population
In local governments with populations of over 50,000, in addition	Urban passenger transport service	Total population, total surface area
	Protection of the environment	Total surface area

Table 2: Economic budgetary classification

Expenditures		Revenues	
Operating transactions			
Chapter I	Personnel expenditure	Chapter I	Direct taxes
Chapter II	Current goods & services expenditures	Chapter II	Indirect taxes
Chapter III	Financial expenditures	Chapter III	Charges & other receipts
Chapter IV	Current transfers	Chapter IV	Current transfers
		Chapter V	Patrimonial revenues
Capital transactions			
Chapter VI	Real investments	Chapter VI	Sales of real investments
Chapter VII	Capital transfers	Chapter VII	Capital transfers
Chapter VIII	Financial assets	Chapter VIII	Financial assets
Chapter IX	Financial liabilities	Chapter IX	Financial liabilities

Table 3: Summary statistics for inputs and outputs (years 1995 and 2000)

	Mean		Std.Dev.	
Inputs[a]	1995	2000	1995	2000
Wages and salaries (X_1)	864,346.60	1,122,714.00	1,256,679.00	1,604,780.00
Expenditure on goods and services (X_2)	644,187.50	875,483.80	883,407.40	1,351,792.00
Current transfers (X_3)	138,861.90	190,149.30	267,201.20	305,024.20
Capital expenditure (X_4)	665,736.00	1,072,432.00	942,539.30	1,586,199.00
Capital transfers (X_5)	36,526.07	47,104.06	130,652.80	169,483.30
Outputs				
Population (Y_1)	6,523.85	6,371.19	7,749.63	7,217.88
Number of lighting points (Y_2)	878.18	371.14	1,022.09	7,037.98
Tons of waste collected (Y_3)	3,596.86	3,212.82	23,021.65	5,244.80
Street infrastructure surface area[b](Y_4)	206,224.30	264,109.10	211,432.60	264,898.30
Public buildings surface area[b](Y_5)	584.07	612.95	1,119.32	1,255.96
Lonjas surface area[b](Y_6)	725.39	812.83	1,986.34	2,043.42
Registered surface area of public parks[b](Y_7)	37,158.10	67,769.81	211,420.90	777,400.20
Assistance centers surface area[b](Y_8)	102.64	91.10	183.34	151.70
# of observations		1,315		

[a] In thousands of 1995 pesetas (1 euro=166.386 pesetas).

[b] In square metres.

Table 4: Efficiency measurement, intra-group evaluation (β^{s_2})

Model	Size class	Year	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
DEA	Small[a]	1995	0.478	0.217	0.435	0.043	1.000	0.685	−0.085
		2000	0.477	0.211	0.441	0.051	1.000	0.764	0.205
	Medium[b]	1995	0.559	0.220	0.527	0.147	1.000	0.518	−0.550
		2000	0.578	0.206	0.560	0.155	1.000	0.374	−0.503
	Large[c]	1995	0.706	0.201	0.683	0.223	1.000	−0.015	−0.801
		2000	0.722	0.217	0.731	0.196	1.000	−0.288	−0.863
	All	1995	0.519	0.226	0.482	0.043	1.000	0.538	−0.431
		2000	0.526	0.221	0.489	0.051	1.000	0.528	−0.376
FDH	Small[a]	1995	0.805	0.238	0.938	0.076	1.069	−0.942	−0.369
		2000	0.808	0.230	0.922	0.101	1.103	−0.982	−0.088
	Medium[b]	1995	0.876	0.189	1.000	0.248	1.034	−1.469	1.133
		2000	0.897	0.174	1.000	0.274	1.107	−1.658	1.743
	Large[c]	1995	0.969	0.105	1.000	0.374	1.190	−3.221	12.879
		2000	0.965	0.101	1.000	0.521	1.107	−2.898	7.919
	All	1995	0.839	0.222	1.000	0.076	1.190	−1.194	0.254
		2000	0.848	0.213	1.000	0.101	1.107	−1.274	0.627

[a] Municipalities with a population under 5,000.
[b] Municipalities with a population between 5,000 and 20,000.
[c] Municipalities with a population over 20,000.

Table 5: Efficiency measurement, inter-group evaluation (γ^{s_2})

Model	Size class	Year	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
DEA	Small[a]	1995	0.478	0.217	0.435	0.043	1.000	0.685	−0.085
		2000	0.477	0.211	0.441	0.051	1.000	0.764	0.205
	Medium[b]	1995	0.463	0.482	0.399	0.127	8.788	13.419	221.786
		2000	0.452	0.196	0.432	0.110	2.400	3.253	25.588
	Large[c]	1995	0.461	0.171	0.421	0.171	1.018	1.049	1.088
		2000	0.530	0.178	0.516	0.175	1.019	0.434	0.009
	All	1995	0.472	0.322	0.419	0.043	8.788	14.089	345.136
		2000	0.472	0.205	0.442	0.051	2.400	1.434	6.664
FDH	Small[a]	1995	0.805	0.238	0.938	0.076	1.069	−0.942	−0.369
		2000	0.808	0.230	0.922	0.101	1.103	−0.982	−0.088
	Medium[b]	1995	1.191	1.641	0.849	0.167	24.936	9.390	117.944
		2000	0.989	0.645	0.851	0.129	9.587	6.403	76.420
	Large[c]	1995	1.077	0.994	0.844	0.292	7.400	4.609	25.471
		2000	0.967	0.493	0.866	0.313	3.077	1.807	4.779
	All	1995	0.944	0.986	0.900	0.076	24.936	14.361	297.888
		2000	0.878	0.434	0.896	0.101	9.587	7.213	126.195

[a] Municipalities with a population under 5,000.
[b] Municipalities with a population between 5,000 and 20,000.
[c] Municipalities with a population over 20,000.

Table 6: Two-stage model, γ^{s_2}/β^{s_2}

Model		Efficiency indicator	Year	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
DEA	Dominance of agglomeration economies[a]	β^{s_2}	1995	0.485	0.236	0.392	0.147	1.000	1.047	0.188
			2000	0.618	0.304	0.573	0.215	1.000	0.204	−1.632
		γ^{s_2}	1995	0.705	1.081	0.438	0.166	8.788	6.304	45.399
			2000	0.798	0.556	0.636	0.244	2.400	1.686	3.362
		γ^{s_2}/β^{s_2}	1995	1.291	0.994	1.104	1.001	8.788	6.556	47.347
			2000	1.246	0.397	1.137	1.017	2.659	3.169	11.100
	Dominance of agglomeration diseconomies[b]	β^{s_2}	1995	0.602	0.219	0.575	0.000	1.000	0.279	−0.668
			2000	0.601	0.213	0.583	0.000	1.000	0.241	−0.618
		γ^{s_2}	1995	0.421	0.150	0.399	0.000	0.934	0.731	0.733
			2000	0.453	0.161	0.441	0.000	1.000	0.526	0.380
		γ^{s_2}/β^{s_2}	1995	0.713	0.131	0.693	0.000	0.999	0.025	1.403
			2000	0.762	0.108	0.770	0.000	1.000	−1.259	5.256
FDH	Dominance of agglomeration economies[c]	β^{s_2}	1995	0.933	0.161	1.000	0.254	1.000	−2.500	5.365
			2000	0.938	0.150	1.000	0.335	1.000	−2.567	5.636
		γ^{s_2}	1995	1.786	2.120	1.306	0.322	24.936	7.169	67.523
			2000	1.363	0.749	1.197	0.401	9.587	6.248	63.885
		γ^{s_2}/β^{s_2}	1995	1.876	2.091	1.335	1.006	24.936	7.366	70.283
			2000	1.436	0.704	1.244	1.002	9.587	7.354	79.369
	Dominance of agglomeration diseconomies[d]	β^{s_2}	1995	0.857	0.194	0.962	0.000	1.190	−1.380	1.517
			2000	0.884	0.180	1.000	0.000	1.107	-1.638	2.539
		γ^{s_2}	1995	0.654	0.192	0.662	0.000	0.999	−0.323	−0.316
			2000	0.683	0.192	0.706	0.000	1.086	−0.419	−0.295
		γ^{s_2}/β^{s_2}	1995	0.762	0.148	0.770	0.000	0.999	−0.758	1.661
			2000	0.769	0.147	0.768	0.000	0.997	−0.738	1.651

[a] # of observations year 1995: 72(14.31%); # of observations year 2000: 17(3.32%).
[b] # of observations year 1995: 431(85.69%); # of observations year 2000: 495(96.67%).
[c] # of observations year 1995: 228(45.33%); # of observations year 2000: 228(44.53%).
[d] # of observations year 1995: 275(54.67%); # of observations year 2000: 284(55.47%).

Table 7: Distribution hypothesis tests

Model	Null hypothesis (H_0)	T-test statistics	Ten-percent significance level (critical value: 1.28)	Five-percent significance level (critical value: 1.64)	One-percent significance level (critical value: 2.33)
DEA	$f(\beta^{s_2}_{1995}) = g(\gamma^{s_2}_{1995})$	31.68	H_0 rejected	H_0 rejected	H_0 rejected
	$f(\beta^{s_2}_{2000}) = g(\gamma^{s_2}_{2000})$	24.58	H_0 rejected	H_0 rejected	H_0 rejected
	$f(\beta^{s_2}_{1995}/\gamma^{s_2}_{1995}) = g(\beta^{s_2}_{2000}/\gamma^{s_2}_{2000})$	64.16	H_0 rejected	H_0 rejected	H_0 rejected
FDH	$f(\beta^{s_2}_{1995}) = g(\gamma^{s_2}_{1995})$	241.36	H_0 rejected	H_0 rejected	H_0 rejected
	$f(\beta^{s_2}_{2000}) = g(\gamma^{s_2}_{2000})$	262.34	H_0 rejected	H_0 rejected	H_0 rejected
	$f(\beta^{s_2}_{1995}/\gamma^{s_2}_{1995}) = g(\beta^{s_2}_{2000}/\gamma^{s_2}_{2000})$	0.14	H_0 not rejected	H_0 not rejected	H_0 not rejected

Table 8: Summary statistics for temporal efficiency measurement (1995–2000)

Model	Index	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
DEA	Agglomeration economies index	1.057	0.301	1.053	0.108	2.895	0.976	3.765
	Technical change index	1.072	0.309	1.062	0.108	3.079	1.106	3.691
	Efficiency change index	1.013	0.285	0.995	0.080	2.089	0.547	0.995
FDH	Agglomeration economies index	1.086	0.796	1.004	0.039	14.774	10.437	174.588
	Technical change index	1.800	1.340	1.417	0.188	14.119	3.371	19.384
	Efficiency change index	0.764	0.519	0.662	0.028	4.958	2.728	14.280

Figure 1: Public spending decentralization, 1981-1999

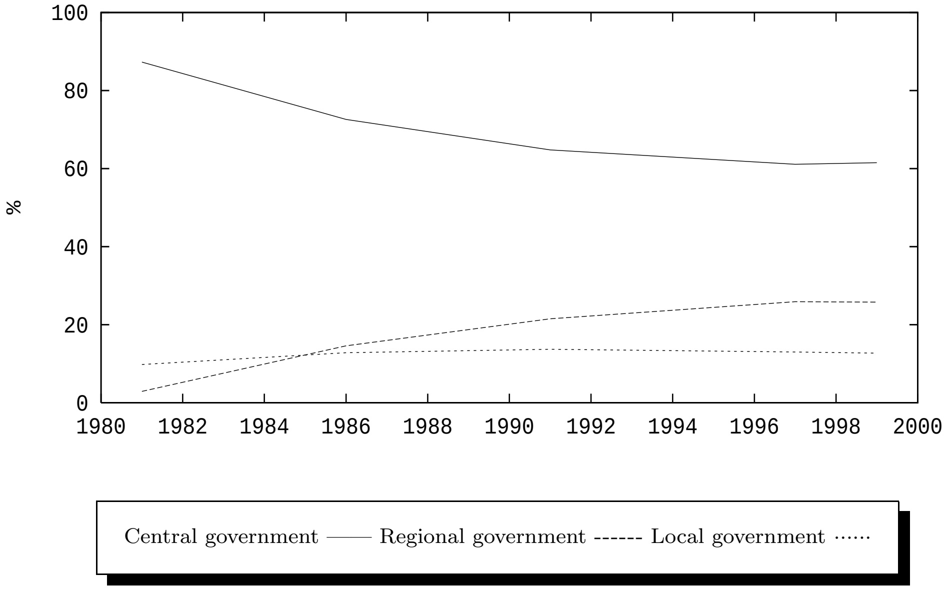

Figure 2: Overall cost evaluation according to Program (5)

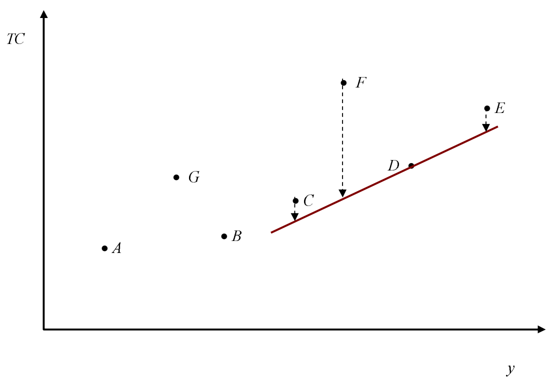

Figure 3: Overall cost evaluation according to Program (6)