Número 603

Stochastic Frontiers and Technical Efficiency of Local Public Expenditure in Mexico

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FEBRERO 2017
CENTRO DE INVESTIGACIÓN Y DOCENCIA ECONONÓMICAS

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Agradecimientos

Agradecemos los valiosos comentarios de Antonio Álvarez Pinilla y Fausto Hernández Trillo.

Abstract

This work analyses the effect of the institutional design of the public spending on the technical efficiency. The model controls the technical efficiency with two institutional variables for earmarked and autonomous revenues and assess them using two stochastic frontier models. The main findings show that the expenditure of municipalities, regardless of its type, reduces to the technical efficiency of local production. These results support the Brennan-Buchanan collusion hypothesis that decentralization generates an increment in government spending, but it is not translated into better population welfare.

Keywords: stochastic frontier, technical efficiency, earmarked and autonomous revenues, local economies

Resumen

Este trabajo analiza el efecto del diseño institucional del gasto público en la eficiencia técnica. El modelo controla la eficiencia técnica con dos variables institucionales para los ingresos condicionadas y no condicionadas y los evalúa utilizando dos modelos de fronteras estocásticas. Los principales hallazgos muestran que el gasto de los municipios, independientemente de su tipo, reduce la eficiencia técnica de la producción local. Estos resultados apoyan la hipótesis de colusión de Brennan-Buchanan de que la descentralización genera un incremento en el gasto público, pero no se traduce en un mejor bienestar de la población.

Palabras claves: fronteras estocásticas, eficiencia técnica, transferencias condicionadas y no condicionadas.

Introduction

Municipalities in Mexico are the closest level of government to the local economies within the federal system. The country has a centralized federal system, which distributes part of the tax collection to the subnational governments with non-earmarked and earmarked transfers. While municipalities provide local public services, and collect property taxes within their faculties. Hence, it is quite important to understand how autonomous local public expenditure favor local industry development. Economically, this relationship could be analyzed using the technical efficiency, which allows to measure the output gap given a certain amount of inputs (Farrel, 1957). The government has direct and indirect influence over the exogenous factors that determine the economic efficiency, but public expenditure by itself does not influence the aggregate production (Adkins, Moomaw & Savvides, 2002). For example, government can improve efficiency through public investments like roads, well designed institutions, and a legal framework that guarantees and facilitates business. There are several works that analyze the municipal institutional design for Mexico (García del Castillo, 1995; Cabrero & Carrera, 2000; Cabrero, 2001), but few of them study their relationship with the aggregate production within their jurisdictions.

Previous works that have analyzed the fiscal system focus on the transparency of their processes (Cejudo & Gerhard, 2010), on the effects of its design to achieve their objectives (Arellanes, 2011) or on poverty alleviation (Hernández, 2016), but not in how efficient is their relationship with aggregate production. The importance of knowing this relationship lies in the fact that a design that incentives the efficiency of local economies would generate positive spillovers, such as an improvement in the contractual wages. In other words, the institutional design of municipal finances could be a main determinant to boost regional development and face structural problems such as poverty.

To measure the effect of the institutional design in the local economies, this work controls the technical efficiency with two institutional variables of revenues following the theoretical statements of Shadbegian (1999) and assess them using stochastic frontier models, which are commonly used in recent literature. Specifically, by measuring such efficiency, this work seeks to answer two questions simultaneously. Which is the effect of municipal fiscal design of municipalities in technical efficiency of aggregate production? Connected to it, the second questions, which are the determinants of technical efficiency, specifically, the effect that the municipal revenues structure has in this efficiency?

This work analyses a sample of 328 municipalities of the metropolitan areas in the country. We have chosen these municipalities because they are the ones with more developed administrative infrastructure. So, they have more proficiency to take over new responsibilities granted by the federal government or to implement tagged resources of the federal government with specific policy destinations.

This paper has five additional sections. The following section makes a literature review and presents the contributions of this work. The third section describes the technical efficiency models. The fourth explains the dataset and the empirical strategy. Meanwhile the fifth presents the results and the last section the conclusions and policy discussions.

1. Technical efficiency and the decentralization debate for the Mexican case

Mexico is a federal system composed of three levels of government: federation, states and municipalities. In practice, decision making has been centralized in the federal government (Hernández, 2008). Decentralization was introduced in the political agenda in the early eighties and municipalities were recognized as a government level in the late nineties.[1] The debate about power distribution among government levels is still open and is part of the political agenda, so it deserves a short description of the legislation.

In 1980, the government created a branch in the federal budget for states and municipalities called Ramo 28 (Peña, 2011), which aimed the simplification and coordination of the tax system. Under it, the collection of broad-base taxes was centralized in the federal government, and then distributed in a compensative way to the states, following an established criterion by law. However, as subnational governments are sovereigns, they do not have accountable responsibilities to the federation for the use of these resources.

It follows two reforms to decentralize the education system in 1992 and the health system in 1996 (Peña, 2011). However, additional resources were not available to finance the new decentralized powers. To address this problem, the government created a branch of earmarked transfers in 1997 called Ramo 33, which is composed by eight funds designed to provide financial support to the local governments to take over their new responsibilities (Guizar, 2004). However, as these new transfers are earmarked, municipalities must follow established criteria by the federation. In sum, new powers were decentralized, but not the budget control to accomplish them.

Parallel, in 1983 started the decentralization process through a series of constitutional reforms. The first reform gave municipalities the command of a set of local public services and the power to collect the property tax. Hence, revenues coming from either property tax collection or non-earmarked transfers could be freely spent by municipalities. Lastly, in 1999, there was another constitutional reform which gave municipalities the level of government instead of just local managers (Faya, 2004). Even though it appeared to be a small reform, this change generated unprecedented policy implications for local governments.

[1] For conceptual simplification reasons, in this work we use the words: municipalities, local governments and jurisdictions indistinctly.

As a new level of government, municipalities have the power to release regulations and to take over the command as a principal of local bureaucracies. Likewise, local governments are now an agent of their citizens, as they are responsible of their new constitutional faculties. Therefore, at first, they could be incentivized to improve their collection system, so they could be able to respond to their population demands.

Within the broad public finance literature, few works have aimed to study the relationship between local government finances and the technical efficiency, and to the best of our knowledge, there are not studies that focus on that relationship for the Mexican fiscal structure. Our study aims to involve public spending in a direct form and follows the work of Shadbegian (1999) to construct hypotheses about the effects of the fiscal structure in technical efficiency. Shadbegian (1999) presents his hypothesis from the spending point of view and tests the principles of Traditional Fiscal Federalism and Public Choice for the United States case. From Fiscal Federalism perspective, the author takes back the work of Wallis (1988). Following the decentralization theorem of Oates (1972), Wallis establishes that decentralization increases local government sizes due to they have to attend several heterogeneous demands. Whereas, from the Public Choice perspective, the author takes back the collusion hypothesis of Brennan & Buchanan (1980), which argues that all levels of government would behave as a cartel in order to maximize their revenues, without improving public services or, in this case, the technical efficiency. In this way, this work aims to test both hypotheses for the Mexican case considering the relationship between revenues and spending versus technical efficiency. Thus, the resources in which local governments have more power and the last decision (non-earmarked transfers and local tax collection) are considered as a proxy of Wallis-Oates hypothesis. While earmarked transfers constrain the discretionality on the resources and are classified as a proxy of Brennan & Buchanan hypothesis.

Inefficiency is measured using the output gap between the actual and potential output, given an amount of inputs (Farrel, 1957). The potential production of a firm or, in this case, a municipality, could be shaped as a frontier (Álvarez, Arias & Orea, 2003). There are two main ways to measure the production frontier: stochastic frontier models or non-parametric methods. In this paper, we will use the former one due to the flexibility to include explanatory variables. For the case of local government finances, previous works have constrained their scope not including heterogeneity controls for the inefficiency term. Hence the main contribution of this paper, it is to analyze the effect of local government finances on the technical efficiency by including local institutional variables among other in the inefficiency side. Additionally, a second contribution is to control by heteroscedasticity in the idiosyncratic error, which is usually ignored in this type of studies.

For the Mexican case, there are some sectorial and regional works of stochastic frontiers, but any of them is directly related to public expenditure (e.g. Bannister and Stolp 1995, Becerril, Álvarez & Moral 2010, Braun and Cullmann 2011, Aguilar 2011, and Chávez and López 2013) and few of them explore the determinants of the inefficiency. Hence, this research presents a third contribution to the empirical literature about the case of Mexico. That is to control for several variables that have an impact on technical efficiency, such as: public capital, labor capital and geographic controls, but specifically local expenditure variables.

2. MODELS FOR MEASURING TECHNICAL EFFICIENCY

As mentioned previously, technical efficiency is measured with the output gap, given an amount of inputs. Aigner et. al. (1977) in their seminal work, proposed a model that divided the error term in two parts to model the stochastic component as the technical inefficiency. Pitt & Lee (1981) presented an extension for modeling panel data. However, their specification did not allow time variation for the stochastic term. In this sense, Battese & Coelli (1995), proposed a model that overcomes the problem by allowing exogenous variables to explain the inefficiency term.

But Battese & Coelli model does not allow to control for heteroscedasticity in the error term, which could result in biased estimators as it overestimates the intercept and underestimates coefficients slope (Caudill & Ford, 1993). Reifschneider & Stevenson (1991) were the first in attending this problem allowing variances in the mean of the error in one side. They assumed the inefficiency error as non-negative and truncated in zero. Caudill, Ford & Gropper (1995) extended this model assuming multiplicative heteroscedasticity and incorporating it directly to the variance of the stochastic error (from now on, this model would be referred as CFG), given thus the model shown in equations (1) and (2).

$$y_{it} = x_{it}\beta + v_{it} - u_{it} \tag{1}$$

$$\sigma_{it} = \exp(z_{it}\gamma) \tag{2}$$

Where y_{it} it represents the production for periods $t = 1,2,\dots,T$ for the observations $i = 1,2,\dots,N$. x_{it} are the explanatory variables in the frontier. u_{it} is the inefficiency term that follows a Half-Normal distribution, $N^{+}(0, \sigma_{u_{it}}{}^{2})$. z_{it} are the control variables in the stochastic term. Finally, v_{it} is the idiosyncratic error that follows a normal distribution $N(0, \sigma_v^2)$.

Lastly, Hadri (1999) takes back CFG model for the inefficiency term u_{it} and expands the specification to allow to control for heteroscedasticity in the idiosyncratic error v_{it}, where the variance, σ_{it},, follows an exponential distribution and is explained for a set of exogenous variables, h_{it}, as in the inefficiency error, as shown in equation (3).

$$v_{it} \sim N(0, \sigma_{it}), \quad \sigma_{it} = \exp(h_{it}\theta) \tag{3}$$

For this research, we will consider CFG (equations 1 and 2) and Hadri (equations 1 and 3) models. Further research should be addressed to implement most recent stochastic frontier specifications such as Wang (2002) to allow combination between a truncated normal distribution for the inefficiency term and a variance that is exponentially distributed and Greene (2005) to add fixed effects to separate the variant inefficiency in each period from the unobserved heterogeneity that remains unchanged throughout time. Despite of the flexibility of the later model, a dataset with, at least, 10 times periods is necessary for estimation due to the large number of parameters (Belotti & Ilardi, 2012).

3. DATA AND THE EMPIRICAL MODEL FOR FISCAL STRUCTURE

AND TECHNICAL EFFICIENCY

We use a balanced panel dataset composed of 328 Mexican municipalities and four years observations of the 59 metropolitan areas defined by the National Population Council (CONAPO) 2010 classification.[2] The four time periods correspond to the economic censuses taken by the National Statistics and Geography Institute (INEGI) for 1993, 1998, 2003 and 2008. The advantage of this span is that we have information for two periods before the reform (Ramo 33): 1994 and 1997, and two after: 2004 and 2009. Metropolitan areas are defined as the set of two or more municipalities, with 50 thousand or more inhabitants and with high level of socioeconomic concentration. They are composed by either central municipalities, municipalities defined by statistical and geographic criteria, or exterior municipalities defined following urban and political planning criteria.

Municipalities of metropolitan areas were chosen as they are the local governments with more administrative infrastructure and that have more proficiency to take over new responsibilities granted by the federal government or to implement tagged resources of the federal government with policy destinations. All the metropolitan areas account for about 57% of the total population of the country (CONAPO, 2010) and contribute to 85% of domestic total value added (INEGI). Descriptive analysis in the following section strengths the importance of choosing municipalities of metropolitan areas. Despite of being just 13% of the total number of municipalities in 2009, they received 25% of total transfers (INEGI, 2010) by then. Hence, this analysis has an impact for most Mexican population and their economy. Following the previous section and following a Cobb-Douglas production function, the specification of the model is as equation (4) displays.

Regarding to the variables of the model, firstly, we use as proxy of production (y), the total value added from the four principal economic sectors: manufactures,

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[2] Some municipalities did not exist in our base period 1993, so that, 13 new municipalities were collapsed with their origin jurisdictions. Mexico City delegations have another fiscal institutional design, so they were excluded of the analysis. Also, other municipalities were excluded due to the lack of information, all of them belong to the state of Oaxaca.

mining, trade and services in 2008 prices.[3] Labor (l) represents the sum of total number of workers in the same four economic sectors. Similarly, capital (k) is the total fixed assets value in 2008 prices. All the information was gathered from the Economic Censuses of INEGI from 1993, 1998, 2003 and 2008. Table 1 presents the summary statistics of these and the rest of variables. Value added reports a mean of 573 million Mexican pesos (MXN). There are municipalities with zero value, but other reached MXN 26,000 million. Capital and labor display means of MXN 737 million and 23,719 workers and maximums value of MXN 26,600 million and 614,547 workers, respectively.

Following Aschauer (1989), our model includes controls variables for public and human capital, labor specialization and population density. Infrastructure (infra) is used as a proxy of public capital and it is constructed as the Human Development Index (HDI) published by INEGI (it includes electricity, piped water and drained). This variable does not include highways, airports and ports, as this kind of hard infrastructure is not within the municipal constitutional powers. This variable reports a standard deviation of 0.05 points, where the most disadvantaged municipality has an index of 0.592, whereas the best one has an index of 0.927 as shown in table 1.

Education (educ), defined as the average years of education of the employed population, was used as a proxy of human capital. Summary statistics table shows that the minimum average value of education is 3.1 years, which is equal to incomplete elementary school. While the maximum average value is 12.1, which is equal to high school level.

Labor specialization (specialization) and population density (density) complete the set of control variables. On one side, the specialization index is defined as the ratio between number of workers in the manufacture sector over the total number of workers. On the other side, we included a variable that divides the population over the area of each jurisdiction in order to control for the municipality size. The mean density is 1,856 inhabitants per squared kilometer.

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[3] Seven municipalities have negative value added values in different periods for two main reasons. The first one establishes that they are auxiliary jurisdictions, in other words, that are places where firms have their warehouses, which represents costs, but not revenues. The second one suggests that important investments were implemented during those periods. In order to be specified as natural logarithms, their values were equaled to zero as shown in the summary statistics table.

Finally, our main variables of interest, i.e. fiscal structure, were constructed following the power over the resource criteria. Non-earmarked transfers and municipalities own taxes are constructed together as they could be spent in an autonomous way, and are associated with Wallis-Oates hypothesis. On the contrary of earmarked transfers, which are closer to the Brennan & Buchanan perspective. Both variables are defined as in equation (4) and (5), respectively.

$$autonomous = \frac{own\ taxes + non\text{−}earmarked\ transfers}{total\ revenues} \qquad (4)$$

$$earmarked = \frac{earmarked\ transfers}{total\ revenues} \qquad (5)$$

Additionally, two institutional variables that consider an origin criterion were included. As mentioned above, revenues can come from both the municipal tax collection and the federation, so this criterion divides the autonomous variable in two different variables. The first one divides own tax revenues over total revenues (r_taxes). The second one divides non-earmarked transfers over total revenues (r_nonear). They are incorporated together in some specifications in substitution of the decentralized variable. These institutional variables were constructed with annual data from the State and Municipal System of Data Bases (SIMBAD) from INEGI. Figure 1 presents the evolution over time of earmarked and autonomous variables for the aggregated municipalities included in this study. It is possible to identify a significant reduction in municipal own revenues beginning in 1997 after the reform.

Some endogeneity issues can arise between the institutional variables and local production. However, homogeneity among selected local governments minimizes reverse causality suspects because earmarked transfers were created once the economic features of the metropolitan areas were already established. Table 2 shows further that there is not a strong linear correlation between the institutional variables and the other controls, including the main targets of the conditional transfer, namely, education and infrastructure. Similarly, population density and total number of workers are weakly correlated with the non-earmarked transfers.

Finally, we consider eight variables in the error terms. Six of them are the same as in the frontier: specialization, density, r_taxes, r_nonear, autonomous and earmarked. Additionally, we include two explanatory variables. The first one is a trend (trend) that controls for technical change. The second one is a geographic variable (distance), that is defined as the number of kilometers between the center of each municipality and the nearest border point to the United States. This variable follows the new economic geography principles about the importance of the proximity among the units under analysis (Krugman & Lizas-Elizondo, 1996). For its specification, we used the application Traza tu Ruta of the Ministry of Communications and Transportation (SCT).[4] We use a Cobb-Douglas production function for the empirical specification, resulting in the stochastic frontier model in equation (6).

$$\ln y_{it} = \beta_0 + \gamma_t t_t + \theta_i r_i + \beta_1 \ln k_{it} + \beta_2 \ln(edu_{it} * l_{it}) + \beta_4 \ln idh\_services_{it} + \beta_5 specialization_{it} + \beta_6 density_{it} + \beta_7 r\_taxes_{it} + \beta_8 r\_nonear_{it} + \beta_9 earmarked_{it} + v_{it}(.) - u_{it}(.) \qquad (6)$$

Where (i) refers to municipalities and (t) for time. The variable (y) refers to production, (k) capital, (l) labor, x_{jit} is a set of control variables, all mentioned above, t_t and r_i are time and regional fixed effects, respectively. Up to this part of the equation is referred as the frontier. $u_{it}(.)$ is the term for measuring inefficiency and $v_{it}(.)$ is the idiosyncratic error, both error terms are referred as the stochastic part of the model as in CFG and Hadri models (equations 2 and 3, respectively) and include the variables described previously.

4. RESULTS

Two different specifications were estimated for the stochastic frontier models. The first one follows the origin criterion for the institutional variables, that is to include both *r_taxes* and *r_nonear* as shown in equation (6). The second specification follows the

[4] http://aplicaciones4.sct.gob.mx/sibuac_internet/ControllerUI?action=cmdEscogeRuta

spending independence criteria, so it uses the *autonomous* variable instead. Results are presented in table 3. There is not a significant difference between CFG and Hadri models estimation results in the frontier.[5] Likewise, specification of institutional variables seems to not affect coefficients sign and magnitude, therefore we will describe them without emphasizing in a model or specification.

Coefficients for capital and labor are significant at 1% level in all specifications and report positive expected signs. Likewise, null hypothesis of constant returns to scale is rejected. Infrastructure is statistically significant for all models and reports a negative value. Despite this might appear to be counterintuitive, results are supported by Duran-Fernández & Santos (2014). The authors explain that spillovers generated by domestic infrastructure have already been internalized by the industry. Labor specialization also is statistically significant and presents the positive expected sign. Population density coefficient is almost zero, but statistically significant.

In the stochastic section, labor specialization has a negative and statistically significant coefficient, therefore, higher specialization of the municipality would imply an efficiency increase. On the contrary, population density coefficient is positive and significant. Hence, denser municipalities would be more inefficient. Although this could be counterintuitive because denser territories represent higher public services costs, this might happen as bigger municipalities have enough territory to afford big industries accordingly to the size of their jurisdictions.

Time trend coefficient presents a negative sign, which means that technological changes diminish technical inefficiency. However, the coefficient is not statistically significant. Distance to the U.S. border coefficient is almost zero, but positive and statistically significant, which means that the further away from the US border, the lower the inefficiency. Even though this might seem counterintuitive as well, Duran-Fernandez & Santos (2014) explain that accessibility to the U.S. market is mainly important for the border municipalities focused in *maquiladora* activities. So, if

[5] Results of the idiosyncratic error for Hadri model are different in comparison with the inefficiency error. Population density, labor specialization and distance to the border are statistically significant at 99%, 95% and 90% confidence level, respectively. But the rest of the variables are not statistically significant. Hence, is possible to conclude that the heteroscedasticity problem is lower in the idiosyncratic error than in the inefficiency one.

metropolitan municipalities present agglomeration economies and lower concentration levels of *maquiladora* industry, there is no reason to be directly beneficiated of the proximity to the U.S.

Regarding to our central variables, results show that institutional variables do not contribute positively to technical efficiency. Regardless the specification either *earmarked* or *autonomous* revenues present positive signs, so government spending increases inefficiency in the aggregated local production. These results are consistent also in the divided specification of the *autonomous* variable following the origin criteria. Municipalities with better tax collection are the ones with larger coefficients. Likewise, both in the frontier and in the inefficiency side, all the specifications are statistically significant at 1% of confidence. Although institutional variables present positive signs in the frontier, this could represent that they have a positive contribution to production, but not to efficiency. Figure 2 shows the results of the efficiency ranking for CFG model for the four years. Maps allow us to identify that northern areas of the country have higher efficiency levels. Hence, regardless the origin and the level of autonomy, we find that local government spending diminishes technical efficiency, what confirms the collusion hypothesis of Brenan-Buchanan (1980) within Public Choice literature.

Conclusions

Throughout spending local governments increases technical inefficiency regardless whether the revenues are earmarked or autonomous. This conclusion supports the collusion hypothesis established by Brennan-Buchanan within the Public Choice field. The hypothesis establishes that decentralization generates an increment in government spending, but it is not translated into population welfare, as all levels of government are colluded and behave as a cartel. The main assumption of hypothesis collusion establishes that public servants are selfish individuals that seek to maximize their utilities, even against society welfare. In a weak checks and balances framework at the municipal level, it is not surprising that inefficiency coefficient is even bigger for most independent municipalities.

This problem has already been identified by the literature (Hernández & Jarillo 2007, Timmons & Broid, 2013; Cejudo & Gerhard, 2010). From a horizontal perspective, weak internal checks allow selfish public servants to maximize their utility functions instead of citizen's welfare. While, from a vertical perspective, as transfers pass through state governments, discretionality and opacity bias the distribution of resources (Timmons & Broid, 2013). However, earmarked transfers have a bigger negative effect on technical efficiency than non-earmarked ones. Which confirms another already identified problem of the perverse incentives created by the institutional design (Arellanes, 2011).

This research has used a quantitative model to analyze technical efficiency. Nevertheless, in order to propose structural policy solutions, it is necessary to strength these conclusions with a qualitative methodology for a deeper knowledge of municipal features. Likewise, conclusions are constrained to the municipal role on technical efficiency, so the municipal performance in other responsibilities is not considered. Following a Public Choice perspective, regardless the level of government, bureaucracies, politicians, and power groups will seek to maximize their utility curves. Therefore, it is necessary to create an institutional design that minimizes discretionality opportunities.

To sum up, there are different theoretical perspectives on the studies of fiscal relations in a federal system and its effect on technical efficiency. Literature for the Mexican case has focused in transfers institutional design and different bias in their distribution, but has forgotten its role for economic development. Finally, our results show that current fiscal design and its spending do not have a positive effect in local economies performance. This problem has a direct negative effect on population welfare as lower technical efficiency levels are related with lower investment and wages levels. Thus, regional inequality is perpetuated among municipalities of the most efficient and inefficient metropolitan areas.

Appendix

Table 1. Summary Statistics

Variable	Mean	Standard Deviation	Min	Max
VA (1,000 MXN) (*y*)	573,000	1,810,000	0	26,000,000
Number of workers (*l*)	23,719	61,024	0	614,547
Total fixed assets (1,000 MXN) (*k*)	737,000	1,800,000	0	26,600,000
Average education (years) (*edu*)	7.83	1.51	3.10	13.50
Specialization index (*specialization*)	0.31	0.20	0.00	0.92
Autonomous	0.62	0.26	0.00	0.99
Earmarked	0.18	0.20	0.00	0.83
Distance to the border (km) (*distance*)	977.83	346.27	1.00	2,315.64
Infrastructure (HDI) (*infra*)	0.85	0.05	0.59	0.93
Population density (*density*)	966.27	1,855.90	2.10	19,357.83

Table 2. Correlations

	y	l	k	edu	infra	density	spec	auton	earm
y	1								
l	0.9	1							
k	0.8		1						
edu	0.3	0.3	0.4	1					
infra	0.2	0.2	0.3	0.7	1				
density	0.3	0.3	0.3	0.3	0.26	1			
spec	0.1	0	0	-0.1	0	0	1		
auton	-0.1	-0.1	-0.1	-0.3	-0.2	-0.1	0.07	1	
earm	0	0	0	0.2	0.16	0	-0.1	-0.6	1

Table 3. Stochastic frontier estimations for the natural logarithm of production (Frontier)

	Model			
	CFG-1	Hadri-2	CFG-3	Hadri-4
Central	-0.05 (-0.09)	-0.05 (-0.09)	-0.01 (-0.09)	0.00 (-0.09)
North	-0.27 (-0.13)	-0.29* (0.13)	-0.22* (0.13)	-0.25* (0.13)
South	-0.18 (-0.13)	-0.21 (-0.13)	-0.15 (-0.13)	-0.17 (-0.13)
1999	-0.62*** (0.07)	-0.62*** (0.08)	-0.65*** (0.08)	-0.66*** (0.08)
2004	-0.11 (-0.11)	-0.10 (0.11)	-0.15 (-0.11)	-0.12 (-0.11)
2009	-0.30** (0.14)	-0.24** (0.14)	-0.36** (0.14)	-0.29* (0.14)
k	0.10*** (0.01)	0.10*** (0.01)	0.09*** (0.01)	0.09*** (0.01)
l*educ	1.17*** (0.01)	1.16*** (0.01)	1.16*** (0.01)	1.16*** (0.01)
Infra	-1.39** (0.67)	-1.45** (0.67)	-1.49** (0.69)	-1.45** (0.71)
density	0.00* (0.00)	0.00*** (0.00)	0.00 (-0.00)	0.00 (-0.00)
Specialization	0.72*** (0.16)	0.46** (0.20)	0.87*** (0.16)	0.52** (0.22)
r_taxes	3.13*** (0.49)	3.09*** (0.48)	-	-
r_nonear	2.38*** (0.23)	2.38*** (0.26)	-	-
Autonomous	-	-	2.19*** (0.24)	2.23*** (0.25)
Earmarked	2.02*** (0.32)	2.00*** (0.33)	1.77*** (0.32)	1.75*** (0.33)
Constant	3.86*** (0.59)	4.01*** (0.62)	4.32*** (0.60)	4.33*** (0.65)
Observations	1312.00	1312.00	1312.00	1312.00
Log-likelihood	-1815.81	-1798.65	-1831.91	-1819.71
H_0: Contant returns to scale	Rejected: $\beta_1+\beta_2 > 1$			

*p < 0.10, **p < 0.05, ***p < 0.01. Standard error in parenthesis.
Models 1 and 2 include the institutional variables following the origin criteria. Meanwhile, the models 3 and 4 include the aggregate specifications of centralized and decentralized revenues.

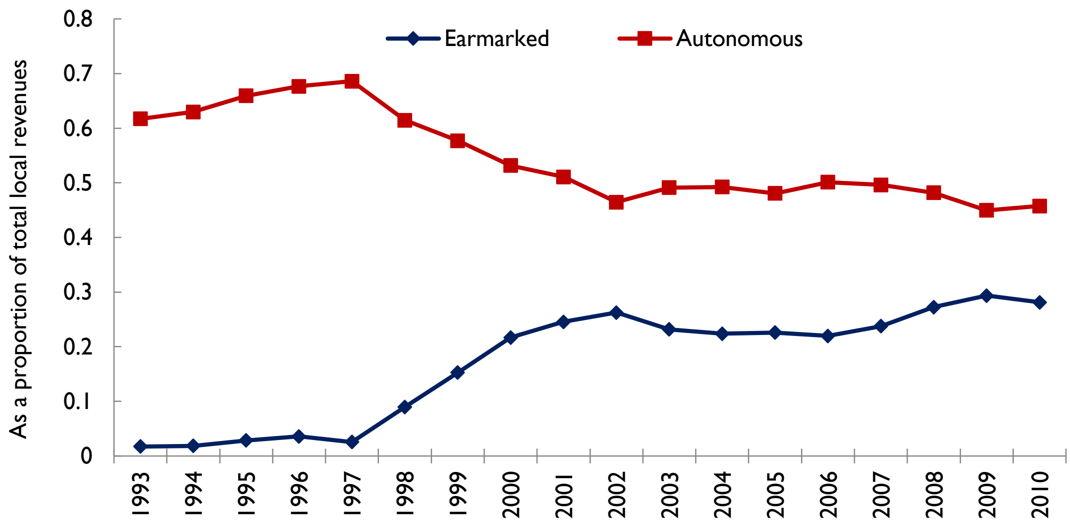
Table 4. Stochastic frontier estimations for the natural logarithm of production (Error term)

	Model			
	CFG-1	Hadri-2	CFG-3	Hadri-4
	Inefficiency			
Specialization	-1.03** (0.42)	-1.31*** (0.46)	-0.60*** (0.34)	-1.75*** (0.71)
density	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
r_taxes	14.07*** (1.62)	15.46*** (1.50)	-	-
r_nonear	9.51*** (1.01)	10.33*** (0.94)	-	-
Autonomous	-	-	7.52*** (0.81)	8.34*** (0.82)
Earmarked	9.84*** (1.10)	10.51*** (1.04)	7.81*** (0.91)	8.49*** (0.95)
Distance	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Trend	0.00 (-0.11)	0.06 (-0.11)	-0.16 (0.10)	-0.12 (0.11)
Constant	-6.94*** (0.91)	-7.41*** (0.91)	-4.66*** (0.72)	-4.27*** (0.69)
	Idiosyncratic error			
Specialization	-	0.94** (0.36)	-	0.91** (0.44)
Density		0.00*** (0.00)		0.00*** (0.00)
r_taxes		-0.75 (-1.46)		-
r_nonear		-0.09 (-0.65)		-
Autonomous		-		0.17 (0.71)
Earmarked		-0.19 (-0.73)		0.26 (0.71)
Distance		0.00 (0.00)*		0.00* (0.00)
Trend		-0.02 (-0.09)		-0.05 (0.10)
Constant	-0.98*** (0.07)	-0.91 (0.57)	-1.07*** (0.08)	-1.18*** (0.56)

*p < 0.10, **p < 0.05, ***p < 0.01. Standard error in parenthesis.
Models 1 and 2 include the institutional variables following the origin criteria. Meanwhile, the models 3 and 4 include the aggregate specifications of centralized and decentralized revenues.

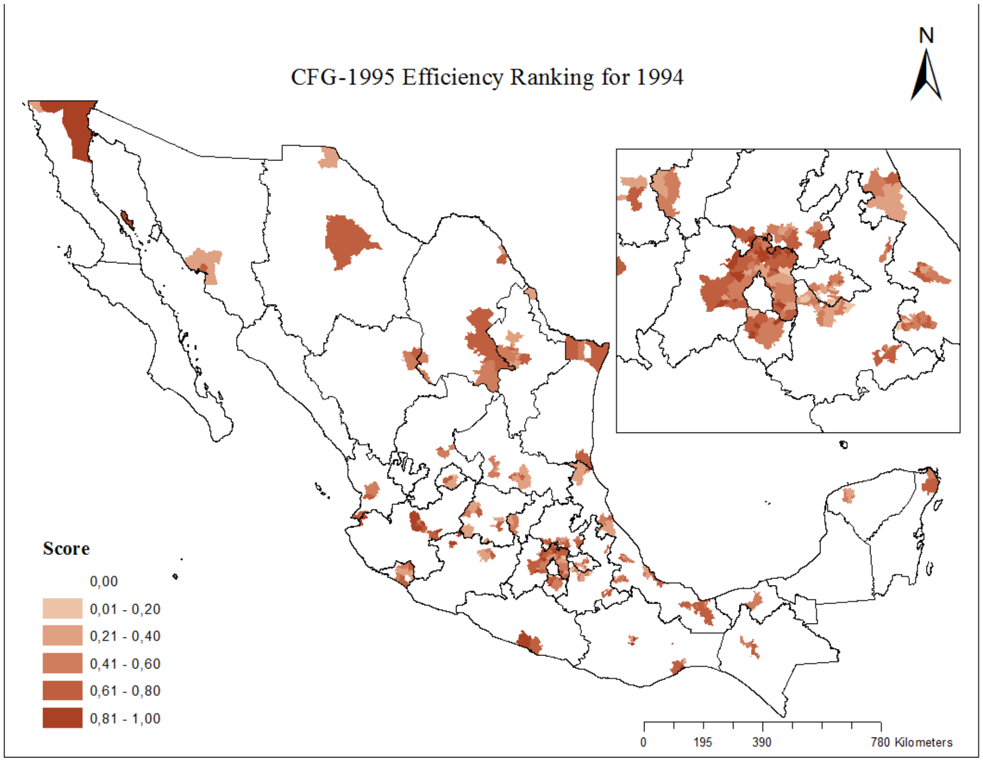
FIGURES

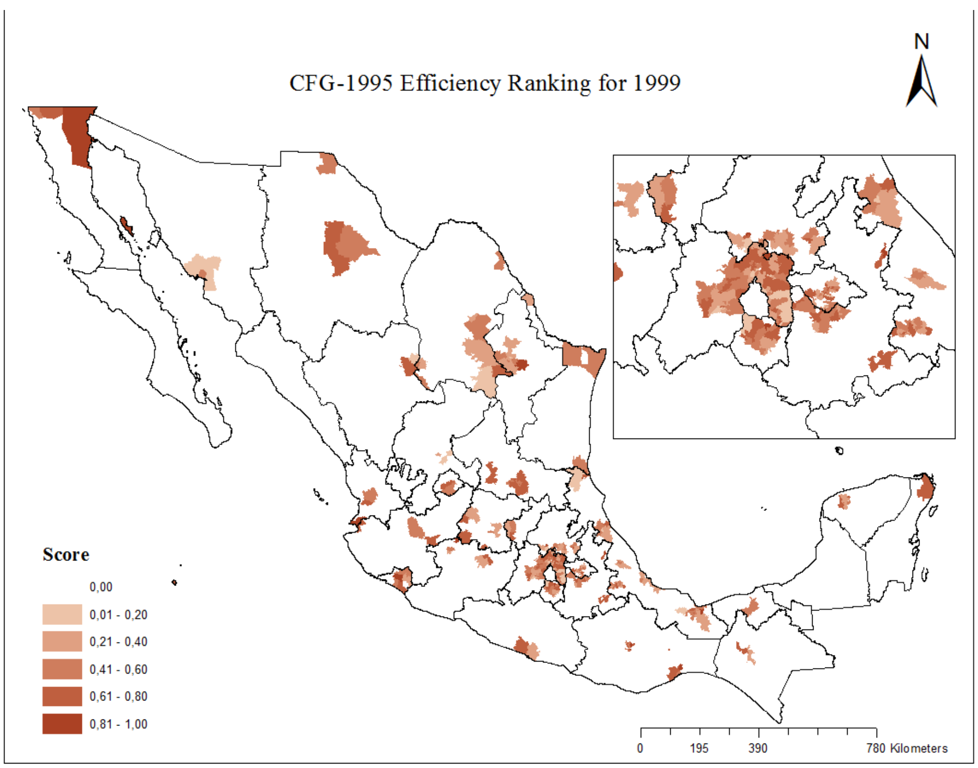
Figure 1. Municipal revenues

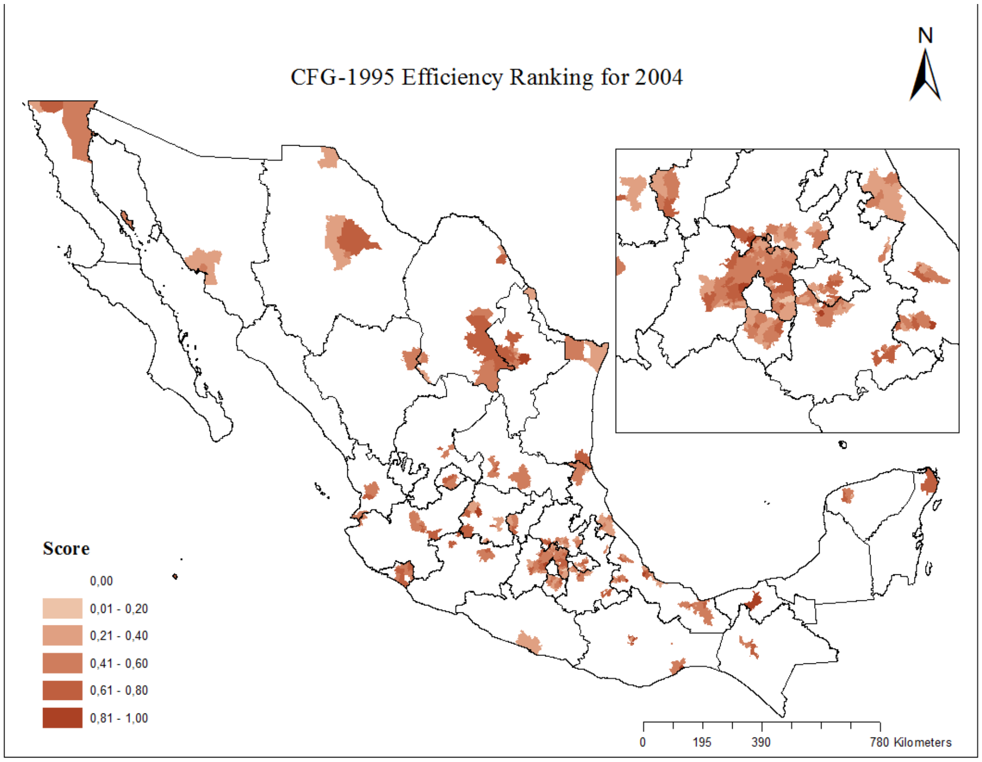


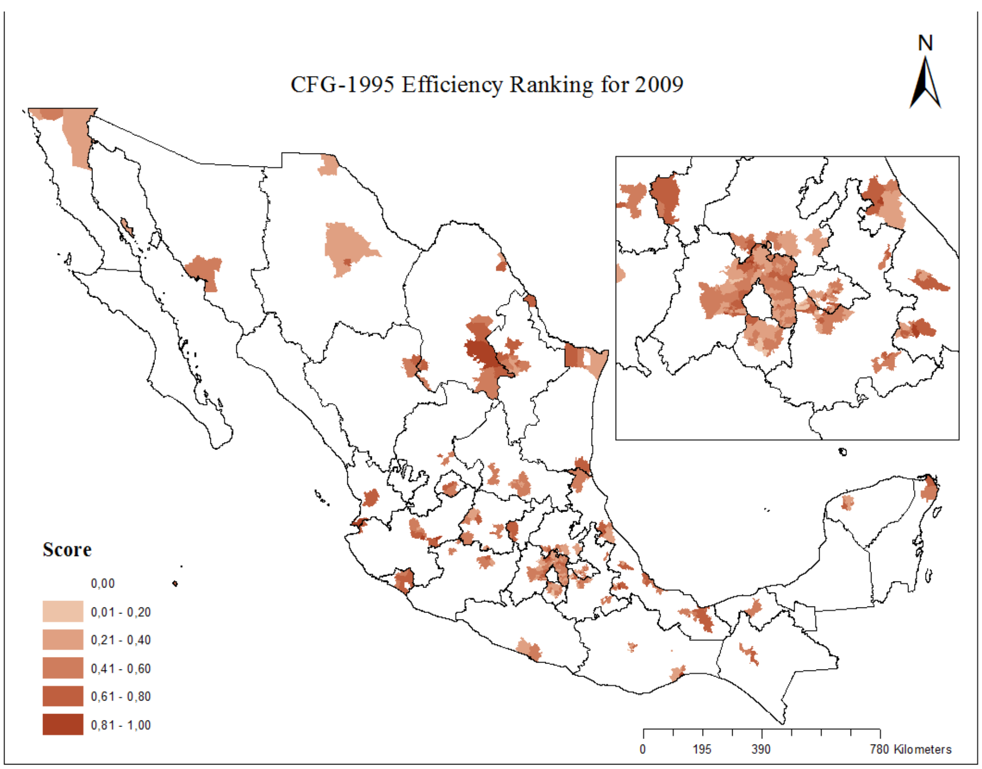
Own elaboration using data from the Sistema Municipal de Bases de Datos of INEGI.

Figure 2. Maps of the technical efficiency rankings from 1994 to 2009






CFG-1995 Efficiency Ranking for 2004
N
Score
0,00
0,01 - 0,20
0,21 - 0,40
0,41 - 0,60
0,61 - 0,80
0,81 - 1,00
0
195
390
780 Kilometers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