ipea Instituto de Pesquisa Econômica Aplicada

Título do capítulo	CHAPTER 12 **AN EVALUATION OF THE EFFICIENCY OF BRAZILIAN MUNICIPALITIES IN THE PROVISION OF PUBLIC GOODS USING DATA EVELOPMENT ANALYSIS**
Autores (as)	Rogério Boueri
DOI	

Título do livro	ASPECTS OF THE FISCAL DEVELOPMENT
Editor (es)	Rogério Boueri Maurício Saboya
Volume	
Série	
Cidade	
Editora	Instituto de Pesquisa Econômica Aplicada (Ipea)
Ano	2007
Edição	1ª
ISBN	
DOI	

CHAPTER 12

AN EVALUATION OF THE EFFICIENCY OF BRAZILIAN MUNICIPALITIES IN THE PROVISION OF PUBLIC GOODS USING DATA ENVELOPMENT ANALYSIS

Rogério Boueri*

Brazil has had quite a tough fiscal regime in place in the last years. The attempt to generate successive fiscal surpluses is aimed at reducing the debt-GDP ratio, to create conditions for sustained decrease of internal interest rates and the resumption of economic growth.

The problem with this strategy is that it is reaching the limit of its effectiveness. This is happening, first, because the policy of achieving fiscal surpluses has been strongly based on increasing the tax burden, which in the last years has been breaking successive records and is bordering 40% of the Brazilian gross domestic product. Therefore, it would not be surprising if, in the near future, tax burden increases cease to occur.

On the other hand, social demands have been driving considerable increases in government transfers. Coupled with the growth of personnel expenditures, the average growth cost expenditures a year is of 6%.

A third obstacle to the continued use of the fiscal surplus generation policy is the increasingly unsustainable compression of government investment expenditures. In order to resume growth soundly, Brazil needs high investments in infrastructure and much of it will have to be done by the federal government, since most of the country's economic infrastructure depends on public investment.

The current path of the Brazilian economic policy has benefited from a favourable international scenario, with external demand raising the prices of commodities and other primary inputs that Brazil exports. This has led to an appreciation of the Real and helps control inflation. However, it should not be expected that this favourable world economic environment will last forever. When the world economy begins to decelerate, internal pressures in Brazil will increase.

* Planning and Research Technical Experts of the Directorate of Regional and Urban Studies (Dirur) of Ipea and Catholic University of Brasília. E-mail: boueri@ipea.gov.br.

One of the means for the government to maintain fiscal surpluses and still be effective in the promotion of economic development is the improvement of public expenditure. This alternative would allow the social demands for public services to be met at decreasing costs, that is, without additional tax burden. Thus, it would be possible to combine the pressure for more services with the restriction imposed by the taxation limit.

However, there is a long path ahead to achieve overall improvement in the efficiency of public expenditure in Brazil. The first step is to try to size and measure the magnitude of the waste. Without a notion of how much more is spent than necessary, one can hardly establish reasonable goals to reduce waste.

Recent studies on efficiency of public expenditure have been using techniques that are commonly used in the analysis of efficiency of productive units in general. According to this approach, the government is a producer of goods and services and can have its productivity evaluated and compared to that of other producing units.

The techniques used for the evaluation of government performance can vary according to the goals of the measurement. In general, when the aim is to measure the impact of government action (outcome) econometric methods are more appropriate, since they allow incorporating into the analysis the effect of external factors that, although influencing the evaluated variables, are not under the control of the government action (see Coelli *et al.* 2005).

However, this analysis is restricted to the cases where a single impact variable is analysed. Nevertheless, in most cases, the government action occurs simultaneously across sectors. Thus, a government needs to meet educational, health, national defence needs, etc., at the same time. Furthermore, given that resources are scarce, increase of government action in one sector entails reduction in another, or increased tax burden or indebtedness.

The method of *Data Envelopment Analysis* (DEA) can be appropriate in situations where the provision of multiple outputs has to be evaluated. This non-parametric method is quite flexible and does not impose standards to the evaluated units; the evaluation criteria are based on the performance of the units within the sample.

Recent literature provides examples of application of the DEA method for evaluation of government performance in the delivery of public services. Afonso, Schuknecht and Tanzi (2006) use the method to evaluate the performance of national governments, using public expenditure as a proportion of gross domestic product as input variable and indicators such as level of corruption, level of unemployment, growth of GDP, among others, as representative of public output.

Other studies have focused on sectoral inefficiency in the delivery of public services. For example, Anderson, Walberg and Weinstein (1998), Caballero *et al.* (2004) and Chakraborty, Biswas and Lewis (2001) studied education spending, while other authors, such as Sola and Prior (2001) and Butler and Li (2005) studied efficiency in the public provision of health services.

The DEA instrument has also been used for comparison of efficiency among sub-national governments. For example, Afonso and Fernandes (2006) compare the performance of local governments in Portugal (more specifically, in the Lisbon region), while Gasparini and Melo (2004) investigate the optimum level of transfers to Brazilian municipalities based on the difference between how much such governments would need to bridge their respective fiscal gaps if they used the available resources efficiently.

This paper proposes to evaluate the amount of resources that could be saved if Brazilian municipalities spent budgetary resources efficiently, efficiency being defined here as corresponding to the municipalities with the best performance. Analyses will also be carried out on the geographic distribution and population bracket of the inefficiency, as well as on the scale efficiency of the municipal public production.

1 METHODOLOGY

1.1 Data Envelopment Analysis (DEA)

The principle of the DEA methodology is based on the physical definition of efficiency, according to which efficiency is given by the relation between inputs used and outputs generated. Thus, the bigger the production of a unit for a given amount of inputs, or alternatively, the lower the amount of inputs used for a certain amount of output, the greater the efficiency of this unit will be. The problem is that this definition cannot be applied directly in the case of multiple inputs and/or outputs. In this case, it is necessary to attribute weights to the amounts produced and the inputs used. When both inputs and outputs can be clearly priced, this limitation is easily overcome by the use of prices as weights and evaluation.

However, this pricing is often difficult or impossible to be done. In this case, the attribution of weights to outputs and inputs would have to be based on some arbitrary criterion established by the evaluator. The great merit of the DEA methodology is that it spares the evaluator from the establishment of arbitrary criteria: the weights will be established by the available data set. The idea is for such weights to be chosen in the most favourable way for each unit, according to certain consistency rules.

In this paper, the *Data Envelopment Analysis* (DEA) methodology will be used to evaluate the efficiency of the Brazilian municipalities in the delivery of public services. The DEA method was first proposed by Farrel (1957), but only became popular in literature after Charnes, Cooper and Rhodes (1978) used it for evaluations of concrete problems. These first models used, known today as CCR models, adopt the hypothesis of constant returns to scale. This limitation, however, was overcome by the work of Banker, Charnes and Cooper (1984), which extends the original model to the case of variable returns to scale (BCC model).

An interesting result that can be obtained from the comparison of the solutions provided by the BCC and CCR models is the verification of inefficiency due to production scale. It is possible to show that the relative efficiency index obtained with the CCR model will always be lower than the one obtained through the BCC model [see Cooper, Seiford and Tone (2006), page 88]. With this, the ratio between the two indices will show the proportion of inefficiency derived from the unit's production scale. This analysis allows, on the one hand, to distinguish how much of a unit's inefficiency is due to the size of the unit and how much is due to management and administrative weaknesses. It also allows drawing inferences on the optimum size of the units.

1.2 Application of the DEA Method to measure the inefficiency of Brazilian municipalities

The main areas of action of the Brazilian municipalities are, by order of importance, education, health and housing and urban planning. In 2005, activities linked to these areas took up about 64% of the Brazilian municipal budget, according to the National Treasury Secretariat. These expenditures correspond to about 92% of the municipal expenditure on core activities.[1]

Thus, to evaluate the relative efficiency of the Brazilian municipalities, one must consider the outputs and services offered by the municipalities in these three areas, as well as the total spent by them.

In education, the Constitution attributes to the municipalities the responsibility for basic education. Based on this fact, this paper uses the number of school enrolments in the municipal network of basic education as municipal output in the education area. Naturally, this number is not perfectly correlated with the efficiency of the municipality in the education area. For

1. Administrative activities are responsible for 30.7% of the municipal expenditures.

example, a municipality that spends more than average on cultural activities, or that has a lower pupil-teacher ratio, will not necessarily be less efficient, in spite of some loss in the DEA evaluation.

On this point, it is worth noting that the evaluation through the DEA methodology applied here is incapable of evaluating efficiency in terms of results (outcomes), and is limited to investigating efficiency in terms of services delivered (outputs).

As health indicator, the number of hospital admissions in the municipal network will be considered. Once again, it is necessary to acknowledge the limitations of the indicator. According to the methodology used, two short admissions would have twice the weight as a single admission for twice the time, which could result from the severity of the patient's problem rather than the efficiency of the hospital unit.

The last area to be considered is that of urban planning. There is a large number of candidate indicators for this one. Kilometres of paved avenues and streets, addition of street signs, etc. The great problem of most of these indicators is that the expenditures with urban planning generally reflect permanent investments, which, once done, need only maintenance to continue providing services to the population. Perhaps an example will help clarify the nature of the problem. Let us assume that a municipality has not carried out any road works in a certain year. In this case, the efficient expenditure of this municipality for this year would be zero, since if there were no improvements all the money spent would be a complete waste. However, if the amount of paved streets were used as an indicator, this municipality would have the expenditures justified by the works carried out in previous periods.

The variation of the indicators could be used as a measure of efficiency. However, at municipal level, such indicators are collected every ten years, so it is impossible to use them in annual analyses.

The attempt to overcome these difficulties has led to the use of the number of municipalities with garbage collection as the only indicator in the urban planning area. This indicator does present the problems described above, since the expenditure with the service takes place at the same time as its delivery.

Once the outputs to be considered are described, the choice of input should be discussed. In this evaluation, the budgetary expenditure of each municipality in 2000 will be considered as input. This choice is based on the principle that, in economic terms, the municipalities exist to deliver services to their populations.

As seen above, most of the services delivered can be categorized in the areas[2] of education, health and urban planning. Therefore, the total cost of such services is given not only by the direct expenditures of the municipalities in these areas, but also by the expenditures carried out in the administrative activities, without which it would be impossible for the municipalities to offer the services. The total budgetary expenditure of the municipalities takes into account all these expenditures taken together.

Once again, this choice entails some measurement imprecision. For example, municipalities that have expenditures with public security will have their efficiency underestimated, since these expenditures will not have effects on the output indicators. However, such imprecision is the price if to pay for such an aggregated analysis.

1.3 Databases

The information on number of children enrolled in basic education in municipal schools, the number of admissions in hospitals of the municipal network and number of households served with garbage collection, were obtained from the Municipal Information Base (BIM) produced by the Brazilian Institute of Geography and Statistics (IBGE). The data on budgetary expenditures of the municipalities were obtained from the Finbra data of the National Treasury Secretariat. All the information refers to 2000, which is the last census year in Brazil.

Only the data of the municipalities that contained information on all the variables were used, that is, those municipalities on which any information was missing were not included. This lack of information can have two causes: either the municipality does not deliver some of the services, for example, some of the municipalities do not have hospitals, or there was some failure in obtaining the data. After the application of this criterion, 3.215 of the 5.506 municipalities remained in the sample.

It was also necessary to carry out a critical filtering of the data, so as to eliminate from the sample municipalities that presented strong evidence of incorrectness in their data. Such refining was done as follows: the per capita expenditures of each one of the 3.215 remaining municipalities were calculated

2. The use of the term "area" rather than the budgetary term "function" is due to the fact that the "area" of health includes expenditures belonging to the health function as well as expenditures related to other functions, such as sanitation, for example. The same occurs with the area of education and the area of urban planning.

and those that presented a value under R$ 50,00 or over R$ 5,000.00 were excluded. After this filtering, the sample was left with 3,206 municipalities. In table 1 some of the characteristics of the sample used are described, while table 2 presents descriptive statistics of the sample. It should be noted that, in population terms, this sample of municipalities shelters 146.82 million inhabitants, corresponding to 86.46% of the Brazilian population in 2000.

TABLE 1
Representativeness of the sample

Region	Population in the sample	Number of municipalities in the sample	% of the sample	% Representativeness of the sample
North	10,288,506	222	6.92	49.44
Northeast	39,592,259	1,033	32.22	57.81
Southeast	65,607,588	868	27.07	52.10
South	22,680,373	759	23.67	65.49
Mid-West	8,647,265	324	10.11	72.81
Total	146,815,991	3,206	100.00	58.23

Prepared by the author.

TABLE 2
Aggregated results of the CCR and BCC Models

Expenditure	71,816,545,042
Waste CCR	50,596,171,025
% Waste CCR	70.45
Waste BCC	34,026,128,790
% Waste BCC	47.38
Scale Waste	16,570,042,234
% Scale Waste	32.75

Prepared by the author.

2 ANALYSIS OF THE RESULTS

2.1 Comparisons between the aggregated results of the CCR and BCC Models and scale efficiency

The information on the 3.206 municipalities was used in the construction of two models using DEA methodology.[3] In the first, the hypothesis of constant returns to scale was established (CCR model) and in the second, the hypothesis of variable returns to scale (BCC). The aggregated results of each model are presented in table 3.

3. The SAS software was used for the implementation of the models, since the large number of units to be considered exceeds the capacity of most existing DEA methodology implementation programs.

TABLE 3
Regional distribution of municipal inefficiency

Region	Budgetary expenditure R$ million	Waste CCR R$ million	Waste R$ million	Waste BCC CCR %	Waste BCC %	Per capita expenditure R$
North	3,434	2,333	67.95	1,507	43.87	333.78
Northeast	13,249	8,685	65.55	5,431	40.99	334.63
Southeast	38,856	28,071	72.24	17,485	45.00	592.25
South	12,236	8,675	70.89	7,281	59.51	539.51
Mid-west	4,041	2,832	70.09	2,322	57.46	467.34
Total	71,817	50,596	70.45	34,026	47.38	489.16

Prepared by the author.

The first line of table 3 shows the aggregated total of the budgetary expenditure of the 3.206 municipalities in the sample, totalling 72 billion Reals almost (in current values). The second line shows the total of waste detected by the CCR model in the sample. This total reaches 70.45% or 50.5 billion Reals. This number, however, should be interpreted carefully. Its meaning is that, if all municipalities managed their resources in the way the most efficient municipalities (only 3 in the CCR model) do, the same amount of services could be delivered with little less than 30% of the resources effectively spent. It should be noted that the CCR model does not take into account the scale gains and losses that might occur in the provision of the public services considered.

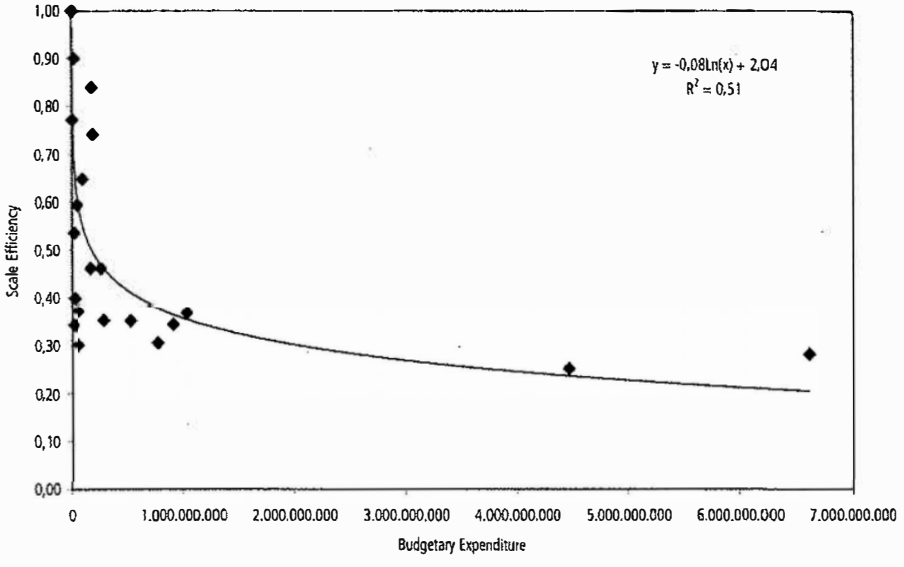
As already mentioned in section 2, the BCC model is more flexible in this aspect and allows the data to adapt to the existing scale variations. The use of this second model indicated a waste of 34 billion, which represents 47.38% of the total expenditure (lines 4 and 5 of table 3). This means that, even deducting the scale effects, the public services could have been delivered with about half of the resources that were used by the municipalities in 2000, if all the municipalities managed their budgetary resources with maximum relative efficiency.

The fact that the municipalities in general do not present the optimum scale is reflected in the difference between the waste calculated by the CCR model and the one resulting from the application of the BCC model. This difference, which aggregately reaches 16.5 billion Reals, is the waste of resources due to scale problems and represents approximately 1/3 of the total lost.

Another interesting result appears when we examine the individual values of the efficiency coefficients of the municipalities in relation to the scale. The BCC model reveals the existence of 23 efficient municipalities when the scale effects are taken into consideration. As seen in section 2, the result of the division

of coefficient BCC by coefficient CCR indicates the scale efficiency of a given unit. In graph 1 such scale efficiency coefficients are plotted against the budgetary expenditure of the 23 efficient municipalities under the BCC criterion.

GRAPH 1
Aggregated results of the CCR and BCC Models



Prepared by the author.

Contrary to what might be expected, a pattern of negative returns to scale was detected, that is, larger municipalities tend to present a greater degree of inefficiency in the CCR criterion, given their efficiency in the BCC criterion. This result might be derived from the fact that larger municipalities have more expenditures in indicators not considered in this paper. Since the efficiency criterion here is based only on the three indicators chosen, the larger municipalities would turn up as less efficient, since they "waste" budgetary resources in the generation of other outputs and services for their populations. The logarithmic regression shown in graph 1 only serves to illustrate the trend of decreasing returns to scale observed in the data.

2.2 Distribution of waste according to regions and size of the budgets

The regional distribution of waste of budgetary resources is shown in table 4. One aspect that should be noted is that the inefficiency has a strong correlation with the per capita spending. When the correlation of the latter variable with the level

of waste in the CCR criterion is measured, a value of 0.9405 is found, which indicates the strong link between inefficiency and per capita spending. When the experiment is done replacing the CRR inefficiency criterion with the BCC criterion, the positive correlation remains, although less high, reaching 0.5094.

The regional patterns of waste, however, present little variation, especially when the CCR criterion is considered, with differences of approximately 10% between the regions of maximum waste (Southeast) and minimum waste (Northeast).

When the distribution of waste by population brackets is analysed, a much clearer pattern is detected. As observed in table 5, the municipalities with less population have a level of waste (BCC criterion) of almost 75%. This coefficient drops as the population brackets grow, reaching its minimum level in the bracket that contains municipalities with a population of more than one million inhabitants. In this bracket, waste is reduced to less than 10% of the expenditure.

In terms of percentage of total waste, the smaller municipalities participate basically with 30% of the totality, although their budgetary expenditures reach only 19% of the total of the sample. On the other hand, the municipalities with more than one million inhabitants (12 in the sample) carry out 28.5% of the total of the expenditures of the sample and participate with 5.9% of the waste. It is important to highlight that such figures are obtained when the scale losses of the BCC model are considered.

TABLE 4
Distribution of inefficiency according to size of the municipalities – BCC Model

Population bracket	Number of municipalities	Population sample %	Total expenditures R$ million	Waste R$ million	Waste %	Participation waste total %
<30.000	2,360	21.29	13,635	10,198	74.79	29.97
<100.000	632	22.25	12,735	7,979	62.66	23.45
<250.000	132	13.90	10,061	6,102	60.64	17.93
<1.000.000	70	20.56	14,951	7,753	51.86	22.79
>1.000.000	12	21.99	20,434	1,994	9.76	5.86

Prepared by the author.

Such results for waste are probably underestimated, since there is no reason to expect that the municipalities outside the sample will present a better performance than those included in it. On the contrary, the fact that some of them were not included due to unavailability of information is already good evidence of their administrative deficiencies, which can be reflected in their efficiency. Furthermore, many of the municipalities excluded from the sample have a small population, which is another indication that their inclusion

would tend to increase the numbers on waste, since, according to the analysis carried out here, the less populous municipalities are the ones that waste the most resources.

3 CONCLUSIONS

This paper used the DEA method to evaluate waste in the Brazilian municipal budgetary execution. This method allows a comparison of the relative efficiency of the decision units, municipalities in this case. Waste is calculated as being the difference between what one municipality spent and how much the more efficient units of the sample would have spent to deliver the same level of services as the evaluated unit.

To this end, two different DEA models were used. The first is the CCR model, which considers constant returns to scale, or analogously, disregards any scale losses or gains among the evaluated units. The BCC model incorporates variable returns to scale, which allows a more flexible analysis. The comparison of the results of the two models allows inferences on scale performance in the delivery of municipal services in Brazil.

A sample of 3,206 municipalities, representative of all geographic regions of the country, was used. The results refer to 2000. As municipal outputs, the following variables were used: number of children enrolled in the municipal network of basic education, number of admissions in the municipal hospital network and number of households with garbage collection in the municipality. As input, the total municipal budgetary expenditure was used.

For this group, a waste of 50.6 billion Reals was detected with the use of the CCR model. This figure corresponds to 70.5% of the budgetary expenditure of the municipalities studied. Waste drops to 34 billion Reals when the scale effects are considered (BCC model).

It was also detected that a lot of waste occurs in the municipalities with less population, even though the data indicates decreasing returns to scale in the provision of municipal services.