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The inefficiency of IPTU collection in São Paulo municipalities

Jefferson Valentin

Thiago Costa Monteiro Caldeira

ABSTRACT

This study analyzes the IPTU collection capacity of São Paulo's municipalities. The Data Envelopment Analysis (DEA) methodology was used to construct a non-parametric efficiency frontier, formed by the municipalities with the best relationship between the output (IPTU collection) and three categories of variables used as inputs: demographic, income and budgetary. It can be seen that tax collection inefficiency is higher in the smaller municipalities. The scale efficiencies of the municipalities were also analyzed, which made it possible to identify that more than 97% of the municipalities, in addition to technical inefficiency, operate with scale inefficiency. The technical inefficiency index found and, consequently, the budgetary impact it causes was also presented with bias correction and in the form of a confidence interval, using bootstrap.

Keywords: IPTU, DEA, *bootstrap*.

JEL classification: H21, H23, H60.

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SUMMARY

1. INTRODUCTION

The legal-tax structure of a given taxing entity, such as municipalities, is the transcription, in the form of rules, of political choices. The set of government guidelines that shape the tax regulatory framework is usually called tax policy.

Tax policy, however, finds limits and opportunities in the socio-economic conditions of the population subject to the imposition of the burden, as well as in the structural conditions of the entities themselves, if not in higher rules, such as constitutional ones.

The Brazilian federation grants autonomy to three spheres of political organization: the Union, the States and the Municipalities. In order to guarantee this autonomy, it has endowed all political entities with active tax capacity (the ability to institute taxes), as well as setting up an intricate network of transfers of budgetary resources from the larger entities to the smaller ones.

Municipalities have been given the power to impose the following taxes: Services Tax (ISS), Property Transfer Tax (ITBI) and Urban Property Tax (IPTU).

IPTU, the subject of this study, is a typically local tax (AFONSO, ARAUJO and NOBREGA, 2013). It is levied on the ownership of real estate located in the urban area of municipalities and its calculation basis is the venal value, which can be defined as the most probable price at which a property would be sold under the market conditions in force on the date of valuation (De Cesare, 2005). Each municipality, however, establishes the "venal value" based on its own criteria, which are not always technical, which means that it deviates from the market value.

The rates are set by each municipality with the constitutional authorization for them to be progressive, which would allow for higher taxation in prime areas of the city, with better infrastructure, and for resources to be directed towards investments in more peripheral areas, complying with the constitutional principle of combating inequality and poverty.

While the collection of the other taxes that municipalities are subject to (ISS and ITBI) depends on economic activity, IPTU, because it is levied on property, a manifestation of wealth that is less subject to variations in the economic cycle, has a predictable characteristic, an important attribute in the composition of the municipal budget.

The vast majority of municipalities in Brazil, however, do not have IPTU as a major source of revenue. While countries such as the United States, the United Kingdom, New Zealand and Australia collect around 2 to 3% of GDP from this type of tax, in Brazil, although the tax burden has exceeded 35% of GDP (ORAIR et al, 2013), the collection did not reach 0.5% (DE CESARE, 2005). Updating this figure, Brazil's GDP in 2020 was 7.6 trillion reais (IBGE) while total IPTU collection (National Treasury - Siconf) was 50.14 billion, which leads to IPTU collection equivalent to 0.66% of GDP.

As for the state of São Paulo, GDP was R$2.377 trillion, while IPTU collection was R$24.712 billion, which means that IPTU collection is around 1.04% of GDP for the state of São Paulo. Due to the disparity between the figures presented by the state of São Paulo and the rest of the country, as well as the greater availability of access to information on this state, it was decided to analyze only the municipalities of São Paulo.

Taking into account municipal socio-economic and budgetary indicators, this study assessed the size of potential IPTU collection in São Paulo municipalities and the difference between potential IPTU collection and actual collection.

The aim is to identify which municipalities, given the budgetary and socio-economic conditions of the population, have a sub-optimal level of efficiency in urban property taxation, how much this inefficiency impacts on the budget of these municipalities and whether there are inefficiencies of scale.

This research is justified by the fact that, since there are no pre-established efficiency parameters, municipalities do not have diagnostic tools of their tax collection capacity to guide their tax or budget policy. Observing the best practices of municipalities with a higher level of efficiency can be an important tool for political decision-making.

This article contributes to the literature insofar as it highlights the relevant potential of revenues that are little exploited by municipal public entities, especially at times when tax reforms are being discussed: i) executes a methodological tool for measuring the relative efficiency of Municipalities, with recent data; ii) carries out an analysis of scale efficiency, enabling an assertive diagnosis for the orientation of municipal tax policy; iii) applies the DEA methodology in an innovative way, considering three sets of variables (demographic, income and budgetary), adopting as relative efficiency the best index among the three sets, which also addresses political questions about the results achieved; and iv) uses the most modern methodological tools related to efficiency analysis with DEA, for greater consistency of results, correction of possible bias and obtaining results in the form of a confidence interval.

Finally, showing the relative size of the budget impact generated by IPTU collection inefficiency for all municipalities can also be used as a tool to assess the tax responsibility of municipal public management in the administration of their own revenues, both for social control and to serve as a guide in the allocation of voluntary transfers from the Federal Government and the States. In this sense, the results indicate a potential additional revenue for São Paulo municipalities of between 13.3 billion and 30.3 billion reais, if the less efficient municipalities achieved the efficiency of the *benchmarking* municipalities

Section 2 presents a review of the literature on IPTU. Section 3 contains the methodology and identification of the data used. Section 4 analyzes the results and, finally, section 5 presents the final considerations.

2. THEORETICAL FOUNDATIONS

Despite the poor use of IPTU, the literature presents several positive points in real estate taxation:

a) As an urban policy instrument, taxation captures for society the income generated by real estate appreciation (CARVALHO JR. 2006) and can be used to stimulate the use of urban land (DE CESARE, 2005);

b) From the point of view of citizenship and tax education, the IPTU is highly visible and its taxable event is universal (DE CESARE, 2005). It is a tax that makes the community more aware of their rights and generates demands for improvements in their locality (CARVALHO JR. 2006);

c) From the point of view of tax administration, the IPTU generates a stable and predictable flow of revenue and, regardless of the economic cycle, has the capacity to produce a reasonable level of revenue. It is difficult to evade and can be one of the few means of imposing a tax burden on wealthy taxpayers who are able to evade income tax (DE CESARE, 2005; 2012).

Giffoni and Villella (1987) verified the poor performance of IPTU in the composition of the tax burden and attributed this to the lack of human and technical resources available to organize a tax administration at local level. It was also mentioned that the municipal government, since it is closer to the taxpayer, is more susceptible to political pressure. Villela (2001) found that the IPTU was losing out in budgetary importance to the ISS, an indirect tax with a value embedded in the price of services.

The secondary importance of IPTU in municipal budgets was also noted by Afonso and Araujo (2000), Afonso, Araujo and Nobrega (2013) and De Cesare (2005). The former, as well as Carvalho Jr. (2006), point out that there were no criteria for creating municipalities and, as a result, there was no concern about balancing the conditions for financing local spending through their own revenues. They also point out that the constitutional transfer model discourages municipalities, especially the smaller ones, from structuring themselves to efficiently collect their own revenue. De Cesare (2005), for his part, points to administrative inefficiency in maintaining quality real estate registers as one of the main difficulties in establishing a tax base that reflects the market value of properties. Another factor pointed out is that the need for the municipal legislature to approve the generic value plan weakens any technicality in the estimation work, subjecting property values to purely political criteria.

Christensen and Garfias (2020) point to political reasons for maintaining a defective cadastral infrastructure, while Hollenbach and Silva (2019) show that political influence results in a reduction in the tax capacity of entities, which is more intense when inequality is higher

A much debated topic in the literature is the issue of fiscal federalism and, specifically in Brazil, its municipalist bias. With regard to expenditure, there are studies that aim to identify the occurrence in Brazil of the so-called *flypaper* effect, which refers to the effect that unconditional intergovernmental transfers can have on the expenditure of the entities that receive them, causing them to increase at a faster rate than the increase in the income of the local population, instead of (any excess) being used to reduce the collection of taxes from the taxpayer (RIOS and COSTA, 2005).

Costa and Castelar (2015), using the autoregressive vectors technique and the quantile regressions model for panel data, applied to data from 5,293 Brazilian municipalities from 1999 to 2009, did not find conditions that confirm the practice of *flypaper* by municipal public administration in Brazil. On the other hand, Almeida (2015), using panel data from 5,507 Brazilian municipalities from 2002 to 2010, applied the ordinary least squares method, fixed effects estimation and random effects estimation, and found results that show the expansive effect of municipal public spending is greater, in relative terms, than that which would be generated by an increase in local income.

Mattos et al (2011), using the non-parametric *Free Disposable Hull* (FDH) methodology, propose a reinterpretation of the *flypaper* effect and verify that, instead of the income effect, there is an induction of inefficiency in local tax collection motivated by unconditional budget transfers.

Granai (2022), in turn, states that the FPM has been significantly important for the autonomy and socio-economic development of municipalities. However, it has been ineffective in promoting socio-economic development in low-income micro-regions. He also states that the transfer of resources from the Federal Government has been adequate in meeting criteria of economic and tax rationality, generating political balance in the federation.

Gasparini and Miranda (2011) state that the FPM can create distortions, such as fiscal "caronism", and that municipal public revenues could almost double if municipal tax bases were properly exploited.

In general, the authors are unanimous in attributing to the IPTU a tax potential that can be exploited, but they also point out the need to take into account the socio-economic aspects of each municipality, given the heterogeneity of such aspects that can be seen in Brazil.

As for measuring the effects of IPTU tax collection inefficiency on municipal budgets, studies are even rarer. Tolder (2007) defines the tax *gap* as the difference between the tax liability in any given year (provided for in the legislation) and the amount of tax that is voluntarily paid on time. Franzoni (1999), in turn, defines the tax gap as the difference between potential and actual tax collection due to tax evasion.

Carvalho Jr. (2012) used a sample of 8,408 apartments valued by Caixa Econômica Federal between 2006 and 2009 to verify the index of undervaluation of the venal value used by the Municipality of Rio de Janeiro in relation to the actual market value of the properties and found regressivity in the distance between the IPTU calculation base and the market value.

Gasparini and Miranda (2011) estimated the total tax collection potential of municipalities using an efficiency frontier calculated by *Data Envelopment Analysis* (DEA), treating local socioeconomic variables related to tax collection potential (*output*) as *input*. The authors aimed to verify the efficiency of municipalities in collecting all the taxes they are responsible for (IPTU, ITBI and ISS). The variables they used as *input* were municipal GDP, urban population, staff employed in real estate activities and the provision of services to companies, value added in services by the municipality and staff employed in activities related to food and accommodation. As an *output*, the authors used the value of own tax revenues (all taxes).

Hollenbach and Silva (2019) found correlations between municipal GDP, the size of the urban population, transfers from the federal and state governments to each municipality and the Gini coefficient. (2006), in turn, indicates a relationship between the municipality's per capita income, current transfers, the urbanization index and the amount of IPTU collected.

In general terms, the studies that analyzed IPTU collection by comparing it with budget indicators and socioeconomic characteristics of municipalities used samples made up of municipalities from all regions of the country and concluded that:

a) Municipalities with larger populations charge more IPTU per capita than smaller municipalities. There is a great political cost in increasing the IPTU and, for this reason, the proximity of the public administrator to the taxpayer politicizes the work, which should be technical, of assessing properties for tax purposes (AFONSO and ARAÚJO, 2000, DE CESARE, 2005 and CARVALHO JR., 2006 and 2012);

b) The model of current transfers discourages municipalities, especially the smaller ones, from seeking to collect their own taxes, especially IPTU, which is a direct tax and therefore more rejected by citizens (AFONSO and ARAUJO 2000, DE CESARE, 2005, and CARVALHO JR., 2006);

c) Similar-sized municipalities can have different IPTU collection capacities depending on their socio-economic development and the income level of the population (AFONSO and ARAUJO, 2000).

d) Municipalities with higher levels of inequality have lower fiscal capacity (HOLLENBACH and SILVA, 2019).

3. METHODOLOGY

3.1. Stages of the methodological strategy

This work consists of five stages. The municipalities in the state of São Paulo were divided into *clusters* in order to achieve better homogenization (1). Next, a DEA model was used to plot the different relative efficiency indices calculated from three sets of *inputs* (demographic, budget and income variables, i.e. three different DEA calculations) (2). The variables with an inverse correlation (gini, current transfers and total collection without IPTU) were worked out as divisors of 1 (1/variable).

Having chosen the highest level of relative efficiency among the three sets of variables, the budget impact caused by IPTU collection inefficiency in each municipality was calculated (3).

The option to choose the highest level of efficiency found among the three sets of *input* variables is due to the fact that when one of the sets indicates a maximum level of efficiency, the variables relating to the others become irrelevant. For example, if a given municipality has a maximum level of efficiency in IPTU collection considering the volume of funds received in current transfers and the volume collected from other own revenues, it is expected that there will be no motivation to increase IPTU collection, even if the population's income allows it. In the same way, if a municipality has maximum efficiency in collecting IPTU considering the income of its population, no matter how much demographic or budgetary variables indicate that it could collect more, it will find the income level of its population a limitation to this increase in collection.

A scale efficiency analysis was carried out and the municipalities were separated into six possible diagnoses, considering the type of scale efficiency and the level of efficiency (4).

Finally, the *bootstrap* was used to correct the bias of the DEA estimators and construct a confidence interval (5). The results were presented in three ways: original efficiency index, bias-corrected efficiency index and confidence interval.

3.2. DEA Models

DEA (*Data Envelopment Analysis*) is a methodology used to estimate the relative efficiency of a group of DMUs (*Decision Making Units*). Based on linear programming techniques, it verifies efficiency relationships between the *inputs* and *outputs* of the DMUs, creating a non-parametric efficiency frontier with the most efficient units.

Once this efficiency frontier has been established, the position of the other firms in relation to this frontier is defined (it is called an envelopment because it involves all the DMUs).

Normally, this methodology is used to measure relative efficiency in a production relationship, with *inputs* as *inputs* and products as *outputs*. However, DEA not only estimates production functions, it is also used for *benchmarking*, i.e. it can be used to construct not a production frontier, but a frontier of good practices (ZHU, 2014).

Efficiency, a term used broadly here, is a relative measure in DEA, as it is not measured using a predetermined model, but by comparing the DMUs that make up the group, and varies between 0 and 1. The most efficient DMUs are assigned a value of 1 (*score*) and these make up the efficiency frontier. For DMUs that fall below the efficiency frontier, DEA creates a projection (*target*) and calculates their efficiency in relation to the DMUs that are on the frontier.

According to Zhu (2014), DEA measures relative performance by considering lower levels of *inputs* to generate higher levels of *outputs*.

DEA is applied in three phases (GOLANY and ROLL, 1989):

1 – Definition of the DMUs that will make up the analysis;

2 – Selection of the appropriate and relevant variables to calculate the relative efficiency of the DMUs;

3 – Execution of the DEA (for which we will use the R software).

DEA assumes that there is homogeneity between the DMUs (in terms of the nature of the operations carried out and the conditions under which the activities are carried out). To ensure this assumption, some form of *cluster* analysis can be adopted (HAIR et. al., 2009). Care should also be taken with the selection of DMUs, as DEA is highly sensitive to extreme values (*outliers*), which is positive on the one hand, as it portrays best practices, but can lead to deviations in the analysis when this *outlier* is, for example, incorrect data (FARIA, JANNUZZI and SILVA, 2008). Another precaution when choosing *input* variables is that there must be a direct relationship between them and the *outputs*.

In this study, the efficiency frontier was product-oriented (IPTU collection) since administrators have little or no influence over the budgetary and socioeconomic variables used as *inputs*.

3.3. Data

To compose the DEA model, the following data was gathered:

a) Total population size - Fundação Seade;

b) Degree of urbanization, IBGE/Seade Foundation;

c) Gross Domestic Product - Seade Foundation;

d) Gini Index, calculated by IBGE for the year 2010, published by the Ministry of Health;

e) Transfers from the Union and States to Municipalities, published by the Fiscal Data Monitor Portal - Siconf;

f) Total amount of the municipality's tax revenue, except IPTU (Withholding Income Tax on income paid, Service Tax, Tax on the Transfer of Real Estate by Onerous Act, Improvement Contribution, Fees, Other Taxes).

The municipalities were grouped based on two characteristics: their classification as tourist destinations and the size of their urban population (which aggregated the population size and urbanization index variables).

This study also considered that the size of the municipality's population can add other unobservable variables, such as cultural aspects, and that this would be better dealt with in the DEA model as a criterion for forming clusters, seeking greater homogeneity between the municipalities that make up each group.

Due to absences or inconsistencies in the databases, we excluded the municipalities of Américo de Campos, Carapicuíba, Cássia dos Coqueiros, Chavantes, Dois Córregos, Lupércio, Ouro Verde, Pongaí and Taquaritinga from the analysis.

Table 1 below shows the descriptive statistics for all the municipalities.

	Minimum	Maximum	Average	Weighted Average	Median	1st quartile	3rd quartile	Standard Deviation
IPTU Total (R$)	18.396	11.704.858.845	38.852.146		1.850.835	364.877	9.433.147	468.178.621
IPTU per capita (R$)	4,77	2.137,98	209,15	559,97	133,84	66,14	263,28	241,50
Total population	812	11.869.660	69.393		13.584	5.544	41.188	483.363
Degree of urbanization (%)	25,89	100	86,83		91,29	82,67	96,01	13,42
GDP (R$)	33.931.071	748.759.006.965	3.723.315.106		399.717.064	146.179.109	1.571.584.079	30.474.940.120
GDP per capita (R$)	9.876	369.866	39.657	53.664	30.725	22.656	43.566	36.344
Gini	0,3142	0,6661	0,5413		0,5442	0,5049	0,5819	0,0575
Current Transfers (R$)	4.214.264	18.498.539.693	154.287.423		43.367.793	22.939.667	107.620.256	769.155.089
Current Transfers per capita (R$)	1.299	24.187	3.834	2.224	3.178	2.565	4.458	2.059
Tax revenue without IPTU (R$)	255.424	23.814.596.120	75.489.175		4.402.084	1.559.838	15.048.392	953.887.801
Tax revenue, excluding IPTU, per capita (R$)	9,86	27.125,09	488,38	1088,01	350,65	240,13	493,29	1.164,00

Table 1 - Descriptive statistics for all 636 São Paulo municipalities studied.

3.4. Formation of clusters and choice of input variables for DEA

The exploratory analysis of the data showed that most of the municipalities with the highest per capita IPTU tax collection are well known for their tourism, as shown in Table 2.

Municipalities	IPTU per capita	Tourist resort
Ilha Comprida	R$ 2.137,98	YES
Bertioga	R$ 1.926,11	YES
São Sebastião	R$ 1.868,42	YES
Águas de São Pedro	R$ 1.515,65	YES
Praia Grande	R$ 1.469,83	YES
Guarujá	R$ 1.352,82	YES
Ilhabela	R$ 1.170,02	YES
Santos	R$ 1.149,77	YES
São Caetano do Sul	R$ 1.136,17	NO
Águas de Santa Bárbara	R$ 1.088,47	YES

Table 2 - List of the 20 municipalities with the highest per capita IPTU collection

It was therefore considered that the dynamics of real estate taxation in municipalities with an economic vocation for tourism are different from the others. In these municipalities, the number of commercial establishments is proportionally much higher than in other municipalities, for which the IPTU tax is an indirect tax, since it can be included in the cost of products and passed on to the purchasers of the goods or services. There are also a large number of summer or seasonal properties, which generally belong to people who live in other municipalities and are part of the higher social strata. This condition allows these municipalities to levy higher taxes, either because of the higher standard of property values, or because of the greater number of properties per inhabitant, or because there is less political pressure against taxing such properties, since the manager of these municipalities is less close to the taxpayer and the owners of these properties are generally not voters in these municipalities[1].

In this sense, the São Paulo legislation (Law 17.469, of December 13, 2021) classifies 70 municipalities in the state of São Paulo as tourist resorts. The municipalities were thus separated into two groups: 1 - Tourist Resorts and 2 - Non-Tourist Resorts.

In order to achieve the greater level of homogenization required by DEA, the municipalities in each group were separated into *clusters*. Initially, a test was carried out to identify *outliers* (municipalities with an urban population at least three standard deviations higher or lower than the average), which indicated the municipality of Santos for the group of tourist resort municipalities and the municipality of São Paulo for the group classified as non-tourist resort municipalities. Due to the existence of *outliers* in both groups, the data was normalized according to amplitude, i.e.,

$$\frac{(x-\mu)}{\sigma}$$

Where: μ = average

σ = standard deviation

The number of *clusters* to be used in each group was defined using the *elbow* method, which tests the variance of the data based on the number of *clusters*. The "elbows" in the graphs indicate that there is no gain from increasing the number of *clusters*.

Municipalities were classified into groups using the *k-means* method, by minimizing the variation within the *cluster* by the sum of the squares of the Euclidean distances between the items and their centroids, using the number of inhabitants in the urban area as the grouping criterion.

Although the elbow method showed three as the optimum number of *clusters* (figure 1), this would result in a group with only five municipalities, a very small number to use a *benchmarking* technique, which is why, and considering that we only have 70 municipalities that are tourist resorts, we opted to work with only two *clusters*.

1 Christensen and Garfias (2021) found evidence that mayors are sensitive to the political cost of collecting IPTU.

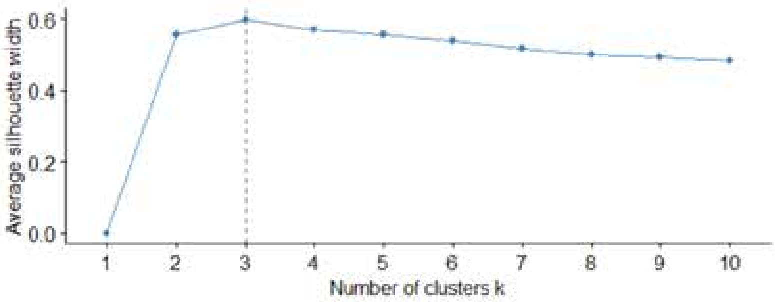

Figure 1 - Definition of the optimum number of *clusters* for the set of Tourist Resort Municipalities using the *Elbow Method*.

Let's move on to the formation of the *clusters*, as shown in figure 2:

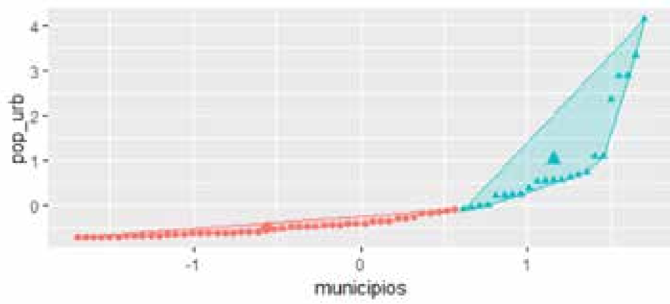

Figure 2 – Clusters of tourist resorts using the *k-means* method, with the grouping criterion being the number of inhabitants in the urban area.

The groups were thus formed:

• Group 1: 47 Tourist Resort Municipalities with an urban population of up to 56,606 inhabitants.

• Group 2: 23 Tourist Resort Municipalities with an urban population of more than 56,606 inhabitants;

Figure 3 shows the optimum number of clusters for municipalities that are not tourist resorts.

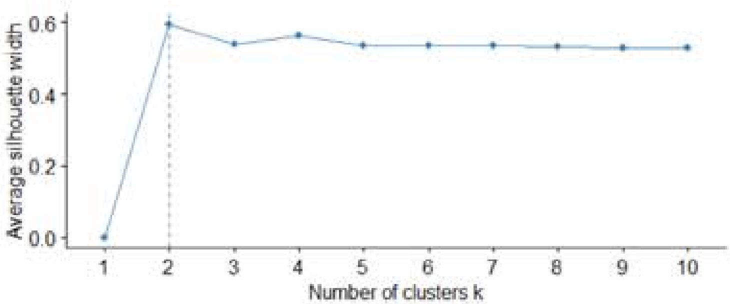

Figure 3 – Definition of the number of *clusters* for the set of Municipalities Not in Tourist Resorts using the *Elbow Method*.

The clusters were formed as follows:

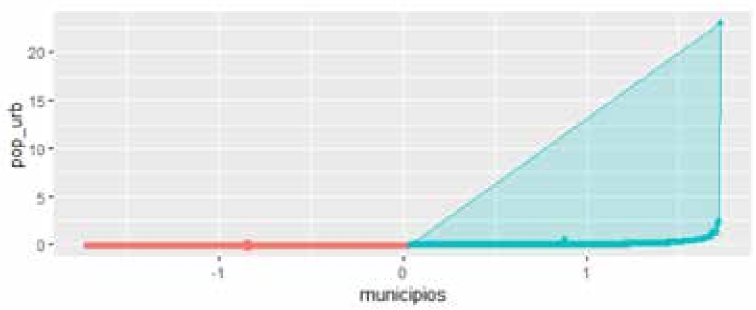

Figure 4 – Clusters using the *k-means* method, with the grouping criterion being the number of inhabitants in the urban area.

So two more groups were formed:

- Group 3: 288 non-resort municipalities with an urban population of up to 10,216;
- Group 4: 278 non-resort municipalities with an urban population of more than 10,216;

3.5. Bootstrap

The *bootstrap* is a non-parametric statistical resampling technique. Using this technique, samples of the same size as the original sample are taken, with replacement, a process that is repeated countless times (in this study, 3000 repetitions were applied). This process allows a distribution of the variable of interest to be created, allowing inferences to be made and information to be drawn about the parameters studied.

DEA is a method that measures efficiency in relation to an estimate of the production frontier, although the literature sometimes refers to it as deterministic. Frontier estimators are obtained from finite samples, which makes them susceptible to sampling variations (SIMAR and WILSON, 1998). The *bootstrap* provides an approach to estimating the sample variation of efficiency estimators. With it, it is possible to correct the bias of DEA estimators and construct a confidence interval (SIMAR and WILSON, 2000).

In this study, the *bootstrap* was applied to the DEA that showed the best efficiency index among the three sets of variables used as *input* (demographic, budget or income). As a result, the technical efficiency index (DEA), the bias-corrected technical efficiency index and the confidence interval for the technical efficiency index were calculated.

3.6. Calculation of the budgetary impact resulting from the inefficiency of IPTU collection in each municipality

Based on the technical efficiency index found, the theoretical IPTU was calculated, i.e. the amount of IPTU that would be collected by each municipality if they were all on the same efficiency line. This calculation is done by dividing the amount of IPTU collected by the efficiency index found. We then subtract the value of the IPTU actually collected from the value calculated as theoretical IPTU. The difference is the budgetary impact on each municipality of its collection inefficiency.

The value of the budget impact was calculated considering the efficiency index originally found by DEA, but also for the technical efficiency index corrected for bias and in the form of a confidence interval, values arrived at using the *bootstrap*.

4. RESULTS

Let's move on to the results of applying the DEA model to each group [2]

4.1. Group 1: Municipalities classified as tourist resorts with an urban population of up to 56,606 inhabitants.

Group 1, made up of the 47 smallest tourist resort municipalities, showed efficiency curves for the three sets of variables, as shown in figure 5.

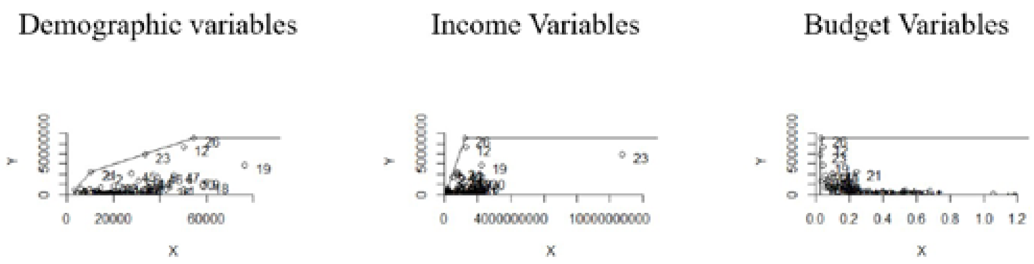

Figure 5 – DEA efficiency curves for the 3 sets of variables in group 1..

Having chosen the best of the three sets of variables (demographic, income or budget) as the technical efficiency index, the municipalities with the worst IPTU collection efficiency are

2 The input budget variables were multiplied by 1,000,000 exclusively for the construction of the graph representing the efficiency frontier in order to improve its visualization.

shown in Table 3 (full list in the Appendix).

Municipality	Type of Variables with better technical efficiency	RVE (Technical Efficiency)
Cunha	Demographic	4,48%
Ilha Solteira	Budget	4,70%
Pereira Barreto	Demographic	5,62%
Joanópolis	Budget	5,97%
Eldorado	Income	6,16%
Bananal	Demographic	6,42%
Morungaba	Income	7,75%
Nuporanga	Income	8,16%
Presidente Epitácio	Demographic	10,55%
Caconde	Demographic	13,69%

Table 3 - Municipalities in group 1 with the worst efficiency levels.

4.2. Group 2: Tourist resort municipalities with an urban population of more than 56,606 inhabitants

Group 2 was made up of 23 municipalities and its efficiency curves are shown in figure 6.

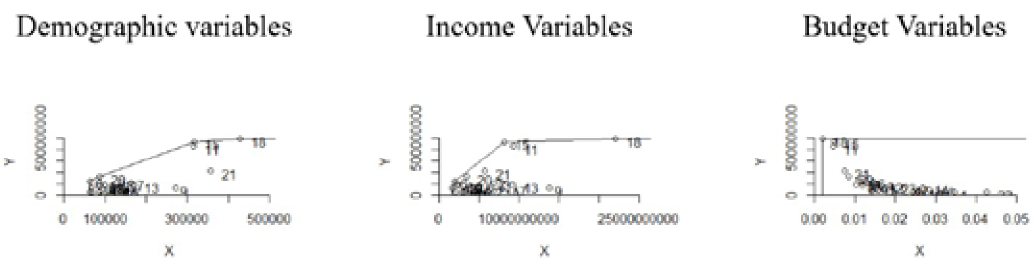

Figure 6 - DEA efficiency curves for the 3 sets of variables in group 2.

The least efficient municipalities (considering the best index among the three sets of variables) are shown in Table 4 (full list in the Appendix).

Municipality	Type of Variables with best technical efficiency	RVE (Technical Efficiency)
São Roque	Income	14,08%
Tupã	Income	17,21%
Itanhaém	Budget	17,92%
Guaratinguetá	Demographic	18,50%
Itu	Income	19,43%
Embu das Artes	Income	19,45%
Ribeirão Pires	Demographic	22,70%
Atibaia	Income	25,92%
Bragança Paulista	Income	27,56%
Macaws	Income	28,42%

Table 4 - Municipalities in group 2 with the worst efficiency levels.

4.3. Group 3: Municipalities not classified as tourist resorts, with an urban population of up to 10,216

After running the model with 288 municipalities, the efficiency curves shown in figure 7 were formed.

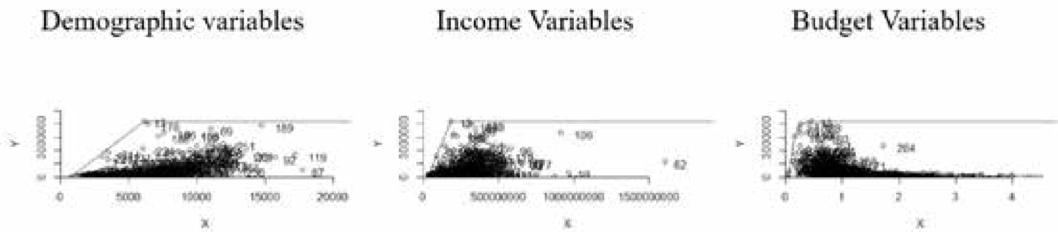

Figure 7 - DEA efficiency curves for the 3 sets of variables in group 3

Having selected the best efficiency indices from the three sets of variables, the municipalities with the worst technical efficiency indices are shown in Table 5 (full list in the Appendix).

Municipality	Type of Variables with best technical efficiency	RVE (Technical Efficiency)
Indiaporã	Income	0,88%
Queiroz	Demographic	2,05%
Lutetia	Demographic	2,13%
Macedonia	Income	2,23%
Mirassolândia	Demographic	2,84%
Paranapuã	Demographic	2,92%
North Star	Income	3,53%
Plateau	Demographic	3,77%
Lucianópolis	Demographic	3,99%
Taciba	Budget	4,48%

Table 5 - Municipalities in group 3 with the worst efficiency levels

4.4. Group 5: 278 municipalities not classified as tourist resorts, with an urban population of more than 10,216 inhabitants

Figure 8 shows the efficiency frontiers for group 4.

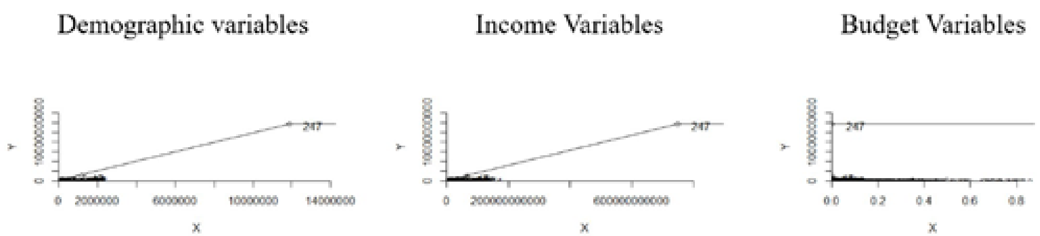

Figure 8 - DEA efficiency curves for the 3 sets of variables in group 4

Choosing the best technical efficiency indices from the three sets of variables, the municipalities with the worst indices are shown in Table 6 (full list in the Appendix).

Municipality	Type of Variables with best technical efficiency	RVE (Technical Efficiency)
Macatuba	Demographic	2,86%
Igarapava	Demographic	4,15%
Apiaí	Income	6,10%
Agudos	Demographic	7,33%
Valparaíso	Demographic	9,65%
Miguelópolis	Demographic	10,47%
Paulinia	Demographic	10,70%
Buri	Demographic	11,52%
Américo Brasiliense	Income	11,83%
Luís Antônio	Demographic	12,16%

Table 6 - Municipalities in group 4 with the worst efficiency levels

4.5. Main findings

4.5.1 Scale efficiency analysis

DEA was used to calculate the efficiency indices considering four levels of returns to scale: Variable Returns to Scale (VLS), which also represents the level of (pure) technical efficiency, Constant Returns to Scale (CRS), Non-Decreasing Returns to Scale and Non-Increasing Returns to Scale. DEA was used to calculate the relative efficiency index for three sets of variables (demographic, income or budgetary) and the efficiency indices for the set of input variables that showed the highest level of technical efficiency were selected.

The scale efficiency index was calculated by dividing the index calculated for RCR by the index calculated for RVE, while the types of returns to scale were calculated as follows: when the RCE index is equal to the RVE index, the DMU operates with constant returns to scale. When the RCE index is different from RVE and the RNC index is equal to the RVE index, the DMU operates with decreasing returns to scale. And when the RCE and RNC indices are different from the RVE index, the DMU operates with increasing returns to scale.

Once the calculations have been made, we have 6 possible diagnoses depending on the type of scale efficiency in which the DMU operates, combined with the existence or not of technical efficiency, as shown in figure 9. A full list of the results of the Scale Efficiency Analysis can be found in the Appendix.

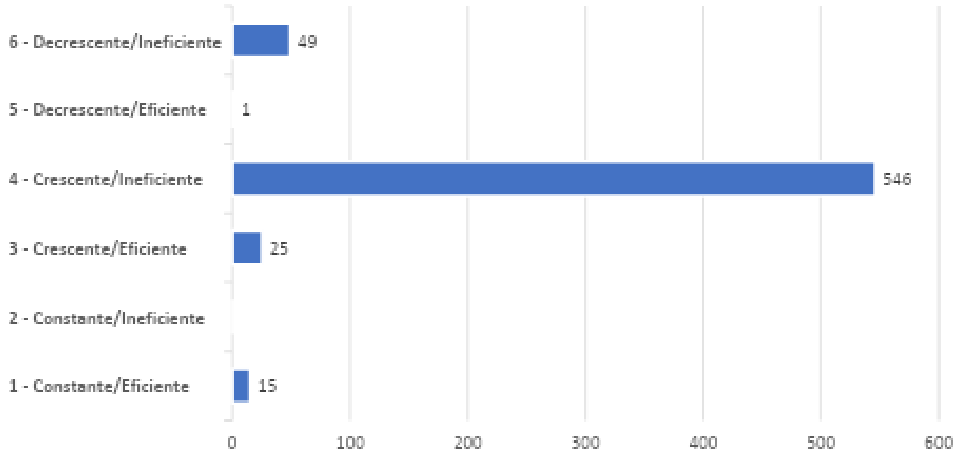

Figure 9 – Number of municipalities by type of diagnosis

Although the recommendations that the literature prescribes for each of the six diagnoses are limited in this case, given that we are dealing with DMUs that do not have full control over the levels of the *input* variables, nor full control over the scale of production, some recommendations can be very useful for improving the collection of IPTU by the various municipalities.

As the DEA model used here is product-oriented, since municipal administrators have little or no control over the input variables used, any technical inefficiency found can be corrected by increasing the level of taxation. There is even less control over the level of scale, leaving administrators interested in improving scale efficiency to set up municipal consortia, pooling tax administration efforts or improving the level of technology used.

The municipalities with the best situation are those with constant returns to scale and maximum technical efficiency (diagnosis 1 - Constant/Efficient). This diagnosis indicates that the DMU operates on an optimum scale without wasting resources. In all, 15 municipalities had this condition.

No municipality presented diagnosis 2 - Constant/Inefficient. This diagnosis would indicate that the DMU would be operating on an optimum scale, however, there would be technical inefficiency, which would indicate that there could be an increase in the value of IPTU collection considering the *input* levels adopted in the model.

Diagnosis 3 - Growing/Efficient was verified in 25 municipalities. This means that these municipalities are technically efficient, but the volume of production is on a sub-optimal scale.

The overwhelming majority of DMUs presented diagnosis 4 - Growing/Inefficient (546 Municipalities), which indicates the existence of two problems: technical inefficiency and scale inefficiency. Scale inefficiency stems from the fact that DMUs are operating below the optimum scale. Municipalities with this diagnosis that aim to improve their tax collection efficiency should increase the level of taxation and at the same time, as far as possible, increase their scale.

Only one municipality presented diagnosis 5 - Decreasing/Efficient, which indicates that this DMU, although technically efficient, is operating above the optimum scale. Improving technology could be an alternative for increasing productivity.

Diagnosis 6 - Decreasing/Inefficient was presented by 49 municipalities. In this situation, the DMU is operating above the optimum scale and there is also technical inefficiency. There is room for increasing the level of taxation and improving technology could be an alternative for improving scale efficiency.

4.5.2. General analysis and bootstrap results

The total collection of IPTU in the state of São Paulo, in the municipalities analyzed, in 2020, was R$ 24,709,965,105.69 (R$ 24.7 billion).

The best index obtained among the three sets of variables was indicated as the municipality's relative efficiency index and, based on this, it was calculated that the potential IPTU collection from these municipalities is R$36,212,354,453.66 (R$36.2 billion). In other words, the budgetary impact resulting from the inefficiency of IPTU collection in the municipalities that had a relative efficiency index of less than 1 (considering the best index among the three sets of variables analyzed), added together, is R$11,502,389,347.97 (R$11.5 billion), which is equivalent to 31.76% of potential collection. The results by municipality can be found in the Appendix.

When we apply the *bootstrap* to the DEA model, the bias correction of the estimators reveals a much higher level of technical inefficiency, as shown in Table 7, resulting in a potential revenue of R$ 47,512,268,135.59 (R$ 47.5 billion), and a budget impact of around R$ 22,802,303,029.90 (R$ 22.8 billion), i.e. 47.99%. Using the *bootstrap* to create a confidence interval, we arrive at a potential revenue of between R$ 38,103,155,714.64 (R$ 38.1 billion) and R$ 55,059,924,852.83 (R$ 55 billion) or a budget impact of between R$ 13,393,190,608.95 (R$ 13.3 billion) and R$ 30,349,959,747.14 (R$ 30.3 billion).

IPTU collection	Loss due to technical inefficiency	Loss due to technical inefficiency, with bias correction	Minimum impact (confidence interval)	Maximum impact (confidence interval)
R$ 24.709.965.105,69	R$ 11.502.389.347,97	R$ 22.802.303.029,90	R$ 13.393.190.608,95	R$ 30.349.959.747,14

Table 7 - Total budget impact caused by IPTU collection inefficiency

The relative size of this impact, however, does not behave in the same way in each group analyzed. Table 8 shows the results for each group of municipalities.

Group	Collection of IPTU	Loss due to technical inefficiency	Loss due to technical inefficiency, with bias correction	Minimum impact (confidence interval)	Maximum impact (confidence interval)
1	R$ 450.174.793,08	R$ 261.549.304,91 36,75%	R$ 476.488.053,09 51,42%	R$ 294.823.734,81 39,57%	R$ 658.035.880,54 59,38%
2	R$ 2.924.383.604,87	R$ 752.021.464,94 20,46%	R$ 1.184.849.820,70 28,83%	R$ 810.130.733,61 21,69%	R$ 1.589.410.159,65 35,21%
3	R$ 180.035.911,57	R$ 469.135.092,53 72,27%	R$ 611.574.762,95 77,26%	R$ 503.616.462,01 73,67%	R$ 727.541.161,29 80,16%
4	R$ 21.155.370.796,17	R$ 10.019.683.485,58 32,14%	R$ 20.529.390.393,15 49,25%	R$ 11.784.619.678,52 35,78%	R$ 27.374.972.545,67 56,41%

Table 8 – Total budget impact caused by IPTU collection inefficiency, by group of municipalities. The percentages refer to the relative size of the budget impact in relation to potential collection.

It can be seen that both in groups 1 and 2, made up of tourist resort municipalities, and in municipalities 3 and 4, made up of non-tourist resort municipalities, there is a tendency for the relative budget impact to decrease as the size of the municipality's population increases.

5. FINAL CONIDERATIONS

The IPTU can have important fiscal effects, as it is a tax that is not subject to the volatility of economic cycles, guaranteeing a constant source of revenue for municipalities.

The literature has long pointed out the underutilization of this tax and how beneficial it would be to have a higher tax on property, not necessarily in order to increase the tax burden, but eventually to make it possible to replace the tax on consumption, contributing to a more equitable tax matrix.

In this work, the DEA model was used with three sets of *input* variables to calculate the municipality's relative efficiency index in IPTU collection: demographic, income and budgetary.

Once the best technical efficiency index had been chosen from the three sets of *input* variables, the levels of scale efficiency were analyzed. Finally, the *bootstrap* was used to correct the bias of the DEA estimators and create a confidence interval, which allowed the results of the budgetary impact of inefficiency to be presented both by the original level of relative efficiency calculated and by the level of relative efficiency corrected for bias and in the form of a confidence interval.

Among the 636 municipalities studied, 546 (85.84%) showed increasing returns to scale and technical inefficiency, which indicates room for increasing the level of taxation and improving scale.

Some municipalities have such a small population that the total amount of revenue that could be collected makes any investment in improving the structure of their tax administration questionable, i.e. the low level of tax collection efficiency could be explained by the low cost-benefit of investing in the apparatus needed to increase collection (information technology tools, qualified personnel, real estate appraisal methods, etc.). The evolution of technology, on the other hand, has lowered costs, allowing more and more small municipalities to improve their tax administration without major investments. The formation of municipal consortia is another possible alternative for bringing together smaller municipalities and generating a scale that allows investments to be made. States and the Federal Government can also be a source of support for municipalities by sharing information and tools needed for tax administration.

In this sense, the National Land Information Management System - Sinter (a public management system that integrates cadastral, geospatial, fiscal and legal data relating to real estate) and the Brazilian Real Estate Registry - CIB (a database that is part of Sinter, in which real estate units will be registered), established by Federal Decree no. 8.764/2016 and currently governed by Federal Decree no. 11.208/22, can be an important tool in helping municipalities, especially those with smaller populations, to improve their land registry.º 8.764/2016 and currently governed by Federal Decree nº 11.208/22, which are currently beginning to be implemented, can represent an important tool in helping municipalities, especially those with smaller populations, to improve their tax management.

The literature also points out that smaller municipalities, due to the fact that their managers are closer to taxpayers, are under greater political pressure from groups of property owners to maintain low levels of property taxation. The tendency for the level of efficiency to increase for groups of municipalities with larger populations, found in this study, can be pointed to as evidence for this thesis. In this sense, changing legislation at federal level, either by establishing minimum tax parameters or by creating incentives for higher (or disincentives for lower) levels of efficiency, could mitigate this problem.

The merits of this work, however, lie in using a *benchmarking* method and demonstrating that, regardless of any measures that may be taken at federal level that could contribute to a better structuring of municipal tax bases, it is possible to identify the best practices so that they can be taken as a basis for a restructuring that each municipality can do on its own.

By using a DEA model, it was shown that, given the combination of socio-economic factors that have long been pointed out in the literature as likely to influence the level of property taxation, there are municipalities that achieve a much higher level of efficiency than others and that could serve as an example for these others to promote restructuring in order to improve their level of budgetary autonomy or the quality of services provided to their population, without relying on aid from the Union and States.

Another merit of the work is that it provides a quantitative parameter of relative efficiency which, while on the one hand values the efforts of those municipalities that achieve a higher level of tax collection efficiency, on the other shows how much the efficiency of others can be improved, once the socio-economic conditions are in place to do so.

Finally, since the model used is based on a comparison between municipalities, it shows that it is feasible to make better use of IPTU for most municipalities (which had indices below the efficiency frontier) and also demonstrates the potential increase in revenue for each municipality's budget if restructuring brought them to the same level of efficiency as the municipalities with the best indices.

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