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The Property Tax Base and its Revenue Potential: The Case of Brazil

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Abstract

Since 2000, the municipal urban property tax in Brazil has generated revenue of between 0.4% and 0.5% of GDP; however, there is a need to increase revenues to fund municipal governments that are affected heavily by the recent economic and fiscal crisis. Data availability restricts the scope of this study to medium and large municipalities with populations exceeding 70,000. First, the study simplifies the original Bahl’s Property Tax Identity, where property tax performance is a function of tax base size, cadastral coverage, taxation on market values and collection rate. A linear regression model is used to predict the tax base size (urban market values), which is estimated to be between one and four times the municipal GDP in most of the municipalities. Using a stochastic frontier model based on the best indicators of taxation and collection found in each one of the three clusters established by this study, the potential tax burden is estimated at 1.4% of GDP. The study identifies the main causes of heterogeneity of municipal performance heterogeneity as differences in urban property tax base size (moderate effect) and collection rates (high effect). Indeed, compared to lower-income municipalities, high-income municipalities have a larger tax base (3.2 versus 1.2),

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higher collection rates (81% versus 46%), and therefore higher ratios of property tax to GDP (0.70% versus 0.18%). The study proposes reforms at national and local level, including the tax base expansion to rural properties, cadastral reforms focused on taxpayer identification, and collection-led strategies with the use of less costly instruments to recover arrears. It also highlights some policies to increase the tax burden equitably, such as the establishment of a four-year assessment cycle, the relaxation of rules to promote local revaluations, and the use of progressive and selective tax rates.

Keywords: property tax; tax performance and potential; federalism; local finances

JEL Codes: H7, H71

1. Introduction

The Brazilian property tax system comprises two recurrent taxes on immovable properties: the rural property tax levied by the federal government and the urban property tax levied by 5,570 municipal governments. The rural property tax, or *Imposto Territorial Rural* (ITR), was not designed for fiscal purposes, but as an instrument of land reform and rural development. Its revenues have been insignificant, between 0.02% and 0.03% of Brazil's GDP for the period of 2012 to 2016. On the other hand, the urban property tax, or *Imposto Predial e Territorial Urbano* (IPTU), has generated around 0.45% to 0.5% of Brazil's GDP during this period and has comprised about 10% of all municipal revenues[2] (STN 2017). In 2016, Brazil was still under the average OECD ratio of 1.2% and some other developing countries, such as South Africa (1.2%), and Colombia and Uruguay (0.9%) (IMF 2017; OECD 2017).

The current level of Brazil's urban property tax does not achieve its potential, which has been estimated at about 1% of Brazil's GDP by some studies (Carvalho Jr. 2017; De Cesare et al. 2014; Orair and Albuquerque 2016). Additionally, the level of revenues is very heterogeneous amongst municipalities, being highly concentrated among the largest and richest ones. In 2016 for instance, the Municipality of Sao Paulo alone accounted for 25% of all urban property taxes revenues in Brazil, and 1% of all municipalities raised

[2] This indicator is a national mean, which is greatly impacted by the performance of large cities. However, the usual share of property tax of total revenues has been less than 2% in 80% of all municipalities.

67%. This concentration is much higher than the GDP concentration of these two examples, which was 11% for Sao Paulo and 42% for the 1% of municipalities. In addition, the mean indicator of property tax performance (the ratio of property tax to GDP) is about three times greater in Southern municipalities than Northern municipalities (0.08% versus 0.25%), or between municipalities with populations lower and greater than 600,000 (0.19% versus 0.53%).

There are two reasons why these findings are topical for Brazil's positions on municipal finances and federalism. First, the 2011 to 2014 real estate bubble likely enhanced the horizontal and vertical regressivity in property taxation since assessed values did not increase proportional to market values.[3] Second, since 2015, Brazil's economic downturn has reduced both the amount of governmental transfers to municipalities[4] and the revenues from municipal sales tax on services, generating an urgent need to enhance property taxation in an efficient and equitable way to fill this budget gap.

This study tests three main hypotheses in an effort to explain the low and heterogenous level of property tax performance, which will be useful in the design of a feasible scenario of revenue potential based on municipalities' specificities. The first hypothesis tests whether municipalities present urban property tax bases that are heterogenous in size. Second, it needs to be established whether the level of taxation on market values is heterogenous among municipalities due to, for example, shortcomings on valuation systems or an over-taxation on non-residencial properties. The third hypothesis entails the test whether the level of collection is heterogenous among municipalities due to, for example, shortcomings in tax administration or the harder collection on vacant land parcels.

Bahl (1979) formulated an identity where the level of property tax in a jurisdiction is a function of the property tax base size, cadastral coverage, assessment level, tax rate and collection rate. This identity was used by many other authors to estimate the property tax potential in a country, such as, Bahl and Martinez-Vazquez (2008), Bahl and Wallace (2008), Carvalho Jr. (2017), De Cesare et al. (2014), Lewis (2003) and Norregaard (2013).

[3] Horizontal regressivity in property taxation occurs when properties with similar market values are taxed in a very different level while vertical regressivity occurs when high market valuated properties are taxed in a lower level than low market valuated properties. Both distortions are due to shortcomings in the assessment systems.

[4] The per capita level of governmental transfers was reduced by 8% from 2014 to 2017.

The study therefore has three main objectives: a) to estimate the size of the tax base at local level (urban market values); b) to establish a feasible scenario of revenue potential among medium and large municipalities (municipalities with population greater than 70,000)[5], and c) to identify the causes of the low and heterogeneous property tax performance in Brazil.

The municipal indicators of the level of taxation on market values and the collection rate will be gathered or estimated to identify what has caused the sizable property tax disparities among Brazilian municipalities. Therefore, the study's main contribution to the literature is that it considers all property tax performance determinants in the analysis and establishes a method to estimate the urban property tax base size at local level, which is primordial to determine a property tax potential.

This research paper is divided into five sections. The first section reviews the relevant literature; the second section describes briefly how the property tax works in Brazil, given some details of the legislation and empirical data on the fiscal cadastres, valuations, tax rates and collection. The third section describes the research methodology, explaining the property tax performance identity first developed by Bahl (1979). The fourth section develops an econometric model to predict the size of the urban property tax base in a municipality. Finally, the fifth section estimates the level of taxation on market values as a residual term of Bahl's identity to identify which ratio(s) has caused the performance disparities in Brazil through a correlation analysis. This section also designs a feasible scenario of property tax revenue potential in Brazil amongst medium and large municipalities.

2. The Literature Review

This section briefly describes the literature on two topics: the size of the property tax base and its relation with property market values and GDP level, and Bahl's property tax identity of ratios that will be used to estimate the property tax potential.

[5] The choice of this level of population is to avoid any sample bias in the estimations, since the available data source mostly comprises municipalities with populations greater than 70,000.

2.1 The Size of the Property Tax Base

Case, Quigley and Shiller (2011: 7) use data of the Federal Reserve Flow of Funds and the Bureau of Economic Analysis to estimate that residential market values amounted to approximately 110% of the United States' GDP in the period from 1980 to 2002. The indicator increased to about 160% in the 2005 to 2007 period due to the real estate boom. The authors explain that the housing credit boom caused real estate prices to triple in large cities, such as Miami and Los Angeles. Real estate market values therefore vary greatly over time and among different jurisdictions.

According to Dickson (2007), Chinese house prices rose by 130% from 1999 to 2009, while household income increased by only 83%. Xu (2017) demonstrates that interest rates, income and economic growth have complex and interdependent relationships with house prices in China. Xu (2017) also finds that household income and GDP growth are positively related to house prices; every 1% rise in GDP leads to a 0.37% increase in house prices.

2.2 The Property Tax Performance Identity

Bahl (1979), Linn (1980) and Bahl and Linn (1992) were three of the first studies that evaluated property tax performance in a country based on an identity of ratios (Lewis 2003). This identity states that property tax performance is related to six main indicators: two policy ratios (tax base and tax rate), three administrative ratios (cadastral coverage, valuations and collection) and one exogenous ratio (property market values).

The identity is based on the rationale that any tax revenue is a result of a certain tax rate applied on a tax base. However, property tax is somewhat different from most other taxes since its tax base (the property value) needs to be correctly registered, assessed and collected. The main strength of this model is its focus on four political and administrative indices (registration, assessment, tax rate and collection) that policy makers can control. Other property tax performance models, such as, the Stochastic Frontier Analysis developed by both De Cesare et al. (2014) and Orair and Albuquerque (2016), or the Fuzzy Sets Approach developed by Afonso et al. (2016), rely on economic indices as a proxy for the direct determinants of the property tax revenue. Therefore, these latter models cannot estimate the direct impact of an administrative reform.

On the other hand, the main model shortcoming is that the tax base size ratio is an exogenous variable and may vary greatly over time, demanding its recurrent (and hard) estimation. In addition, there are some challenges in the other ratios that the model does not evidence, as explained by three examples. First, the model does not take into account the financial costs and the demanding scale to implement a modern cadastral, assessment and collection system. Second, despite a given general assessment ratio, the model does not evidence the accuracy level in the assessment, which may provoke vertical and horizontal inequality. Third, despite a given general taxation level, the model does not take into account the different types of taxpayers that have different preferences or capacities to bear a certain tax rate, such as commercial properties, low-income individuals or vacant plots.

As examples of empirical studies, Kelly (2000, 2004) uses the Property Tax Performance Identity to determine the property tax performance in Kenya, while both Kelly (2003) and Lewis (2003) apply it to Indonesia following the administrative reforms undertaken by its central government. Bahl and Martinez-Vazquez (2007), Bahl and Wallace (2008) and Norregaard (2013) also propose a general identity of ratios to estimate property tax performance in a country, which is the decomposition of the ratio of property tax revenues to GDP. The authors note three major challenges with this approach. The first is stipulating an optimum level of property tax revenues. The second is the lack of data. The third is the inability to take the financial, administrative and political costs of implementing suggested ratio improvements into account. The authors highlight that the revenue yields must be high enough to compensate the upfront costs of any reform. This identity of ratios (Bahl's Identity of Property Tax Performance) is given as follows:

$$PT/Y = MV/Y * CC * VR * RR * CR \quad (1)$$

where PT is property tax revenue; Y is the country's GDP; MV is the market value of all properties; CC is the cadastral coverage ratio, which is the ratio of the market value of properties on fiscal cadastres to the market value of all properties; VR is the valuation ratio, which is the ratio of the assessed value of properties on fiscal cadastres to the market value of properties on cadastres; RR is the rateable ratio, which is the ratio of total tax levied to total assessed value; CR is the collection ratio, which is the ratio of total tax collected to total tax levied.

It is important to detail other case studies that apply the mentioned identity. Bahl *et al.* (2009) estimate all of India's property tax yields and potential through a sample of the 36 most populated Indian local governments. At the time of the study, India had a total of 5,161 local governments and the authors established three estimations through three different assumptions. In the first estimation, the property tax performance indicators in the remaining 5,125 municipalities were equal to the four less populated municipalities in their sample. In the second estimation, the indicators were equal to the sampled municipally with the lowest per capita revenues. Finally, in the third estimation, the remaining municipalities had their performance indices based on the sampled municipalities with the lowest per capita revenues in their respective states. The study finally estimated that the property tax revenues were likely to be between 0.15% and 0.23% of Indian GDP, with the potential to achieve 0.8% if an index of 85% for both collection and coverage ratios was achieved. Carvalho Jr. (2013, 2014) formulates a similar model to estimate cities' property tax performance in Brazil, studying Rio de Janeiro and São Paulo.

3. An Overview of the Property Tax Determinants in Brazil

This section analyses the main characteristics of property tax determinants in Brazil: the tax base size, the cadastral coverage, the valuations level, the tax rates and the collection rate.

3.1 Tax Base

Despite municipal autonomy in legislating and managing their own urban property tax systems, municipalities are bound by national rules. For example, the Brazil's National Tax Code establishes fair market value as the urban property tax base, which theoretically would be properties' capital value at its highest and when used best. In addition, the same legislation provides the rules to classify a property as urban, which must be a property located within the legal urban zone, with nonrural use and benefiting from certain urban services. In addition, Brazil's 1988 Constitution exempts all governmental properties and those of religious entities, political parties, unions and charities; municipalities however have autonomy to expand this roll of exemptions.

3.2 Fiscal Cadastres

Municipalities also have full autonomy in establishing and managing their own property tax cadastres. This may provide a revenue incentive to keep records transparent, comprehensive and recurrently updated, to choose a method or technology to update records in keeping with the local reality, to treat taxpayers equally and resolve their complaints, and finally to collect the tax efficiently.

The economies of scale in cadastral administration greatly increase when the number of assessed properties exceeds 750,000 (IPTI, 2007; as cited by De Cesare, 2012); however, 70% of municipalities have fewer than 20,000 inhabitants. This evidences the reality of many precarious cadastres in Brazil; De Cesare (2017) relies on data of the IBGE (2013) to state that about 30% to 40% of poorer municipalities still use paper cadastres. Carvalho Jr. (2017) reports that 82% of a sample of municipalities reporting the use of digital cadastres with Geographic Information Systems (GIS); this indicator is however reduced to 40% amongst the poorest municipalities. The same study also finds that while fiscal cadastres cover 77% of residential properties, on average, the metric drops to 60% in metropolitan areas due to their higher level of informal settlements.

Recently, comprehensive cadastral updates performed by some municipal governments may raise the number of taxable properties significantly, promote synergies with valuations and collection systems, and generate substantial revenue outcomes. For example, the taxable properties of Manaus rose by 67% between 2010 and 2013, while real revenue rose by 105% between 2010 and 2014. In Salvador, taxable properties increased by 41% in 2013, while real revenue rose by 66% in 2014.

3.3 Valuations

Despite the existence of a national guideline and technical standard on property valuation for non-fiscal purposes, Brazilian municipalities have the autonomy to choose their own cycle of revaluations and design their own method of valuation for property tax purposes. The most-used method of valuation has been the Cost Approach, where land zone values and construction cost values are specified separately. The method has been chosen for tradition, simplicity and transparency; the assessment entails the summation of the adjusted statutory values of construction costs and land zones.

Franzsen and McCluskey (2013) note that the same simplified cost approach method is used in Indonesia, and may also be convenient for other developing countries.

National interference on municipal property taxation however stems from a jurisprudence of the Superior Court of Justice that requires valuations to be specified in a municipal law. Politics was thus introduced into the revaluation process since bills must be passed on municipal-council level. Therefore, revaluations may be postponed, limited or rejected by them, being adjusted by only the official inflation index for many years. Although cases of outdated valuations in large Brazilian cities, such as in Belo Horizonte (2010), Porto Alegre (1992) and Joao Pessoa (1972) exist, there is a recent trend of municipal revaluations due the fiscal crisis, as occurred in Salvador and São Paulo (2014), Recife (2015) and Rio de Janeiro (2018). Carvalho Jr. (2017) finds that, on average, valuations ware eight years outdated according to a sample of 47 municipalities.

3.4 Tax Rates

Tax rates are an important element to predict the amount of revenue that a property tax system will generate. Although the Brazilian Constitution explicitly permits progressive tax rates and their annual increase on vacant land to encourage land development,[6] municipalities have full autonomy to set the tax rates and their mechanisms of discretion.

Carvalho Jr. (2009) catalogues that statutory tax rates in a sample of 365 municipalities are generally between 0.2% and 1.5% for residential properties, between 0.5% and 2% for commercial properties and between 1.0% and 6.0% for vacant land parcels. Effective tax rates on assessed values are much lower however, at 0.6% for residential properties, 1% for commercial land and 1.6% for vacant land (Carvalho Jr. 2017). In addition, 66% of the municipalities had a proportional system, 14% a progressive system and 20% applied other mechanisms of discretion.

Local property tax exemptions are generally granted to low-valuated residential properties, generally not covering more than 15% of the local cadastres. There are cases of significant exemptions granted for political reasons though, such as in Rio de Janeiro (60%) and São Paulo (32%) (Carvalho Jr. 2017).

[6] Progressive tax rates have been widely applied by municipalities to increase equity and the overall taxation level; however, the annual increase of tax rates to encourage land development, the *IPTU Progressivo no Tempo* has not been implemented widely due to its complex regulation and administration.

3.5 Collection

Implementing efficient instruments of property tax billing, collection and enforcement is primordial to achieve any fiscal, distributive or urban policy (Kelly 2013). Unlike many developing countries, Brazil is very efficient in the way it addresses property, its postal services, banking system and telecommunications. Property tax billing is therefore generally not a great concern if taxpayers' personal information is correctly registered and updated. However, the indicators of the collection rate in Brazil are diverse and depend largely on the local fiscal culture and the types of properties that are registered. Evidence shows that collection rates are higher in larger municipalities than smaller ones (76% versus 44%), and also higher in southern municipalities than northern municipalities (67% versus 44%) (Carvalho Jr. 2017; IBGE 2001). The causes of higher ratios among large municipalities are relatively straightforward, since they tend to have better tax administration. In the case of the higher ratios amongst southern municipalities, their better fiscal culture, higher level of legalised construction and higher non-residential tax base have been identified as the main reasons for higher collection rates. Indeed, if a great share of the cadastre consists of vacant land, low-income or informal properties, tax collection tends to be harder.

Brazil has a wide range of property tax enforcement instruments, although they are rarely applied to their full potential by municipal governments. The most common instrument applied has been the costly and time-consuming tax liens. Cunha, Klin and Pessoa (2011) find that the average time of a federal tax lien conclusion has been nine years and the probability of a full recovery of arrears has been about 25%, while its average administrative cost has been approximately five Brazilian minimum wages.[7] Carvalho Jr. (2017) finds that tax liens were the only enforcement instrument applied in about 50% of a sample of 47 municipalities.

Under this scenario, some municipalities have increasingly explored other legally permitted means of property tax enforcement, such as the issue of a Notice of Dishonor, which places delinquents on the national blacklist. In addition, intermunicipal corporations in tax administration can be created to improve economies of scale and scope, and to reduce administrative costs. For example, Ribeiro et al. (2014) studied the successful case of 24 Brazilian municipalities that instituted a multi-purpose inter-

[7] In June 2018, five times the minimum wage amounted to US$1,150.

municipal corporation to promote regional development, which included a digital mapping of their rural areas and the unification of the tax collection procedures.

4. Methodology

This section describes the methodology of this study and the available data; it will also provide a simplification of the original Bahl's property tax performance identity.

4.1 Available Data

This study uses data from the following Brazilian and international institutes that recurrently release relevant publications and datasets with information regarding the real estate market and property taxation.

The Brazilian Institute of Geography and Statistics (IBGE) is the official statistics institute that performs several census and surveys, including the (decennial) Brazilian Demographic Census, and the calculation of national and municipal production (GDP). The Demographic Census compiles very comprehensive demographic and household data, including level of per capita income and the type of residential construction. IBGE also currently releases (with a lag of two years) a survey, The GDP of Brazilian Municipalities, that catalogues municipal GDP. This survey compiles the level of production of the agricultural, industrial, services and governmental sectors that occurred in each municipality.

Brazil's National Treasury (STN) has a relevant database, The Fiscal and Accounting Information System of the Brazilian Public Sector (Siconfi), that displays the public finances of all Brazilian municipalities, including the municipal property tax revenues. It is important to mention that according to the Fiscal Responsibility Law, the publication of some balance sheets and financial statements are mandatory to all municipal governments as a condition to receive voluntary transfers from federal and state governments, amongst other enforcement mechanisms in law.

The Foundation Institute of Economic Research (Fipe) is a private foundation that publishes the Fipezap Index of Real Estate Adverts, a price index of real estate in the main Brazilian cities (Fipe 2016). This index is based on internet advertisements of apartments, compiling approximately 500,000 advertisements per month. It has provided evidence of the real estate bubble in Brazil between 2011 and 2014. During the 2009 to 2017 period, the Fipezap Index average annual growth was 10.3%, outstripping real GDP growth of 0.9% as shown in Table 1.

Table 1 Brazil's Real Estate Prices (Fipezap Index) and GDP

Year	Value (December of 2009 = 100)		Growth (in %)	
	Fipezap Index*	Brazil's GDP	Fipezap Index	Brazil's GDP
2009	100	100	-	-
2010	108	108	8.0	7.5
2011	136	110	26.3	2.7
2012	155	111	13.7	0.9
2013	175	114	12.7	2.3
2014	187	115	6.8	0.5
2015	188	110	0.9	-3.8
2016	188	106	0.1	-3.6
2017	182	107	-3.2	1.0

Data source: Fipe (2016); IBGE (2017).

The Lincoln Institute of Land Policy is an international economic research institute based in Cambridge, Massachusetts, which promotes studies in property taxation and land regulation. The institute has an up-to-date database of property taxation in Latin American countries (including Brazil) that will be used in this study to extract assessment levels of 24 municipalities (Lincoln Institute of Land Policy 2018). Carvalho Jr. (2017) also catalogued some municipal assessment levels, which will be used to complement the database sample.

Municipalities or regions in Brazil often have local online newspapers that publish reports about the property tax that is being levied in their communities and also the collection rate in the jurisdiction amongst other relevant data. Carvalho Jr. (2017) collected these local online newspaper reports in 2012 and catalogued the collection rates in 164 municipalities with populations exceeding 70,000.

4.2 Simplification of Property Tax Performance Identity

Due data unavailability, Bahl's original identity has to be simplified. Assessment levels and tax rates level can be merged in a variable named Taxation on Market Values (TMV). This is because the assessment level tends to be inversely related to tax rates. In other words, an increase in assessment level would demand a reduction in the tax rate to generate the same amount of revenues. The simplified Bahl's Indentity of Property Tax Performance is given by Equation 2:

$$PT/Y = MV/Y * CC * TMV * CR \quad (2)$$

where TMV = VR * RR .

Even applying the simplified version of Bahl's identity may be limited due to the lack of data related to these five ratios, especially in developing countries, as discussed below.

The local property tax revenue (PT) is generally available and does not cause great concern in the identity. A problem arises however when revenues need to be given in terms of local GDP (PT/Y) since in many countries the GDP of subnational governments is not estimated. Fortunately, IBGE calculates both national and subnational GDPs for Brazil; however, if an official country estimation is not available, some alternative indices can be applied to determine the subnational shares in a national GDP, such as the local indicators of value-added tax revenues, income, salaries, number of companies or employees, or the energy consumption of non-residential properties.

The tax base size (MV) is a challenging estimation, generally being a residual term of the equation (Bahl and Wallace 2008). In Brazil, MV would be the full market values of all urban taxable properties. However, if a sample of observable MV is available, it can be estimated by a linear regression model.

The cadastral coverage (CC) is generally unknown but may be estimated at residential level by comparing the number of residential properties on the fiscal cadastre to the number of surveyed households in the National Census. Actually, the cadastral coverage needs to be related to the level of cadastres' capture of all market values, rather than the number of all properties. This is because the importance of few high-valuated properties is generally greater than various low-valuated residential properties (Carvalho Jr. 2017; Lewis 2003).[8] Based on the scholarly work of Carvalho Jr. (2017) and the Lincoln Institute of Land Policy (2018), this study stipulates a cadastral coverage of 85% for all jurisdictions.

To calculate the taxation on market values (TMV), indicators for the level of assessment (VR) and taxation on assessed values (TAV) are both necessary. The availability of both ratios is challenging however, and therefore TMV will be determined as a residual term in the equation.

[8] For example, considering that all high-valuated properties are included in a cadastre, its coverage (in terms of all market values) can be greater than 90% even if this cadastre just includes 60% of all properties that exists in the jurisdiction.

Finally, the collection rate (CR) is simply the ratio of the property tax demanded and collected and generally presents no great challenge due to its availability from local governments.

To summarise, the estimation of property tax performance and potential through the simplified Bahl's identity of ratios requires the availability of at least four of its five ratios since one ratio, TMV, will be determined as a residual. Considering that CC is stipulated as 85% by this study, PT/Y is published annually by STN and IBGE, and a sample of CR was recorded by Carvalho Jr. (2017), the next section will estimate MV/Y in other to allow the calculation of TMV.

5. Estimating Urban Market Values per GDP (MV/Y)

The market value of all taxable properties in a jurisdiction constitutes the potential property tax base when capital value is the method of valuation. This is the case in Brazil, where the potential tax base of a municipality is the market values of their urban taxable properties.

The relationship between the revenue potential and the the size of tax base is a key factor in a tax performance analysis. However, in many jurisdictions around the world, data of all properties' market values are not available. This problem may be bypassed using economic indices that may have some correlation to the property market values, such as GDP, per capita income and real estate price indices, among others. For instance, Bahl and Wallace (2008) use a factor of three to four times GDP as a proxy for the total property market values in developing countries. However, this is still not accurate, especially at local level.

5.1 The Relation Between Local GDP and Income

Several estimations of total property market values have already been performed in Brazil. Carvalho Jr. (2009) estimated residential market values as approximately 1.5 times municipal GDP amongst large Brazilian municipalities in 2003, using data from the 2002-3 Brazilian Families' Budget Survey (IBGE 2004), which reports both imputed rentals for owner-occupied residences and rentals effectively paid by tenants. In other studies, using Bahl's Identity, Carvalho estimated all property market values (residential and non-residential) as being about 2.8 times municipal GDP in Rio de Janeiro and São Paulo (Carvalho Jr., 2013; 2014). Thus, an index of three times municipal GDP amongst the largest

Brazilian municipalities may be considered a good proxy for total market values during the 2012-13 period.

However, stipulating properties' market value as three times the municipal GDP in all Brazilian municipalities during the 2013-15 period may be inaccurate, especially amongst the small municipalities. They likely have varying MV/Y ratios. For instance, a more industrial municipality may have high levels of production, but undervalued properties due to the urban and environmental degradation, amongst other negative externalities of industrial cities. On the other hand, dormitory or touristic municipalities may have high-valuated properties but lower industrial production or service provision.

Therefore, this study considers MV/Y as negatively related to the ratio of per capita GDP to per capita income (Y/Income). The main rationale is that in municipalities where per capita GDP is relatively high and per capita income is relatively low, the MV/Y ratio will be lower than in municipalities where this relation is opposite. Carvalho Jr. (2017) estimates MV/Y ratios as being between 0.5 and 5.1 in all Brazilian municipalities in 2011, based on Y/Income ratios only. However, only the cases of Rio de Janeiro and São Paulo were observed to develop this estimation. Also, between 2011 and 2014, Brazil experienced a real estate bubble where real estate prices grew 73%, while the country's GDP rose by only 7% (as shown in Table 1). Therefore, it is expected that the values of MV/Y have risen since 2011.

5.2 The Proportion of Vertical Buildings

The ratio of the number of apartments (vertical buildings) over total residential constructions is a good proxy for the development of the real estate market, which likely influences MV/Y. For example, more vertical cities have more developed real estate markets, higher rates of empty buildings, faster appreciating land plots due to the higher permitted floor area ratios, higher quality of construction, higher number of building projects and stronger effects of the real estate bubble. The proportion of apartments in the total residential households at municipal level is available at Brazil's National Census. This study considers MV/Y as positively related to the proportion of apartments (apart) in a municipality.

5.3 Predicting Urban Market Values

As discussed in the previous section, MV/Y is negatively related to Y/Income and positively related to apartments; data for both are available from IBGE. Carvalho Jr. (2017) and the Lincoln Institute of Land Policy (2018) published data for both the valuation ratio (VR) and total assessed values (AV) in 24 municipalities.[9] There are 24 observable cases of MV/Y, calculated as a residual term of Bahl's identity through Equation 3, where the required data are: total assessed values (AV), valuation ratio (VR) and cadastral coverage (CC):

$$\frac{\text{MV}}{\text{Y}} = \frac{\text{AV}}{\text{VR x CC x Y}} \quad (3)$$

This permits the development of a cross-section log-log regression model to predict MV/Y in the rest of the Brazilian municipalities. Table A in the Annexure displays the dependent variable (MV/Y) and independent variables (Y/Income and apart) in the 24 selected municipalities. Using the data of Table A, a log-log linear regression model was run using IBM/SPSS 19.0 software. Table B in the Annexure shows its statistical outcomes. The outcomes show that the model has an adjusted R^2 of 73%, while Y/Income and apart were at a significant level, with their expected relations and no meaningful correlations. Thus, Equation 4 was designed to predict MV/Y in 2013:

$$\ln(\text{MV/Y})_{2013} = 2.13 - 0.52 \ln(\text{Y/Income})_{2010} + 0.44 \ln(\text{apart})_{2010} + \varepsilon \quad (4)$$

Table 2 describes the percentiles of *MV/Y* frequencies amongst medium and large municipalities[10] by class of population.

Table 2 Ratios of Urban Market Values to GDP (MV/Y)
(Per class of population and percentile, 2013)

Class of Population	No of Municipalities	Perc 10	Perc 25	Perc 50	Perc 75	Perc 90
70,000 – 600,000	414	0.68	1.00	1.48	2.11	2.76
More than 600,000	32	1.46	2.03	2.71	3.47	3.88

Data Source: Carvalho Jr. (2017); IBGE (2011, 2017); Lincoln Institute of Land Policy (2018).

[9] This sample comprises municipalities with a population greater than 200,000, with the exception of Corumbá with a population of 107,347.

[10] This study will conservatively be restricted to medium and large municipalities since the sample of 24 municipalities basically comprises municipalities with population greater than 200,000.

Table 2 shows that 80 percent (percentiles 10 to 90) of MV/Y ratios are from 1 to 2.8 among medium municipalities and from 1.5 to 3.9 among large municipalities. This reveals that MV/Y tends to be much higher in large cities, confirming the evidence of Case, Quigley and Shiller (2001) in the United States. Furthermore, the Pearson correlation between MV/Y and property performance (PT/Y) amongst these 446 medium and large municipalities was 0.38 (excluding outliers). This effect size is considered moderate,[11] which means that the size of the urban property tax base is partially correlated with the revenue performance and other relevant factors (coverage, tax rates and/or collection rate) are likely also causing the revenue disparities in Brazil, as will be discussed in the next section.

6. Estimating Revenue Potential in Medium and Large Brazilian Municipalities

This section will estimate property tax revenue potential amongst the 446 medium and large municipalities in Brazil, that is, those with populations greater than 70,000 according to IBGE.[12] In 2015, this group of municipalities represented 62% of the population, 76% of Brazil's GDP and 89% of property tax revenues generated. Its tax burden was 0.54% of the group's GDP (compared with the national ratio of 0.49%). Nevertheless, this ratio has a potential to be raised through cadastral updates, revaluations and collection-led reforms.

Orair and Albuquerque (2016) estimate the national property tax revenue potential in Brazil as being 0.9% of GDP based on an adapted stochastic frontier model, initially described by Aigner, Lovell and Schmidt (1977), and Meeusen and Van den Broeck (1977). The stochastic frontier model establishes the maximum potential of an industry according to the best technical parameters performed by the companies. Therefore, Orair and Albuquerque (2016) consider the higher property tax to GDP ratio in each of the sixteen determined clusters in their study as the property tax potential. However, the authors note the common existence of outliers that had to be excluded. De Cesare et al. (2014) and Carvalho Jr.

[11] According to Cohen (1988), the effect size of a Pearson correlation between 0.1 and 0.3 is considered small, between 0.3 and 0.5 is considered moderate, and above 0.5 is considered high.

[12] Unlike previous research that estimates Brazil's national property tax potential, this study opted to restrict the scope to medium and large municipalities to minimise the problem of sample bias since most of the database comprises municipalities with populations greater than 70,000. A higher estimation is therefore expected since this study is restricted to large cities that have a higher property tax potential.

(2017) use an approach similar to Orair and Albuquerque's (2016) to estimate the national property tax revenue potential for Brazil as 1% and 1.3% of GDP, respectively.

6.1 Compiling Collection Ratios

Carvalho Jr. (2017) catalogues 164 collection ratios in a sample of municipalities with populations exceeding 70,000. This compilation was performed in 2012 from electronic regional news available on the internet, as is shown in Table 3 according to regional location.

Table 3 Property Tax Collection Rates in 164 Sampled Municipalities (By regional location, 2012)

Region	No of Municipalities	Collection Rate
Northern	34	44%
Southern	130	68%
Total	164	63%

Data source: Carvalho Jr. (2017: 238)

Table 3 shows that collection rates (CR) were higher among southern municipalities (Pearson correlation of 0.53), which impacted property tax performance (PT/Y) (Pearson correlation of 0.50). The effect size is considered high for both regions (Cohen 1988).

6.2 Estimating Taxation on Market Values

The level of taxation on market values (TMV) can be estimated as a residual of the simplified Bahl's identity, using the MV/Y predictions, and the availability of the indicators of cadastral coverage (CC, established as 85%) and collection rate (CR). Table C in the Annexure shows the following indices for 164 selected municipalities: a) MV/Y estimated from Equation 4; b) CR, as catalogued by Carvalho Jr. (2017), and c) TMV as the residual term from Equation 2. Table 4 shows the matrix of Pearson correlations (with outliers excluded) between PT/Y, MV/Y, TMV, CR, Income (per capita) and southern location (dummy).

Table 4 Pearson Correlations between Property Tax per GDP (PT/Y), Urban Market Values per GDP (MV/Y), Taxation on Market Values (TMV), Collection Rate (CR), Per Capita Income, and Southern Location (Dummy) (2013)

	PT/Y	MV/Y	TMV	CR	Income	Southern
PT/Y	1.00	0.38	0.15	0.50	0.53	0.44
MV/Y		1.00	-0.27	0.13	0.58	0.25
TMV			1.00	-0.14	-0.15	0.11
CR				1.00	0.49	0.53
Income					1.00	0.60
Southern						1.00

Data source: Carvalho Jr. (2017); IBGE (2011, 2017); IBM Corp. (2010), STN (2017).

According to the matrix of correlations, property tax performance is highly correlated with collection rate, level of income and southern location, and moderately correlated with property tax base size.

6.3 Clustering Database

The greatest challenge when using a stochastic frontier model to estimate property tax potential is to take the differences amongst municipalities into account, since their tax potential is diverse and varies according to tax base size, level of income, population, regional location and availability of administrative infrastructure, among other factors. Thus, it is important to design a good scenario of clusters of municipalities based on similar property tax potential.

The design of the clusters must consider that: a) the capacity to bear a level of effective tax rate (TMV) is highly dependent on the level of per capita income (for residential properties) and per capita GDP (for non-residential properties); and b) the collection rate (CR) depends on the level of tax administration (which in turn depends on the population, income and GDP for instance) and on fiscal culture (regional differences). Nevertheless, all three of these variables (per capita income, GDP and southern location) are highly correlated with each other.[13]

Thus, due to the high correlation among the variables, the level of per capita income was selected to design the clusters. Following Carvalho Jr. (2017) and De Cesare et al.

[13] The Pearson correlation between income and GDP was 0.48, 0.60 between income and southern location, and 0.33 between GDP and southern location.

(2014), the IBM/SPSS 19.0 software's K-Means Cluster Analysis function is used to design the three clusters (high income, medium income and low income).[14] Table 5 shows the cluster frequency amongst all medium and large municipalities and amongst the sample of 164 municipalities that contain data of TMV and CR.

Table 5 Best Three Clusters Design using K-Means by Per Capita Income

Cluster	Number of Cases	
	All Municipalities	Sample
1 (High Income)	32	20
2 (Medium Income)	248	112
3 (Low Income)	166	32
Total	456	164

Data source: IBGE (2011); IBM Corp. (2010).

Thus, the high-income cluster (monthly per capita income greater than R$1,097) comprises 32 municipalities, the medium-income cluster (per capita income between R$648 and R$1,087) comprises 248 municipalities and the low-income cluster (per capita income under R$638) has 166 municipalities. The sample included 63% of municipalities in Cluster 1, 45% in Cluster 2 and 19% in Cluster 3.

6.4 Excluding Outliers and Defining a Revenue Potential

Outliers are atypical higher or lower values in a dataset that greatly differ from other cases and disturb the mean value. They may be present for different reasons, such as a wrong imputation, or the presence of a very singular specificity that the model does not capture. A general method to detect an outlier is the Inner and Outer Fences Method. This method considers an observation an outlier if it exceeds a distance of 1.5 times (or 3 times if it is an extreme outlier) the interquartile range below the first quartile or above the third quartile (Cousineau and Chartier 2010).[15]

[14]This procedure attempts to identify relatively homogeneous groups of cases based on selected characteristics and a predetermined number of clusters (Ibm Corp 2010). Running simulations, this study concluded that three clusters would be the most suitable number for a sample of this size.

[15] For example, if the first and third quartile of a dataset are 0.31 and 0.53 (with a difference of 0.22); a higher outlier must be 1.5 times this difference (0.33) above the third quartile. This will be any variable higher than 0.86.

SPSS 19.0 software can detect and exclude outliers through its Explore function. Table 6 reports the following for each of TMV and CR, per cluster: a) the number of excluded outliers; b) the mean value, and c) the highest case, considering the outlier exclusion.

Table 6 Number of Outliers, Mean Value and Maximum Value of Taxation on Market Values and Collection Rate (Per Cluster, Results with Outlier Exclusion)

Clusters		Taxation on Market Values			Collection Rate		
Level of Income	**No of Cases**	**No of Outliers**	**Mean**	**Maximum**	**No of Outliers**	**Mean**	**Maximum**
1	20	0	0.30%	0.54%	0	81%	95%
2	112	6	0.34%	0.74%	0	66%	95%
3	32	4	0.32%	0.65%	0	46%	75%

Data source: Carvalho Jr. (2017); IBGE (2011, 2017); Lincoln Institute of Land Policy (2018); STN (2017).

The results in Table 6 show that the mean value of TMV was around 0.32% in 2013 in all of the clusters; however, the indicator has the potential to achieve 0.54%, 0.74% and 0.65% in clusters 1, 2 and 3, respectively. As expected, CR decreased according to the clusters' income, along with its potential, estimated as 95% for Clusters 1 and 2, and 75% for Cluster 3.

Table 7 displays the potential tax burden (ratio of means)[16] using the maximum TMV and CR per cluster, and a potential CC stipulated as 95% for all clusters. The table also shows the results if only CR and CC improved without any change in TMV.[17]

[16] In taxation, the tax burden is given by the Ratio of Means measure. Ratio of Means (μ_{rm}) calculates the ratio between the sum of the terms of each ratio and is given by the equation: $\mu_{rm} = \Sigma (X_i) / \Sigma (Y_i)$. Mean of Ratios ($\mu_{mr}$) calculates the mean of each ratio (X_i/Y_i) in the studied population (n) and is given by the equation: $\mu_{mr} = 1/n \ \Sigma(X_i/Y_i)$ (Formenti 2014).

[17] In this second scenario, the calculated 164 TMV ratios will be maintained, while the other 282 non-observed remaining cases will have their respective cluster's mean value imputed as TMV (0.30%, 0.34% and 0.32% for Clusters 1, 2 and 3, respectively).

Table 7 Potential of the Property Tax Burden Amongst Medium and Large Brazilian Municipalities (as Percentage of Cluster GDP, Ratio of Means, 2013)

Cluster	Baseline	Potential	
		Coverage, Taxation and Collection	Coverage and Collection
1	0.71%	1.58%	0.92%
2	0.40%	1.37%	0.63%
3	0.18%	0.62%	0.32%
All	**0.50%**	**1.37%**	**0.71%**

Data source: Carvalho Jr. (2017); IBGE (2011, 2017); Lincoln Institute of Land Policy (2018); STN (2017).

Table 7 shows that the potential property tax burden among medium and large Brazilian municipalities is almost triple the current ratio (1.37% versus 0.50%); all three clusters verify this tendency. The estimated potential tax burden was slightly higher than in prior studies because it is limited to municipalities with populations greater than 70,000. If only collection improved without any change in the level of taxation, the total tax burden would rise 42%. This result is particularly relevant in Clusters 2 and 3, where total tax burden would increase by 58% and 78% respectively.

7. Conclusions

This study aimed to estimate the local property tax base size (urban market values) as well as a feasible scenario of revenue potential amongst medium and large Brazilian municipalities. It also set out to identify the causes of the low and heterogeneous level of property tax performance among municipalities.

The urban property tax base (MV/Y) was estimated to be between one and four times the local GDP in 2013. This was estimated by running an econometric model that considered MV/Y negatively related to the ratio of GDP and income, and positively related to the proportion of apartments. This allowed the estimation of a property tax potential of 1.4% of GDP through a stochastic frontier model, using the clusters' maximum value of cadastral coverage, taxation on market values and collection rate. It was also found that revenues will increase by 42% if only cadastral coverage and collection rates improved, without raising tax rates.

A simplified version of Bahl's property tax performance identity was the main instrument to estimate this potential. The simplified identity states property tax revenue as a function of tax base size, cadastral coverage, taxation level and collection rate. The study resolved the lack of data on urban market values, which permitted the estimation of taxation level as a residual term of the identity. The method may be useful in other case studies, especially in developing countries that generally face data unavailability.

The estimation based on the stochastic frontier approach and the property tax performance identity might produce different estimates than others derived exclusively from socioeconomic indices. The reason for this is that better socioeconomic indices may be correlated to tax base size, but they are not always correlated to better tax administration. In addition, this approach identifies where the main administrative gaps are (in the cadastre, tax rates or collection), allowing the specification of more detailed (and often higher) revenue scenarios.

Some improtant limitations affect these estimations, however. First, the MV/Y estimation was developed for the year of 2013 while real estate prices are dynamic, especially in developing countries, and this estimation can become outdated rapidly. Second, the potential collection rate of 75% to 95% did not take the differences in tax base composition and administrative capacity among municipalities in the same cluster into account. It is well known that vacant land parcels and informal settlements present harder collection and the upfront costs to undertake a tax reform vary greatly amongst municipalities. The dataset clusterisation may mitigate these shortcomings; however, it must be designed extremely well to capture the main differences in tax capacity. Third, the establishment of a potential of 0.6% to 0.7% on taxation on market values (TMV) did not consider the likely shortcomings and iniquities that exist in the local valuation systems. This is important since a heightened tax burden must take equity considerations into account, especially if there is pre-existing horizontal and vertical regressivity on valuations. In Brazil, this shortcoming is exacerbated since the revaluations must be performed under a municipal law that requires approval by the local councils.

The findings on the three hypotheses tested in this study are, first, that Brazilian municipalities present a heterogeneous level of urban property tax base size (MV/Y), which was highly correlated with the level of income (0.55) and moderately correlated with property tax performance (0.38). Second, the level of TMV was not meaningful correlated with property tax performance, income or southern location. Finally, collection rates were highly correlated with the property tax performance (0.50), the level of income (0.43) and southern location (0.49), which may be considered the main factor that explains the performance heterogeneity amongst municipalities.

Indeed, the study verified that the average collection rate in a sample of 164 municipalities was 81% amongst the higher-income municipalities (Cluster 1) and 46% amongst lower-income (Cluster 3). Therefore, collection-led reforms, that are generally less costly and time-consuming than valuations or GIS reforms, may be the first point in the agenda for small or low-income jurisdictions. This strategy includes cadastral reforms focused on better taxpayer identification. Indeed, comprehensive cadastral reforms should always be part of any property tax reform, since updates on construction allow more accurate assessments, while updates in taxpayers' personal details allow better tax billing and enforcement.

The problem of low tax base size and collection amongst small municipalities highlights the need to further investigate their causes in subsequent studies. For example, they likely have higher number of rural properties (excluded from the tax base) or they likely have higher number of vacant land parcels, informal settlements, low income taxpayers, and challenges in basic tax administration, which affects the collection rate negatively.

Some reforms can be proposed. In relation to the tax base size, Brazil – unlike many other countries – has two separate recurrent property taxes, one weak federal rural tax with regulatory purposes, and one municipal urban tax with fiscal purposes. However, some studies (Carvalho Jr. 2018) show that rural properties in Brazil are an important stock of wealth, especially amongst locations with a relevant agribusiness sector. Therefore, the tax base expansion to rural properties would achieve a revenue increment amongst small municipalities and resolve the judicial disputes on property classification. Nevertheless, this would require an amendment in the Brazilian Constitution.

In relation to the proposals to collection level, several instruments can be applied at local level, such as cadastral reforms to better identify taxpayers, intermunicipal partnerships in tax administration to take advantage of economies of scale and the issuance of notices of dishonour to delinquent taxpayers to reduce the cost of arrears claims, among others. In addition, progressive or selective tax rates can better graduate the tax burden according to taxpayers' capacity. To achieve Brazil's property tax potential will also require a reform of the valuations systems, which could be regulated at national level by establishing a valuation cycle of maximum four years, the mandatory use of official technical standards on local valuations and the permission to implement revaluations through a executive government ordinance.

In conclusion, this study emphasises the need for follow-up research, including case studies of small municipalities, the use of more comprehensive samples, and recurrent data gathering, since the indicators used by this study can vary greatly over time.

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Table A Brazil's Economic and Urban Property Tax Indicators (23 municipal governments and Federal district, Brasilia)

Jurisdiction	Population (2013)	Year Base (1st Jan)	Assessed Values (on fiscal cadastre)[1]	Cadastral Coverage (of market values)	Assessment Ratio	Total Market Values[1]	Per Capita GDP (2010)	Per Capita Income* (2010)	Market Values per GDP	GDP to Income (2010)	Apartments
São Paulo	11.821.873	2014	967,180	85%	59%	1,928,574	39,412	15,559	3.38	2.53	28%
Rio de Janeiro	6.429.923	2014	182,054	87%	20%	1,046,288	30,064	15,750	3.70	1.91	38%
Brasilia	2.789.761	2014	137,190	95%	40%	361,026	58,326	19,331	2.06	3.02	26%
Belo Horizonte	2.479.165	2014	125,762	90%	40%	349,339	21,669	16,299	4.29	1.33	33%
Porto Alegre	1.467.816	2015	73,012	89%	25%	328,142	30,473	18,910	5.13	1.61	47%
Santos	433.153	2014	64,853	95%	75%	91,022	65,855	18,290	4.72	3.60	63%
Campinas	1.144.862	2013	48,249	85%	30%	190,333	33,990	15,484	4.45	2.20	24%
Manaus	1.982.177	2013	27,874	93%	20%	149,859	26,879	8,951	3.01	3.00	10%
Santo André	704.942	2014	26,086	84%	40%	77,637	25,518	13,934	2.76	1.83	18%
Belém	1.425.922	2014	18,821	91%	30%	68,943	12,917	9,418	2.68	1.37	11%
São José Rio Preto	434.039	2014	14,766	93%	30%	53,211	21,999	13,308	4.01	1.65	16%
Teresina	836.475	2015	13,595	96%	23%	61,572	12,933	8,714	3.47	1.48	8%
Aracaju	614.577	2014	10,327	93%	18%	61,829	15,317	11,810	4.44	1.30	22%
Jab. Guararapes	675.599	2014	10,095	85%	40%	29,690	11,930	6,895	2.48	1.73	18%
Itajaí	197.809	2013	7,861	90%	25%	34,939	86,834	12,111	1.77	7.17	15%
São Vicente	350.465	2014	7,129	95%	40%	18,760	9,862	9,265	4.28	1.06	22%
João Pessoa	769.607	2014	7,075	96%	11%	66,995	13,532	10,845	4.51	1.25	21%
São José dos Pinhais	287.792	2014	6,525	84%	40%	19,420	52,134	10,169	0.77	5.13	6%
Betim	406.474	2014	5,095	95%	40%	13,409	75,015	7,659	0.60	9.79	8%
Barueri	256.756	2013	3,983	80%	10%	49,789	115,306	12,418	1.50	9.29	11%
Palmas	257.904	2013	3,795	88%	40%	10,782	17,183	12,728	2.61	1.35	6%
Olinda	388.127	2013	1,490	93%	17%	9,478	8,346	7,534	2.57	1.11	16%
Corumbá	107.347	2013	1,448	90%	45%	3,596	31,327	7,921	0.96	3.95	3%
Criciúma	202.395	2014	1,246	89%	6%	23,341	19,219	12,415	4.19	1.55	21%

Data Source: Carvalho Jr. (2017); IBGE (2010, 2017); Lincoln Institute of Land Policy (2018). Note: *Equal to the per capita monthly income multiplied by 12.

Table B Ratio of Market Value to GDP: Statistical Outcomes from the Linear Regression Model of IBM/SPSS 19.0

Table B1 Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
0.870[a]	0.756	0.733	0.315
a. Predictors: (Constant), ln(Y/Income), ln(apart)			

Table B2 ANOVA[a]					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	6,470	2	3,23	32,61	,000[a]
Residual	2,080	21	0,10		
Total	8,550	23			
a. Predictors: (Constant), ln(Y/Income), ln(apart) b. Dependent Variable: ln(MV_Y)					

Table B3 Coefficients					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	2.129	0.18		11.62	0.00
ln(Y/Income)	-0.519	0.10	-0.560	-4.98	0.00
ln(apart)	0.440	0.10	0.510	4.54	0.00
a. Dependent Variable: ln(MV/Y)					

Table B4 Coefficient Correlations[a]			
Model		Y/Income	ln(apart)
Correlations	ln(Y/Income)	1	0.306
	ln(apart)	0.306	1
a. Dependent Variable: ln(MV/Y)			

Table C Urban Market Values per GDP (MV/Y), Taxation on Market Values (TMV), and Collection Rate (CR) in 2013 (164 selected medium and large municipalities, cadastral coverage equal to 85%)

Municipality	MV/Y	CR	TMV	Municipality	MV/Y	CR	TMV
São Paulo	2.98	0.88	0.0043	Mossoró	1.52	0.20	0.0035
Rio de Janeiro	3.91	0.82	0.0024	Gov. Valadares	2.73	0.58	0.0031
Salvador	3.86	0.27	0.0061	Santa Maria	4.23	0.70	0.0017
Brasília DF	2.60	0.61	0.0022	Volta Redonda	1.96	0.70	0.0042
Fortaleza	3.08	0.61	0.0027	Gravataí	1.21	0.58	0.0016
Belo Horizonte	4.45	0.82	0.0030	Várzea Grande	1.32	0.20	0.0067
Manaus	1.76	0.44	0.0024	Foz do Iguaçu	1.90	0.65	0.0028
Curitiba	3.47	0.84	0.0020	Juazeiro do	1.10	0.23	0.0046
Recife	3.59	0.85	0.0022	Camaçari	0.74	0.60	0.0065
Porto Alegre	4.69	0.74	0.0018	Imperatriz	1.38	0.30	0.0033
Belém	2.71	0.43	0.0025	Sumaré	1.14	0.69	0.0041
Goiânia	3.48	0.73	0.0033	Barueri	1.00	0.90	0.0006
Guarulhos	1.75	0.69	0.0068	Embu das Artes	1.09	0.56	0.0064
Campinas	3.01	0.76	0.0038	Palmas (TO)	2.04	0.35	0.0069
São Luís	2.04	0.25	0.0044	Viamão	1.01	0.35	0.0051
São Gonçalo	2.31	0.60	0.0026	Magé	1.02	0.41	0.0080
Maceió	3.00	0.50	0.0034	São Carlos	2.07	0.75	0.0050
Duque de Caxias	0.89	0.60	0.0047	Marília	2.20	0.63	0.0038
Teresina	2.28	0.54	0.0024	Sete Lagoas	1.14	0.75	0.0027
Natal	2.85	0.60	0.0024	Divinópolis	3.16	0.72	0.0019
Campo Grande	2.21	0.91	0.0066	São Leopoldo	2.86	0.75	0.0024
Nova Iguaçu	1.72	0.50	0.0038	Jacareí	1.48	0.71	0.0041
São Bern. Campo	2.32	0.83	0.0035	Maracanaú	0.62	0.58	0.0024
João Pessoa	3.76	0.60	0.0014	Araraquara	2.08	0.80	0.0038
Santo André	2.87	0.81	0.0037	Presidente	2.12	0.75	0.0038
Osasco	1.50	0.77	0.0035	Indaiatuba	1.77	0.85	0.0045
Jaboatão	3.00	0.30	0.0039	Cotia	1.54	0.60	0.0228
Ribeirão Preto	2.88	0.95	0.0036	Itabuna	2.71	0.40	0.0016
Uberlândia	2.10	0.75	0.0011	Santa Luzia	2.44	0.43	0.0014
Contagem	2.05	0.66	0.0024	Rondonópolis	1.22	0.60	0.0036
Sorocaba	1.93	0.74	0.0028	Dourados	1.63	0.69	0.0067
Aracaju	3.80	0.65	0.0023	Alvorada	2.28	0.65	0.0019
Feira de Santana	1.39	0.45	0.0037	Criciúma	3.35	0.42	0.0016
Cuiabá	2.64	0.29	0.0074	Cachoeiro	2.25	0.50	0.0021
Joinville	2.27	0.90	0.0023	Cabo St	0.46	0.32	0.0141
Juiz de Fora	4.17	0.55	0.0037	Chapecó	2.77	0.78	0.0015
Londrina	3.30	0.72	0.0035	Rio Claro	1.62	0.90	0.0047
Niterói	5.59	0.75	0.0032	Itajaí	1.29	0.66	0.0026
Belford Roxo	1.11	0.20	0.0082	Passo Fundo	2.93	0.80	0.0020
Aparecida de	2.06	0.75	0.0051	Rio Verde	1.15	0.95	0.0025
Campos (RJ)	1.04	0.50	0.0011	Araçatuba	1.93	0.50	0.0052
Caxias do Sul	2.59	0.90	0.0016	Nova Friburgo	3.04	0.60	0.0025
Porto Velho	2.76	0.30	0.0015	Santa Bárbara	1.47	0.82	0.0042

Municipality	**MV/Y**	**CR**	**TMV**	**Municipality**	**MV/Y**	**CR**	**TMV**
Florianópolis	5.01	0.85	0.0026	Luziânia	1.21	0.75	0.0038
Mauá	1.44	0.75	0.0060	Angra dos Reis	0.77	0.60	0.0155
Vila Velha	4.56	0.40	0.0032	Ferraz	2.31	0.65	0.0041
Serra	1.56	0.44	0.0027	Guarapuava	1.59	0.50	0.0030
Santos	3.53	0.85	0.0054	Itu	1.49	0.88	0.0056
São José do Rio	2.87	0.80	0.0040	Lages	2.45	0.45	0.0018
Macapá	1.87	0.30	0.0013	Poços de Caldas	2.38	0.85	0.0025
Mogi das Cruzes	2.43	0.76	0.0045	Teixeira de	1.92	0.30	0.0031
Diadema	1.58	0.89	0.0058	Palhoça	2.71	0.48	0.0033
Campina Grande	2.32	0.60	0.0013	Barreiras	1.52	0.44	0.0013
Betim	0.84	0.50	0.0036	Sapucaia do Sul	2.16	0.60	0.0024
Olinda	3.53	0.44	0.0021	Botucatu	1.61	0.80	0.0035
Jundiaí	2.00	0.85	0.0017	Varginha	1.34	0.52	0.0042
Carapicuíba	3.37	0.83	0.0020	Cachoeirinha	1.62	0.65	0.0017
Piracicaba	2.06	0.80	0.0023	Sinop	1.35	0.60	0.0062
Maringá	3.11	0.90	0.0026	Ji-Paraná	1.88	0.52	0.0016
Cariacica	1.99	0.52	0.0014	Votorantim	1.22	0.70	0.0101
Rio Branco	2.57	0.25	0.0030	Passos	2.10	0.76	0.0024
Bauru	2.50	0.87	0.0029	Três Lagoas	0.63	0.60	0.0068
Anápolis	1.25	0.75	0.0038	Corumbá	0.90	0.39	0.0071
São Vicente	4.15	0.58	0.0098	Ourinhos	0.94	0.75	0.0120
Vitória	2.91	0.56	0.0017	Eunápolis	1.45	0.30	0.0015
Pelotas	3.64	0.60	0.0026	Ituiutaba	0.97	0.52	0.0046
Itaquaquecetuba	1.90	0.60	0.0053	Erechim	2.57	0.90	0.0014
Canoas	1.44	0.65	0.0026	Barra do Piraí	1.86	0.57	0.0026
Franca	2.00	0.82	0.0052	Jataí	0.81	0.70	0.0039
Ponta Grossa	1.97	0.65	0.0029	Cáceres	0.97	0.25	0.0065
Blumenau	2.78	0.81	0.0020	Moji Mirim	1.40	0.82	0.0059
Vitória da	1.98	0.57	0.0023	Pará de Minas	1.41	0.83	0.0018
Paulista	3.37	0.30	0.0041	Sarandi	1.32	0.55	0.0192
Petrolina	1.67	0.60	0.0013	Cachoeira do Sul	1.73	0.68	0.0036
Uberaba	2.09	0.40	0.0030	Paranavaí	1.53	0.95	0.0030
Petrópolis	2.17	0.75	0.0038	Esteio	2.07	0.85	0.0014
Boa Vista	2.30	0.50	0.0026	Bebedouro	0.69	0.70	0.0019
Cascavel	2.69	0.67	0.0016	Alfenas	1.14	0.52	0.0085
Taubaté	1.57	0.80	0.0032	Caçador	1.78	0.80	0.0012
Limeira	1.63	0.63	0.0060	Sorriso	1.05	0.60	0.0016
São José dos	1.05	0.74	0.0011	Telêmaco Borba	1.06	0.65	0.0015
Suzano	1.41	0.73	0.0053	S. Sebastião	1.25	0.79	0.0036

Data Source: Carvalho Jr. (2017); IBGE (2010, 2017); Lincoln Institute of Land Policy (2018).