



ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

European Journal of Political Economy

journal homepage: www.elsevier.com/locate/ejpe

Fiscal decentralization and tax collection: evidence from the rural property tax in Brazil

Thiago Costa Monteiro Caldeira^{a,*}, Philipp Ehrl^b, Tito Belchior Silva Moreira^c^a Instituto Brasileiro de Ensino, Desenvolvimento e Pesquisa – IDP, SGAN Quadra 609, Módulo A, Via L2 Norte, Brasília, DF, CEP 70.830-40, Brasil^b Escola de Políticas Públicas e Governo da Fundação Getúlio Vargas - FGV EPPG, SGAN Quadra 602, Asa Norte, Brasília, DF, CEP 70830-020, Brasil^c Universidade Católica de Brasília – UCB, QS 07, Lote 01, EPCT, Brasília, DF, CEP 71966-700, Brasil

ARTICLE INFO

JEL classification:

JEL
H7
H77
H2

Keywords:

Fiscal federalism
Decentralization
Taxation
Impact evaluation

ABSTRACT

The present paper investigates whether the decentralization of the rural land property tax (ITR) in Brazil increases the aggregate volume of tax collection from this source. We apply a difference-in-differences strategy where treatment is defined as the switch from a federal administration to the decentral management of the ITR by a municipality. The panel data from 2002 to 2017 show that decentralization leads to an average increase in overall ITR collection by about 42% in the first year, which rises to 109% in the 8th year. Our results are robust to balancing with entropy weights, the anticipation of treatment as well as the multi-period staggered timing of the ITR decentralization. Due to these peculiarities of our research design, we show that the increase in ITR collection is related to a more efficient tax management, i.e., a rigorous implementation and charge of tax duties.

1 Introduction

The last few decades have been marked by a global tendency to decentralize fiscal, political and administrative responsibilities (Qiao et al., 2019, Gemmill et al., 2013). One case in point is the tax on rural land property (ITR) in Brazil. It was centrally administered by the Federal Government for decades, poorly managed and plagued by a high rate of evasion (Brasil, 2003a, 2003b; Brugnaro et al., 2003; Simonetti et al., 2013). This assessment was the basis for a constitutional change¹ in 2008 that made it possible for municipalities to assume the supervision, collection and full appropriation of the ITR. By December 2017, 36% of the 5570 municipalities in Brazil were responsible for their own ITR management.

The present paper investigates whether the decentralization of the rural land property tax (ITR) in Brazil increases the aggregate

* Corresponding author. SGAN Quadra 609, Módulo A, Via L2 Norte, Brasília, DF, CEP 71966700, Brasil.

E-mail addresses: thiago.caldeira@idp.edu.br (T.C.M. Caldeira), philipp.ehrl@gmail.com (P. Ehrl), tito@pos.ucb.br (T.B.S. Moreira).

¹ The ITR decentralization was introduced by the Constitutional Amendment 42 in 2003 (EC 42/2003), which finally entered into force in December 2008 through regulation by Decree 6433.

volume of tax collection from this source. We apply a difference-in-differences strategy where treatment is defined as the switch from a federal administration to the decentral management of the ITR by a municipality. To the best of our knowledge, this is the first quantitative evaluation of this public policy change.²

We collect panel data for all Brazilian municipalities over the period from 2002 to 2017 and include control variables such as the local area, gross domestic product per capita and the share of agricultural production. Our estimations account for the staggered, multi-period treatment, that may occur between 2009 and 2017, using the estimator proposed by Callaway and Sant'Anna (2021). As one among several robustness checks, municipalities are made more comparable to each other through the application of weights from the entropy balance method according to Hainmueller (2012). Either way, the data show that the parallel trend assumption holds and our results are robust to a number of different specifications. In sum, decentralization leads to an average increase in overall ITR collection by about 42% in the first year, which rises continually over time to 109% in the 8th year. This finding, qualitatively, does not depend on the geographic region of the municipality nor on its population size or agricultural participation.

The present article contributes empirical evidence to the discussion about the optimal design of the division of powers in federalized states. Martínez-Vázquez, Lago-Peñas and Sacchi (2017) draw a net positive conclusion from their review on the economic effects of fiscal decentralization.³ In theory and in the context of a developing country with deficient institutions (Naritomi et al., 2012), however, a positive impact could not be taken as granted. In fact, theoretical expectations from fiscal decentralization have fallen short in Latin American countries (Smith and Revell, 2016).

Much of the literature on fiscal federalism and decentralization focuses on public spending rather than on the fundraising side. This fact may be due to the greater importance given by researchers, especially economists, to study the optimal level of expenditure in a society and who is best suited to manage these expenditures (Chalfun, 2005). The following papers are directly related to our research question, namely the impact of fiscal decentralization on the government size, as measured by the revenue collection that stems from the rural land property tax. Overall, the theoretical and empirical literature yield positive as well as negative relations (Golem, 2010). Among OECD countries, tax revenue decentralization is associated with a decrease of the public sector, while expenditure decentralization has the opposite effect (Liberati and Sacchi, 2013; Fiva, 2006). Using the total government expenditure relative to GDP, Qiao et al. (2019) observe that the negative effect of fiscal decentralization is mitigated by the country's level of democracy. According to their measure from Freedom House, Brazil scores 73 out of 100 points and is thus considered as a free country. Feld et al. (2010) also obtain results that are contrary to ours, that is, in Switzerland, revenue decentralization is associated with lower tax revenue. Note that compared to ours, these papers apply different econometric strategies.

Despite the predominantly negative relation between fiscal decentralization and tax collection, several papers that evaluate the impact of decentralization on other economic indicators (without analyzing the direct effect on public spending or revenues) report a favorable development. Sanogo (2019) shows that revenue decentralization favors public services and reduced poverty in the Ivory Coast. Revenue decentralization also seems to promote economic growth (Gemmell et al., 2013; Canavire-Bacarreza et al., 2020).

The main advantage of studying the ITR reform in Brazil, which distinguishes our paper from most previous work, is the possibility to isolate a specific mechanism through which the fiscal decentralization works. Based on the discussion of the theories of fiscal federalism, Feld et al. (2010) distinguish the following four transmission mechanism through which government size may be affected. According to the decentralization hypothesis, decentralization may increase the public sector because the local administration may tailor spending and revenues to the specific demands of the population (Tiebout, 1956; Oates, 1985). The tax competition or fragmentation hypothesis imply that tax competition between local administrations should decrease the average size of the public sector (Brennan and Buchanan, 1980; Wilson, 1999). Third, as a response to tax evasion or migration, local jurisdictions may increase the taxation of nonresidents (tax exporting hypothesis). In the present setting these three channels are turned off, because we are only studying the revenue side of a specific tax rather than aggregate tax collection, because the municipalities have no control over the ITR rates, and because the taxable resource is immobile.

According to Feld et al. (2010), a final way through which decentralization may affect the government size is the laboratory federalism (discovery) channel. This hypothesis suggests that under a decentralized tax regime, local units may experiment with new implementations that, if successful, are adapted by others (Weingast, 2009; Oates, 1999). In line with the discovery hypothesis, Miranda (2012), among others, suggests that decentralization has the benefit of facilitating the gathering of specific information about the taxed asset. Especially taxes on immobile belongings, such as the ITR and the urban property tax, would be better allocated to subnational entities, because local governments are better informed. On the other hand, decentralization brings the public administration closer to the taxed subject and could thus increase the possibility of capturing public power by interest groups (Shon and Cho, 2020). Lockwood (2008) confirms that the well-known decentralization theorem of taxation does not hold when the government is not benevolent, i.e., considering the existence of lobbying. Moreover, local decision makers can hardly be held accountable for failure, misbehavior or bad decisions because they can always blame the entity above (Weingast, 2009). The agricultural sector is known for its

² Reydon and Oliveira (2012) and Simonetti et al. (2013) provide case studies on the ITR decentralization that apply to a few municipalities. Neither considers a large database or employs econometric methods for statistical confirmation. The first article makes a historical review of rural land tax in Brazil and calculate the ITR collection potential based on data from 7 municipalities in the state of São Paulo, considering the under-reported price of land in these municipalities and average market parameters. The second article uses methodology of interviews with farmers from two municipalities in the state of Paraná to investigate their understanding of how to calculate the tax and consequences of tax evasion.

³ Among the incentives to centralize the provision of public services and tax competence are gains from economies of scale, avoiding the multiplicity of structures for tax administration and the provision of public services, in addition to less coordination problems and externalities (Myerson, 2006; Weingast, 2009, 2014).

powerful lobbying and naturally would oppose paying higher taxes on rural properties (Gozetto & Thomas, 2014).

Due to these peculiarities of our research design, changes in the amount of ITR collection are necessarily related to the inspection and charge of the land owners. That is, in the present case, there is no change in the tax burden per se, unless in case of defiance prior to the tax management by the local fiscal authorities. Since the ITR is composed of different rates that depend on size and agricultural usage degree of the rural property, land owners are able to manipulate their tax duties.

Estimating the lead and lag coefficients regarding ITR decentralization indicates that the average treatment effect on tax collection is positive and increasing over time. Complementary quantile regressions show that the decentralization impact decreases with the tax revenue from the ITR. Both observations are consistent with the notion that the mechanism behind the increase in ITR collection is related to a more rigorous implementation and charge of tax duties. In that sense the municipalities seem to acquire greater knowledge in tax management over time, and due to their specific knowledge on the local rural properties, they are better suited as administrators in line with the discovery hypothesis.

The rest of the paper is organized as follows. Section 2 provides a review of the literature on the ITR, tax decentralization and fiscal federalism in Brazil. It seeks to contextualize the existing economic and political understanding of the ITR, in view of the decentralization allowed since 2009. Section 3 describes the database and our identification strategy used to evaluate the effect of the decentralization of the ITR. Section 4 presents the results and robustness checks. Section 5 concludes and points to future research topics.

2 Tax decentralization and federalism

2.1. The Brazilian experience with the ITR

Unsuccessful attempts to apply taxes on land ownership in Brazil have been recurrent since the 19th century (Costa, 1994, 1998, 2013). With the proclamation of the Republic in 1889, regional forces sought to decentralize the powers of the central government, resulting in a federative structure marked by the expansion of the tax base in favor of the federal states (Costa, 1998, p. 160). The proper Federal Constitution of 1891 mentions the first forecast of tax incidence on rural and urban properties, which at the time was attributed to the states. The ITR represented little in their tax collection for decades and, with a Constitutional Amendment in 1964, later confirmed in the Federal Constitution of 1967, the tax was transferred back to the competence of the federal government (Souza and Jorge, 1995). Yet, municipalities in Brazil are entitled to receive, through transfers from the federal government, 50% of the amount collected from the ITR related to properties located in their territories.

In 2003, a Constitutional Amendment was presented by the Executive Branch with the original objective of changing the competence of the ITR to the states (Brasil, 2003a, 2003b). The justification for the amendment, contained in the explanatory memorandum of the proposal, was based on the understanding that the states “*have inspection and collection structures physically closer to rural properties*”, which would facilitate the administration of the tax. Although the debate at the time of Constitutional Amendment n° 42/2003 was not based on a specific empirical study, the pros and cons of fiscal decentralization were based on the literature produced in countries with a federal structure, as can be seen in the annals of the constitutional amendment process (Brasil, 2003a, 2003b).

The ITR has the nature of an extrafiscal tax, that is, it is designed to promote objectives that go beyond the mere interest of collection (Baleeiro, 1981). Both the constitutional norms and the regulation of the ITR, especially Law 9393/1996, try to incorporate incentives for landowners through the tax rates, defining them directly proportional to the size of the property and inversely proportional to its degree of use. The objective is to encourage greater land productivity and recognize different payment capacities among small and large landowners through progressive rates.

Regarding the use of the ITR for public policies (extrafiscal objective), one of the great defenders of the use of the ITR to carry out agrarian reform was the economist, minister, diplomat and politician Roberto Campos (Campos, 1994: 684). He affirmed the lower conflictive potential of this instrument, in comparison to an agrarian reform that would lead to expropriations. In an analysis of the last decades of the 20th century, Campos claims that the “*Land Statute was a technocratic dream, with modulations difficult to apply in a country with outdated rural cadastres and at a time when the use of information technology [...] was almost non-existent.*” Additionally, the author states that there was no interest in using this instrument, since the “*federal government was only responsible for the costs and complexities of collection, with the revenues destined exclusively to the municipalities*”.

There is a consensus that the current tax collection through the ITR is poor. Di Sabbato (2008) reports that the total ITR represents only about 10% of its potential tax collection. Note that such simulations are based on the rates and rules in force, that is, implementing more efficient collection, inspection and correct declaration measures would generate a large ITR collection increase. A study by Instituto Escolhas (2019) estimated that the ITR collection could increase even further when changes in legislation stimulated the productive use of land. In comparison to other countries, Souza (2004) highlights that Brazil would have to increase the collection of the ITR by more than 30 times its current value to reach the share of the tax levied on rural lands in France and Italy, and by 50 times to achieve the participation in the USA and Canada.

In a study of the impact of the decentralization of the ITR in some municipalities in the state of São Paulo, Reydon and Oliveira

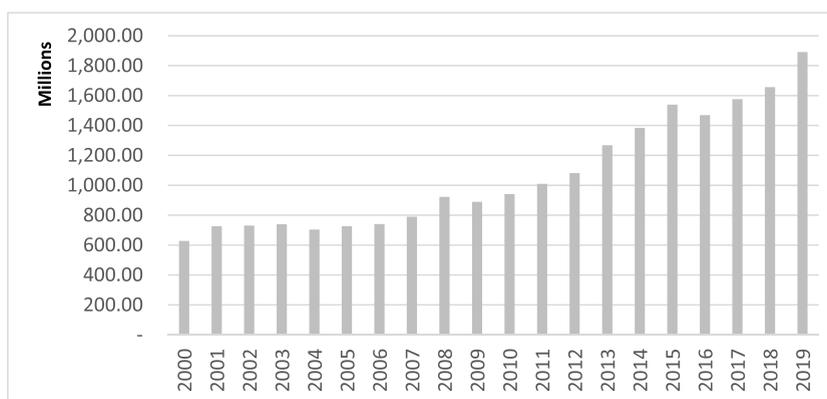


Fig. 1. ITR collection (at constant 2020 BRL).

(2012) identified that the total ITR could increase by more than four times, largely due to the opportunity that the municipalities will have to update the land value (tax calculation basis). Although the ITR seems to fall short of its potential, the evolution of tax collection is rising, especially since 2009, the first year with effective decentralization, as shown in Fig. 1.

Municipalities seem to have an incentive to opt for the collection and inspection of the ITR, given that they immediately receive 100% of the amount collected, instead of receiving 50% from the federal government. Thus, even if the municipality has no intention of carrying out a ITR collection effort, it seems reasonable that municipalities opting for the decentralization, just to increase their disposable funds. However, to conclude the process of ITR decentralization, municipalities are required to prove their capacity to collect and inspect to the Federal Revenue Service. For example, the municipality must have enough public servants with specific role of tax auditor and sufficient information technology structure to manage the tax (Brasil, 2016). An adequate local system for the collection and inspection of the ITR minimizes the risk of reducing the tax burden due to administrative incapacity.

According to data available on the ITR Website of the Federal Revenue,⁴ 2019 of all 5570 municipalities in Brazil had adhered to the agreement for the decentralization of the ITR at the end of 2017. Therefore, the sample size of both the municipalities that did not adhere (control group), and the municipalities that carried out the decentralization of the collection and inspection of the ITR (treatment group) is relatively large. The share of municipalities that decentralized by federal state is presented in Fig. 2. The variation across states is considerable. In some states more than 60% of the municipalities opted for the decentralization of the ITR, such as in São Paulo, Tocantins, Mato Grosso, Mato Grosso do Sul and Goiás, while in others more than 90% of municipalities did not decentralize (Acre, Alagoas, Amazonas, Maranhão, Paraíba, Pernambuco and Roraima). Most decentralizations occurred in 2009, being the inaugural year allowed by constitutional amendment. In the following years, the frequency of new adhesions varies between 218 and zero, as shown in Fig. 3.

3. Database and empirical strategy

The database and the empirical strategy are designed to answer the question whether the decentralization of the rural property tax (ITR) affects the overall collection of this tax. In order to isolate the effect of this policy change from other factors that can influence the amount of collected ITR, we apply a difference-in-differences model.

First of all, it is important to clarify the determinants of the amount collected from the ITR. The definition of the amount paid by each taxpayer corresponds to the tax rate multiplied by the calculation base. Changes beyond these two items are related to the proper implementation of the tax collection which may be systematically affected by the administrative level of the responsible tax authority, being either the municipality or the central government.

The ITR rates are established in Law 9393/1996. Since the publication of this law in 1996, it underwent only minor changes, and the rates have remained unchanged since then. The ITR consists of several rates, depending on the degree of use and total area of the property, as shown in table A1 in appendix. For the smallest properties up to 50 ha and the highest usage rate (above 80%) the tax rate is as low as 0.03%, while for the largest properties (>5000 ha) and lowest usage rate (<30%) it climbs to 20%. To account for the potential variations in the actual ITR rates, we include control variables for the area of the municipality and the share of agricultural gross value added in our estimations. Additionally, no relevant changes were identified in the rules of exemptions and immunities to the ITR payment over the period analyzed in this research.⁵

Regarding the calculation base, the same Law 9393/1996, defines it as the “Value of Terra Nua” (VTN), i.e., the value of the

⁴ Available at: http://www.enat.receita.economia.gov.br/pt-br/area_nacional/areas_interesse/porta-itr-1.

⁵ The main exemption/immunity applies to lands that do not exceed the size defined for “small rural land”, with the limit defined at 100 ha (Western Amazon or Pantanal), 50 ha (Drought Polygon or Eastern Amazon) and 30 ha (other locations).

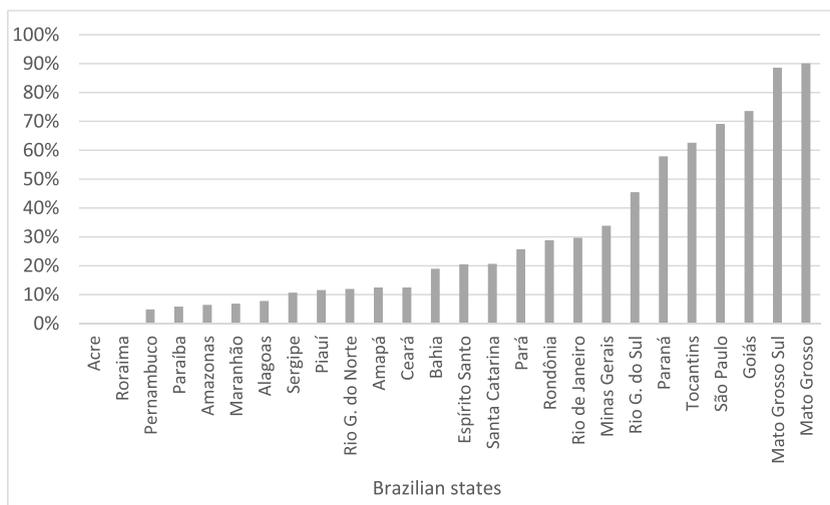


Fig. 2. Percentage of municipalities that decentralized the ITR until 2017, by state.

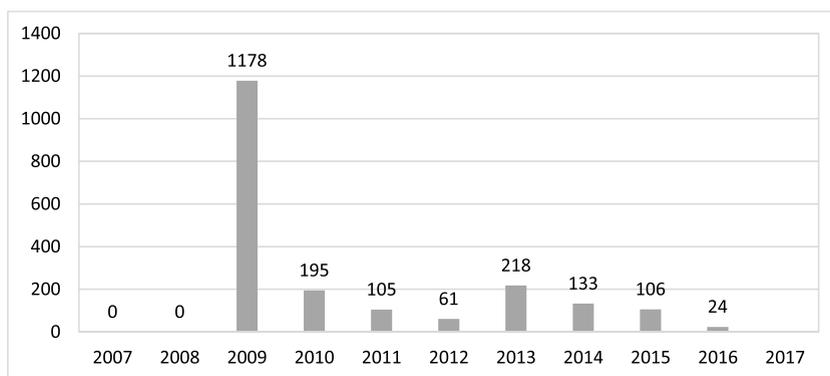


Fig. 3. Adhesions to the decentralization of the ITR.

property “by nature”. Thus, any second nature, technical improvements as well as the value of buildings, plantations, etc. are irrelevant for the ITR base.⁶ Unfortunately, the underlying VTN value is not available for the period under consideration.⁷ As demonstrated by Malassie et al. (2015), the gross value of agricultural production, among other factors, affects the VTN. Therefore, variations in this item are also captured by the combination of the control variables total gross value added (GVA) and agricultural participation in the municipality’s GVA.

Given that the first year of the ITR decentralization is 2009, we assembled a municipality level panel data that comprises the years from 2002 to 2017. The dependent variable is the total amount of ITR collected, i.e., the total amount paid by taxpayers. As such, we are not interested in the amount received by the municipalities, because it depends directly on the collection regime. Our interest is to discover whether the ITR collected, on aggregate, is affected by the decentralization per se. As explained above, the following municipality specific control variables are used: area, population, Gross Domestic Product per capita, gross value added and the share of agricultural activities in the GVA. Monetary values are deflated using the common consumer price index ICPA. Table A2 in the appendix provides a summary of the variables and lists their sources.

Table 1 presents the descriptive statistics of the variables, separately for the treatment group (municipalities that decentralized) and control group (municipalities that did not decentralize), at constant monetary values. The table shows that the amount collected as

⁶ Several normative instructions from the Federal Revenue Service govern the parameters that must be considered for arbitration, by the tax auditor, of the value of the land declared by the owner of the property, such as Normative Instruction 1877, of March 14, 2019.

⁷ There is a land value database (INCRA, for example), however for a few (and discontinuous) years. Additionally, the land value tables used by official bodies are only referential (and largely delayed in updating), for the purpose of marking the taxpayer, who is responsible for estimating and declaring the market value of the land for the purpose of calculating the tax.

Table 1
Descriptive statistics for the municipalities.

Variables	N.	Mean	Std. Dev.	Min.	Max.
TREATED GROUP					
ITR collection	15,208	441,651.80	817,002.20	-124,621.40	11,684,538.90
Population	15,220	34,351.60	176,070.10	931	6,520,266.00
Part. Agro	15,220	0.234	0.163	0	0.899
Municipality Area	15,220	1858.80	5836.00	5	160,755.00
ln GDP per capita	15,220	3167	0.571	1.66	5895
GROUP CONTROL					
ITR collection	69,970	97,306.30	672,797.70	-780,956.50	55,694,516.5
Population	72,844	34,005.90	207,285.20	804	12,106,920
Part. Agro	72,844	0.204	0.151	0	5179
Municipality Area	72,844	1,329,372	4,677,545	2900	160,755.00
ln GDP per capita	72,844	2606	0.669	0	6.975

Note: Part. Agro is the share of agricultural activities in the total, represented by the ratio of gross agricultural value added (agricultural GVA) divided by the total GVA of the municipalities.

ITR in the municipalities in the treatment group is, on average, higher than the amount collected in the municipalities in the control group.

3.1. Empirical strategy

To estimate the impact of the decentralization agreement between the Federal Government and a municipality on the rural property tax (ITR) collection, we apply the following differences-in-differences (DiD) specification:

$$\ln(\text{ITR})_{it} = \alpha X_{it} + \beta \text{Decentralization}_{it} + \lambda_t + \delta_i + \varepsilon_{it} \quad (1)$$

Where $\ln(\text{ITR})_{it}$ represents the log of the aggregate amount of ITR collection in municipality i at time t . Recall that this the total value paid by all ITR taxpayers, i.e., the sum of the ITR collection by the municipality and the Federal Government, in case of a centralized collection regime. The vector X_{it} represents the control variables: area, population, participation of the agricultural sector in the total gross value added, and GDP per capita.

$\text{Decentralization}_{it}$ is an indicator variable with value 1 if municipality i has a decentralized ITR collection (treatment group) in year t , and value 0 otherwise. λ_t and δ_i represent the time and municipality fixed effects (FE), respectively. Finally, ε corresponds to the error term. Since the dependent variable is in logarithm, the coefficient β , that represents the impact of decentralization on tax collection, can be interpreted as percentage changes.

In analogy to equation (1), we also perform the DiD estimation with weights calibrated by entropy balancing from the explanatory variables according to Hainmueller (2012), equalizing differences between municipalities in the treatment and control group. This balancing minimizes the entropy distance with normalization and non-negativity constraints, incorporating knowledge about sample moments (Hainmueller and Xu, 2013). Several papers highlight the superiority of this method over other balancing methods in general and in a difference-in-difference setting (Cefalu et al., 2020; Harvey et al., 2017).

Table 2 presents differences in the means of the control variables, before and after applying the entropy weights. As expected the existing pre-pairing differences are either eliminated or significantly reduced after the pairing.

Table 2
Differences in means of covariates.

	Pre-pairing average			Post-pairing average		
	Treated	Control	P-value	Treated	Control	P-value
ln(Population)	9446	9398	0.00 ***	9446	9455	0.305
ln(GDP per capita)	2991	2536	0.00 ***	2991	2951	0.00***
ln(Part. Agro)	-1801	-2163	0.00 ***	-1801	-1825	0.013**
ln(Area of the Municipality)	6541	5996	0.00 ***	6541	6539	0.832

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The null hypothesis of the t -test is that the means are equal.

The premise of the DiD model is that the unobservable characteristics of the municipalities remain constant over time, especially after the implementation of the ITR decentralization. If the assumption does not hold, the estimates can be biased. For example, changes regarding the control and effectiveness of tax collection level may affect the amount of ITR collection in municipalities. In this sense, we found that actions were taken in Brazil by the National Institute of Colonization and Agrarian Reform - INCRA and by the Federal Revenue Service of Brazil - RFB to improve the National Registry of Rural Property - CNIR, to unify the records of the Federal Revenue and INCRA (Brasil, 2020), allowing more detailed and reliable information for the registration of rural properties in Brazil. Such actions, however, operate horizontally across the country's municipalities, and exclusive treatment to specific regions or municipalities has not been identified. Moreover, we test the parallel trends assumption using the common graphical representation in the next section.

4- Results

4.1. Effect of decentralization on ITR

The results for the baseline differences-in-differences model according to equation (1) that estimates the impact of decentralization on ITR revenue is presented in Table 3. The first column indicates that decentralization is associated with a 62.08% increase in the ITR amount paid by taxpayers. Once the control variables (covariates) are added to the model, the impact decreases only slightly to 60.04%. The control variables show the expected positive sign, that is, municipalities that are richer, have a higher participation of agriculture, and larger in terms of population (but not area) collect more rural property taxes. With the application of the entropy weights, that equalize the differences between the municipalities in columns 3 and 4, decentralization still results in a considerable 37% increase in the amount of ITR collected.

Considering that the percentage of municipalities that decentralized the ITR differs largely between regions (see Fig. 2), we repeat the previous DiD estimations for each of the five great regions in Brazil. According to Table 4, the positive impact of decentralization in the more conservative model with entropy weights ranges between 13% and 31%, except for the Midwest region, where the impact on ITR is not significant.

About Midwest region, although statistically significant at 95% confidence, the results are not robust for the inclusion of entropy weights. It was evaluated whether in this region are political-partisan conditions that differentiate from other regions of Brazil, which could lead to the management of the ITR in a different way. In this sense, there is no difference between the country's regions in the proportion of mayors linked to rural activities, which would tend to benefit their peers and themselves (clientelistic pressure on municipal management)⁸. Other evaluations based on this political-partisan approach, such as party affiliation, are shown to be unfeasible in view of the wide range of parties in Brazil, of many political colors. In Brazil there is mayors affiliated with 29 different political parties managing municipalities across Brazil. None of them with more than 15% of the municipalities, and uncertain framing in the political spectrum (whether left, right or center).

Once the difference of political groups has been ruled out, the non-robust statistical effect for the Midwest region may be due to the fact that the dynamics of land use in the region has been more strongly pressured by the boom in agricultural production in recent years. Other factors, which generate value to the land use, and therefore affect the amount collected from the ITR, may be undermining the effects of the decentralization of the ITR. Over the past 20 years, Brazil has continued to grow its international share of important agricultural commodities (such as soybeans), and this is especially due to the expansion of production in the Midwest region (Flexor and Leite, 2017). Although covariates were used in the statistical models to control (such as the covariate Part Agro, see Table 3), other factors that affect land use (new villages, for example) may be operating. New studies on the dynamics of land use in this region can be explored in another study.

4.2. Parallel trends and impacts over time

To analyze the premise of parallel trends between treatment and control groups, as well as to assess the possibility of an oscillating temporal impact of decentralization, we generalized equation (1) including the pre-treatment effects (leads), equivalent to a placebo test, and post-treatment effects for each year (lags). This event study design identifies possible divergent trends before treatment, including a possible anticipatory effect (Cunningham, 2021).

Fig. 4 shows that, despite a jump between 2007 and 2008, the evolution of the ITR collection (in logarithm) is remarkably parallel between treatment and control group until 2009. After that first year where municipalities assumed responsibility for their own ITR collection, its value in the control group remained flat while the treatment group experienced a dynamic treatment effect. That is, municipalities with a decentralized ITR collected steadily increase the amount of ITR over time. When the weights calibrated by entropy balancing are applied, the pre-treatment lines are again parallel and closer to each other, see Figure A1 in appendix. After

⁸ The database on municipal managers (the mayors), for the purposes of framing them as "ruralist", is available at the Superior Electoral Court – TSE. This database contains information about candidates in each Brazilian election, their name, party, declared assets, occupation, election results, among others. The following occupations were considered for the mayor to be classified as ruralist: agricultural producer (*produtor agropecuário*); farmer (*agricultor*); rancher (*pecuarista*); rural worker (*trabalhador rural*). A mayor with property exceeding R\$500,000 in assets linked to land was also considered a ruralist. The data show that there is very similar representation of rural mayors across geographic regions: the percentage of rural mayors in the regions is 13.4% in the Northeast, 14.6% in the Midwest, 15.2% in the North, 15.9% in the Southeast and 16.1% in the South.

Table 3
Impact of decentralization on the amount collected from ITR.

	(1)	(2)	(3)	(4)
Decentralization	0.483 *** (0.02)	0.470 *** (0.02)	0.319 *** (0.03)	0.321 *** (0.03)
ln(Population)		0.249 *** (0.08)		0.429 *** (0.14)
ln(GDP per capita)		0.154 *** (0.03)		0.251 *** (0.04)
ln(Part Agro)		0.167 *** (0.02)		0.151 *** (0.03)
ln(Area)		0.051 (0.07)		0.049 (0.11)
Cons.	10,151 *** (0.00)	7409 *** (0.91)	10,790 *** (0.01)	5935 *** (1.54)
<i>Impacts on Revenue</i>	62.08%	60.04%	37.63%	37.79%
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
<i>Covariates</i>	No	Yes	No	Yes
<i>Weights</i>	No	No	Yes	Yes
<i>N</i>	88,019	88,019	88,019	88,019

Notes: Significance levels are represented by ***p < 0.01, **p < 0.05, *p < 0.10; the value in parentheses represents the clustered standard error at the municipality (Abadie et al., 2017). The estimate of the “Impacts on Revenue” for our log-lin model with a dummy variable is derived from following equation: $100 * [\exp(\beta) - 1]$ (Giles, 2011). The period of the database used is from 2002 to 2017. The treatment variable *Decentralization* is an indicator whether the municipality has a decentralized ITR collection or not. The dependent variable is the logged total annual value of ITR collected in the municipality area, deflated. The weights are according to the entropy balance method in Hainmueller (2012).

Table 4
Impact of decentralization by Brazilian region.

	(1)	(2)	(3)	(4)
MIDWEST				
Decentralization	0.146 ** (0.06)	0.146 ** (0.06)	-0.020 (0.11)	-0.017 (0.11)
<i>N</i>	7421	7421	7421	7421
<i>Impacts on Revenue</i>	15.72%	15.74%	-1.96%	-1.73%
NORTH EAST				
Decentralization	0.261 *** (0.06)	0.258 *** (0.06)	0.127 ** (0.06)	0.123 ** (0.06)
<i>N</i>	28,248	28,248	28,248	28,248
<i>Impacts on Revenue</i>	29.82%	29.48%	13.58%	13.11%
NORTH				
Decentralization	0.355 *** (0.09)	0.354 *** (0.09)	0.272 *** (0.10)	0.263 *** (0.10)
<i>N</i>	6768	6768	6768	6768
<i>Impacts on Revenue</i>	42.69%	42.46%	31.20%	30.10%
SOUTHEAST				
Decentralization	0.361 *** (0.04)	0.354 *** (0.04)	0.208 *** (0.05)	0.207 *** (0.05)
<i>N</i>	26,594	26,594	26,594	26,594
<i>Impacts on Revenue</i>	43.46%	42.44%	23.10%	23.06%
SOUTH				
Decentralization	0.372 *** (0.04)	0.340 *** (0.04)	0.212 *** (0.05)	0.233 *** (0.06)
<i>N</i>	18,989	18,989	18,989	18,989
<i>Impacts on Revenue</i>	45.11%	40.50%	23.57%	26.20%
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
<i>Covariates</i>	No	Yes	Yes	No
<i>Weights</i>	No	No	Yes	Yes

Notes: Significance levels are represented by ***p < 0.01, **p < 0.05, *p < 0.10; the value in parentheses represents the clustered standard error at the municipality (Abadie et al., 2017). The estimate of the “Impacts on Revenue” for our log-lin model with a dummy variable is derived from following equation: $100 * [\exp(\beta) - 1]$ (Giles, 2011). The period of the database used is from 2002 to 2017. The treatment variable *Decentralization* is an indicator whether the municipality has a decentralized ITR collection or not. The dependent variable is the logged total annual value of ITR collected in the municipality area, deflated. The weights are according to the entropy balance method in Hainmueller (2012).

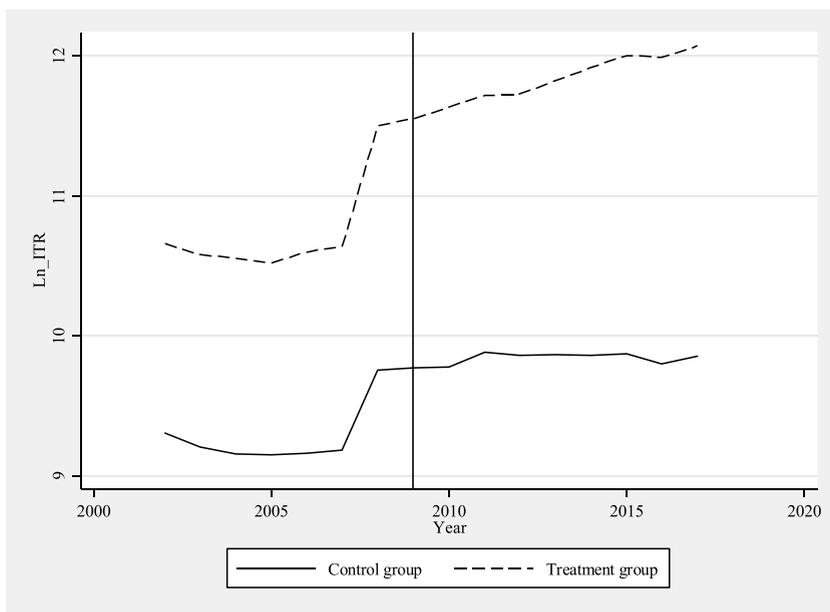


Fig. 4. Evolution of ITR revenue over time.

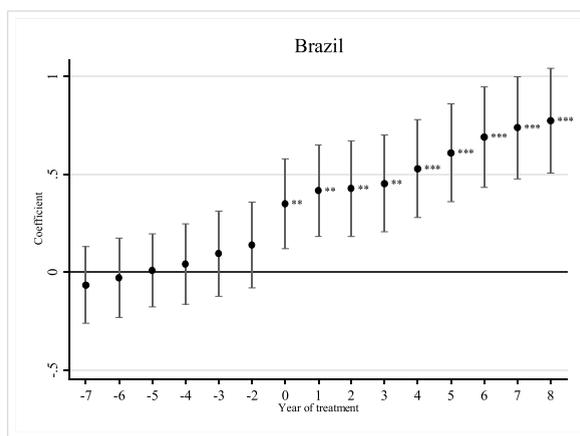


Fig. 5. Event study.

2009, the treated municipalities still experience a steeper increase in their ITR collection over time. When we consider the parallel trend analysis only for municipalities that decentralized in 2009, the new graph (see Figure A2 in appendix) is very similar to the graph with the entire treatment group (Fig. 4), and we did not find relevant differences in the event study for this sample.

The results from estimation with lags and leads for the average of municipalities in Brazil are displayed as an event study in Fig. 5. The insignificant differences between treatment and control group confirm the visual inspection of the parallel trend. Since the first year after the decentralization of the ITR management, differences become significant and positive. The impact increases year after year, as the result of a possible cumulative learning in the collection of the tax. In the ninth year of exposure to treatment, the coefficient is 0.774, which is equivalent to an increase of 116.84%. The exact values for each of the estimated lead and lag coefficients can be seen in table A3 in appendix. Event studies for each of the five regions are in figures A3 and A.4 in appendix.

4.3. Robustness test 1: subsample and quantile analyses

As a first robustness check, we run a quantile regression and a subsample analysis, according to the population size and agricultural participation of the municipalities. This exercise reveals whether there is a selection bias into treatment regarding these characteristics of municipalities. In particular, one may be concerned that the municipalities with the greatest potential for increasing ITR collection would be primarily those that decentralized.

According to Table 5, in the agglomerations with more than 100,000 inhabitants the decentralization effect is equal to a 63.8%

Table 5
Results for different profiles of municipalities.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Baseline Model	Biggest Population	Minor Pop.	Biggest Agro.	Minor Agro.	Agro q. 25	Agro q. 75
Decentralization	0.470*** (0.02)	0.498*** (0.12)	0.474*** (0.08)	0.407*** (0.08)	0.503*** (0.08)	0.270*** (0.06)	0.535*** (0.09)
Ln(Population)	0.249*** (0.08)	0.494*** (0.11)	0.470*** (0.02)	0.406*** (0.04)	0.499*** (0.03)	0.270*** (0.05)	0.536*** (0.04)
Ln(GDP per capita)	0.154*** (0.03)	1460** (0.60)	0.305*** (0.08)	0.489*** (0.16)	0.191** (0.10)	1218*** (0.20)	0.371*** (0.13)
Ln(Part Agro)	0.167*** (0.02)	0.098 (0.19)	0.151*** (0.03)	0.126** (0.05)	0.128*** (0.04)	0.110 (0.07)	0.146** (0.07)
Ln(Area)	0.051 (0.07)	-0.088 (0.08)	0.178*** (0.02)	0.175*** (0.04)	0.165*** (0.02)	0.078** (0.03)	-0.017 (0.08)
Cons.	7.409*** (0.91)	-1382* (0.74)	0.074 (0.07)	0.181 (0.20)	0.041 (0.08)	0.245* (0.14)	-0.065 (0.16)
N	88,048	4340	83,699	22,401	65,255	21,696	21,821
Impact on Revenue	60.0%	63.8%	60.0%	50.1%	64.7%	31.0%	70.9%
Municipality FE	Yes						
Year FE	Yes						

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; the value in parentheses represents the cluster standard error for the municipality (Abadie et al., 2017). The estimate of "Impacts on Revenue" derives from the proposed adjustment Giles (2011), which, since it is a log-lin model with a dummy variable, we use the following equation: $100 * [\exp(\beta) - 1]$. The period of the database used is from 2002 to 2017. The DD variable consists of a dummy with value 1 if the municipality belongs to the treatment group (decentralized the ITR) and value zero, if it is a control group. Larger population equals more than 100,000 inhabitants. "Biggest agro" means that Gross Value Added from agricultural activities total more than R\$50,000 and "Major Part. Agro" means data only for the 75th quantile and higher of the variable GVA agro/total GVA.

Table 6
Impact of decentralization by quantile of the dependent variable.

	(Q10)	(Q20)	(Q30)	(Q40)	(Q50)	(Q60)	(Q70)	(Q80)	(Q90)
with weights									
DD	0.395*** (0.06)	0.426*** (0.05)	0.444*** (0.05)	0.432*** (0.05)	0.359*** (0.05)	0.272*** (0.05)	0.254*** (0.06)	0.251*** (0.07)	0.155 (0.11)
N	88,048	88,048							
Impact	48.4%	53.11%	55.89%	54.03%	43.18%	31.25%	28.91%	28.53%	16.75%
without weights									
DD	0.789*** (0.06)	0.851*** (0.05)	0.827*** (0.05)	0.704*** (0.04)	0.600*** (0.04)	0.398*** (0.04)	0.182*** (0.05)	-0.009 (0.06)	-0.049 (0.08)
N	88,048	88,048							
Impact	120.3%	135.2%	129.7%	102.9%	82.95%	48.88%	19.96%	-0.009%	-0.04%
Mun. FE	Yes	Yes							
Year FE	Yes	Yes							
Covariates	Yes	Yes							

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; the value in parentheses represents the cluster standard error for the municipality (Abadie et al., 2017). The estimate of "Impacts on Revenue" derives from the proposed adjustment Giles (2011), which, since it is a log-lin model with a dummy variable, we use the following equation: $100 * [\exp(\beta) - 1]$. The period of the database used is from 2002 to 2017. The DD variable consists of a dummy with value 1 if the municipality belongs to the treatment group (decentralized the ITR) and value zero, if it is a control group. Q(10) are the municipalities with the lowest revenue and Q(90) are the municipalities with the highest revenue.

increase in tax collection. For the remainder 95% of smaller municipalities with less than 100,000 inhabitants, the impact changed slightly to 60.0%, the same value as in the baseline estimation (repeated in column 1). Dividing the sample with respect to either the absolute or relative value of agricultural production in the municipality leads to similar results. Applying the weights for balancing observable characteristics in treatment and control group also leads to the same conclusions, i.e., a significant, two-digit percentage increases in tax collection after the decentralization of the ITR, see appendix table A4. Hence, there is no sign of selection into treatment based on the local size of population or agricultural production.

The estimation for different ITR revenue quantiles in Table 6 shows that the effect of decentralization tends to decrease with the amount of ITR collection. For the 90% quantile the effect even becomes statistically insignificant. This observation gives us a hint about the mechanism behind the positive decentralization impact. Given that the dependent variable is equal to the total amount of ITR collection, we interpret this finding as an indication that in case the ITR collection is already implemented well, the municipality has less to gain from taking over the ITR collection from the Federal Government and incurring its management cost.

Another possible explanation for the results, not evaluated in this article due to limitations in the database, is the effect of the efficiency of municipal tax collection, which can vary greatly between municipalities.

Table 7
Impact of decentralization with treatment only in 2009 and staggered adjustments.

	(1)	(2)	(3)	(4)
	with treatment only in 2009		CS without anticipation	CS with anticipation
Decentralization	0.391 *** (0.04)	0.394 *** (0.04)	0.0837 ** (0.020)	0.232 ** (0.032)
Impacts on Revenue	47.84%	48.29%	8.73%	26.11%
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Covariates	Yes	No	Yes	Yes
Weights	Yes	Yes	Yes	Yes
N	74,579	74,596	88,019	88,019

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; The estimate of “Impacts on Revenue” derives from the proposed adjustment Giles (2011), which, since it is a log - lin model with a dummy variable, we use the following equation: $100 * [\exp (\beta) - 1]$. The period of the database used is from 2002 to 2017. The DD variable consists of a dummy with value 1 if the municipality belongs to the treatment group (decentralized the ITR) and value zero, if it is a control group. In columns (1) and (2) only municipalities that decentralized in 2009 are considered as the treatment group, and municipalities that decentralized after 2009 are removed from the sample. In the CS models, we use the method proposed in Callaway and Sant’Anna (2021), without and with considering the correction for the anticipation of treatment in columns (3) and (4), respectively. The weights by entropy balance (Hainmueller, 2012).

4.4. Robustness test 2: staggered and anticipation adjustments

The recent literature on the identification in two-way fixed effects/DiD models by Goodman-Bacon (2021), Callaway and Sant’Anna (2021), Sun and Abraham (2021), among others, demonstrates that estimates can be contaminated when treatment is observed in multiple periods. Moreover, anticipation of treatment or treatment effects heterogeneity may also yield results that do not have a causal interpretation. We incorporate the lessons from this recent string of literature to test the robustness of our previous findings.

In the present case, the adhesion by municipalities to decentralization is concentrated in 2009, with 1178 adhesions, that is, 58% of the total of 2019 adhesions until December 2017, as shown in Fig. 2. In the following years, there was an average of 120 annual subscriptions by the year 2016. For all municipalities, the treatment is staggered meaning that once decentralization is adopted, municipalities hold that status over the entire observation period. Goodman-Bacon (2021) discusses extensively that the treatment in multiple periods may cause problems in the interpretation of aggregate parameter estimates, such as those in our baseline Table 5, and even in the event study estimates (Sun and Abraham, 2021). This so called “negative weight problem” will be address by using the methodology proposed by Callaway and Sant’Anna (2021). Alternatively, we simply reduce the treatment group to municipalities that decentralized their ITR collection in 2009 and thus exclude the multi-period treatment.

Columns (1) and (2) in Table 7 show that, without the treated after the first possible year 2009, the impact of decentralization is greater than the baseline scenario. Adding covariates or not makes little difference as the positive impact of decentralization is estimated at 48% in both specifications, as compared to 38% in Table 3. Note that in this setting, the coefficient increase could simply reflect that the treatment effect is increasing over time (as observed in Fig. 4) and since in the current subsample units remain treated for a longer period, the average treatment effect is higher.

To address the multiple treatment setting with statistical rigor, we apply the recent method proposed by Callaway and Sant’Anna (2021). In essence, the authors show how to aggregate the time specific treatment effects such that the resulting effect has a causal interpretation. Their framework still allows us to include control variables and, importantly, it is also suited to identify whether municipalities anticipated their treatment. The event study in appendix figure A5 shows that in the pre-treatment period ($t = -1$) there is indeed a positive and significant increase in ITR collection among treated units. Once this anticipation behavior is not accounted for, both the event study in Fig. 6 as well as the aggregate decentralization impact on tax revenue (Table 7) are reduced to about half of the size. Nevertheless, Callaway and Sant’Anna (2021) DiD estimator qualitatively confirm our previous interpretations regarding the effect of decentralization: i) it is significant and economically relevant ii) it increases with the time of exposure to the treatment.

4.5. Robustness test 3: placebo falsification test

As a final robustness check, we estimate the effect of decentralization on a placebo dependent variable (*placebo falsification*). The aim of this exercise is to identify a possible spurious causality, for example arising from cyclical or unobservable factors not captured by the fixed effects. To this end, we use the tax collection from the Urban Property and Territorial Tax (IPTU), levied on *urban* properties in Brazil. The crucial difference with respect to the ITR is that the IPTU is entirely managed, administrated and appropriated by the municipalities.⁹ In analogy to the ITR, changes in the amounts collected from this tax may result from better tax management by the municipalities. For example, they may take efforts to update the property register in search for additional revenue (Christensen and Garfias, 2021). However, there is no expectation that the decentralization of the ITR will have any effect on the IPTU collection.

Table 8 presents the results of the placebo falsification test according to four specifications in our baseline table, that is, varying the

⁹ Municipality level data on this tax was obtained from the IPEADATA website, an economic research institute of the Brazilian Federal Government.

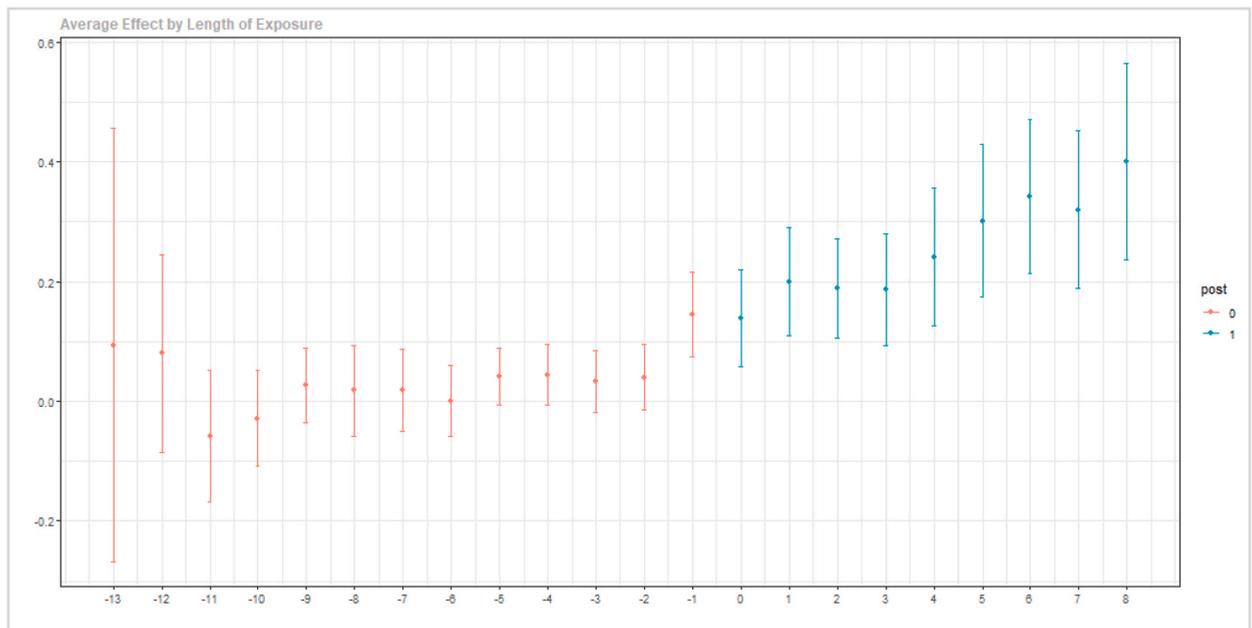


Fig. 6. Event Study with Callaway and Sant'Anna estimator with anticipatory treatment.

Table 8

Test for false dependent variable (IPTU).

	(1)	(2)	(3)	(4)
Decentralization	-0.112	-0.104	-0.200	-0.193
	(0.10)	(0.10)	(0.12)	(0.11)
ln(Population)		0.487 **		1027 **
		(0.22)		(0.41)
ln(GDP per capita)		0.311 ***		0.213 **
		(0.07)		(0.09)
ln(Part agro)		-0.100		-0.051
		(0.07)		(0.07)
ln(Area of the Municipality)		0.175		0.079
		(0.21)		(0.27)
cons	13,049 ***	6342 **	13,397 ***	2453
	(0.02)	(2.88)	(0.03)	(4.62)
N	88,036	88,019	88,036	88,019
Fixed effects				
Municipality	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Covariates	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; the value in parentheses represents the cluster standard error for the municipality (Abadie et al., 2017). The period of the database used is from 2002 to 2017. The DD variable consists of a dummy with value 1 if the municipality belongs to the treatment group (decentralized the ITR) in year I, and value zero, if it is a control group. The dependent variable in this table is the amount collected as IPTU in the municipality. The weights are by entropy balance (Hainmueller, 2012).

use of entropy weights and the inclusion of control variables. As expected, there is no statistically significant effect of ITR decentralization on IPTU collection, that is, there is no effect where there should not be.

5 Conclusion

In Brazil, the lack of progressivity of the tax system is recurrently discussed (Gobetti and Orair, 2016). In this debate, much of the attention is on the creation of new taxes (such as a tax on large fortunes) or the withdrawal of exemptions and privileges that are mostly exploited by wealthy individuals. This paper studies the tax on rural properties, which constitute a historically forgotten heritage in a country of continental dimension. The results demonstrate that it is possible to increase the amount of tax collection without even changing tax rates or calculation rules.

Specifically, this paper shows that when municipalities take over the management of the rural property tax (ITR) from the Federal

Government, the overall amount of ITR collection increases by about 41,8% in the first year (table A3 in appendix). This positive and significant effect increases gradually to about 109% after 8 years. Our difference-in-differences strategy is robust to anticipation of treatment as well as the multi-period staggered timing of the ITR decentralization. The data also indicate that treatment and control group experience parallel ITR collection trends under a variety of specifications.

To the best of our knowledge, this is the first quantitative evaluation of the Brazilian ITR decentralization. Moreover, our findings add to the literature on fiscal federalism where little attention has been given to the relation between tax collection and tax management. A main contribution of our approach is to isolate the role of tax management as the ITR rates remain constant and equal across Brazilian municipalities and the taxable resource is immobile. In sum, the present results are in line with theoretical predictions regarding a more efficient management of taxes on immobile bases at the local level. We present suggestive evidence that the mechanism behind the tax collection increase stems from the municipality's devotion to a more rigorous implementation and charge of tax duties.

Caution is recommended regarding conclusions about social welfare. Municipalities with a decentralized ITR obviously have to assume the costs arising from its collection and inspection. Unfortunately, we did not have access to this information, thus a complete cost benefit analysis is left for future research. It is worth noting that, although the optimal level for the administration of the ITR appears to be at the municipalities, receiving guidance or coordination from the Federal Revenue Service can still be beneficiary. In the face of chronic fiscal deficits and the relatively low contribution of the property tax in international comparison, policy makers in Brazil could consider reviewing ITR rates of the criteria for legal exemptions.

Statements and declarations

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

Data availability

Data will be made available on request.

APPENDIX

Table A.1
ITR rates

Total area of the property (in hectares)	Degree of use (in %)				
	Bigger then 80	Bigger then 65 to 80	Bigger then 50 to 65	Bigger then 30 to 50	up to 30
up to 50	0.03	0.20	0.40	0.70	1.00
Greater than 50 up to 200	0.07	0.40	0.80	1.40	2.00
Greater than 200 up to 500	0.10	0.60	1.30	2.30	3.30
Greater than 500 up to 1000	0.15	0.85	1.90	3.30	4.70
Greater than 1000 up to 5000	0.30	1.60	3.40	6.00	8.60
over 5000	0.45	3.00	6.40	12.00	20.00

Source: Annex to Law 9393/1996

Table A.2
Variables for empirical model

Variable	Source
ITR collection by municipality	Secretariat of the Federal Revenue Brazil
Date of execution of the ITR decentralization agreement	Secretariat of the Federal Revenue Brazil
Area of municipalities	IBGE
Population of municipalities	IBGE
Gross Value Added - municipal agricultural GVA	IBGE
Gross Value Added - GVA	IBGE
Municipal Gross Domestic Product - GDP	IBGE
IPTU collection by municipality (for false Y test)	IPEADATA
Municipal expenses	IPEADATA

Table A.3
Event study results

	Brazil	Midwest	North East	North	Southeast	South
Exposure -7 years	-0.067 (0.09)	-0.006 (0.06)	-0.035 (0.07)	-0.096 (0.11)	-0.029 (0.09)	-0.072 (0.07)
Exposure -6 years	-0.030 (0.10)	-0.008 (0.06)	0.034 (0.09)	-0.064 (0.12)	0.010 (0.10)	-0.078 (0.08)
Exposure -5 years	0.008 (0.09)	0.069 (0.06)	0.010 (0.07)	-0.053 (0.12)	0.030 (0.09)	-0.034 (0.07)
Exposure -4 years	0.040 (0.10)	0.076 (0.07)	0.063 (0.10)	-0.067 (0.13)	0.091 (0.09)	-0.039 (0.08)
Exposure -3 years	0.093 (0.10)	0.078 (0.08)	0.037 (0.09)	-0.032 (0.16)	0.178 * (0.10)	-0.021 (0.09)
Exposure -2 years	0.138 (0.10)	0.113 (0.08)	0.033 (0.10)	-0.027 (0.14)	0.210 * (0.10)	0.048 (0.09)
Exposure 1 years	0.349 *** (0.11)	0.160 ** (0.07)	0.259 *** (0.09)	0.182 (0.13)	0.323 *** (0.11)	0.248 ** (0.08)
Exposure 2 years	0.416 *** (0.11)	0.206 ** (0.08)	0.250 ** (0.09)	0.225 (0.14)	0.386 *** (0.11)	0.282 *** (0.09)
Exposure 3 years	0.426 *** (0.11)	0.211 ** (0.08)	0.210 ** (0.09)	0.314 ** (0.14)	0.399 *** (0.11)	0.288 *** (0.09)
Exposure 4 years	0.453 *** (0.12)	0.211 ** (0.08)	0.224 ** (0.09)	0.227 * (0.13)	0.436 *** (0.12)	0.294 *** (0.09)
Exposure 5 years	0.528 *** (0.12)	0.237 ** (0.09)	0.245 ** (0.09)	0.322 ** (0.14)	0.476 *** (0.12)	0.334 *** (0.09)
Exposure 6 years	0.610 *** (0.12)	0.239 ** (0.09)	0.351 *** (0.10)	0.307 ** (0.13)	0.498 *** (0.12)	0.391 *** (0.09)
Exposure 7 years	0.690 *** (0.12)	0.252 ** (0.10)	0.348 *** (0.11)	0.399 ** (0.14)	0.559 *** (0.12)	0.395 *** (0.09)
Exposure 8 years	0.737 *** (0.12)	0.261 ** (0.11)	0.425 *** (0.10)	0.520 *** (0.14)	0.542 *** (0.12)	0.421 *** (0.09)
Exposure 9 years	0.774 *** (0.13)	0.228 * (0.11)	0.433 *** (0.11)	0.624 *** (0.14)	0.554 *** (0.12)	0.419 *** (0.09)
<i>Fixed effects</i>						
Municipality	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Weights	No	No	No	No	No	No
N	88,048	7426	28,257	6773	26,594	18,998

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; the value in parentheses represents the clustered standard error at the municipality level. The differences in comparison to Fig. 5 are due to the rounding of the p-value. To estimate the impacts on revenue, we need to adjust as suggested by Giles (2011), which, since it is a log - lin model with a dummy variable, we use the following equation: $100 * [\exp(\beta) - 1]$.

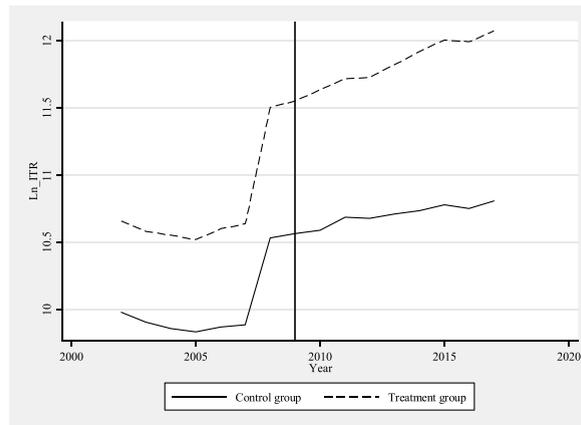


Fig. A.1. Evolution in ITR revenue with weights to equalize differences

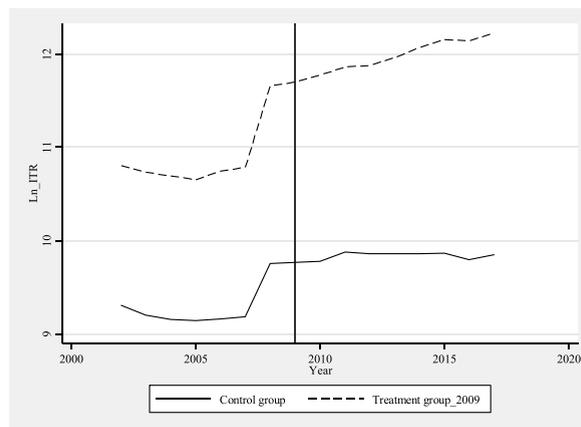


Fig. A.2. Evolution in ITR revenue with treatment only in 2009

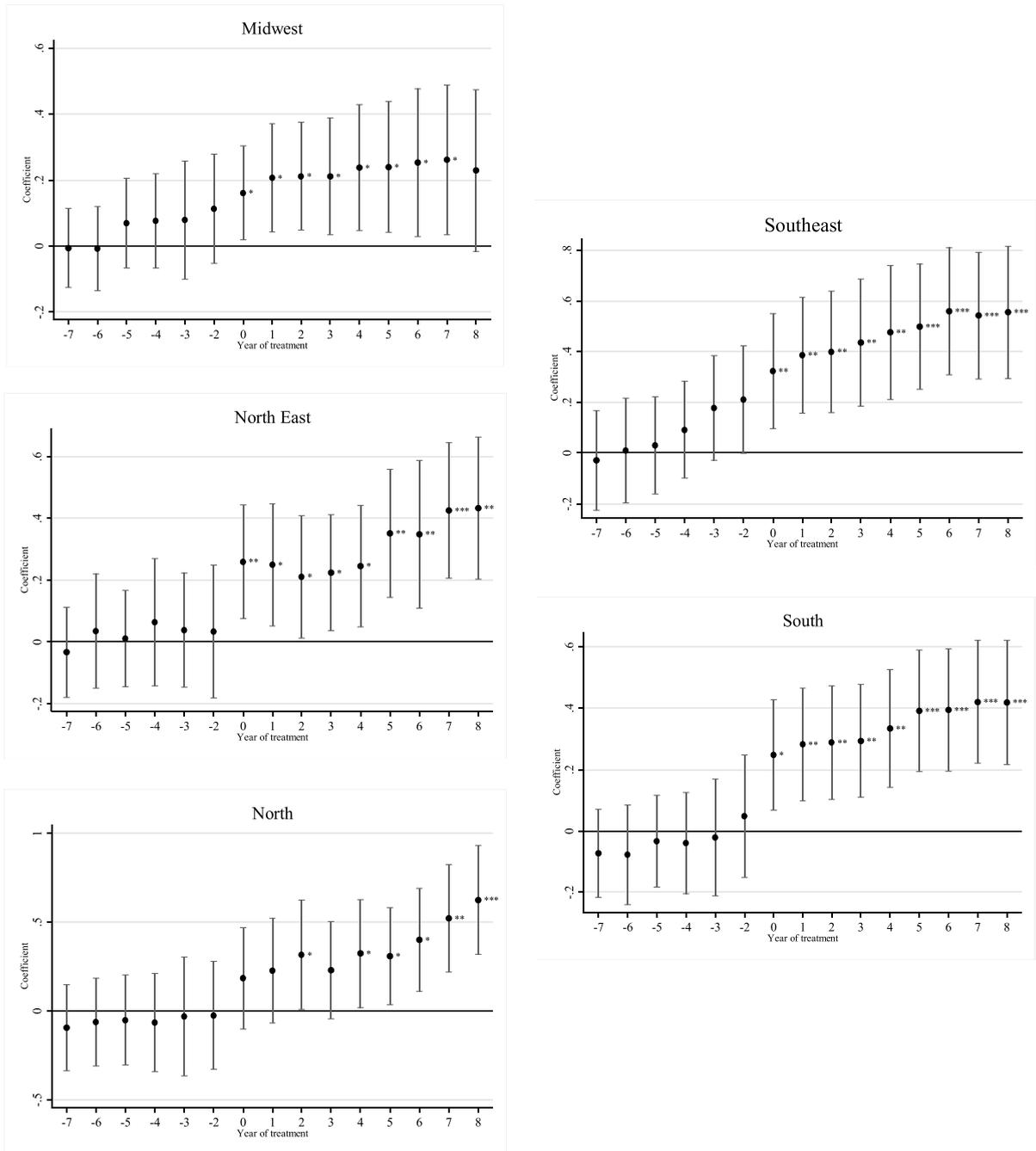


Fig. A.3. Event Study with covariates Notes: Significance levels are represented by ***p < 0.01, **p < 0.05, *p < 0.10; the value in parentheses represents the clustered standard error for the municipality. The model incorporates the covariates and does not consider the *entropy balance weights* (Hainmueller, 2012).

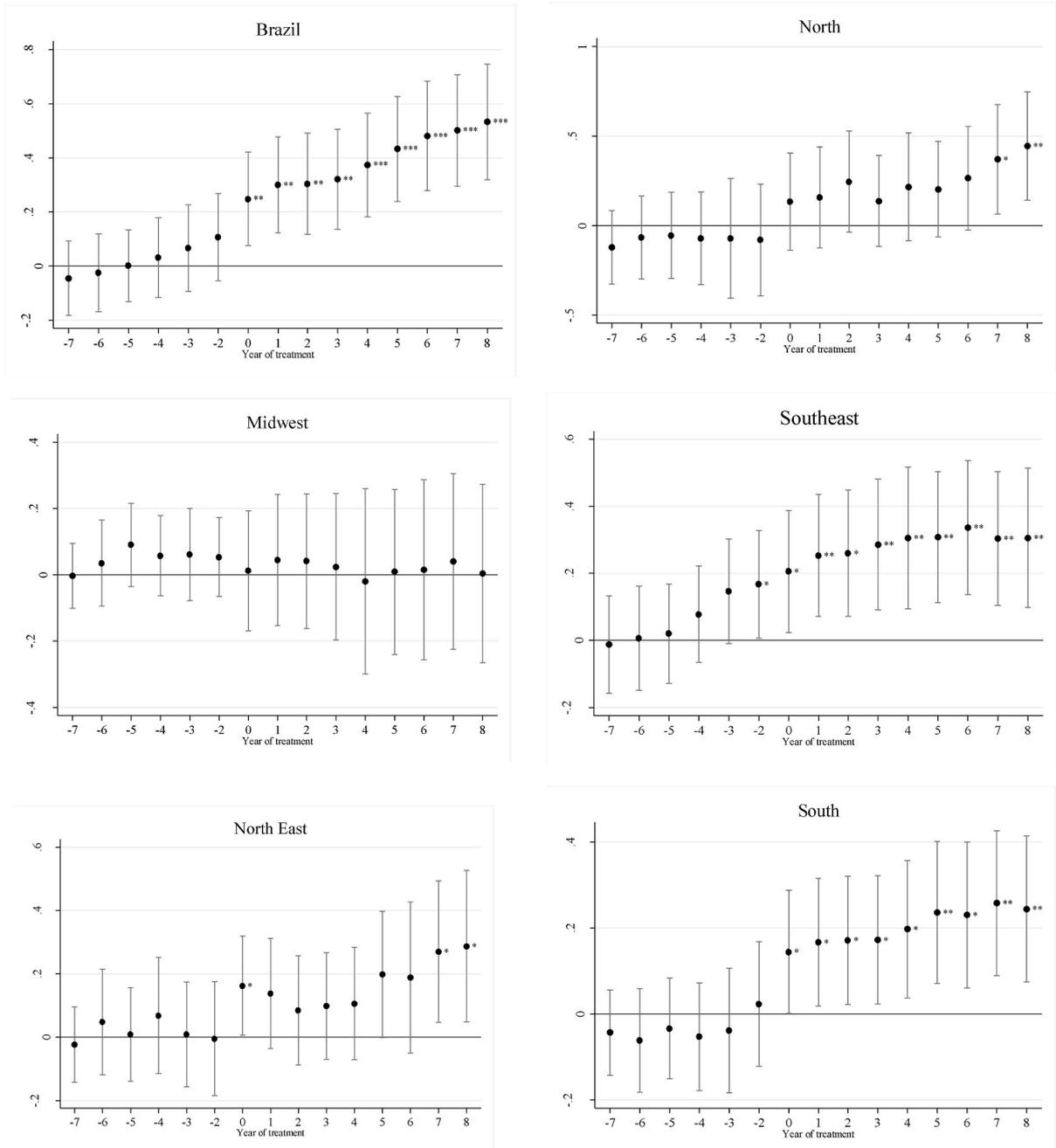


Fig. A.4. Event Study with covariates and weights for balancing Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; the value in parentheses represents the clustered standard error for the municipality. The model incorporates the covariates and consider the *entropy balance weights* (Hainmueller, 2012).

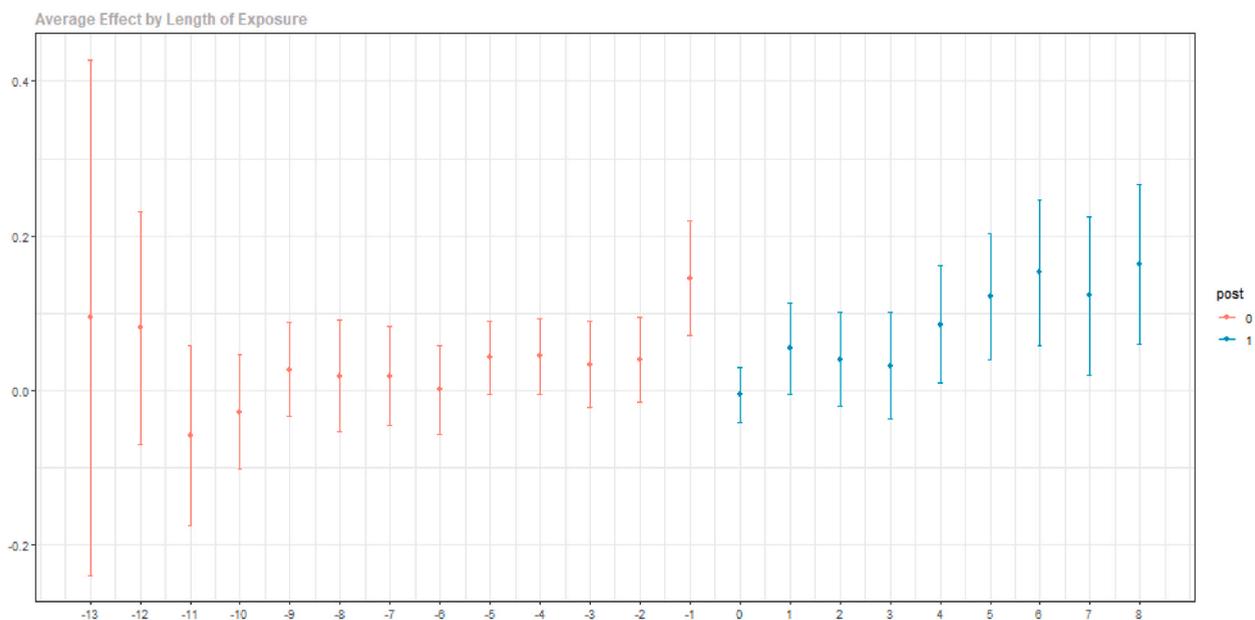


Fig. A.5. Event Study with Callaway and Sant'Anna estimator without anticipatory treatment

Table A.4

Results for different municipalities and with weights for balancing

	Base Model	Biggest Pop	Minor Pop	Biggest Agro	Minor Agro	Minor Part Agro Q (25)	Major Part Agro Q (75)
DD	0.321 *** (0.03)	0.229 ** (0.11)	0.332 *** (0.03)	0.312 *** (0.05)	0.321 *** (0.03)	0.171 *** (0.06)	0.448 *** (0.05)
<i>ln_Population</i>	0.429 *** (0.14)	1699 *** (0.57)	0.483 *** (0.14)	0.724 *** (0.26)	0.326 ** (0.14)	1510 *** (0.40)	0.432 ** (0.20)
<i>ln_GDP per capita</i>	0.251 *** (0.04)	0.057 (0.16)	0.253 *** (0.04)	0.326 *** (0.08)	0.192 *** (0.05)	0.221 ** (0.10)	0.199 ** (0.08)
<i>ln_Part Agro</i>	0.151 *** (0.03)	-0.138 * (0.08)	0.150 *** (0.03)	0.112 ** (0.06)	0.170 *** (0.03)	0.113 *** (0.04)	-0.052 (0.10)
<i>ln_Area</i>	0.049 (0.11)	-0.059 (0.54)	0.040 (0.11)	-0.072 (0.24)	0.090 (0.12)	0.432 *** (0.16)	-0.124 (0.23)
<i>_ cons</i>	5935 *** (1.54)	-8581 (7.40)	5445 *** (1.54)	4223 (3.08)	6373 *** (1.49)	-7844 * (4.37)	7065 *** (2.27)
<i>N</i>	0.321 *** 88,019	0.229 ** 4340	0.332 *** 83,670	0.312 *** 22,394	0.321 *** 65,233	0.171 *** 21,692	0.448 *** 21,806
Impact on Revenue	37.8%	25.7%	39.4%	36.6%	37.8%	18.6%	56.6%
<i>Fixed Effects</i>							
Municipality	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Covariates</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Significance levels are represented by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; the value in parentheses represents the cluster standard error for the municipality (Abadie et al., 2017). The estimate of "Impacts on Revenue" derives from the proposed adjustment Giles (2011), which, as it is a log - lin model with a dummy variable, we use the following equation: $100 * [\exp(\beta) - 1]$. The period of the database used is from 2002 to 2017. The DD variable consists of a dummy with value 1 if the municipality belongs to the treatment group (decentralized the ITR) and value zero, if it is a control group. Larger population equals more than 100,000 inhabitants. "Biggest agro" means that Gross Value Added from agricultural activities total more than R \$50,000 and "Major Part. Agro" means that the only data for the 75th and higher quantile of the variable GVA agro/total GVA. The model incorporates covariates and entropy balance weights (Hainmueller, 2012).

References

Abadie, A., Athey, S., Imbens, G.W., Wooldridge, J., 2017. *When Should You Adjust Standard Errors for Clustering?* (No. W24003). National Bureau of Economic Research.
 Baleeiro, A., 1981. *Direito Tributário Brasileiro*. Forense.
 BRASIL, 2003a. Parecer à Proposta de Emenda Constitucional nº 41/2003. Retrieved from: <http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=113717>.
 Brasil, 2003b. Exposição de Motivos da Proposta de Emenda Constitucional n. 41/2003. Retrieved from: <http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=113717>.

- Brasil, 2016. Secretaria da Receita Federal do Brasil. *Instrução Normativa – IN da Secretaria da Receita Federal n. 1640/2016*. Retrieved from: <http://normas.receita.fazenda.gov.br/sijut2consulta/link.action?visao=anotado&idAto=73816>.
- Brasil, 2020. Secretaria da Receita Federal do Brasil. *Cadastro Nacional de Imóveis Rurais (CNIR). 2020*. Retrieved from: <https://www.gov.br/pt-br/servicos/inscrever-ou-atualizar-cadastro-nacional-de-imovel-rural>.
- Brennan, G., Buchanan, J.M., 1980. *The Power to Tax: Analytic Foundations of a Fiscal Constitution*. Cambridge University Press.
- Brugnaro, R., Del Bel Filho, E., Bacha, C.J.C., 2003. Avaliação da sonegação de impostos na agropecuária brasileira. *Agric. São Paulo*, SP (50), 15–27.
- Callaway, B., Sant’Anna, P.H., 2021. Difference-in-differences with multiple time periods. *J. Econom.* 225 (2), 200–230.
- Campos, R., 1994. *A Lanterna Na Popa: Memórias*, vol. I. Topbooks, Rio de Janeiro.
- Canavire-Bacarreza, G., Martinez-Vazquez, J., Yedgenov, B., 2020. Identifying and disentangling the impact of fiscal decentralization on economic growth. *World Dev.* 127, 104742.
- Cefalu, M., Vegetabile, B.G., Dworsky, M., Eibner, C., Girosi, F., 2020. Reducing Bias in Difference-In-Differences Models Using Entropy Balancing. *arXiv preprint arXiv: 2011.04826*.
- Chalfun, N., 2005. Descentralização tributária e fiscal sob a visão econômica do federalismo. *Econ. e Soc.* 14 (1), 131–158.
- Christensen, D., Garfias, F., 2021. The politics of property taxation: fiscal infrastructure and electoral incentives in Brazil. *J. Polit.* 83 (4), 1399–1416.
- Costa, A.J., 1994. Reforma tributária: uma visão histórica. *Revista da Faculdade de Direito*, Universidade de São Paulo 89, 207–217.
- Costa, W.P., 1998. A questão fiscal na transformação republicana—continuidade e descontinuidade. *Econ. e Soc.* 7 (1), 141–173.
- Cunningham, S., 2021. *Causal Inference*. Yale University Press.
- Escolhas, Instituto, 2019. *Imposto Territorial Rural: justiça tributária e incentivos ambientais*. Retrieved from: https://www.escolhas.org/wp-content/uploads/2019/05/ITR_relatorio_final_FINAL.pdf.
- Feld, L.P., Kirchgässner, G., Schaltegger, C.A., 2010. Decentralized taxation and the size of government: evidence from Swiss state and local governments. *South. Econ. J.* 77 (1), 27–48.
- Fiva, J.H., 2006. New Evidence on the Effect of Fiscal Decentralization on the Size and Composition of Government Spending. *FinanzArchiv/Public Finance Analysis*, pp. 250–280.
- Flexor, G., Leite, S.P., 2017. Land market and land grabbing in Brazil during the commodity boom of the 2000s. *Contexto Int.* 39, 393–420.
- Gemmell, N., Kneller, R., Sanz, I., 2013. Fiscal decentralization and economic growth: spending versus revenue decentralization. *Econ. Inq.* 51 (4), 1915–1931.
- Giles, D.E., 2011. *Interpreting Dummy Variables in Semi-logarithmic Regression Models: Exact Distributional Results*, vol. 1101. University of Victoria Department of Economics Working Paper EWP, pp. 1–24.
- Gobetti, S.W., Orair, R.O., 2016. *Progressividade tributária: a agenda negligenciada* (No. 2190). Texto para discussão. Instituto de Pesquisa Econômica Aplicada. Retrieved from: <https://repositorio.ipea.gov.br/handle/11058/6633>.
- Golem, S., 2010. Fiscal decentralisation and the size of government: a review of the empirical literature. *Financ. Theor. Pract.* 34 (1), 53–69.
- Goodman-Bacon, A., 2021. Difference-in-differences with variation in treatment timing. *J. Econom.* 225 (2), 254–277.
- Hainmueller, J., 2012. Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies. *Polit. Anal.* 20 (1), 25–46.
- Hainmueller, J., Xu, Y., 2013. Ebalance: a Stata package for entropy balancing. *J. Stat. Software* 54 (7).
- Harvey, R.A., Hayden, J.D., Kamble, P.S., Bouchard, J.R., Huang, J.C., 2017. A comparison of entropy balance and probability weighting methods to generalize observational cohorts to a population: a simulation and empirical example. *Pharmacoepidemiol. Drug Saf.* 26 (4), 368–377.
- Liberati, P., Sacchi, A., 2013. Tax decentralization and local government size. *Publ. Choice* 157 (1), 183–205.
- Lockwood, B., 2008. Voting, lobbying, and the decentralization theorem. *Econ. Polit.* 20 (3), 416–431.
- Martínez-Vázquez, J., Lago-Peñas, S., Sacchi, A., 2017. The impact of fiscal decentralization: a survey. *J. Econ. Surv.* 31 (4), 1095–1129.
- Miranda, R., 2012. A restrição orçamentária maleável na abordagem da segunda geração da teoria do federalismo fiscal. In: Linhares, P. (Ed.), *Federalismo à Brasileira: questões para discussão*. Brasília. IPEA.
- Myerson, Roger, 2006. Federalism and incentives for success in democracy. *Quarterly Journal of Political Science* 1 (1), 3–23.
- Naritomi, J., Soares, R.R., Assunção, J.J., 2012. Institutional development and colonial heritage within Brazil. *J. Econ. Hist.* 72 (2), 393–422.
- Oates, W.E., 1985. Searching for Leviathan: an empirical study. *Am. Econ. Rev.* 75 (4), 748–757.
- Oates, W.E., 1999. An essay on fiscal federalism. *J. Econ. Lit.* 37 (3), 1120–1149.
- Oliveira Gozetto, A.C., Thomas, C.S., 2014. Interest groups in Brazil: a new era and its challenges. *J. Publ. Aff.* 14 (3–4), 212–239.
- Qiao, M., Ding, S., Liu, Y., 2019. Fiscal decentralization and government size: the role of democracy. *Eur. J. Polit. Econ.* 59, 316–330.
- Reydon, B.P., Oliveira, T.A.M., 2012. Brazilian land tax decentralization. A case study. In: *Annual World Bank Conference on Land and Poverty*, pp. 23–26.
- Sabbato, A.D., 2008. *A Intervenção no Mercado de Terras Rurais no Brasil: um estudo sobre o crédito fundiário e o imposto territorial rural no período 1997-2002*. Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro. Doctoral thesis. <https://tede.ufrj.br/bitstream/tede/701/1/2008%20-%20Alberto%20Di%20Sabbato.pdf>. Retrieved from.
- Sanogo, T., 2019. Does fiscal decentralization enhance citizens’ access to public services and reduce poverty? Evidence from Côte d’Ivoire municipalities in a conflict setting. *World Dev.* 113, 204–221.
- Shon, J., Cho, Y.K., 2020. Fiscal decentralization and government corruption: evidence from US states. *Public Integr.* 22 (2), 187–204.
- Simonetti, A.P.M.M., Monteiro, M.A., Gasparin, J., Perin, F.A., Júnior, L.C., 2013. Imposto territorial rural (ITR): um estudo de caso. *Revista Thêma et Scientia* 3 (1), 31–37.
- Smith, H.J.M., Revell, K.D., 2016. Micro-incentives and municipal behavior: political decentralization and fiscal federalism in Argentina and Mexico. *World Dev.* 77, 231–248.
- Souza, E.G.D., 2004. ITR: uma legislação eficiente e uma arrecadação incongruente. In: *Prêmio de Criatividade e Inovação, Brazil: Ministério da Fazenda*, pp. 229–276. Retrieved from: <https://repositorio.enap.gov.br/handle/1/4551>.
- Souza, J., Jorge, J., 1995. O imposto territorial no Brasil o processo de descentralização. *Informações Econômicas*, São Paulo 25 (9), 83–94.
- Sun, L., Abraham, S., 2021. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *J. Econom.* 225 (2), 175–199.
- Tiebout, C.M., 1956. A pure theory of local expenditures. *J. Polit. Econ.* 64 (5), 416–424.
- Weingast, B.R., 2009. Second generation fiscal federalism: the implications of fiscal incentives. *J. Urban Econ.* 65 (3), 279–293.
- Weingast, B.R., 2014. Second generation fiscal federalism: political aspects of decentralization and economic development. *World Dev.* 53, 14–25.
- Wilson, J.D., 1999. Theories of tax competition. *Natl. Tax J.* 52 (2), 269–304.