Is it effective or not?
Revisiting the effectiveness of PMAT

Fabio Nishida* Sergio Sakurai†

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Abstract

The Program for the Modernization of Tax Administration and Management of Basic Social Sectors (PMAT), administered by BNDES, constitutes a public policy that provides subsidized loans to finance initiatives aimed at enhancing local tax administration. Its primary objective is to augment the collection of own-source revenues while reducing municipalities' dependence on vertical transfers. This article evaluates the program's impact on tax revenues within Brazilian municipalities, utilizing a difference-in-differences estimator with multiple treatment periods. Unlike earlier studies on this matter, this research innovatively includes municipalities that applied for, but did not receive, program funds as a control group, since they have a more similar profile to the municipalities that benefited. The results differ from those previously documented in the literature, indicating that the program did not have a substantial impact on the tax revenues of the municipalities that received assistance, thereby suggesting that the modernization efforts financed by the program were insufficient to enhance local tax collection.

***Keywords**: PMAT. Tax revenue. Brazil. Local governments. Difference-in-differences.*

*University of Sao Paulo, fabio.nishida@usp.br.
†University of Sao Paulo, sakurai@usp.br.

1 Introduction

Under the current regulations of the Brazilian tax system, municipalities are responsible for collecting two primary taxes: the Tax on Services of Any Nature (ISSQN) and the Urban Property and Land Tax (IPTU). The ISSQN is imposed on the provision of services, while the IPTU is levied on the ownership of urban properties. In addition to these main taxes, municipalities also manage the collection of other significant revenues, including the Property Transfer Tax (ITBI), along with fees and charges defined within the tax system.

In theory, these resources should be sufficient to cover most of the local government expenditures. However, Brazil's federal system includes 5,569 municipalities, most of which have small populations. According to population estimates from IBGE, 1,248 municipalities (almost 23%) have populations of up to 5,000 inhabitants, while 2,447 (approximately 44%) have populations of up to 10,000 inhabitants. Data from the National Treasury Secretariat (STN) reveal that for the first group of municipalities, tax revenue (i.e., own-source revenue) accounts for only about 1.5% of total revenues. For the second group, this proportion is slightly higher, at approximately 1.9%.

Most municipalities in Brazil, with a few exceptions, show low fiscal autonomy and significant dependence on transfers from state and, especially, federal governments, primarily through the Municipal Participation Fund (FPM). Additionally, these municipalities have limited options for obtaining medium- and long-term loans from the financial system. As a result, they rely heavily on vertical fiscal transfers to cover their expenditures. Furthermore, they often seek official credit from public banks to finance investments or projects aimed at improving their overall administrative structure, particularly their tax administration systems.

Traditional fiscal decentralization theory advocates for increased decentralization of fiscal duties, arguing that municipalities ought to have more authority in public resource allocation (Brennan & Buchanan, 1980; Oates, 1972; Tiebout, 1956). It also underscores the significance of vertical transfers to balance local public finances. However, the second generation of this theory points out problems that may threaten the fiscal stability of local governments within federal systems. A significant issue is the "flypaper effect," where local public expenditure is more affected by vertical transfer funds than by a similar increase in local revenue. Furthermore, this generation cautions against the "soft budget constraint," a scenario in which subnational governments assume they will receive financial support during deficits or debts. This belief can result in resource management inefficiencies.

To enhance the locally sourced revenue of local governments, the National Bank for Economic and Social Development (BNDES) launched the Program for the Modernization of Tax Administration and Management of Basic Social Sectors (PMAT) in 1997. This initiative targeted municipalities with revenue below their potential and offered subsidized loans for projects aimed at modernizing local tax administration. To our knowledge, three studies have assessed the impact of the program's implementation on municipal tax revenue,

yielding mixed results. While the study by Bast (2015) found that PMAT did not affect local own-source revenue, Barbosa Filho (2013) and Gadenne (2017) reported that municipalities benefiting from the program's loans experienced an increase in tax revenue following their participation in the program.

To assess the impact of the PMAT on local tax revenue, previous studies employed the difference-in-differences (DiD) method across multiple periods, following the two-way fixed effects (TWFE) specification. However, recent literature points out potential biases in estimates derived from TWFE, especially when there are heterogeneous group or time effects (de Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2021; Roth, Sant'Anna, Bilinski, & Poe, 2022; Sun & Abraham, 2021). Therefore, the main objective of this article is to reevaluate the results obtained using the recent DiD estimator proposed by (Callaway & Sant'Anna, 2021). Furthermore, in contrast to earlier studies, this article selects municipalities that applied for funding but did not receive it as part of the control group since these municipalities have a profile that closely resembles those local governments that benefited from the program.

The findings presented in this article indicate that the PMAT program did not significantly affect tax revenue. This implies that the implementation of projects financed through the program's credit was insufficient to motivate participating municipalities to increase their own-source tax revenue. This conclusion remains valid not only when analyzing the overall tax revenue of Brazilian municipalities that benefited from the program's credit but also when separately evaluating the effects on the main local taxes in Brazil (ISSQN, IPTU, ITBI, and fees).

This study contributes to two strands of the economic literature. The first strand concerns the existence and operation of public banks, particularly development banks, including BNDES. This institution is widely recognized as one of the largest and most significant development banks in the world, and its operations have long been the subject of debate due to the numerous changes in its operational profile since its inception.

Secondly, this article interacts with the extensive literature on fiscal decentralization, specifically addressing the fiscal situation of Brazilian municipalities. It explores the degree to which public policies established by higher levels of government can foster greater fiscal autonomy for local governments. This discussion is intimately connected to the ongoing debate over the reform of the Brazilian tax system, which entails modifications to various taxes and, consequently, impacts the resources available to municipalities through both their own revenue collection and the system of vertical transfers.

In addition to the previously mentioned contributions, this article aims to present new findings in the econometric literature regarding public policy evaluation models. Specifically, it focuses on models that analyze treatment effects when the selection of treated units is not random but endogenous and when treatments occur during different periods. As noted earlier, this study employs the Difference-in-Differences (DiD) model with multiple treatment periods, as proposed by Callaway and Sant'Anna (2021). The utilization of this

model has not only increased significantly in recent years but also represents an important methodological advancement over earlier studies that examined the effectiveness of PMAT as a tool for enhancing tax collection efficiency in Brazilian municipalities.

This article is organized as follows: Section 2 discusses the fiscal decentralization literature, with a particular focus on the flypaper effect and the soft budget constraint. Section 3 explores the Brazilian context, highlighting regulations related to the PMAT program and reviewing existing studies that assess its impact on local tax revenue. In Section 4, we present the Difference-in-Differences (DiD) model with multiple treatment periods, followed by a description of the data used and their sources in Section 5. Finally, Section 6 presents the estimation results, while Section 7 offers concluding remarks.

2 Decentralization and transfers: theory and evidence

Fiscal decentralization is a public sector organization model that combines both centralized and decentralized responsibilities, allowing different levels of government to share fiscal functions (Silva, 2005). A key normative question in this context is determining the appropriate level at which fiscal powers and responsibilities should be delegated from the central government to local governments. Typically, first-generation fiscal decentralization models connect this process to potential social welfare gains, suggesting that it can lead to greater responsiveness to public demands and a more efficient allocation of resources by the public sector (Vo, 2010).

Musgrave (1959) identified three key fiscal functions that the public sector performs: economic stabilization, income distribution, and resource allocation. In a decentralized system, these responsibilities are distributed among various levels of government – central and subnational. Economic stabilization involves implementing fiscal and monetary policies aimed at promoting stable macroeconomic development. Traditional fiscal decentralization theorists argue that resource allocation is the primary fiscal function justifying decentralization. They contend that subnational governments can allocate resources more efficiently because they have a better understanding of local preferences than higher levels of government (Brennan & Buchanan, 1980; Oates, 1972; Tiebout, 1956).

Traditional fiscal decentralization theory suggests that subnational governments should have the ability to collect their own taxes to fund public services. However, in practice, the revenue they generate on their own is often insufficient to cover all local public service needs. As a result, there is a need to enhance subnational revenues. To better align tax capacity with fiscal requirements, first-generation fiscal decentralization proposes the use of unconditional vertical transfers (Oates, 2008). These transfers, which move funds from central to local governments without conditions, would not influence how local authorities manage their own revenue. Consequently, they would not change the relative prices of goods (Bird, 2004).

The second generation of fiscal decentralization theory arose from the observation of fiscally inappropriate behavior exhibited by local governments, which was not anticipated by first-generation models. Specifically, studies have shown that unconditional transfers tend to stimulate public spending more than an equivalent increase in revenue from local sources. This finding contradicts traditional economic theory (Gramlich & Galper, 1973; Hines & Thaler, 1995; Inman, 1971). As a result, local governments that receive central transfers are more likely to increase spending on public services instead of passing these resources on to their constituents through tax reductions. This phenomenon is referred to as the "flypaper effect" (Inman, 2008) and has been extensively documented in empirical research, including studies focused on Brazil (Cossio & Carvalho, 2001; Guedes & Gasparini, 2007; Sakurai, 2013, among others).

To explain this phenomenon, Strumpf (1998) utilized the concept of fiscal illusion from Buchanan (1967), arguing that the median voter does not fully perceive the real value of transfers received by the jurisdiction. Consequently, bureaucrats and political agents can exploit public resources. Wyckoff (1988) posited that public agents engage in more exploitative actions when their bargaining power is greater. Therefore, a higher percentage of transfers relative to total revenues would decrease the voter's bargaining power, as their potential relocation to a neighboring jurisdiction would have less impact on local public revenue. Both authors suggest that the flypaper effect is caused by the rent-seeking behavior of political agents and interest groups, resulting in allocative inefficiencies of resources. In line with these models, Brollo, Nannicini, Perotti, and Tabellini (2013) empirically found that higher central transfer revenues induce greater corruption practices in Brazilian municipalities.

On the other hand, Hamilton (1986) proposed that this phenomenon is the result of an efficient allocation of resources. The author suggests that raising local tax rates creates more distrotions and results in a greater deadweight loss in the economy compared to increasing revenue through unconditional transfers. Thus, when a local government receives more vertical resources, it can select a more efficient level of public spending, which explains the flypaper effect (Gamkhar & Shah, 2007). This increase in resources would also reduce in local tax collection. Indeed, Mattos, Rocha, and Arvate (2011) empirically verified that an increase in central transfers leads to a decrease in tax effort, while an increase in private income stimulates it.

The concept of soft budget constraints in second-generation fiscal decentralization models examines the structural factors that lead central governments to rescue local governments when they face financial difficulties. This phenomenon occurs in the public sector when policymakers, such as governors and mayors, make decisions under the assumption that the central government will bail them out if they encounter fiscal issues, such as persistent budget deficits and rising debt levels. This expectation can foster fiscally irresponsible behavior. In countries like Brazil and Argentina, the fiscal policies implemented by local governments have significantly destabilized the overall fiscal system.

Some authors have proposed models to explain why the central government would bail out subnational entities facing financial difficulties. Goodspeed (2002) suggests that during decision-making, the central government considers not only the cost associated with the decline in local welfare due to insufficient resources for providing public goods but also the electoral repercussions. This is because residents in an unassisted area may blame the central government for their predicament. Conversely, Wildasin (1997) focuses exclusively on the economic costs, presenting a model where the actions of the local government generate externalities affecting neighboring jurisdictions. Consequently, the financial "failure" of one area can lead to a decline in welfare for surrounding federative entities and, ultimately, the entire central system.

Given that the central government often provides bailouts to local governments, these local entities may engage in fiscally irresponsible behaviors. As a result, a potential "common pool" problem arises within a federal system, where subnational governments attempt to extract additional resources from a central source, with the costs being shared across the nation.

A soft budget constraint primarily arises from financing local public goods through vertical transfers. Indeed, Rodden (2003) identifies "transfer dependency" as a key factor that undermines the budget constraint. Furthermore, Vigneault (2005) highlights that an increased vertical fiscal imbalance (the extent local governments depend on transfers for funding services) leads to greater expectations for central bailouts among subnational governments, influenced by both voters and creditors. Considering the limited capacity for local revenue generation, these agents frequently exert pressure on the federal government to assist financially distressed jurisdictions.

To reduce the risk of a soft budget constraint, Oates (2005) recommends establishing an effective and reliable system of local taxation. This approach would ensure that local revenues are sufficient to fund public goods, enabling agents to better assess the benefits and costs of the services provided, thereby promoting greater fiscal discipline. In cases where institutions are underdeveloped, particularly in developing countries, the author suggests implementing fiscal rules that require balanced budgets, set debt limits, and establish clear procedures for managing fiscal crises.

3 Institutional Context

3.1 Brazil in the 1990s

Under the process of Brazilian re-democratization, the promulgation of the 1988 Federal Constitution (CF/88) promoted political and fiscal decentralization by granting greater administrative and political autonomy to municipalities, which were elevated to the status of federal entities alongside the Union, States, and the Federal District. As a result, Brazil became one of the most decentralized countries in the world, with significant subnational

revenue collection (Rodden, 2003).

Since the 1960s, Brazil has faced considerable fiscal crises characterized by high levels of personnel expenses and debt. Voters tended to believe that deficits and debts incurred by state and municipal governments were not the responsibility of governors and mayors. This perception was reinforced by the media and members of the Federal Congress (Souza, 1996). In each of these instances, the subnational entities sought financial assistance, which was provided through federal debt relief (Rodden, 2003).

The fiscal challenges, driven by the soft budget constraint, underscored the necessity for reforming the fiscal relations among various entities. During the second half of the 1990s, there was significant evolution in fiscal legislation and regulation, especially regarding public debt. The Program for Restructuring and Fiscal Adjustment (PAF) (Law 9.496/1997) set specific fiscal targets aimed at reducing the debt-to-revenue ratio, increasing the primary surplus and own-source revenue, limiting personnel and investment expenditures, and privatizing public companies.

The Fiscal Responsibility Law (LRF – Complementary Law 101/2000) and the Fiscal Crimes Law (LCF – Law 10.028/2000) were among the most significant reforms in Brazil's intergovernmental system (Rodden, 2003). The LRF established several important rules, including a prohibition on states and municipalities undertaking internal or external credit operations if they exceeded their debt limits. It also mandated that these entities submit and publicly disclose their budget plans (PPA, LDO, and LOA) to the Legislature. Furthermore, the LRF emphasized the necessity of tax collection, increased Central Bank transparency, and prohibited federal bailouts for subnational entities.

On the penal front, the LCF enhanced the accountability of public officials by introducing potential imprisonment for illegal attempts to issue public debt, as well as provisions for the removal from office of those who fail to comply with personnel and debt expenditure limits (Almeida, 2000, as cited in Rodden, 2003).

The reforms initiated in the 1990s aimed to strengthen budget constraints to address fiscal issues, particularly related to fiscal deficits and indebtedness. While they were effective in controlling the major economic crisis, some fiscal challenges within the federation persisted.

3.2 Program for the Modernization of Tax Administration (PMAT)

In 1997, the Program for the Modernization of Tax Administration and Management of Basic Social Sectors (PMAT) was established by the National Bank for Economic and Social Development (BNDES). This initiative was a response to the financial crisis affecting subnational entities and aimed to implement reforms in intergovernmental relations. At that time, several factors were cited for poor revenue performance, including outdated and costly technology, a lack of updated data and information acquisition, insufficient qualifications among public servants, and inadequate physical facilities for citizen service (Nascimento &

Debus, 2002).

Given these challenges, PMAT's primary objective was to provide credit for improving tax administration in municipalities that were generating less revenue than their potential. This support aimed to enable participating jurisdictions to enhance their own revenue, thereby achieving greater autonomy from state and federal governments. The program offered loans of up to R$ 30 million, R$ 18 per inhabitant, or 7% of net real revenue (whichever was lower), with repayment terms of up to eight years, including a 24-month grace period. Municipalities used their share transfers share on the Municipal Participation Fund (FPM) or the Tax on Circulation of Goods and Services (ICMS) as collateral. These funds come from the federal and state governments, respectively. As a result, vertical transfers could be withheld in the event of debt non-payment, which contributed to low default rates for the program.

To apply for the PMAT, a municipality must submit a modernization project that clearly outlines how it plans to identify, analyze, and monitor its actions and financial goals. The objective is to achieve greater efficiency in revenue collection or effectively reduce the unit costs associated with providing basic social services. The BNDES evaluates the appropriateness of resource allocation across the following categories:

1. Information technology and computer equipment (35%),
2. Computing (35%),
3. Human resource training (25%),
4. Specialized technical services (35%),
5. Support equipment for operation and inspection (25%), and
6. Physical infrastructure (20%).

The percentages in parentheses indicate the maximum financing available for each category in relation to the total loan amount. It is important to note that these values intentionally exceed 100%, providing municipalities greater flexibility in resource allocation (Barbosa Filho, 2013).

Following the enactment of the Fiscal Responsibility Law (LRF), legislative approval became necessary for credit operations, as established by Senate Resolution 43/2001. Until 2010, this authorization could be granted through the Annual Budget Law (LOA), which included the PMAT credit operation as one of the approved items. However, Federal Senate Resolution 10/2010 introduced a requirement for specific legislation for each credit operation.

Once a modernization project is accepted by the BNDES and approved by the municipal council, the credit operation must also receive approval from the National Treasury Secretariat (STN). This process involves submitting a "Request for Verification of Limits and

Conditions" (PVL), in accordance with the Fiscal Responsibility Law (LRF) and Senate Resolutions 40/2001 and 43/2001. The STN evaluates whether the municipality meets the necessary requirements regarding debt levels and repayment capacity to manage any future debts. Upon approval of the PVL, the municipality becomes eligible to receive PMAT funds and can begin implementing the actions outlined in its project.

3.2.1 PMAT effectiveness

Many municipalities participating in the PMAT program have updated their tax records, improved taxpayer oversight, simplified tax payment processes, trained their personnel, and acquired the necessary hardware and software. To evaluate the effectiveness of these measures, three empirical studies have examined the impact of PMAT on per capita municipal revenue, yielding significantly different results (Barbosa Filho, 2013; Bast, 2015; Gadenne, 2017). These studies employed the difference-in-differences (DiD) method, specifically using two-way fixed effects (TWFE) regression, which is known to be susceptible to biases when heterogeneous effects are present (De Chaisemartin & D'Haultfœuille, 2023; Roth, Sant'Anna, Bilinski, & Poe, 2023).

The impact of PMAT funding on tax revenue has been a focal point of analysis. Barbosa Filho (2013) found a statistically significant positive effect of receiving PMAT funding on tax revenue. Similar results were focusing in each type of local tax (IPTU, ISS, and ITBI), although the program had a null effect on local fees. Similarly, Gadenne (2017) found a positive impact on own-source revenue, which increased up to five years after the start of PMAT funding. In contrast, Bast (2015) found a statistically null effect of PMAT on local tax collection.

The methodological approaches employed in these studies varied significantly. Barbosa Filho (2013) used a static Difference-in-Differences (DiD) model, incorporating control variables related to local finances, the tax base, and demographics. Gadenne (2017) adopted a dynamic DiD specification, estimating treatment effects using event study analysis. This study used covariates along with the matching approach proposed by Hirano and Imbens (2001), including variables associated with local finance, the tax base, demographics, and local political-administrative preferences.

Furthermore, Bast (2015) examined both binary and continuous forms of the treatment variable. This distinction was necessary because not all participants in the PMAT program executed their planned actions and, as a result, did not receive the full amount of borrowing originally intended. Similar to Gadenne (2017), this study also employed a matching method to enhance the pairing between treatment and control groups. In this process, it utilized socioeconomic variables as covariates, along with a dummy variable indicating whether the municipality participated in a related tax modernization program called PNAFM, which was managed by the Ministry of Finance.

The effects of PMAT on other aspects of municipal performance were also explored.

Additionally, Bast (2015) considered the existence of jurisdictions participating in PNAFM, another public program that finances actions to modernize tax administration. The author suggested that these factors, along with the potential dose effect and matching at each period, may have contributed to the significantly different results compared to Gadenne (2017).

4 Method

Given the distinct findings from various studies assessing the impact of PMAT on the tax revenue of beneficiary municipalities, along with the recent advancements in the Difference-in-Differences (DiD) model, this article aims to present new results using the estimator proposed by Callaway and Sant'Anna (2021).

Several empirical studies utilize the potential random assignment of public policies to generate exogenous variation in explanatory variables, establishing a quasi-experimental framework that facilitates the identification of policy implementation impacts. However, in the case of PMAT, municipalities voluntarily apply for the program, leading to non-random treatment assignment and potential selection bias. Therefore, this study posits that the assignment can be considered conditionally random, taking into account variables related to treatment assignment (i.e., PMAT participation), allowing for the identification and estimation of the program's effects without bias.

To evaluate the impact of PMAT on the own-source revenue of Brazilian municipalities, this study employs the DiD model. Participation in the program occurred at different times for various municipalities, resulting in multiple treatment periods. Previous studies (Barbosa Filho, 2013; Bast, 2015; Gadenne, 2017) used the two-way fixed effects (TWFE) model for estimating the program's effects. However, this approach can yield biased estimates by failing to account for heterogeneity among groups and by including control group units that may have already been treated (Roth et al., 2023).

5 Data and variables

Due to changes in administrative boundaries caused by territorial divisions, this study uses the minimum comparable area (AMC) as the unit of observation, which is a territory that maintains its boundaries across two time periods. The database that links AMCs to their constituent municipalities was 0developed by (Ehrl, 2017) based on municipal genealogy. This study focused on AMCs from 1999 to 2019; however, we also provided estimates up to 2012 to align with the analyses conducted in three prior studies. To keep things simple, and due to the relatively minor territorial splits during this period[1], we will refer to these areas as municipalities for the remainder of the paper.

[1]Only 91 out of 5,670 are new municipalities that have been established in Brazil since 1999.

Fiscal information was gathered from the Siconfi database, which is the accounting and fiscal information system for municipalities provided by the National Treasury Secretariat (STN) for the years 1991 to 2019. Monetary values were adjusted to 2019 price levels using the historical series of the Broad National Consumer Price Index (IPCA), calculated and provided by IBGE. To ensure comparability among the fiscal variables of the municipalities, these values were measured on a per capita basis. Population estimates were also sourced from IBGE, beginning in 1999.

To gather information on the municipalities that participated in the PMAT (Program for Modernization of Tax Administration), we utilized data on disbursements and credit operations from the National Bank for Economic and Social Development (BNDES), which contains a comprehensive record of all credit operations executed under PMAT along with their beneficiaries since the program began in 1998.

This dataset does not include information on municipalities that applied but did not participate in the program, which could be an arguably better control group. To address this gap, our study proposes utilizing an additional source to gather information of these "almost treated" municipalities.

Table 1: Accepted and rejected PMAT applications

Year	**Accepted**	**Rejected**	**Year**	**Accepted**	**Rejected**
1998	2	2	2009	4	7
1999	4	2	2010	5	1
2000	20	1	2011	7	22
2001	3	15	2012	6	13
2002	63	19	2013	5	1
2003	56	3	2014	10	6
2004	104	58	2015	17	17
2005	13	9	2016	17	13
2006	19	56	2017	6	17
2007	21	15	2018	16	9
2008	14	8	2019	6	5
Total	**418**	**299**			

Sources: BNDES and Sadipem/STN. Notes: This table considers only the first PMAT projects accepted for each participating municipality and the first rejected application from those that did not participate during the entire analysis period.

We requested a list from BNDES identifying the municipalities that applied for PMAT financing but were not successful in securing it. Between the years 1998 and 2019, a total of 299 distinct municipalities did not qualify for this credit (see Table 1). According to BNDES, many factors contributed to the denial of PMAT credit, including clients withdrawing from projects and failing to submit the necessary technical, financial, or legal information on time, preventing BNDES from evaluating the projects.

Furthermore, we propose the utilization of data obtained from Sadipem, a platform of the National Treasury Secretariat (STN), which is used by states and municipalities to require credit operations approval, including those under PMAT. As discussed in subsection 3.2, after the approval of the tax modernization project by BNDES, the credit operation request is made to the National Treasury, which can approve or deny the request based on

the fiscal information of the requesting subnational government. This database's disadvantage compared to BNDES's is that it only starts in 2002, as this process was implemented with the Fiscal Responsibility Law (LRF) in 2001.

Since the selection of municipalities for the PMAT program is not random, we will use information from two different databases to create a more credible control group, which we will refer to as "almost treated." This group will consist of jurisdictions that attempted to obtain credits from the BNDES program but were unsuccessful. Only municipalities whose applications were rejected throughout the entire analyzed period and that did not participate in PMAT will be classified as almost treated. Conversely, municipalities that were initially rejected but later received program credits will be classified as treated. We will assume that a participant is considered treated when they start the program and remains in this state until the final analysis period in 2019, even if the tax modernization project has concluded.

Outcome Variables: The tax revenue, which includes collections from taxes and fees, serves as the primary outcome measure. Within the Brazilian municipal context, this revenue mainly consists of the Service Tax (ISSQN), the Urban Property and Land Tax (IPTU), the Property Transfer Tax (ITBI), and fees. Local governments have the autonomy to establish their tax rates within certain limits and are responsible for collecting these taxes from taxpayers. In addition to analyzing total tax revenue, the impact on ISSQN, IPTU, ITBI and fees collections will also be examined separately.

To strengthen the credibility of the parallel trends assumption, we will include covariates related to the selection of treatment, which indicate a higher or lower likelihood of a municipality participating in PMAT. These variables help control for differences between the treated and untreated groups, thereby reinforcing the assumption of conditionally random treatment assignment. This is essential for ensuring the validity of our estimates and accurately assessing the impact of PMAT implementation on municipal own-source revenue.

Consequently, we implemented the inverse probability weighting (IPW) (Abadie, 2005) matching approach. Should the model be accurately specified according to the selected covariates, the estimation will yield consistent results. We incorporated control variables pertinent to public finance, the tax base, demographics, and political-administrative preferences.

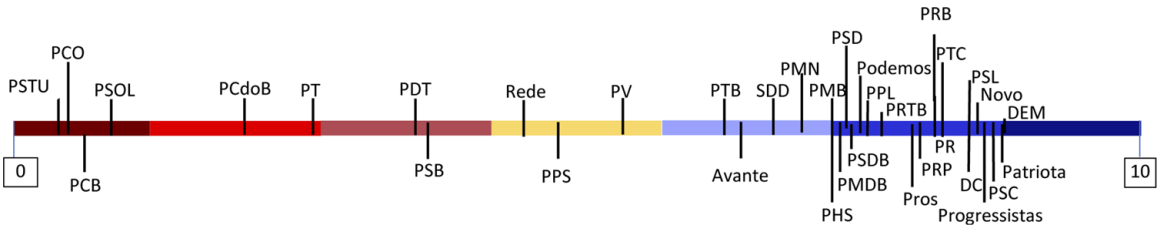
Vertical transfers: Data was acquired from Siconfi/STN between 1999 and 2019. This information encompasses per capita transfers and the vertical fiscal imbalance (VFI), which indicate the level of dependency of municipalities on intergovernmental transfers.

Socieconomic variables: The municipal population estimates and demographic variables, covering urban, young, elderly populations, average salary, and literacy rate, were sourced from the Brazilian Institute of Geography and Statistics (IBGE). Yearly values from 1999 to 2019 were calculated using linear interpolation on Censuses datasets. The municipal gross domestic product (GDP) and the contribution of value added from the service, industrial,

and agricultural sectors were also obtained from the same institute.

Political variables: electoral and political party information was sourced from the Superior Electoral Court (TSE) from the municipal and general elections. We considered whether the incumbent mayor is seeking re-election for a second term in the forthcoming election and whether he is in the president's political party coalition[2]. Furthermore, we applied the party classification from the Brazilian Political Science Association (ABCP)[3] (Bolognesi, Ribeiro, & Codato, 2023; Tarouco & Madeira, 2015) for each elected mayor. This classification reflects the ideological preferences of the political parties on a political spectrum that ranges from 0 (far left) to 10 (far right) (Figure 1).

Figure 1: ABCP's political parties classification (2018)



Source: Bolognesi et al. (2023)

Only municipalities treated from 2000 onward were considered due to database limitations. The statistics in this subsection are based on 1999 data, considered as the baseline year with no program participants. Our sample included 411 treated municipalities (those that received PMAT credit) and 294 almost treated (those that applied but did not receive loan).

In Table 2, the differences in per capita total revenues between almost treated and untreated municipalities, when compared to treated municipalities, are not significant. However, their reliance on vertical transfers is notable. PMAT municipalities relied less on intergovernmental grants and collected more taxes from the local economy. This may indicate a larger tax base in these areas, which typically feature stronger economies and a more populous and urbanized demographic. Additionally, these municipalities have a larger working-age population that is more literate, suggesting a workforce that is more productive and earns higher incomes.

Overall, the average values for the "almost treated" group of variables lie between those of the treated and untreated groups. This suggests that municipalities that applied for, but did not obtain the PMAT loan, have characteristics more similar to those of the treated municipalities, making them more suitable as controls. Nonetheless, the differences in average values between the almost treated and treated variables remain significant, underscoring the need to include relevant selection covariates to ensure the reliability of the conditional parallel trends assumption.

[2]Brazilian politics features a fragmented party system with many parties across the ideological spectrum. This often requires coalition formation to achieve political governance, significantly influencing policy outcomes and resource allocation.

[3]Developed through expert surveys conducted with political specialists in 2010 and 2018 meetings.

Table 2: Statistics of treated, almost treated, and untreated areas (1999)

	treated	**almost treated**	**diff.**	**untreated**	**diff.**
Financial variables					
Total Revenues$^{\times}$	1,552.2	1,448.5	-103.7	1,655.4	103.2
Tax Revenues$^{\times}$	235.5	166.5	-69.0***	71.7	-163.8***
Property Tax (IPTU)$^{\times}$	91.1	69.7	-21.5	23.6	-67.5***
Services Tax (ISS)$^{\times}$	66.7	44.0	-22.7***	17.7	-49.0***
Property Transfer Tax (ITBI)$^{\times}$	18.5	15.0	-3.5*	10.5	-8.0***
Fees$^{\times}$	54.4	34.4	-20.0***	18.4	-36.1***
Transfer Revenues$^{\times}$	1,108.3	1,140.4	32.2	1,473.7	365.5***
Vertical Fiscal Imbalance (%)	74.3	81.8	7.5***	90.4	16.1***
Socioeconomic variables					
Population (×1,000)	170.8	70.5	-100.3***	14.7	-156.1***
Elderly (%)	7.7	7.7	0.0	8.3	0.6***
Working age population (%)	64.8	63.2	-1.6***	60.9	-3.9***
Rural households (%)	15.0	23.4	8.4***	40.5	25.5***
Literacy (%)	90.0	85.5	-4.5***	78.8	-11.2***
Income$^{\times}$	1,074.6	846.9	-227.7***	568.8	-505.8***
GDP$^{\times}$	14,023.3	10,978.2	-3,045.2***	7,617.2	-6,406.1***
Agriculture (%)	10.5	17.0	6.5***	26.1	15.5***
Industry (%)	26.3	20.9	-5.4***	13.5	-12.8***
Services (%)	47.4	41.5	-5.8***	30.3	-17.0***
Political variables					
Mayor trying 2nd term (%)	68.6	66.8	-1.8	66.3	-2.3
Mayor in president's coalition (%)	54.2	56.1	2.0	55.4	1.3
Mayor ABCP index	6.2	6.2	0.0	6.4	0.2**
Observations	411	294		4,761	

Sources: IBGE, Siconfi/STN, Censuses, and TSE. Notes: $^{\times}$per capita, diff. is the difference between the corresponding group with the treated group. $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$.

6 Results

Table 3: PMAT effects on tax revenues

Outcome variables	**(I)**	**(II)**	**(III)**
Tax Revenues	-11.40	-14.01	6.99
	(18.7)	(21.6)	(18.1)
Property Tax (IPTU)	15.90	4.15	10.71
	(9.6)	(7.6)	(9.2)
Services Tax (ISSQN)	-23.76**	-9.22	-6.94
	(9.4)	(10.6)	(8.1)
Property Transfer Tax (ITBI)	-3.20	-1.93	2.04
	(2.3)	(2.1)	(2.6)
Fees	2.93	-2.29	2.07
	(3.4)	(3.9)	(3.1)
Specifications			
Restricted period (1999–2012)	Yes	Yes	No
Almost treated as control	No	Yes	Yes
Observations	5,429	694	704

Notes: $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$. Block bootstrapped standard errors in parentheses. Bootstrapped standard errors in parentheses.

The treatment effects were computed using the *did* package, developed by (Callaway & Sant'Anna, 2021) for R software. The results are displayed in Table 3 and Figures 2 and 3, illustrating the event study effects and group effects (by treatment cohort), along with

their respective confidence intervals at a 5% significance level. The results are presented for total tax revenues and its four main sources: IPTU, ISSQN, ITBI, and fees.

In Table 3, we present a single treatment effect (ATT) for each tax revenue, considering three model specifications. Model I examines the same period (1999–2012) addressed in earlier studies, making it comparable to the methodologies used previously, except for the recently applied difference-in-differences estimator. Model II includes municipalities that self-selected for the program but did not receive the credit, providing a more effective control group than all governments that did not participate. In Model III, we extend the analysis through 2019 to observe the program's longer-term effects. Overall, the estimates for the three specifications are similar.

In contrast to the positive and significant effects identified by Barbosa Filho (2013) and Gadenne (2017), our results revealed a statistically insignificant impact of PMAT on total tax revenues, which aligns with the findings of Bast (2015). As a result, there is insufficient evidence to suggest that municipalities participating in the BNDES program improved their own-sourced revenues as a result of this project.

The estimates for the four primary taxes are also insignificant. The PMAT effects on property tax (IPTU) are positive across the three specifications, similar to the findings of Barbosa Filho (2013) and Bast (2015), although these effects were significant for these authors. In contrast, the services tax (ISSQN) exhibits negative effects, including a significant one from the first model, which aligns with Bast (2015) but contradicts Barbosa Filho (2013) (positive). Additionally, the impact on property transfer tax (ITBI) and fees shows mixed insignificant results, consistent with Barbosa Filho (2013) for fees and contrary for ITBI (positive and significant).

Furthermore, when the results are aggregated by groups/cohorts, they remain unchanged: the treatment effects for all cohorts are not statistically significant (Figure 3). When the estimates are further analyzed using an event study approach (which considers time relative to the year PMAT participation begins), all post-treatment periods show statistically negligible impacts (Figure 2). Moreover, pre-treatment periods also reveal statistically insignificant effects, reinforcing the assumption of conditional parallel trends. Overall, both effects aggregated by group and by time relative to treatment are statistically null, indicating that even in the long term, this program did not significantly impact local tax collection.

The results indicate that the projects implemented by PMAT were insufficient to stimulate growth in municipal own revenue. Bast (2015) points out that although PMAT is a program with a well-defined focus, its resources can be utilized for a wide range of purposes, including information technology, staff training, specialized services, equipment, and physical infrastructure. The flexible spending, which enables the program to be tailored to local needs, can also result in inefficient use of the credit received from BNDES.

An alternative hypothesis that does not dismiss the author's viewpoint is that political

agents may avoid enhancing tax efforts due to political or social pressures, despite effective project implementation. The descriptive statistics in Table 2 reveal that municipalities involved in PMAT had already achieved higher tax revenues and were less dependent on vertical transfers. In this scenario, following Wyckoff's 1988 logic, voters and businesses wield considerable bargaining power. Their option to move to a different jurisdiction can potentially diminish local tax revenue. Consequently, political agents might opt against increasing tax efforts for fear of revenue loss due to tax base migration.

Overall, the estimates reported in this study indicated that PMAT had no significant effect on the tax revenue of participating municipalities, whether assessed globally, by cohort, or by event study. These results are consistent with those of Bast (2015) and differ notably with the findings of Barbosa Filho (2013) and Gadenne (2017), who found evidence of a positive effect of PMAT on own-source revenue.

7 Conclusion

The Brazilian federal system is characterized by numerous small municipalities with a low tax base, which results in a high dependence on financial transfers from both state and federal governments. To enhance the own-source revenue of the country's municipalities, the National Bank for Economic and Social Development (BNDES) launched the Program for the Modernization of Tax Administration (PMAT) in 1997. This initiative includes offering subsidized loans for projects focused on modernizing local tax administration.

As discussed earlier, three studies have assessed the impact of PMAT's implementation on municipal tax revenue, showing mixed results. While one study by Bast (2015) found no effect of PMAT on local own-source revenue, others, including studies by Barbosa Filho (2013) and Gadenne (2017), presented evidence indicating that the local tax revenue of municipalities benefiting from the program's credit increased after receiving it.

In this article, we evaluated the impact of the program on the tax revenue of Brazilian municipalities using a recently proposed difference-in-differences model for multiple periods, as outlined by Callaway and Sant'Anna (2021). This study distinguishes itself from previous research by employing a more suitable estimation model for cases where treatment occurs at different times. Additionally, we included municipalities that applied for but did not receive program resources as part of the control group, an aspect that has not been explored in previous studies.

Unlike the findings of Barbosa Filho (2013) and Gadenne (2017), our results indicate that the PMAT program did not have a statistically significant effect on the per capita tax revenue of participating municipalities. This suggests that efforts to modernize tax administration were insufficient to increase local own-source revenue and address issues related to weak budget constraints and the flypaper effect. This conclusion remains consistent when analyzing the four main local taxes (ISSQN, IPTU, ITBI, and fee) separately. In essence,

this finding points to the program's ineffectiveness, as it did not enhance fiscal autonomy for municipalities. This outcome may be attributed to various factors, including inefficient resource allocation (Bast, 2015) or the political agent's lack of bargaining power to improve tax efforts within their jurisdiction.

The estimator proposed by Callaway and Sant'Anna (2021) does not take into account different treatment intensities. Therefore, we recommend that future research utilize difference-in-differences estimators that consider the dose effect of the treatment. Within the BNDES operations database, one can calculate the proportion of credit received by municipalities in relation to the total amount of credit approved under the PMAT program. This ratio can serve as a proxy for the percentage of the program's implementation, as BNDES disburses new credit installments upon the completion of each project stage. This approach can also be applied when a municipality reapplies for a new PMAT loan.

Furthermore, comparative studies between PMAT and similar programs, such as the PNAFM from the Ministry of Finance, can be conducted to assess the differences in the effectiveness and efficiency of these policies. By comparing various programs, we may be able to identify factors that either facilitate or hinder the implementation and success of tax administration modernization projects in Brazilian municipalities.

In summary, this study aims to advance research on public policies that promote and enhance tax systems, with a specific focus on the potential impacts of PMAT on municipal tax revenue. By employing a recently developed estimation model suitable for scenarios with multiple treatment periods, our results raise important questions regarding the design of this public policy aimed at strengthening the fiscal autonomy of local governments in Brazil.

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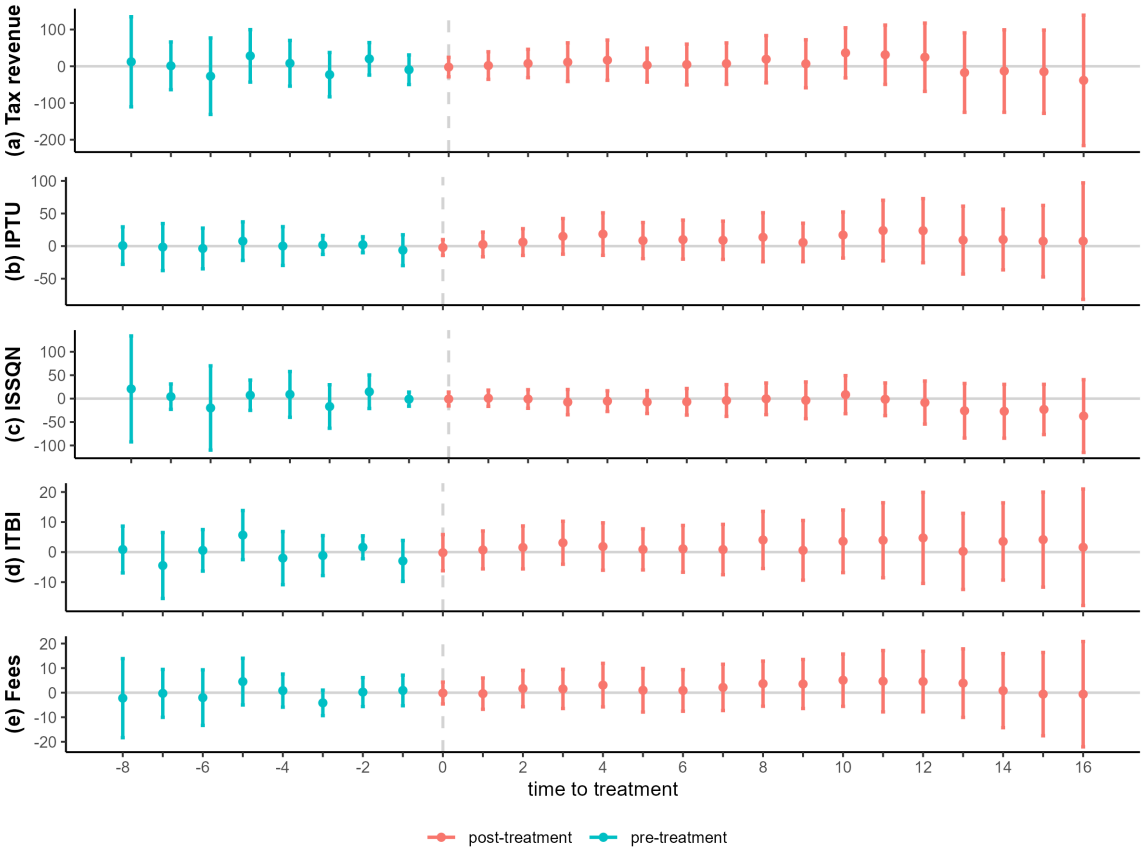
Appendices

Table 4: Outcomes and covariates in previous studies

			Barbosa		Gadenne		Bast	
	Variable	**Sources**	**O**	**C**	**O**	**C**	**O**	**C**
Program for Tax Modernization	PMAT participation	BNDES						
	PNFM participation	Ministry of Finance						x
Public finance	Total revenue	STN		x				
	Tax Revenue	STN	x		x		x	
	IPTU revenue	STN	x				x	
	ISSQN revenue	STN	x				x	
	ITBI revenue	STN	x					
	Fee revenue	STN	x					
	Current transfer	STN		x				
	FPM transfer	STN		x		x		
	ICMS transfer	STN		x				
	SUS transfer	STN		x				
	Educational transfer	STN		x				
	Vertical fiscal imbalance	STN		x				
Political indicators	Mayor's party	TSE				x		
	HHI City Council	TSE				x		
	Reelected mayor	TSE				x		
	Local radio station	IBGE				x		
	Local judicial office	IBGE				x		
	Corruption	Litschig and Zamboni (2012) Brollo et al. (2013)				x		
Socioeconomic indicators	Population	IBGE		x		x		x
	% Urban	Censuses				x		x
	% Male	DATASUS		x				
	% Youth	Censuses and DATASUS		x				x
	% Elders	Censuses and DATASUS		x				x
	Educational attainment	Censuses and RAIS		x		x		
	Literacy rate	Censuses						x
	% Basic sanitation	Censuses						x
	% Public lighting	Censuses						x
	Municipal HDI	Atlas of Human Development						x
	Inequality	Censuses				x		x
	Life expectancy	Censuses				x		
	Infant mortality rate	Atlas of Human Development						x
	New municipality	IBGE						x
	Area (km^2) and Density	IBGE		x				
Tax base	Municipal GDP	IBGE		x		x		x
	% Services GDP	IBGE				x		
	% Agriculture GDP	IBGE				x		
	Salary (formal sector)	RAIS		x				
	Employment rate	RAIS		x				

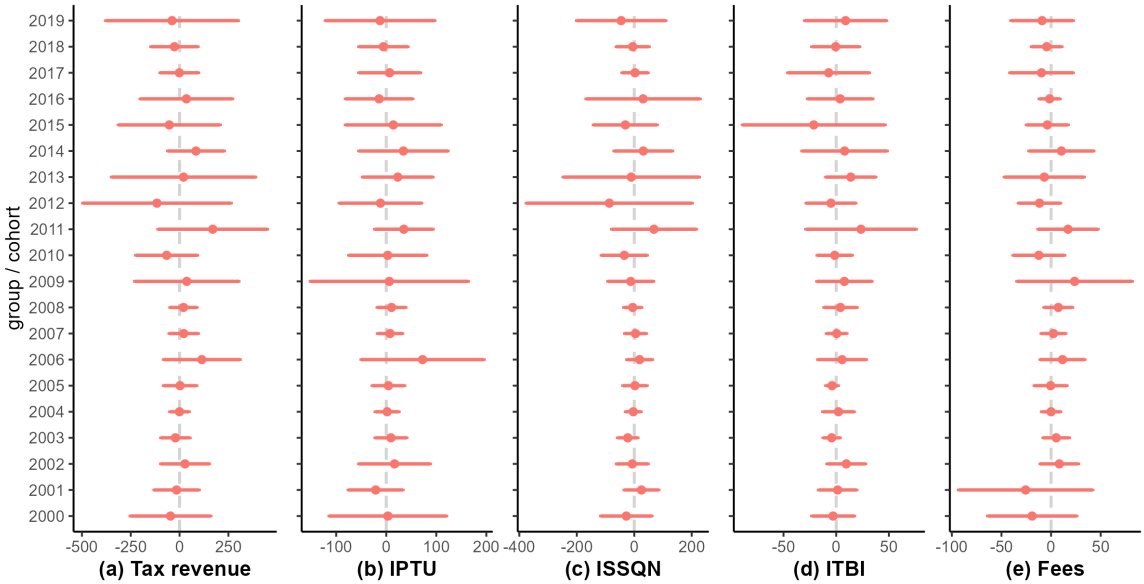
Notes: This table compares the outcome (O) and control (C) variables used in the previous PMAT assessment studies: Barbosa Filho (2013), Gadenne (2017), and Bast (2015).

Figure 2: Event study effects on tax revenues



Notes: These event study estimates are effects aggregated by time relative to treatment period, where 0 indicates the period of the PMAT's contemporaneous effect. The vertical bars represent 95% confidence intervals. Model III was used (treated almost as controls and spans from 2001 to 2019).

Figure 3: Group effects on tax revenues



Notes: These group estimates are effects aggregated by group/cohorts first treated in the year indicated on the vertical axis. The horizontal bars represent 95% confidence intervals. Model III was used (treated almost as controls and spans from 2001 to 2019).