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Does Adoption of Standardized Electronic Tax Systems Increase Tax Collection? Evidence from Brazilian Municipalities

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1 INTRODUCTION

The use of information technology (IT) has gained space in the organizational process, highlighting the use of information systems aimed at management and accounting, in addition to modifying how governments provide services and interact with the population, from public finance management to social programs, elections, and others (World Bank, 2016). These initiatives involve the use of information and communication technologies (ICTs) to improve the efficiency with which government services are provided to citizens, employees, companies, and agencies, in addition to enhancing the transparency and credibility of public administration, combating all types of corruption are known as e-government (Carter & B´elanger, 2005; Zhang & Zhang, 2009; Srivastava & Teo, 2010).

As an aspect of e-government, the e-tax system emerges as a service that allows taxpayers to pay taxes through internet services (Anuar & Othman, 2010; Barati & Bakhshayesh, 2015). It comprises the integration of many services, including tax filing, payment, and reimbursement, all through a single application that facilitates online transactions with tax authorities, helping them to check taxpayer obligations as well as respond to relevant questions quickly (Le, Bui, & Nguyen, 2021).

Electronic tax systems originated in the United States of America, where the Internal Revenue Services began to offer electronic filing of tax returns for refunds only (Muturi & Kiarie, 2015). Today, these systems have been adopted in many countries such as Australia, Canada, Italy, United Kingdom, Chile, Ireland, Germany, France, Netherlands, Finland, Sweden, Switzerland, Norway, Singapore, Brazil, Mexico, India, China, Thailand, Malaysia, Turkey, Uganda, Nigeria, Rwanda, and Kenya (Muturi & Kiarie, 2015).

In an international scenario, it comes out all major economies were willing to standardize their tax systems and develop an electronic model for issuing invoices (Winn & Zhang, 2013). Chile, for example, was a pioneer in its project and the Brazilian NF-e system is very similar to the Electronic Invoice system created in 2002 (Geron, Finatelli, Faria, & Carmo Romeiro, 2011). Mexico invested in the construction of its project with the promise of contributing decisively to its modernization (Urrutia, 2005). Like Chile, Mexico was also one of the first countries to develop digital certification for electronic documents to regulate certification through electronic identification to be used in electronic transactions (Geron et al., 2011).

In European countries, tax authorities have indicated ways to increase business efficiency using a large-scale electronic invoice system (Neto & Martinez, 2016). In June 2010, the European community recommended that private and public sectors adopt a standard invoice and a management model. This centralization model was like the path adopted by the United States and resulted in the ISO 20022 platform (Winn & Zhang, 2013).

In Brazil, the Federal Government's Growth Program (PAC), among other mechanisms and actions, established the Public Digital Bookkeeping System (SPED) by Decree number 6022/07. This initiative comprises a set of bookkeeping tax documents that are of interest to the Treasury Departments (SEFAZ) of each state, as well as the Federal Revenue Service of Brazil (SRF), allowing control of the calculation of taxes originating from the sales of products or services rendered by taxpayers to face the great tax evasion existing in Brazil (Walter & Ribeiro, 2007).

By placing the Brazilian state and municipal governments on the agenda, it is possible to verify that they also sought their modernization alternatives. In 2004, during the 1st National

Meeting of Tax Administrators (ENAT) a joint solution by the three spheres of government was discussed to achieve greater administrative integration, standardization, and better quality of information aiming at reducing costs, the burden of work in the service and an increase in revenue (Duarte, 2009). The meeting ended with the approval of two protocols for technological cooperation in areas of registration (Synchronized Registration Project) and electronic invoices (NF-e).

Based on this, assessing these tax compliance repercussions is crucial for a thorough assessment of any policy intervention (Lopez- Luzuriaga & Scartascini, 2019), as the introduction of ICTs, is expected to bring several benefits, including increased tax revenue (Mascagni, Mengistu, & Woldeyes, 2021).

However, despite the widespread adoption of ICTs in tax administration and the radical changes they have brought to the tax payment process, there is little evidence of their impact on tax administration and tax compliance in developing countries (Besley & Perrson, 2013; Mascagni, Mengistu, & Woldeyes, 2021) and the literature found about the impact-focused on evaluating countries or states (Eissa & Zeitlin, 2014; Pierson & Thompson, 2016; Bin & Shuhua, 2017; Kochanova, Hasnain, & Larson, 2020; Ali et al., 2021; Mallick, 2021; Mascagni, Mengistu, & Woldeyes, 2021; Uyar, Nimer, Kuzey, Shahbaz & Schneider, 2021; Okunogbe & Pouliquen, 2022), where exploring municipalities represents an opportunity.

In Brazilian municipalities, the Federal Constitution of Brazil of 1988 delegated the power to issue its own Municipal Organic Law, which is equivalent to the Municipal Constitution. According to this law, municipalities are responsible for managing the tax on territorial and urban property (IPTU), the tax on the inter-vivo transfer of immovable property (ITBI), and the tax on services of any kind (ISSQN). In addition to these taxes, municipalities also have autonomy over fees due to the exercise of police power, which stems from the need for public authorities to inspect and control individual interests to protect the collective. All particular activities that are previously subject to approval by the public authority or are subject to regular inspection by the public administration, in the interest of the common good, may be taxed by a police power fee if so, prescribed by the law of the policy that approves or oversees the specific activity.

At the same time, Brazilian municipalities are facing a fiscal crisis, directly influenced by the recession that began in 2015. According to the data available in 2021 by the Federation of Industries of the State of Rio de Janeiro (FIRJAN) through the Firjan Fiscal Management Index yearbook (IFGF), of the 5.229 municipalities analyzed, 3.024 were on the margins of financial insolvency, having a difficult or critical fiscal situation. According to the document, many towns are not complying with the expenditure limits established by the Fiscal Responsibility Law (LRF), and the main obstacle stems from the inability to generate revenue by the economies of these municipalities.

Electronic tax systems have been implemented in several Brazilian municipalities, from large capitals to rural ones, and are presented to the population with the title of taxpayer portal, online taxation, online taxation services, and citizen portal, among others. And this implies that governments should, to the extent possible, acquire standardized systems from vendors with track record of successful past performance (Kelman, 1990; Mithas, Tafti, Bardhan, & Goh, 2012). Thus, the electronic tax systems that Brazilian municipalities adopt are very close to what Pierson and Thompson (2016) pointed out as standardized systems, i.e., they can be adapted to suit each municipality and often have a functionality that allows them to be flexible without incurring a lot of additional development costs.

From this information, it is known that the use of electronic tax systems improves control over the registration data of citizens and companies but there is no evidence whether it provides an effective growth in the collection or if it only fills the gaps in administrations of municipalities to adapt to the changes that have taken place in modern economies and which

require from the tax administration more efficient measures for tax management and control. So, **what are the effects of the admission of a standardized electronic tax system on the tax revenue in Brazilian municipalities?**

Managerial, our study provides evidence that endorses the adoption of IT in public management, in addition to increasing control over the acts, also contributes to the increase of collection of the municipalities that adopt it, being able to serve to improve the efficiency of the management of these municipalities. In addition, it is known that most Brazilian municipalities face challenges with compliance with the LRF, and the use of the systems, with possible positive results, can help them to improve this obligation.

At this point, this paper contributes to the literature by analyzing the effects of adopting standardized electronic tax systems on municipalities' collections. The database included 146 Brazilian municipalities in the state of Rio Grande do Norte from 2013 to 2018, years that coincide with the adoption of the systems for the municipalities in the sample. Our study initially emphasizes the results through panel data with bidirectional fixed effects and then adopts the differences-in-differences approach proposed by Callaway and Sant'Anna (2021) to correct the bidirectional fixed effects and estimate the parameters of interest. Among the results, our research reveals that the adoption of standardized electronic tax systems improves the collection of IPTU, on average, 86% of the municipalities that introduced it considering all groups and all periods, in addition to the collection of ISSQN increases on average by approximately 86% after the third year of using the systems.

This paper contributes to different areas of the literature. Initially, it contributes to the growing research area of technology in increasing state capacity (Olken & Pande, 2012; Fujiwara, 2015; Lewis-Faupel, Neggers, Olken, & Pande, 2016; World Development Report, 2016; Muralidharan, Niehaus, & Sukhtankar, 2016; Banerjee, Duflo, Imbert, Mathew, & Pande, 2020). Also, contributes to the rapidly growing literature on the use of IT in tax administration in developing countries (Fan, Li, Qian, & Wen, 2018; Fjeldstad, Kagoma, Mdee, Sjursen & Somville, 2020; Ali, Shifa, Shimeles, & Woldeyes, 2021; Mascagni, Mengistu & Woldeyes, 2021; Mallick, 2021; Bellon, Dabla-Norris, Khalid, & Lima, 2022; Okunogbe & Pouliquen, 2022). Finally, it provides the first evidence of causal impact of standardized e-tax systems at the municipal level. The only study we found that focused on states was done by Pierson and Thompson (2016).

The paper is structured as follows below. The next section presents the literature review. Section 3 describes data sources and variables. Section 4 demonstrates the empirical strategy. Section 5 presents and discusses previous results, and section 6 concludes the study.

2 LITERATURE REVIEW

This literature review section presents the theories that allow us to analyze the phenomenon we studied, then it exposes the main contexts in which ICTs are studied in tax administrations and ends by summarizing recent studies about the impacts of the use of IT in the various types of collections.

2.1 THEORIES

Just like Uyar *et al*. (2021), we consider pertinent the adoption of modernization and institutional theories, as given the nature and structure of our research, the combination of proposals allows us to show the impact of e-government initiatives on tax collection. In this way, we present the main assumptions of these two theories.

2.1 Theory of Modernization

Modernization theory helps explain influences on social change, development, and progress (Barker, 2005; Bernstein, 1971; McClelland, 1961), focusing on macroenvironmental facets such as political enlightenment, economic growth, and technological progress. Although researchers have neglected modernization theory in the context of tax evasion (Uyar et al., 2021), it provides an adequate theoretical basis for this research, as it covers the impact of technological advancement on societies (Barker, 2005). Thus, e-government initiatives and the spread of ICTs represent long-term technological progress, while changes in tax evasion represent the social change caused by this process (Uyar et al., 2021).

Modernization theory posits that modern societies would use and benefit from services provided by emerging technologies compared to less technologically sophisticated societies (Barker, 2005). Given this argument, if e-government is an innovative and recent stimulator of social change, governments that have macro-environmental resources and capabilities (political democracy and economic capital) would be better positioned to carry out e-government actions than their counterparts whose initiatives are restricted to entry-level benefits at an early stage of e-government maturity (Azad, Faraj, Goh, & Feghali, 2010; Layne & Lee, 2001; Norris, 2001; Singh, Das, & Joseph, 2007).

Therefore, due to technological improvements in government services that lead to more efficient government administration, social changes are likely to occur, such as a higher level of tax compliance and a lower level of corruption, which may eventually decrease the level of tax evasion (Uyar et al., 2021). Our study considers the fight against tax evasion as one of the achievements of social change. However, modernization would fail if a society lacked necessary factors such as human resources (McClelland, 1961). Furthermore, modernization theory considers the influence of contextual conditions (Barker, 2005), as the impact of macro-environmental capabilities on social progress may depend on cultural context (Nam, 2018).

2.1 Institutional theory

Formal and informal institutions play a significant role in social change. Formal institutions include laws and codified regulations, while informal institutions include ethical values, moral judgments, and culture (Kılıç, Uyar, & Kuzei, 2020). Institutional theory is established on the central idea that the admission and retention of many organizational practices are dependent on social pressures for compliance and legitimacy, rather than technical pressures for economic performance (Kessler, 2013; Di Maggio & Powell, 1983).

Institutional theory suggests that organizations respond to pressures arising from their external and internal business environments and adopt structures and practices that are accepted as appropriate organizational choices and considered legitimate by other organizations in their fields (Di Maggio & Powell, 1983; Meyer & Rowan, 1977). Using standardized electronic tax systems would be one such practice and, over time, organizations tend to become similar or isomorphic (Hoffman, 1999; Meyer & Rowan, 1977; Scott, 2007). However, institutional isomorphism is a useful tool for understanding events that encompass organizational life (Di Maggio & Powell, 1983), such as tax compliance.

Another fundamental view of institutional theory is to understand that efficiency and effectiveness are not the only, and sometimes not even the main, activities of organizations. Not only do the motivations for adopting innovations differ across cities, but many practices also spread for reasons that have nothing to do with their effectiveness (Brandtern & Suárez, 2021). So, while we assume in this paper that tax collection can be affected by e-government initiatives of municipalities related to formal institutions, such as the adaptability of the legal framework to the digital business model, and informal institutions, such as ethical values and control of

corruption, we also consider that municipalities that adopt electronic tax systems may not be motivated effectively, which in turn may not generate increases in tax revenue.

2.2 ICTs IN THE CONTEXT OF TAX ADMINISTRATION

The literature related to the use of ICTs in the context of taxation focuses especially on the digitization of tax procedures and supports the argument that the level of tax compliance is improved by simplifying tax procedures, tax filing systems, and payment of taxes through electronic services (Sidani, Ghanem & Rawwas, 2014; Tjen & Evans, 2017; Night & Bananuka, 2020). However, limited capacity may result in the inability to make total data use, even if it is available in digital format (Mascagni, Mengistu, & Woldeyes, 2021). Observational evidence shows that tax authorities in low-income countries in several cases do not verify their tax records, even if it is relatively easy (Kangave, Nakato, Waiswa & Zzimbe, 2016; Almunia, Gerard, Hjort, Knebelmann, Raisaro & Tian, 2017; Mascagni, Mengistu & Woldeyes, 2021). Thus, ICTs may not yield the expected benefits in tax revenue and compliance with obligations, much less the possible spillover effects along the value chain (Pomeranz, 2015), especially if governments do not have human capital, technology, and good institutions to fully exploit the advantages of ICTs (Yilmaz & Coolidge, 2013; Lewis-Faupel et al., 2016; World Bank, 2016).

On the other hand, several empirical studies have reported that e-government improves transparency and accountability which in turn increases government efficiency (Rehman, Kamal & Esichaikul, 2016; Porumbescu, 2016; Srivastava, Teo & Devaraj, 2016), but this increase in efficiency and transparency are not obvious consequences of the digitization of government services (Choi & Chandler, 2020) because there have been many e-government initiatives that were not well planned and implemented resulting in poor performance or failures (Dawes, 2008; Anthopoulos, Reddick, Giannakidou, & Mavridis, 2016). Therefore, the digitization of government services increases efficiency and effectiveness if the implementation of e-government innovations is successful and meets the expectations of citizens and organizations, ensuring simplification and reduction of complexity (Choi & Chandler, 2020).

As the level of corruption decreases due to the adoption of e-government systems, the level of tax evasion is expected to decrease as corruption is one of the main factors driving tax evasion (Baum, Gupta & Kimani, 2017) and, while corruption and tax evasion are divergent, they can easily entangle and reinforce each other. So, controlling corruption is a significant factor in reducing tax evasion (Bejakovic, 2014; Alm, Martinez-Vazquez & McClellan, 2016; Faridy, Freudenberg, Sarker & Copp, 2016; Ivanyna, Moumouras & Rangazas, 2016; Rosid, Evan, & Tran-Nam, 2016; Marriot, 2017; Swanepoel & Meiring, 2017; Máchova, Volejníková & Lněnička, 2018).

2.3 IT IMPACTS ON TAX COLLECTION

After performing a systematic review of the literature, we found that the studies that analyze the impacts of the use of IT on tax collection are recent, focusing mainly on the last triennium in progress (2020-2022). In the sequence, we present a summary of the studies that were included in this review as well as some that were identified later.

From a state tax perspective, Pierson and Thompson (2016) sought to identify whether the use of standardized systems, those less customizable, work better than others in addition to verifying whether they increase revenue concerning other states in the United States of America that have chosen the other types of system. The authors' main results showed that the tobacco tax increased by 26% in the year of implementation, 43% after the second year, and 38.8% after the third year. The leisure tax increased by 161.2% after the second year and 126.8% after the third year. The vehicle tax increased by 23.2% after the second year and the tax on the coal of

harvesting resources, oil, or wood increased by 51% after the third year. The authors' work is unique, as it was the only one who analyzed the particularity of this type of system in state taxes.

Moving on to the scenario of studies between countries, strengthening the capacity to collect taxes using ICTs was the subject of a study by Kochanova, Hasnain, and Larson (2020). The main results showed there is an average increase of 0.75 % in income tax revenue to GDP after the adoption of transactional electronic filing systems, but there is an average decline of 0.65% of tax revenue on goods and services to GDP.

Similarly, Uyar et al. (2021) sought to understand the role of the use of ICTs in reducing tax evasion represented by the shadow economy as a percentage of GDP (Schneider & Medina, 2017; Medina & Schneider, 2019). The authors used six indicators from the Global Competitiveness Index (GCI) issued by the World Economic Forum (WEF, 2020), and found that after the adoption of ICTs, tax evasion is reduced by the indicators by 1.2% in electronic participation (E-Participation), 23% on future orientation (FutureOrient), 15% on government adaptability (GovAdaptability), 15% on government response to change (GovRespChange), 17% on the legal framework for digital businesses (LegalFramework) and 8.2 % in the government's long-term vision (GovernVision).

In Latin America, examining the impact of the introduction of electronic invoices on tax compliance and business performance was the focus of research by Bellon, Dabla-Norris, Khalid, and Lima (2022) in Peru. The authors reported that the introduction of the electronic invoice increases the company's sales, purchases, and VAT obligations by more than 5% in the first year after adoption. The results also point out the positive impact of the electronic invoice on sales and reported taxes is mainly driven by smaller companies. Specifically, VAT liabilities increase by 11.6% in the first year after adoption among micro and small businesses.

In Africa, some studies were constructed. One of them is the case of Ethiopia, where the use of sales register machines was performed by Ali et al. (2021), who sought to capture the impact of their use on tax payments by registered taxpayers and representatives of the tax base in companies. The authors' findings indicate that the use of the system results in companies reporting more sales and consequently paying more taxes, the employment levels increase, and more companies working helps to increase overall tax capacity. The impact of machines ranges from 18 to 32% on VAT and VAT contributes almost 20% of total domestic revenue collection in Ethiopia, corresponding to an increase of 3.6% to 6.4% in general revenue.

The sales register machines and their impacts on revenue were also studied by Mascagni, Mengistu & Woldeyes (2021) where through three sets of analysis they showed that taxpayers with taxable sales show an increase in net VAT collection of 73 % in the standard diff- in-diff model while in the triple difference this coefficient decreases to 47.7%, indicating the presence of some differences in the pre-adoption trend. The income tax increase is nearly 30% compared to 12% in the triple difference estimate.

As the main results Mascagni, Mengistu & Woldeyes (2021) show that with registered taxpayers the effect is at least 12% for income tax and 48% for VAT - in the triple difference coefficients. The experiment also carried out by the researchers pointed out that the treatment performed, sending a letter with recommendations, has a positive and significant effect on income tax liabilities, which is attributable to an increase in compliance of about 16% compared to the control group. Furthermore, when looking at the subgroup of users who did not use the sales register machines, the effect almost doubles to more than 30% in VAT and becomes more significant.

In a similar approach, an investigation of the behavior of tax non-compliance with electronic tax devices in companies in Tanzania and the factors that influence it was conducted by Fjeldstad et al. (2020). The main conclusion is that when companies transact with a customer who is aware of their legal obligation to obtain receipts and thinks that there is a real risk of

punishment if detected without a receipt, there is a greater probability of tax compliance, an increase in an average compliance rate of 24 percentage points in VAT. As well as Ethiopia and Tanzania, another African country that was studied was Rwanda, where Eissa and Zeitlin (2014) investigated the adoption rate and tax compliance impacts of the introduction of electronic invoicing machines. The results indicate that although the rate of adoption was not as expected, VAT collection increased by an average of 8%.

Studies on impacts were found in Asia, such as Okunogbe and Pouliquen (2022) who investigated the impact of using electronic filing systems on tax payment from an experiment conducted with companies in Tajikistan. The results showed there is a significant increase of TJS 25,357 (USD 3,600) because of the use of the system among high-risk companies. In contrast, among low-risk companies, adopting the system results in companies paying TJS 15,099 (USD 2,160) less in taxes, although this amount is not statistically significant.

In China, the impact of adopting electronic invoice encryption on VAT revenues was analyzed by Fan et al. (2018). The authors' estimates show that the change contributed 27.1% of VAT revenue and 12.9% of all government revenue during 2002-2007. More than a tenth of total government revenue for the world's sixth-largest economy at the time was due to improved technology in recording VAT transactions.

In India, Mallick (2021) indicated that ICT infrastructures and the quality of governance do not have a positive effect on overall tax collection, and this result may be possible when there is greater scope for taxpayers to easily escape the tax network, carrying out transactions outside the system or without relying on the use of ICT infrastructure, without leaving any traces.

The lesson seems clear. There is an increase in revenue in most results. It is also noteworthy that there is a concentration of studies in developing countries and perspectives of national analysis.

3 DATA

The initial sample of this research consisted of 167 municipalities in the State of Rio Grande do Norte, Brazil. The data in the time range from 2013 to 2018 were collected from various sources. At first, the official documents available on the websites of the municipalities were analyzed to identify the year of the implementation of the electronic tax system and when there was no information available through this means, calls and consultations were made via the Citizen Information Service (E-Sic). Some municipalities, after six months, did not return the consultations, so to solve this problem, the Court of Auditors of the State of Rio Grande do Norte (TCE/RN) was asked to consult the commitments to identify the implementation period.

To find the values of IPTU, ITBI, ISSQN, and police fees, the declarations referring to the annual balance sheets of the municipalities were consulted through the Accounting and Tax Information System of the Brazilian Public Sector (SICONFI) considering the beginning of 2013, the first year in which the declaration is available in the system. It should be noted that we are interested in the municipalities' collection, i.e., the result of the sum of the four mentioned taxes, and not in the total sum offered by SICONFI. At the same time, there were consulted, through the Brazilian Institute of Geography and Statistics (IBGE) the following sources: the estimated population survey, to capture the number of inhabitants, and the survey of the central register of companies, to collect data referring to the number of active companies.

Two other variables were included in the database: the system, which indicates the presence of the system in the municipality over the years, and the event, which indicates the year of adoption of the system in the municipality. To deal with the problem of lack of data, after the first inspections in the database, simple imputations were carried out for the variables

of the collections as suggested by Engels and Diehr (2003) for longitudinal data. In one of the years of the panel of five municipalities, the average of the information from the year before and after the missing was used, and for a municipality that lacked collection data for the year 2018, the data for 2017 was repeated. Continuing with the data cleaning, eleven municipalities were removed from the database due to a lack of information or inconsistencies identified in the statements, another ten municipalities were removed because they had a system implementation before 2013, the beginning of our panel. So, 146 municipalities remained in the sample.

The values of municipal revenues in the period 2014-2018 were deflated by the IBGE's National Index of Consumer Prices (IPCA), the main Brazilian inflation index, based on the year 2013. Seeking to improve the understanding of the data, these were converted into thousands as a unit of measurement. In the sequence, they were placed in a logarithm to better capture the effects, in addition to using one of the methods by MaCurdy and Pencavel (1968) to replace the zeros of the logarithm and not cause missing values.

After cleaning and adjusting the database procedures, Figure 1 shows the number of municipalities with the system functioning versus those that do not, in the period 2013-2018, in the 146 municipalities.

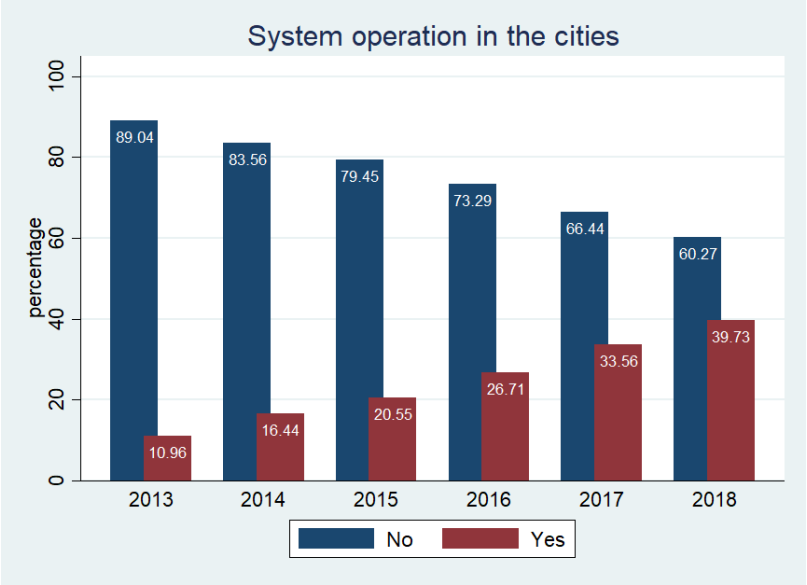

Figure 1. Cities with system operation available.
Source: Prepared by the authors, 2022.

Figure 1 shows that in 2013 there were only 10.96%, equivalent to 16 municipalities with the system in operation, but in 2014, 16.44%, 24 municipalities had already adopted the system. Adherence to an electronic tax system continues to develop over the following years, reaching approximately 39.73% of 58 municipalities in 2018. In this sense, the groups are formed by the following numbers of municipalities: 2013 (16), 2014 (8), 2015 (6), 2016 (9), 2017(10), and 2018 (9). As in our research, we are interested in capturing the effects of adopting these systems on the municipalities' collection. Figure 2 shows the evolution of collections in all municipalities throughout the panel.

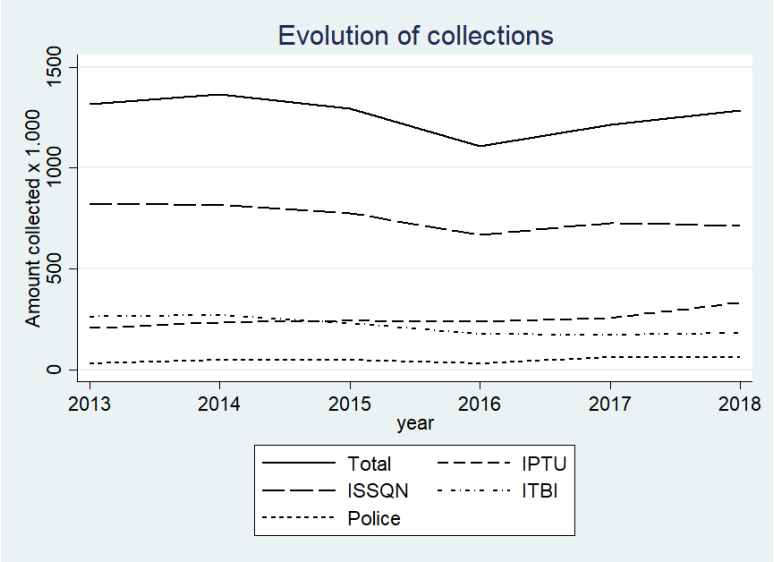

Figure 2. Evolution of collections in all municipalities.
Source: Prepared by the authors, 2022.

First, we emphasize that the collections in Figure 2 are deflated. Thus, it is noted that total collection was in decline until 2016, but presents an upward curve in the following years, recovering collection to the approximate level that was 2014. A similar fact happens with the collection of ISSQN, however, although it recovers between 2016 and 2017, it does not return to the level it was in 2014. On the other hand, IPTU collection shows an increase year after year, contrary to ITBI collection which has declined over the years, although it has stabilized in the last two years old. Finally, the collection by police power shows stability until 2016 and in 2017 it has a slight growth, maintaining it in 2018.

When analyzing the relative importance of each tax concerning the total collection, we notice over the years the IPTU collection evolves. In 2013, it corresponded to approximately 15.52% of the total collection. In 2015, a year that exceeds the collection of ITBI, it amounts to approximately 18.63% and in 2018 it reaches approximately 25.89% of the total collection. On the contrary, ITBI collection is losing relative importance in 2013 representing 19.90% of the total collection, and declines every following year, reaching 2018 representing 14.08% of the total collection. A similar effect occurs with the collection of ISSQN which in 2013 represented 62.32%, but in 2018 it drops to 55.42%. On the other hand, the collection by police power has different effects in 2013 it represents approximately 2.13% of the total collection, and it rises in the following years reaching 3.61% in 2015, but dropped in 2016 to 2.71%, and rises again in the following years, reaching 4.62% in 2018.

Table 1 presents the descriptive statistics of the variables used in the work models. Three-year panel data are presented, with t-tests of differences between means between the treatment and control groups.

Table 2:
Descriptive statistics

	2014			2016			
	(1)	(2)	t-test	(1)	(2)	t-test	(1)
Variable	**Treatment Average/Standard Error**	**Control Average /Standard Error**	**Difference (1)-(2)**	**Treatment Average /Standard Error**	**Control Average /Standard Error**	**Difference (1)-(2)**	**Treatm Avera /Stand Erro**
Deflated total tax collection (x1,000 BRL)	4241,377	800,005	3441,372***	2878,684	465,451	2413,233***	2582,5
	[2595,891]	[246,219]		[1255,110]	[183,253]		[1177,5
Deflated IPTU collection (x1,000 BRL)	1041,130	74,638	966,492***	742,417	52,817	689,600**	736,5
	[733,663]	[31,627]		[476,796]	[30,543]		[474,6
Deflated ITBI collection (x1,000 BRL)	1138,485	98,694	1039,791**	504,752	54,863	449,890**	362,8
	[890,615]	[59,030]		[335,295]	[38,771]		[239,4
Deflated ISSQN collection (x1,000 BRL)	1926,537	597,762	1328,776**	1562,496	341,811	1220,686***	1381,2
	[912,219]	[155,976]		[474,376]	[106,262]		[450,0
Deflated police power collection (x1,000 R$)	135,224	28,910	106,314**	69,018	15,961	53,057**	101,9
	[77,578]	[12,263]		[18,341]	[10,981]		[34,70
Estimated population in the municipality (x1,000)	30765083	9893,475	20871,608***	27045949	8765,766	18280182***	21849
	[9752,658]	[1008,957]		[6482,143]	[997,701]		[4602,5
Number of companies operating in the municipality	447,500	104,689	342,811***	398,231	84,383	313,848***	294,2
	[167,612]	[13,515]		[116,886]	[10,308]		[79,80
No	**24**	**122**		**39**	**107**		**58**
F test of joint significance (F- stat)			**5,288*** **			**4,679*** **	
F test, number of observations			**146**			**146**	

The displayed value for the t-tests are the differences in averages between groups, and the displayed value for the F tests are the F statistics, ***, **, and * indicat
5, and 10 percent, respectively.

Source: Prepared by the authors, 2022.

In 2014, analyzing the result of the t-test in the difference between averages for the group that adopted the system (Treatment) and the one that had not adopted the system (Control), it is noted that all variables present a statistically significant difference between the two groups, at levels of 1 or 5% which is repeated in 2016. On the other hand, in 2018, the ITBI collection does not show statistical significance between the averages of the two groups. The differences in the averages of total collections, IPTU, ISSQN, and ITBI between the two groups decrease between the years, which is expected due to the adoption of the system by the municipalities over the years. Meanwhile, the difference in the averages between the groups in the collection by police power decreases in 2016 but increased in 2018 which indicates a possible effect of better management by the municipalities that adopted the system of fees that comprise this type of collection. In terms of illustration, in 2018, the difference in the average total collection amounted to BRL 2,154,468.00 between the treatment and control groups, a difference of 503.24% between the two groups.

4 EMPIRICAL STRATEGY

To identify the causal effect of adopting the system on municipal collections, we initially implemented a panel model with bidirectional fixed effects. The following equation represents the proposed model for the collection of the municipality at the moment t:

$$LogArrecadação_{it} = X_{it}\beta + \sum_{t=2}^{T}\gamma_t + \alpha_i + u_{it},$$

where the dependent variable is the logarithm of the total municipal tax collection or the individual revenues from IPTU, ITBI, ISSQN, and police power, each estimated individually; X_{it} is a matrix of characteristics of the municipality that vary over time. Two models are estimated in this paper. First, the estimation is done without control variables, while the second is controlled by the estimated population and number of operating companies. γ_t is a dummy variable for the year t; $\alpha_i$represents unobserved characteristics of the municipality i that are fixed in time; and, finally, the term u_{it} represents the model error for the municipality i in the year t. The description of all variables is available in Appendix A.

Our bidirectional fixed-effects have more than two periods and variation in treatment time, deviating from a typical differences-in-differences model. Recent and emerging literature indicates in situations where there is treatment heterogeneity and staggered adoption of a policy, β is a weighted average of these treatment effects varying over time and across units (Athey & Imbens, 2022; Borusyak & Jaravel, 2022; Callaway & Sant'Anna, 2021; Chaisemartin & d' Haultfoeuille, 2020; Goodman-Bacon, 2021). In these situations, β will not reflect the causal parameter of interest that evaluates a policy change, such as the policy implementation of an electronic tax system, this is because the sources of bias may vary according to the context studied.

Although there is no single approach possible to correct the bidirectional fixed effects and estimate the parameter of interest, in our case the effect of adopting the systems on the municipalities' collection, we chose to follow the approach presented by Callaway and Sant'Anna (2021). The authors' approach considers a natural generalization of Mean Treated Treatment (ATT), based only on "clean" comparisons which are suitable for data with multiple treatment groups and multiple periods. Clean comparisons are obtained, focusing on units never treated or units not yet treated, to compose the control group. Specifically, the ATT for time t is defined for individuals treated for the first time in the period g as:

$$ATT(g,t) = E[Y_t(1) - Y_t(0)|G_g = 1]$$

where $Y_t(1)$ is the potential result of the total collection of IPTU, ISSQN, ITBI, or by police in the time t if treated, $Y_t(0)$ is the potential result in the time t if not treated and $G_g = 1$ is a binary variable that indicates the individual who belongs to the group whose treatment starts in period g. The $ATT(g,t)$ allows you to analyze how the average treatment effect varies in different dimensions in a unified way.

To identify the $ATT(g,t)$ and its functionals, the main assumptions of the model consist of: treatment irreversibility, which presupposes that once a unit has been treated that unit will remain treated in the next period; limited anticipation of treatment for all groups eventually treated, which imposes an assumption of "non-anticipation" of treatment, i.e., that one has a good understanding of the horizon of anticipation; and the conditional parallel trends based on a "never treated" or "not yet treated" group which states conditioned to the control variables, the average results for the group treated for the first time in the period g and for the group "never treated" or "not yet treated" would have followed parallel paths in the absence of treatment. All these assumptions are reasonable for the context of our work. For example, the irreversibility of treatment would not be satisfied if a municipality had stopped using the system.

Callaway and Sant'Anna (2021) suggest three types of approaches to estimate $ATT(g,t)$: outcome regression (OR), inverse probability weighting (IPW), or doubly robust (DR). In this research, we use the DR approach, which combines the OR and IPW approaches, and requires only an OR or IPW method, and not necessarily both to correctly specify the outcome evolution for the comparison group or the propensity score model. In our standard error estimation models, we adopted the WildBootstrap multiplicative procedure with standard output that uses 999 repetitions using the "Mammen" approach.

Pretreatment control variables can play an important role in the analysis. The assumption of conditional parallel trends based on a "never treated" or "not yet treated" group suggests that pretreatment control variables potentially associated with outcome evolution $Y_t(0)$ during posttreatment periods should be included. The model explicitly excludes the incorporation of post-treatment control variables, as they could potentially be affected by the treatment.

To summarize the results contained in $ATT(g,t)$ estimates, the approach of Callaway and Sant'Anna (2021) considers aggregation schemes that provide a single parameter of general treatment effect with similarities to the ATT in the two periods and two group cases which we call here of simple ATT, as well as partial aggregations that highlight heterogeneity along certain dimensions, such as (i) how average treatment effects vary across treatment groups by policy adoption date (group-specific effect); (ii) how the average cumulative effects of treatment evolve over calendar time (calendar time effects) and; (iii) how to mean treatment effects vary with duration of treatment exposure (dynamic effects).

5 RESULTS AND DISCUSSION

We begin this section by presenting without further discussion Table 3 which shows the results of the fixed-effects model for all collections. We emphasize for each type of collection there are two models, the first model did not accommodate control variables, while the second included two variables.

Table 3:
The bidirectional fixed effects model

Variable	(1) Total	(2) Total	(3) IPTU	(4) IPTU	(5) ISSQN	(6) ISSQN	(7) ITBI	(8) ITBI	(9) Police	(10) Police
Adoption of electronic systems	**0.240***	**0.295****	**0.453*****	**0.514*****	**0.291***	**0.367****	0.0870	0.174	0.125	0.147
	(0.125)	(0.129)	(0.143)	(0.147)	(0.166)	(0.171)	(0.163)	(0.168)	(0.174)	(0.179)
2014	0.0709	0.119	0.0401	0.0970	0.0279	0.0860	0.0787	0.137	0.0849	0.0837
	(0.0937)	(0.0968)	(0.107)	(0.110)	(0.124)	(0.128)	(0.122)	(0.126)	(0.130)	(0.134)
2015	-0.00529	0.0304	0.00408	0.0453	-0.0477	-0.00158	-0.0261	0.0232	0.151	0.157
	(0.0942)	(0.0960)	(0.107)	(0.109)	(0.125)	(0.127)	(0.122)	(0.125)	(0.131)	(0.133)
2016	-0.451***	-0.416***	-0.111	-0.0729	-0.643***	-0.595***	-0.380***	-0.326**	-0.234*	-0.220
	(0.0955)	(0.0974)	(0.109)	(0.111)	(0.126)	(0.129)	(0.124)	(0.126)	(0.132)	(0.135)
2017	-0.0862	-0.0466	-0.0297	0.0137	-0.169	-0.113	-0.163	-0.0994	0.385***	0.403***
	(0.0977)	(0.100)	(0.111)	(0.114)	(0.129)	(0.133)	(0.127)	(0.130)	(0.135)	(0.139)
2018	-0.0385	0.00713	-0.0634	-0.0112	-0.120	-0.0605	-0.0147	0.0499	0.451***	0.461***
	(0.100)	(0.103)	(0.114)	(0.117)	(0.132)	(0.136)	(0.130)	(0.134)	(0.139)	(0.143)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	876	876	876	876	876	876	876	876	876	876
R-square	0.054	0.058	0.016	0.022	0.053	0.058	0.024	0.030	0.054	0.056
ID number	146	146	146	146	146	146	146	146	146	146

Notes: standard errors in parentheses. ***significance level at 99% (p<0.01), **significance level at 95% (p<0.05), *significance level at 90% (p<0.1).
Source: Prepared by the authors, 2022.

These initial results demonstrate the adoption of the systems reverberates in increments in the total collection of IPTU and ISSQN. We emphasize that in the models with control variables we obtain statically significant coefficients for the adoption of electronic taxation systems: total collection, increased, on average and approximately 30%; IPTU collection, oscillating positively, on average and approximately 51% and collection of ISSQN, rising, on average and approximately, 37%.

Next, we present in Table 4 the results of the approach proposed by Callaway and Sant'Anna (2021), the table presents the ATTs in the simple model, i.e., for all groups and all periods.

Table 4:
Simple ATT

Variable	(1) Total	(2) Total	(3) IPTU	(4) IPTU	(5) ISSQN	(6) ISSQN	(7) ITBI	(8) ITBI	(9) Police	(10) Police
ATT	0.283*	0.371	**0.493****	**0.857****	0.328	**0.698***	0.0717	-0.286	0.144	0.333
	(0.150)	(0.295)	(0.215)	(0.353)	(0.210)	(0.406)	(0.227)	(0.560)	(0.243)	(0.379)
Controls	Não	Sim	Não	Sim	Não	Sim	Não	Sim	Não	Sim
Test parallel trends (p-value)	0.0901*	0.0974*	**0.1404**	**0.1563**	**0.6433**	**0.6790**	**0.6674**	**0.8367**	0.0861*	**0.2072**
Observations	780	780	780	780	780	780	780	780	780	780

Notes: standard errors in parentheses. ***significance level at 99% (p<0.01), **significance level at 95% (p<0.05), *significance level at 90% (p<0.1).
Source: Prepared by the authors, 2022.

The results for the total collection models are very close to those shown in the fixed effects of Table 3, but these results are not statistically significant and violate the parallel trends test for the period before treatment since they are statistically significant at a p-value. These results are in line with Mallick (2021) who indicated that ICT infrastructures do not have a

positive effect on overall tax collection and may be due to limited ability to make full use of data even if they are available for consultation (Mascagni, Mengistu & Woldeyes, 2021).

For the IPTU collection models, the result without controls is like the fixed-effect model. However, the model with controls differs considerably, which refers to the importance of the approach by Callaway and Sant'Anna (2021). In addition, both models do not violate the parallel trends test. Specifically, the model with controls shows that there is an average increase in IPTU collection of approximately 86%, significant at 5%, corroborating the literature that indicates that there is an increase in tax collection with the use of IT (Pierson & Thompson, 2016; Fan *et al*., 2018; Fjeldstad *et al*., 2020; Kochanova, Hasnain & Larson, 2020; Ali *et al*., 2021; Mascagni, Mengistu & Woldeyes, 2021; Uyar *et al*., 2021; Bellon *et al.*, 2022; Okunogbe & Pouliquen, 2022).

The IPTU is the only officially managed tax in many municipalities, that is, it is collected from the population, however, in many cases, due to the lack of a good control system, its collection is not efficiently achieved, showing itself to be sensitive to the use of a system. At the same time, even based on recommendations from consultants from the developers of the systems themselves, municipalities update their local tax code given the adoption of IT, which may also explain this increase. An initiative of electronic government represents what in the theory of modernization is emphasized as technological progress while the considerable increase in the collection of IPTU represents the social change caused by this technological progress, i.e., the use of an electronic tax (Uyar *et al*., 2021).

Like the models for IPTU collection, those for ISSQN collection present similar results to the fixed effect in the version without controls, but different in the version with controls. The model with controls does not violate the assumption of parallel trends and points to a positive average result of approximately 70% increase in revenue, statistically significant at 10%. This indicates with the presence of the system the municipalities can improve the management of their collection and the companies providing services since the system can become an effective tool to improve the management of this important tax. Another reason behind this expressive increase may be the decrease in the common tax evasion by micro and small companies even when detected by the tax administration that often did not issue service invoices and consequently did not collect taxes strengthening what was pointed out by Fjeldstad et al. (2020), as there may be fear of applying some type of penalty by taxpayers, caused by the use of the system as a form of control being a positive point for municipal administrations.

In the collection of ITBI, in both models, the result without controls is like that of fixed effects while the one with controls is different and although both do not violate the parallel trends test, they do not have statistical significance. In addition, the model with controls gives a negative result. It should be noted that this tax includes the transfer of the real estate, and these results could occur for several reasons. First, naturally, there is no significant oscillation in the facts that generate this tax. Second, due to the lack of more effective control, since once the municipality starts to have the property register digitally, better control of its movements would be expected and thus the tax collection will be carried out, and if this occurs, it goes against to which one of the views of institutional theory explains that organizations are not always concerned with efficiency and effectiveness (Brandtern & Suárez, 2021).

A third reason is related to the view that the citizen has of the electronic procedure carried out for the collection of the tax because if it does not meet the expectations that he has mainly in the guarantees of simplification and reduction of complexity (Choi & Chandler, 2020), he may look for another path, for example, by corrupting the professionals involved, which is corruption and comprises one of the main factors that drive tax evasion (Baum, Gupta, & Kimani, 2017).

In the same way as the models for the collection of ITBI, the models for collection by police power present proximity in the version without controls, but divergent with controls

compared to what was found in the fixed effects and only the second does not violate the test of parallel trends but does not have statistical significance. As this type of collection includes possible basic and necessary charges for the operation of business activities such as permits, and those for the harmonious functioning of society as garbage collection fees, construction inspection, etc., it would be expected that the system would provide better control as well as increases in the collection. However, if this does not occur, one of the reasons may be the lack of necessary human resources or good institutions to exploit the advantages of ICTs (McClelland, 1961; Yilmaz & Coolidge, 2013; Lewis-Faupel *et al*., 2016; World Bank, 2016) or because there are no good planning resulting in poor performance or failures (Dawes, 2008; Anthopoulos, Reddick, Giannakidou & Mavridis, 2016).

We present in Table 5 the results of the approach by Callaway and Sant'Anna (2021) considering the ATTs by groups, i.e., the effects for the group who adopted the system in the year.

Table 5:
ATT by groups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Total	Total	IPTU	IPTU	ISSQN	ISSQN	ITBI	ITBI	Police	Police
G2014	0.498***	0.421	0.312	1,373	**0.604*** **	1,082	0.175	-0.659	-0.142	-0.0796
	(0.123)	(0.617)	(0.607)	(0.918)	(0.173)	(0.763)	(0.382)	(1,457)	(0.485)	(0.985)
G2015	0.0895	0.283	0.0982	0.0162	0.00372	0.226	**-0.741*** **	**-1,257** **	-0.155	0.351
	(0.270)	(0.306)	(0.215)	(0.527)	(0.317)	(0.526)	(0.251)	(0.602)	(0.347)	(0.430)
G2016	0.104	0.374	**0.884***	**1,008** **	0.0357	0.574	0.549	0.645	0.691	**0.913***
	(0.249)	(0.395)	(0.495)	(0.444)	(0.285)	(0.608)	(0.566)	(0.550)	(0.490)	(0.500)
G2017	0.438	0.516	0.473	0.471	0.746	0.970	-0.0189	-0.00954	0.328	0.418
	(0.707)	(0.778)	(0.456)	(0.444)	(0.925)	(0.923)	(0.519)	(0.547)	(0.551)	(0.545)
G2018	0.0320	0.0574	**1.221*** **	**1.213** **	-0.0847	0.0230	0.546	0.560	0.160	0.184
	(0.204)	(0.211)	(0.442)	(0.484)	(0.249)	(0.265)	(0.462)	(0.455)	(0.475)	(0.441)
controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Test parallel trends (p-value)	0.0901*	0.0974*	**0.1404**	**0.1563**	**0.6433**	**0.6790**	**0.6674**	**0.8367**	0.0861*	**0.2072**
Observations	780	780	780	780	780	780	780	780	780	780

Notes: standard errors in parentheses. ***significance level at 99% (p<0.01), **significance level at 95% (p<0.05), *significance level at 90% (p<0.1).
Source: Prepared by the authors, 2022.

From now on, we will focus on the discussion of statistically significant results with controls and do not violate the parallel trends test, as we understand that the latter was evident in the discussion in Table 4. We start by observing what happens with the IPTU collection. For the group that introduces to the system for the first time in 2016, there is an approximate average result of 101%, significant at 5%, as well as the group that starts using the system in 2018 on average and approximately, 121%, significant at 5%. Both results are expressive and, in the literature consulted, only Pierson and Thompson (2016) showed operational results greater than a 100% increase in collections.

This, however, leads us to reflect on the reasons that can point to these results and when consulting the websites of these municipalities, we realize there is something in common, the simplified way for citizens to issue their IPTU charges, so it would be permissible to point out one of the reasons for this significant improvement in tax compliance comes from the simplification of tax procedures of electronic tax systems (Sidani, Ghanem & Rawwas, 2014; Tjen & Evans, 2017; Night & Bananuka, 2020).

An inverse result to that of IPTU happens with the ITBI model for the group that introduces the system in 2015 in which there is a decline in its collection of approximately 126%, significant at 5%. This leads us to believe that taxpayers find ways to deviate from the charging network reflection of one of the assumptions of modernization theory, the need for macro-environmental resources and capabilities-political democracy and economic capital (Azad, Faraj, Goh & Feghali, 2010; Layne & Lee, 2001; Norris, 2001; Singh, Das, & Joseph, 2007) because if there are ways to charge, but the result is the opposite, some factor may be missing such as skilled labor to use the system, financial resources for training or even the absence of a public manager committed to the democracy and sustainable growth of the municipality. In addition to observing the websites of the six municipalities that introduced the system in 2015, we note that they are systems developed by different suppliers, generating different impacts, for example, there is a municipality that has zero collection of this tax in the year, directing us to reflect on possible difficulties faced.

For the group that introduced the system in 2014, the collection of ISSQN shows a positive oscillation on average and approximately 60%, statistically significant at 1%. First, it is important to emphasize the 2014 group is made up of eight municipalities and these municipalities, compared to the others in the sample, can be considered medium or large and this reveals how much they failed to collect from this tax and among the reasons for this could be a corruption of public employees. Using this premise as true, reinforces the argument of Baum, Gupta, and Kimani (2017) because as corruption decreases due to the adoption of e-government systems, the level of tax evasion is expected to decrease.

On the other hand, the group that introduced the system in 2016 presents a statistically significant result at 10% for the collection by police power pointing out that the municipalities that start using the system this year increased, on average, by approximately 93%. This may be related to what modernization theory reports on the influence of contextual conditions (Barker, 2005) because if we consider this type of collection is a social advance, it would be possible that these municipalities are being impacted by macro-environmental capacities as this progress may be related to cultural context (Nam, 2018).

Contrary to what occurs for ITBI collection in the 2015 group, the 2016 group appears to be better positioned to carry out the e-government innovation (Azad, Faraj, Goh & Feghali, 2010; Layne & Lee, 2001; Norris, 2001; Singh, Das, & Joseph, 2007) and it manages to capture collections that did not occur before, for example, charges for license fees and so on. This fact reinforces one of the arguments of modernization theory, the occurrence of social changes, leads to a higher level of tax compliance and a lower level of corruption which can eventually decrease the level of tax evasion (Uyar *et al*., 2021).

Next, we will explain in Table 6 the results of the approach by Callaway and Sant'Anna (2021) considering the ATTs per calendar, that is, the effects per year in the municipalities that have a system.

Table 6:
ATT by calendar

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Total	Total	IPTU	IPTU	ISSQN	ISSQN	ITBI	ITBI	Polícia	Polícia
T2014	0.273***	-0.0103	-0.539	0.564	**0.372***	0.169	-0.262	-0.415	-0.348	-1.694
	(0.0975)	(0.521)	(0.897)	(1.429)	(0.191)	(0.634)	(0.549)	(1.616)	(0.421)	(1.359)
T2015	0.313**	-0.712	-0.189	0.382	**0.339****	-1.054	-0.626	**-1.948***	-0.315	-0.678
	(0.143)	(0.809)	(0.535)	(0.801)	(0.172)	(1.142)	(0.607)	(1.155)	(0.377)	(0.827)
T2016	0.457	0.230	0.337	**1.068***	0.419	0.0963	0.154	-0.270	0.215	-0.100
	(0.298)	(0.578)	(0.241)	(0.609)	(0.489)	(0.920)	(0.367)	(0.746)	(0.442)	(0.674)
T2017	0.224	0.450	**0.574****	**0.793****	0.345	0.525	0.0376	-0.308	0.0640	0.718
	(0.288)	(0.312)	(0.235)	(0.404)	(0.375)	(0.385)	(0.315)	(0.630)	(0.334)	(0.482)

T2018	0.225	0.820	**0.939*** **	**1.006** **	0.253	**1.849** **	0.349	0.302	0.414	**0.990** **
	(0.203)	(0.539)	(0.230)	(0.503)	(0.286)	(0.793)	(0.231)	(0.385)	(0.293)	(0.494)
Controls	Não	Sim	Não	Sim	Não	Sim	Não	Sim	Não	Sim
Test parallel trends (p-value)										
	0.0901*	0.0974*	**0.1404**	**0.1563**	**0.6433**	**0.6790**	**0.6674**	**0.8367**	0.0861*	**0.2072**
Observations	780	780	780	780	780	780	780	780	780	780

Notes: standard errors in parentheses. ***significance level at 99% (p<0.01), **significance level at 95% (p<0.05), *significance level at 90% (p<0.1).
Source: Prepared by the authors, 2022.

Starting with the collection of ISSQN the municipalities that used the system showed an average and approximate increase of 37%, significant at 10%. A similar result to the municipalities that had the system in operation in 2015 with an average and approximate increase of 34%, significant at 5%. Both results reinforce the argument that it is possible with the use of systems there is fear of applying some type of penalty by companies (Fjeldstad, *et al*., 2020).

In the IPTU collection, we observed the municipalities that in 2016 operated under electronic tax systems obtained an increase in their collection, on average, and approximately 107%, significant to 10%. The other two years also express positive and statically significant results, 2017 presents an approximate average increase of 79% in tax collection, now with greater power of significance, i.e., at the level of 5%, while 2018 presents an approximate average increase of 101%, significant at 5%. These results in addition to collaborating with the literature point out that there is an increase in tax collection with the use of IT (Pierson & Thompson, 2016; Fan *et al*., 2018; Fjeldstad *et al*., 2020; Kochanova, Hasnain & Larson, 2020; Ali *et al*., 2021; Mascagni, Mengistu & Woldeyes, 2021; Uyar *et al*., 2021; Bellon *et al*., 2022; Okunogbe & Pouliquen, 2022), it would also be possible that this is the result of post-2015 economic crisis recovery.

In 2018, these positive results are not limited to the IPTU, but there are also increases for other types of collection, the ISSQN, for example, reaches a very high level making an average oscillation around 185%with a significance of 5%. 2018 is the last year of our panel and where the largest number of municipalities using the system is concentrated making 58 in total, and when analyzing these municipalities by the estimated population and number of operating companies (control variables) we note these are concentrated in municipalities with greater numbers supporting the assumption of modernization theory that modern societies would use and benefit from services provided by emerging technologies compared to less technologically sophisticated societies (Barker, 2005).

In 2018, the collection by police power grows on average to 99%, with a significance of 5%. This more efficient result may reflect improved transparency and accountability (Rehman, Kamal **&** Esichaikul, 2016; Porumbescu, 2016, Srivastava, Teo & Devaraj, 2016) since ITBI is a tax involving real estate purchase and sale operations it would be possible for municipalities to create control mechanisms using the system involving buyer, seller, and notary's office.

Unlike what happened with the collection of ISSQN in 2015, the collection of ITBI shows an average decline of approximately 195%, significant to 10%. Once again highlights one of the assumptions of modernization theory is necessary for these macro-environmental resource and capacity municipalities – political democracy and economic capital (Azad, Faraj, Goh & Feghali, 2010; Layne & Lee, 2001; Norris, 2001; Singh, Das, & Joseph, 2007) to be able to improve the collection of this tax.

Finally, Table 7 presents the dynamic effects of the treated municipalities, i.e., the ATT are estimated for each period concerning the first treated period, in all cohorts.

Table 7:
ATT by dynamic effects

	(1)	(two)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Total	Total	IPTU	IPTU	ISSQN	ISSQN	ITBI	ITBI	Police	Police
T-4	0.233	0.229*	0.0204	0.0278	0.160	0.156	0.0794	0.0836	0.535	0.520
	(0.145)	(0.138)	(0.664)	(0.643)	(0.171)	(0.176)	(0.447)	(0.426)	(0.327)	(0.332)
T-3	-0.302*	-0.311**	-0.0810	-0.0772	-0.471	-0.485	-0.320	-0.323	0.0682	0.0498
	(0.154)	(0.149)	(0.292)	(0.269)	(0.575)	(0.483)	(0.360)	(0.368)	(0.214)	(0.233)
T-2	0.360	0.335	0.114	0.178	0.508	0.483	0.236	0.233	0.0875	0.0224
	(0.236)	(0.248)	(0.182)	(0.195)	(0.394)	(0.354)	(0.191)	(0.198)	(0.282)	(0.276)
T-1	-0.145	-0.206	-0.125	-0.0542	-0.152	-0.231	-0.0965	-0.117	-0.267	-0.295
	(0.193)	(0.214)	(0.225)	(0.227)	(0.267)	(0.275)	(0.260)	(0.262)	(0.230)	(0.232)
T+0	0.260	0.189	0.404	**0.640****	0.336	0.279	-0.0976	-0.234	0.103	-0.118
	(0.196)	(0.245)	(0.254)	(0.298)	(0.272)	(0.303)	(0.285)	(0.411)	(0.232)	(0.325)
T+1	0.195	-0.0905	0.240	0.566	0.178	-0.164	-0.00597	-0.523	0.205	0.155
	(0.257)	(0.391)	(0.329)	(0.379)	(0.380)	(0.550)	(0.295)	(0.552)	(0.323)	(0.439)
T+2	0.439**	0,500	**0.665****	**1.272****	**0.513****	0.776	0.419	0.118	0.163	0.252
	(0.206)	(0.534)	(0.265)	(0.530)	(0.230)	(0.789)	(0.421)	(0.769)	(0.453)	(0.737)
T+3	0.172	0.674*	**0.684*****	1,009	0.205	**0.857***	0.126	-0.550	0.110	1,340
	(0.150)	(0.372)	(0.189)	(0.685)	(0.193)	(0.513)	(0.214)	(1,295)	(0.404)	(0.936)
T+4	0.511***	2,334	**1.178*****	1,740	**0.590****	**5.957***	0.187	-0.274	0.107	1,901
	(0.185)	(1,817)	(0.333)	(1,438)	(0.242)	(3,257)	(0.300)	(1,466)	(0.411)	(1,804)
controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Test parallel trends (p-value)	0.0901*	0.0974*	**0.1404**	**0.1563**	**0.6433**	**0.6790**	**0.6674**	**0.8367**	0.0861*	**0.2072**
Observations	780	780	780	780	780	780	780	780	780	780

Notes: standard errors in parentheses. ***significance level at 99% (p<0.01), **significance level at 95% (p<0.05), *significance level at 90% (p<0.1).
Source: Prepared by the authors, 2022.

Looking at Table 7, two types of collection deserve to be highlighted, IPTU and ISSQN. In the year of implementation of the system (T+0), the collection of IPTU rises in the municipalities on average by 64%, significant to 5%, and this increase continues over the years because the results show after two years of the beginning of the use of the system (T+2), the collection of IPTU rises, on average, of 127% with a significance level of 5%. These results reinforce the findings of Pierson and Thompson (2016) who pointed out there are taxes that increase in the year of adoption and that this also fluctuates upward after the second year.

On the other hand, the ISSQN results indicate benefits in the collection appear from the third year of use of the systems reflecting an average increase of approximately 86%, significant at 10%. However, after the fourth year, the results comprise on average and approximately an astonishing 596% with a significance of 5%. These results strengthen the findings of Pierson and Thompson (2016) because in the authors' study there are types of taxes that only show positive results after the third year of operation of the system. And, if we reflect the collection of ISSQN is derived from the provision of services by companies it is permissible to claim that as an effect of technological expansion citizens start to charge the issuance of tax documents for the services they hire consisting of social pressure for compliance and legitimacy (Kessler, 2013; Di Maggio & Powell, 1983) which is an important feature of institutional theory.

Briefly, if we consider only the two-way fixed effects models, we obtain the use of standardized electronic tax systems increases, considering the statistical significance, the total collection of IPTU and ISSQN. However, if we consider the approach proposed by Callaway

and Sant'Anna (2021), simply we obtain only statistically significant results, without violating the parallel trend test for the collection of IPTU. The approach by Callaway and Sant'Anna (2021) also shows other results such as the effects by groups for IPTU, ISSQN, ITBI, and police power collections, those of calendar year for IPTU, ISSQN collections, and police power, and finally, the dynamic effects with expressive results for the collection of IPTU and ISSQN.

6 CONCLUSIONS

This research sought to analyze the effects of adopting standardized electronic tax systems on the collection of municipalities in the State of Rio Grande do Norte. Based on the results obtained, it is permissible to claim that the use of electronic tax systems can help municipalities to increase their collections and the impacts on individual taxes vary, not being the same for all.

Regarding the social contribution, the results provide subsidies for the improvement of the fiscal management of the municipalities since the findings show that there are improvements in the collection and these results can reflect in the best offer of services for the citizens and the civil society. In addition, it is known that most Brazilian municipalities face challenges with compliance with the LRF, and the use of the systems, according to the results indicated, can help them to improve this process.

Recent studies have already identified that the use of ICTs helps to improve revenue (Pierson & Thompson, 2016; Fan *et al*., 2018; Fjeldstad *et al*., 2020; Kochanova, Hasnain & Larson, 2020; Ali *et al*., 2021; Mascagni, Mengistu & Woldeyes, 2021; Uyar *et al*., 2021; Bellon *et al.*, 2022; Okunogbe & Pouliquen, 2022), and others have identified issues relating to the use of systems (Dawes, 2008; Yilmaz & Coolidge, 2013; Sidani, Ghanem & Rawwas, 2014; Rehman, Kamal, Esichaikul, 2016; Anthopoulos *et al*., 2016; Kangave *et al*., 2016; Lewis- Faupel *et al*., 2016; Porumbescu, 2016; Srivastava, Teo & Devaraj, 2016; World Bank, 2016; Almunia *et al*., 2017; Tjen & Evans, 2017; Night & Bananuka, 2020; Mascagni, Mengistu & Woldeyes, 2021). However, this paper is a pioneer in seeking to analyze the collection of municipalities in their specific taxes, especially in inland regions of the country, contributing to the advancement of literature.

The main managerial implication of the research concerns the provision of evidence that corroborates the adoption of technology in public management, in addition to increasing control over the acts that can become a tool that contributes to the increase of collection. From a practical angle, it would be interesting for municipal entities that, in addition to implementing the systems, mechanisms were also created to encourage, for example, the request for service invoices by citizens, and incentives for municipal servants for greater oversight. These actions could generate greater increases in collections if added to the implementation and use of the system.

Among the limitations of this study, we can mention the fact that data on variables are not available for some municipalities, or it was not possible to use an imputation method to fill these gaps, and these towns were removed from the sample. With this information, perhaps it would be possible to have other results or a better understanding of recent reality.

As proposals for future work, it is proposed to deepen the analysis at the municipal level, comparing between states, at a state-level, or in groups of municipalities with similar characteristics. The latter in virtue of being able to better compare one municipality with another. Other emerging approaches to event studies can be used, such as Athey and Imbens (2018), Borusyak and Jaravel (2017), Chaisemartin and d' Haultfoeuille (2020), and Goodman-Bacon (2018). A qualitative study with municipal managers who implemented these systems is also suggested to verify the differences between them and the challenges faced. Furthermore,

"policies to modernize tax management" is, no doubt, a thriving area for research, mainly due to the expectation of tax reform at the national level with some proximity.

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APPENDICES

Appendix A: Variables description

VARIABLE	DESCRIPTION	UNITY
id	Municipality identification	-
year	Indicates the year of the panel in each municipality	-
event	Indicates the year of occurrence of the event in the municipality	-
System	Dummie indicates whether the municipality has a system including if the first year is partial	**1 if you own the system; 0 if not**
lnTotal tax collection (x1000 BRL)	Logarithm of the annual collection of the Total Tax Collection	**(log) BRL x 1000**
lnIPTU collection (x1000 BRL)	Logarithm of annual IPTU collection	**(log) BRL x 1000**
lnITBI collection (x1000 BRL)	Logarithm of the annual collection of ITBI	**(log) BRL x 1000**
lnISSQN collection (x1000 BRL)	Logarithm of the annual collection of the ISSQN	**(log) BRL x 1000**
lnPolice power collection (x1000 R$)	Logarithm of police power collection	**(log) BRL x 1000**
Estimated population	Total population of the municipality	**people**
Number of active companies	Total number of companies headquartered in the municipality	**units**