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João Paulo Oliveira Lucena

ESSAYS ON INFORMATION TECHNOLOGY IN TAX ADMINISTRATIONS: A REVIEW OF LITERATURE AND BRAZILIAN EVIDENCE OF IMPACTS ON COLLECTION

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Thesis submitted to the Graduate Program In Administration at the Federal University of Rio Grande do Norte, in partial fulfillment of the requirements for the Doctor in Administration degree.

Supervisor: Raquel Menezes Bezerra Sampaio.

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I dedicate this work to two souls who are no longer present on the earthly plane today, but who, in life, always encouraged me to never give up: my great friend, Felipe Diego Silva, and my father, José Lucena.

Felipe was more than just a friend; he was a companion who stood by my side throughout my school career, from my first steps in preschool to the third year of high school. His friendship, perseverance, and support were constant sources of strength and inspiration, shaping not only my social life but also my academic path.

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ABSTRACT

Information Technology (IT) plays a fundamental role in the reform of any tax administration, enabling better collection and analysis of information, proactive management of workload and resources, promotion of cooperative engagement and standardization in the treatment of taxpayers, thus facilitating uniformity and application of tax legislation (Jimenez, Mac An tSionnaigh, & Kamenov, 2013). Given this perspective, this thesis explores the use of IT in tax administrations, consisting of three essays. The first essay consists of a Systematic Literature Review (SLR) that seeks to comprehensively analyze the current literature on the intersection between Information Technology (IT) and tax collection. The RSL was conducted following the protocol proposed by Tranfield, Denyer, and Smart (2003) and identified three research clusters: the impacts of IT on tax collection, the factors that influence the adoption of technology in this context, and the aspects related to IT and its application in tax administration. Alongside these clusters, we present the main theories used and the main challenges identified for the implementation of IT in governments. Finally, we propose our research agenda. Among the technologies identified in the RSL, standardized electronic tax systems stand out, as explored in the second essay of this thesis. The objective of the second essay is to analyze the effects of adopting this system on the tax collection of municipalities in a Brazilian state. Using a database composed of 146 municipalities in the state of Rio Grande do Norte, from 2013 to 2018, the study initially uses a panel with two-way fixed effects. Then it applies the difference-in-differences approach proposed by Callaway and Sant'Anna (2021). The results reveal that the adoption of standardized electronic tax systems resulted in an average increase of approximately 52% in Urban Property and Territorial Tax (IPTU) while the Tax on Services of Any Nature (ISSQN) recorded an average increase of around 43%. Examining the effects over time, we found that IPTU collections increased on average by approximately 77% after the third year of the system's implementation. On the other hand, ISSQN revenue increased by an average of 72% after the fourth year of adoption of the aforementioned system. The third essay addresses the use of another technology, the Electronic Consumer Invoice (NFC-e). It aims to analyze the impact of the NFC-e project on the Tax on Circulation of Goods and Services (ICMS). The database used is made up of 4,652 municipalities in Brazil, from 2013 to 2016, and uses the differences-in-differences approach of Callaway and Sant'Anna (2021). The results of this test indicate that the adoption of NFC-e impacts municipalities in different ways depending on their size. Larger municipalities had more substantial increases in the transfer of participation installment in the ICMS per person. Specifically, in the simple effects, large size municipalities recorded an average increase of approximately 3.6% per person, while medium size municipalities recorded an increase of approximately 2.7% per person. About dynamic effects, large size municipalities showed an average increase of around 18.6% per person two years after the states implemented the policy. It is concluded that IT plays a significant role in tax administrations, offering substantial benefits. This is evident through the implementation of standardized electronic systems and NFC-e, which significantly contribute to improving municipal revenues.

Keywords: Information Technology; Tax administration; Tax collection; Electronic Tax Systems; Electronic Consumer Invoice.

RESUMO

A Tecnologia da Informação (TI) desempenha papel fundamental na reforma de qualquer administração tributária, permitindo uma melhor coleta e análise de informações, gestão proativa da carga de trabalho e recursos, promoção de engajamento cooperativo e padronização no tratamento dos contribuintes, facilitando assim a uniformidade e aplicação da legislação tributária (Jimenez, Mac An tSionnaigh, & Kamenov, 2013). Diante dessa perspectiva, esta tese explora o uso da TI nas administrações tributárias, sendo composta por três ensaios. O primeiro ensaio consiste em uma Revisão Sistemática da Literatura (RSL) que busca analisar de forma abrangente a literatura atual sobre a intersecção entre Tecnologia da Informação (TI) e arrecadação tributária. A RSL foi conduzida seguindo o protocolo proposto por Tranfield, Denyer e Smart (2003) e identificou três *clusters* de pesquisa: os impactos da TI na arrecadação tributária, os fatores que influenciam a adoção da tecnologia nesse contexto e os aspectos relacionados à TI e sua aplicação na administração tributária. Ao lado desses *clusters*, apresentamos as principais teorias utilizadas e os principais desafios identificados para a implementação de TI nos governos. Por fim, propomos nossa agenda de pesquisa. Dentre as tecnologias identificadas na RSL, destacam-se os sistemas de imposto eletrônico padronizados, explorados no segundo ensaio desta tese. O objetivo do segundo ensaio é analisar os efeitos da adoção desse sistema na arrecadação própria de municípios de um estado brasileiro. Utilizando uma base de dados composta por 146 municípios do estado do Rio Grande do Norte, no período de 2013 a 2018, o estudo emprega inicialmente um painel com efeitos fixos bidirecionais e, em seguida, aplica a abordagem de diferenças em diferenças proposta por Callaway e Sant'Anna (2021). Os resultados revelam que a adoção de sistemas de imposto eletrônico padronizados resultou em um aumento médio de aproximadamente 52% no Imposto Predial e Territorial Urbano (IPTU) enquanto o Imposto sobre Serviços de Qualquer Natureza (ISSQN) registrou um aumento médio em torno de 43%. Examinando os efeitos ao longo do tempo, descobrimos que a arrecadação do IPTU sofreu um aumento médio de aproximadamente 77% após o terceiro ano de implementação do sistema. Por outro lado, a receita do ISSQN aumentou em média 72% após o quarto ano de adoção do referido sistema. O terceiro ensaio aborda o uso de outra tecnologia, a Nota Fiscal de Consumidor Eletrônica (NFC-e), e tem como objetivo analisar o impacto do projeto NFC-e no Imposto sobre Circulação de Mercadorias e Serviços (ICMS). A base de dados utilizada é composta por 4.652 municípios do Brasil, no período de 2013 a 2016, e emprega a abordagem de diferenças em diferenças de Callaway e Sant'Anna (2021). Os resultados desse ensaio indicam que a adoção da NFC-e impacta de maneiras distintas os municípios conforme o seu porte. Os municípios maiores tiveram aumentos mais substanciais no repasse da cota-parte do ICMS por pessoa. Especificamente, nos efeitos simples, os municípios de grande porte registraram um aumento médio de cerca de 3,6% por pessoa, enquanto os municípios de médio porte registraram um aumento de aproximadamente 2,7% por pessoa. No que diz respeito aos efeitos dinâmicos, os municípios de grande porte apresentaram um aumento médio de cerca de 18,6% por pessoa dois anos após a implementação da política pelos estados. Conclui-se que a TI desempenha um papel significativo nas administrações tributárias, oferecendo benefícios substanciais. Isto fica evidente através da implementação de sistemas eletrônicos padronizados e NFC-e, que contribuem significativamente para melhorar as receitas municipais.

Palavras-chave: Tecnologia da informação; Administração tributária; Arrecadação tributária; Sistemas de Impostos Eletrônicos; Nota Fiscal de Consumidor Eletrônica.

LIST OF ABBREVIATIONS AND ACRONYMS

ATTs	Average Treatment Effects on the Treated
BP-e	Electronic Ticket
CNAE	National Classification of Economic Activities
CT-e	Electronic Invoice Transport
DR	or Doubly Robust
ECF	Tax Accounting Bookkeeping
ECT	Expectancy-Confirmation Theory
EFDs	Electronic Fiscal Devices
ENAT	National Meeting of Tax Administrators
FIRJAN	Federation of Industries of the State of Rio de Janeiro
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
IBGE	Brazilian Institute of Geography and Statistics
ICMS	Tax on Circulation of Goods and Services
ICT	Information and Communication Technologies
IPCA	Broad National Consumer Price Index
IPTU	Urban Property and Territorial Tax
IPW	Inverse Probability Weighting
IS	Information Systems
ISSM	Information Systems Success Model
ISSQN	Tax on Services of Any Nature
IT	Information Technology
ITBI	Tax on Inter-Vivos Real Estate Transfers
LRF	Fiscal Responsibility Law
MDF-e	Electronic Manifesto of Tax Documents
NFA-e	Electronic Avulse Invoice
NFC-e	Electronic Consumer Invoice
NF-e	Electronic Invoicing
OECD	Organization for Economic Co-operation and Development
OR	Outcome Regression
SBEs	Small Businesses
SDT	Self-Determination Theory
SEFAZ	Finance Secretariats
SICONFI	Brazilian Public Sector Accounting and Fiscal Information System
SINEFI	National Economic and Fiscal Information System
SLR	Systematic Literature Review
SPED	Public Digital Bookkeeping System
SRF	Brazilian Federal Revenue Secretariat
TAM	Technology Acceptance Model
TOE	Technology-Organizational Environment Framework
TPB	Theory of planned behavior

TRA	Theory of Reasoned Action
UTAUT	Unified Technology Acceptance Theory
VAT	Value Added Tax
WEF	World Economic Forum

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1 PRESENTANTION

Tax administrations perform various functions in the tax context, which can be categorized into main and auxiliary activities (Umar & Mas'ud, 2020). One prominent main activity is taxpayer registration, involving collecting essential identification information, such as names, addresses, and types of legal entities. This data enables the tax authority to comprehend and locate taxpayers and understand the nature and scale of their operations.

Another crucial activity involves receiving and processing taxpayer statements and returns. Presently, tax administrations utilize electronic systems that enable them to receive remotely submitted declarations. Both electronically and manually submitted declarations undergo processing with the aid of Information Technology (IT), ensuring the verification of information consistency and integrity.

Paying and collecting taxes are fundamental activities. Although cash payments can be made through banks, records are electronically updated via tax administrations' IT platforms. Automated systems facilitate the determination of amounts owed, late payments, and fines, providing agility in this process.

Concerning auxiliary functions, taxpayer accounting stands out. Through IT, tax administrations can store and manage the accounts of millions of taxpayers in their databases. This allows for the easy determination of financial relationships between tax authorities and individuals, including taxpayers' responsibilities for taxes owed, fines, claimed tax credits, and refunds, among other aspects.

Tax auditing also benefits from IT. Through this technology, it is possible to flag high-risk accounts, as all financial transactions between taxpayers and tax authorities are available on the platform. This enables access to taxpayers' income and tax payment histories, making it easier to detect unexplained deviations.

Furthermore, tax revenue accounting plays a crucial role. Given the existence of various types of taxes, accurately recording, and categorizing tax revenues is essential. IT facilitates this accounting, allowing for more efficient planning and control by providing information on how revenues fit into different tax categories.

Tax administration is pivotal in the financial management of a country, extending beyond mere tax collection. Its primary objective is to enhance control over taxpayers, aiming not only to reduce tax evasion but also to promote tax justice and ensure the equitable distribution of the tax burden based on each person's economic capacity.

In this context, promoting voluntary compliance, streamlining tax procedures, and leveraging efficient technologies is important. Transparency and reduction of information asymmetry stand as crucial objectives, fostering an environment where both taxpayers and the tax administration have clear access to necessary information.

Moreover, effective tax administration doesn't merely enforce regulations but also fosters economic activity, catalyzing growth. The integration of advanced technologies, such as data analysis and integrated systems, facilitates more efficient management, enabling the monitoring of financial transactions and proactive identification of tax evasion.

Tax education also plays a pivotal role by informing taxpayers about the significance of taxes and contributing to a culture of fiscal responsibility. International cooperation is indispensable in combating cross-border tax evasion, requiring agreements and information exchanges between countries.

Therefore, as tax administration pursues its objectives, it contributes to creating a fiscally fair, transparent, and efficient society. This, in turn, stimulates economic growth, promotes voluntary compliance, and strengthens international cooperation against tax evasion.

The impact of e-government on a country's tax evasion can be initially examined by exploring the role played by digitalization in enhancing the transparency and accountability of public organizations (Uyar, Nimer, Kuzey, Shahbaz, & Schneider, 2021). Moreover, e-government plays a vital role in the modernization of public management, serving as a tool to improve and maintain good governance, accountability, and transparency. This leads to a more efficient and effective government, enabling citizens to access government services more seamlessly (Aggelidis & Chatzoglou, 2009).

Numerous empirical investigations have illustrated that e-government fosters increased transparency and accountability, thereby enhancing government efficiency (Rehman, Kamal, & Esichaikul, 2016; Porumbescu, 2016; Srivastava, Teo, & Devaraj, 2016). Nonetheless, some scholars argue that heightened efficiency and transparency are not direct outcomes of the digitalization of government services (Choi & Chandler, 2020). This is because, historically, several e-government initiatives have failed or underperformed due to inadequate design and implementation (Dawes, 2008; Anthopoulos, Reddick, Giannakidou, & Mavridis, 2016). Therefore, the digitalization of government services can only lead to effective gains in efficiency and effectiveness if its implementation is successful and aligns with the expectations of citizens and organizations, offering simplification and reducing complexity (Choi & Chandler, 2020).

In this context, this thesis aims to understand the evolution of current practices associated with the incorporation of information technologies in tax administration, examining their interconnections and evaluating the impacts on the effectiveness of tax collection. It was organized into three initial studies.

Our initial essay aims to comprehensively analyze the current literature on the intersection between information technology and tax collection. We have identified three research clusters: the impacts of IT on tax collection, the factors influencing the adoption of technology in this context, and aspects related to IT and its application in tax administration. Alongside these clusters, we present the primary theories utilized and the main challenges identified for the implementation of IT in governments. Finally, we propose our research agenda.

An additional approach to exploring the relationship between e-government and tax revenue centers on the effects of e-tax systems and tax regulations on tax compliance. The implementation of an electronic tax system as part of e-government practices requires regulatory reforms to make the system more flexible, simple, and efficient (Uyar et al., 2021). These regulatory reforms, as emphasized by the Organization for Economic Co-operation and Development (OECD, 1997), should aim to create simpler and more effective regulations, utilizing information technologies as essential tools to reduce manual burdens, simplify procedures, and facilitate data sharing.

In the context of electronic tax systems, tax evasion, tax elision, and tax elusion play crucial roles. Tax evasion, involving the illegal practice of not paying taxes owed to tax authorities, can be combated through the implementation of more efficient electronic tax systems. With the automation and digitalization of processes, it is possible to reduce the opportunities for omitting information or providing false information in tax returns, ensuring greater tax compliance, and consequently, fairer, and more effective collection (Allingham & Sandmo, 1972).

On the other hand, tax elision, referring to legal strategies adopted to minimize the tax burden, can also leverage technological advances. Electronic tax systems can provide greater transparency and visibility into financial transactions, thereby reducing loopholes that could be exploited for tax avoidance purposes. Improved control and monitoring mechanisms empower tax authorities to identify and address abusive tax avoidance practices more effectively, ensuring a fairer application of tax laws (Graetz & Warren, 2006).

Moreover, technology can play a crucial role in preventing tax elusion. With advanced electronic tax systems, we can conduct more sophisticated analyses of international

transactions, identifying and investigating cases of transfer pricing manipulation, double taxation treaties, and other complex mechanisms deliberately used to circumvent tax obligations (Avi-Yonah & Slemrod, 2002; Shaviro, 2008).

Despite the numerous potential benefits of IT for tax administration, it is imperative to address a series of challenges highlighted in our initial essay. Among these challenges, crucial elements related to costs, integration, security, adoption of new technologies, training, and user experience stand out.

The assessment of costs associated with implementing and maintaining IT systems in tax administration emerges as a critical point. While systems modernization promises operational efficiency, the allocation of financial resources for implementation and ongoing maintenance expenses is constantly questioned and highlighted as elements to be critically analyzed.

The integration of different IT systems in the collection, processing, and analysis of tax data is often a challenge, considering the need for effective integration with other government bodies and private entities. The efficient exchange of information is vital to the effectiveness of tax administration, requiring a careful assessment of system interoperability.

Security risks associated with IT systems in tax administration require meticulous analysis. Exposure to cyber threats and the need to protect sensitive tax data highlight the importance of investing in robust security measures. Furthermore, ethical concerns related to taxpayer privacy in the context of collecting and storing tax data require implementing clear policies and strategies for compliance with privacy regulations.

Resistance to adopting new technologies in tax administration is a common phenomenon. Evaluating the effectiveness of existing systems compared to emerging technologies enables informed decision-making about modernization. The smooth transition to new technologies must be strategically planned to minimize disruptions and ensure acceptance.

The training and qualification of professionals responsible for tax administration are essential to optimizing the performance of IT systems. A lack of technical skills can negatively impact the effectiveness of systems, emphasizing the importance of investing in skills development.

User experience in IT systems is a determining factor in the success of tax administration. Collecting and interpreting feedback provides valuable insights to identify areas for improvement, contributing to the continuous evolution of systems and overall user satisfaction.

The implementation of electronic tax systems and the utilization of advanced technologies can significantly contribute to enhancing tax collection and addressing issues such as tax evasion, avoidance, and fraud. The automation and digitalization of tax processes enable greater tax compliance, reducing opportunities for fraudulent activities and facilitating effective monitoring of financial operations.

Thus, through our first essay, we found a lack of research investigating the effects of systems or other technologies at municipal levels related to tax collection. One of the types of IT that emerged in this initial essay was electronic tax systems, which according to Pierson and Thompson (2016) are systems that can be customized to meet the needs of each municipality and often come with features that allow flexibility without incurring additional development costs.

Therefore, our second essay aimed to analyze the impacts of implementing standardized electronic tax systems on the tax collection of Brazilian municipalities. A sample composed of 146 municipalities in the state of Rio Grande do Norte, Brazil, was used, with data referring to the period between 2013 and 2018.

Our results reveal that the adoption of standardized electronic systems for Urban Property and Territorial Tax (IPTU) and territorial property tax presented an average increase of approximately 52%, while the Tax on Services of Any Nature (ISSQN) recorded an average increase of around 43%. Examining the effects over time, we found that IPTU collection experienced an average increase of approximately 77% after the third year of system implementation. Conversely, ISSQN revenue increased by an average of 72% after the fourth year of adopting the system.

Through the initial two essays, we realized the importance of adopting IT in tax administration, with the implementation of systems being a natural path for governments. In state governments, tax administration plays a pivotal role in financial management, with the integration of tax processing systems emerging as a significant component in this context. The development of these systems, whether through collaborations with specialized companies or internal initiatives, underscores the significance of a strategic and effective approach to revenue collection.

Initially, through the implementation of integrated tax processing systems, state governments aim to enhance efficiency and transparency in the collection process. These technological tools provide the capability to streamline and automate multiple phases of the tax cycle, spanning from data collection to financial reporting. Consequently, tax administration

can diminish bureaucracy, reduce errors, and ensure the more efficient management of public resources.

Moreover, the implementation of integrated systems enables greater agility in responding to changes in tax policies and legislation. The dynamic nature of tax laws demands swift responses from governments to ensure compliance and fair tax collection. Modern systems facilitate timely updates and agile adaptation to these changes, fostering a more responsive and efficient tax administration.

The implementation of integrated tax processing systems in the tax administration of state governments represents a significant evolution in financial management. However, it is crucial to balance potential benefits with careful consideration of associated challenges, including data security issues and the need for ongoing staff training. By doing so, state governments can effectively align their tax practices with the demands of an ever-changing society.

We have identified that various state governments are presently at different stages of implementing integrated tax processing systems, either acquired from companies specialized in government revenue management or developed internally (Pierson & Thompson, 2016).

Despite the wide adoption of Information and Communication Technologies (ICTs) within the scope of tax administration, along with the radical transformations these technologies have generated in the process of paying taxes, there remains little evidence regarding their impact on tax administration and compliance with tax obligations in developing nations (Mascagni, Mengistu, & Woldeyes, 2021).

Our third essay addresses the use of another technology, the Electronic Consumer Invoice (NFC-e), and aims to analyze the effects of its adoption by Brazilian states on the transfer of the share of the Tax on Circulation of Goods and Services (ICMS) to municipalities. The database used comprises 4,652 municipalities in Brazil from 2013 to 2016. The results of this study indicate that the adoption of NFC-e affects municipalities differently based on their size.

Larger municipalities attained more substantial results in augmenting the transfer of the ICMS share by the states. On average, in simple terms, large municipalities experienced an increase of around 3.6% per person, whereas medium-sized municipalities recorded a rise of about 2.7% per person. Concerning dynamic effects, large municipalities exhibited an average increase of approximately 18.6% per person two years after the states implemented the policy.

The implementation of information and communication technologies in tax administrations is a crucial step in modernizing tax processes. These innovations play a vital

role in enhancing the efficiency and effectiveness of activities related to tax collection and control.

Advanced electronic tax systems play a crucial role in identifying and analyzing intricate tax planning strategies. By incorporating cutting-edge technologies, these systems can examine complex financial transactions, identify patterns, and detect possible elusive practices. This technological sophistication not only strengthens the government's ability to enforce tax laws effectively but also contributes significantly to ensuring a fair and equitable approach to taxation.

The strict application of these advanced systems promotes the integrity of the tax system, mitigating potential loopholes and tax evasion. By identifying and correcting discrepancies, the State reinforces citizens' confidence in the tax system, demonstrating a commitment to equity and transparency. The population's trust in tax justice is essential to maintaining the stability and legitimacy of the government, as it ensures that all taxpayers are treated fairly and that tax responsibilities are distributed equitably.

Furthermore, effective implementation of advanced electronic tax systems not only facilitates compliance with tax obligations but also contributes to administrative efficiency. Automation and real-time data analysis enable a more agile response to changes in economic dynamics, enabling rapid adaptations to the constantly evolving needs of the tax system.

Therefore, the adoption and continuous improvement of advanced electronic tax systems not only strengthen the oversight and enforcement of tax laws but also play a key role in promoting fairness, transparency, and trust, essential elements for the effective functioning of any modern tax system.

This thesis is divided into five chapters. The first chapter consists of this introduction. The second chapter presents our initial essay, titled 'What are the relationships between information technology and tax collection? Evidence from a systematic literature review.' The third chapter addresses our second essay, titled 'Does the Adoption of Standardized Electronic Tax Systems Increase Tax Collection?' The fourth chapter highlights our third essay, titled 'Is Municipality Size a Factor? Impact of Introducing the Electronic Consumer Invoice (NFC-e).' Finally, the fifth chapter provides the overall conclusions of this thesis.

2 ESSAY 1: WHAT ARE THE RELATIONSHIPS BETWEEN INFORMATION TECHNOLOGY AND TAX COLLECTION? EVIDENCE FROM A SYSTEMATIC LITERATURE REVIEW

ABSTRACT

Purpose
This article aims to comprehensively analyze the current literature on the intersection of Information Technology (IT) and tax collection.

Method
This research adopts a Systematic Literature Review (SLR) approach, following the protocol established by Tranfield, Denyer and Smart (2003) as a methodological guideline.

Results
The literature analysis reveals the existence of three main research clusters: (1) the impacts of IT on tax collection; (2) the factors that influence technology adoption in this context; and (3) aspects related to IT and its application in tax administration. Furthermore, twelve theories emerge as foundations for the sample studies, with emphasis on the Technology Acceptance Model (TAM). The challenges inherent in implementing IT in tax collection encompass technical issues, risks associated with the IT implementation process, and management of relationships with relevant stakeholders.

Originality/Contribution
This article contributes to the literature by providing a comprehensive analysis that combines descriptive statistics and a qualitative metasynthesis of the existing literature. Furthermore, the article identifies promising areas of investigation that can deepen our understanding of IT in tax administration, thus contributing to the evolution of this field of study.

Keywords: Tax Collection; Information Technology; Systems; Systematic review.

2. 1 INTRODUCTION

Information Technology (IT) is driving significant changes in the delivery of public services and interactions with the general population. From public financial management to social programs, elections, and various other domains, governments have felt the impact of this transformation (World Bank, 2016). In developing countries, where the administrative infrastructure for taxation is limited, there are challenges in ensuring that taxpayers comply with their tax obligations due to the absence of reliable records regarding taxpayers' taxable bases. Consequently, tax authorities in these nations are keenly interested in harnessing the potential of IT to gather and analyze extensive volumes of taxpayer data in an easily accessible manner (Ali, Shifa, Shimeles, & Woldeyes, 2021).

These initiatives, aimed at utilizing IT to enhance access and enhance the efficiency of government services for citizens, employees, companies, and agencies, are commonly referred to as electronic government (Carter & Bélanger, 2005). In essence, electronic government entails harnessing Information and Communication Technologies (ICTs) to deliver public services to citizens and enhance government effectiveness and efficiency (Srivastava & Teo, 2010).

Numerous studies have demonstrated that, in response to the proliferation of ICTs, the knowledge revolution, and the accelerated pace of globalization, forward-thinking governments have initiated the implementation of electronic government practices (Bounabat, 2017). This entails the updating and online availability of services (Shareef, Kumar, Kumar, & Dwivedi, 2009; Shareef, Kumar, Kumar, & Dwivedi, 2011; Rana, Dwivedi, Williams, & Weerakkody, 2014; Alcaide-Muñoz, Rodríguez–Bolívar, Cobo, & Herrera–Viedma, 2017).

The ICTs in electronic government systems have garnered increasing attention from researchers worldwide. Numerous studies have investigated citizens' adoption of e-government services and the factors influencing it in various contexts (Alzahrani, Al-karaghouli, & Weerakkody, 2017; Carter, Weerakkody, Phillips, & Dwivedi, 2016; Gao & Lee, 2017; Rana & Dwivedi, 2015; Santhanamery & Ramayah, 2018; Shareef et al., 2009). In addition to enhancing service delivery, e-government initiatives often aim to combat corruption by automating processes and reducing employee discretion. A prominent example of e-government's application in developing countries is in tax administration (Okunogbe & Pouliquen, 2022).

These initiatives are driven by the significant challenges posed by limited tax capacity, and the adoption of electronic tax systems has been a key focus of tax reforms as a means of mitigating tax evasion (Ali et al., 2021). Tax reform efforts aimed at improving the monitoring of tax bases and tax collection in developing countries often revolve around ICTs (Bird & Zolt, 2008).

Global tax environments are rapidly evolving, with electronic tax systems serving as contemporary channels for interaction between tax authorities and taxpayers (Muturi & Kiarie, 2015). Consequently, the utilization of IT in tax administration has gained prominence in the literature (Ali et al., 2021).

However, through preliminary research, akin to a scoping review (Williams, Clark, Clark, & Raffo, 2021), we have identified that prior studies have not furnished comprehensive and compelling evidence regarding the relationship between the digitalization of government services and tax collection (Uyar, Nimer, Shahbaz, & Schneider, 2021). These studies have

primarily explored how tax reforms and simplification of tax filing, payment, and processes may enhance tax compliance levels in specific countries (Sidani, Ghanem, & Rawwas, 2014; Night & Bananuka, 2020).

Given the absence of a previous review focusing on this subject and considering its significance in the context of economic development, this article aims to comprehensively analyze the current literature on the intersection of Information Technology (IT) and tax collection. To guide this review, we have sought to answer the following questions: (RQ1) What are the primary research clusters identifiable within the literature? (RQ2) Which reference theories are applied or referenced in the study of these topics? (RQ3) What challenges exist in implementing IT in these contexts?

To adequately address these questions, our study employs a systematic literature review (SLR), following the protocol proposed by Tranfield, Denyer, and Smart (2003). The metasynthesis conducted through this protocol yields significant contributions for stakeholders interested in monitoring the correlation between IT usage and tax collection.

Tax administration managers can use the results of this study as a basis for their decisions regarding the adoption of IT. For example, when considering the implementation of information systems and process automation, it is essential to consider the importance of systems integration and the need to raise awareness about the benefits of IT. Furthermore, when facing resistance to change, it is possible to draw inspiration from successful strategies identified in the literature.

These contributions carry significant implications for society. Effectively implementing IT in tax administration can lead to a more efficient and equitable collection process. By reducing tax evasion and simplifying tax procedures, we can boost citizens' confidence in the tax system and promote tax justice. Simultaneously, the utilization of advanced technologies can enhance the identification of irregularities and the selection of taxpayers for inspection, resulting in a more efficient and balanced system.

Furthermore, this study distinguishes itself through its originality. It presents a comprehensive systematic review of literature, summarizing the research conducted thus far on the interaction between IT technology and tax collection. Moreover, this study is connected to the study of Bassey, Mulligan, and Ojo (2022), who conducted a review to categorize the factors influencing the success of digital services in tax administration bodies. Their review aligns with the digital taxation ecosystem proposed by Canares (2016). Nevertheless, we enhance this discussion by identifying the factors pertinent to the adoption of IT in the context of tax

collection. We also outline their impacts on tax collections and highlight the primary challenges encountered.

Through this approach, we can enhance the discourse on the increasing utilization of IT in delivering government services. Moreover, pinpointing clusters of studies, primary theories, and current challenges, establishes a valuable foundation for future research. Simultaneously, by outlining pathways for a more thorough analysis, like evaluating successful cases related to IT in tax management, this study promotes the advancement of fresh research in this domain.

In terms of contributions to the market, this study offers valuable insights for companies operating in the technology sector, particularly within the realm of tax administration. Technology firms can develop innovative products, such as advanced tax data collection systems, predictive analysis platforms, and tax process automation tools tailored to the specific needs of tax administrations. Furthermore, consulting firms can bolster their recommendations with robust evidence drawn from qualitative metasynthesis analysis of the literature. Systems integration companies and startups could provide solutions that facilitate the adoption of IT by tax administrations, considering the factors influencing this implementation.

This article follows the structure outlined below. In the second section, we detail the methodological procedures used in the study. Next, in the third section, we present the descriptive statistics obtained during the research. In the fourth section, we conduct a metasynthesis of the findings from the literature review. In the fifth section, we propose a research agenda aimed at investigating relevant issues that still warrant exploration. The sixth section offers practical recommendations based on the results obtained. Finally, the last section focuses on the study's concluding remarks.

2.2 RESEARCH METHODOLOGY

In this research, we adopted a systematic literature review using the protocol proposed by Tranfield, Denyer, and Smart (2003) consisting of three stages and nine phases.

Phase 0, titled 'Identification of the need for review,' was previously addressed in the introduction to this study. Phase 1, 'Preparation of a review proposal' (APPENDIX A), was completed and discussed by the authors from September 2020 to August 2021.

Phase 2, known as "Development of a review protocol", was designed to meet the requirements proposed by Tranfield, Denyer and Smart (2003), where they defined: i) the objective of the systematic literature review; ii) the issues to be clarified; iii) reference

management software; iv) data sources; v) keywords and search strings; vi) inclusion criteria; and vii) exclusion criteria. Items i and ii are presented in the first section of this research, while the other items are discussed in detail in the description of the conduct of the next phases.

Phase 3 of the study comprises the "Research Identification" phase, which begins with the selection of keywords and search terms. Initially, we associated the terms "information technology" and "systems" with "tax collection" or "tax evasion" to explore potential associations. During the scoping review, as the initial search was conducted, new terms were progressively added in subsequent searches. In total, six exploratory searches were carried out. Consequently, the final search query consisted of the following expression: (("*digitalizing tax collection systems*" OR "*e-Governmen*t" OR "*e-gov*" OR "*electronic government*" OR "*electronic tax register*" OR "*electronic taxation*" OR "*electronic tax system*" OR "*e-tax systems*" OR "*electronic tax filing*" OR "*e-filing*" OR "*information communication technology*" OR "*information and communication technologies*" OR "*ICTs*" OR "*on-line tax*" OR "*online tax*" OR "*on-line tax system*" OR "*online tax system*" OR "*digital transformation*" OR "*digital technology*") AND ("*tax evasion*" OR "*tax collection*" OR "*tax revenue*" OR "*tax compliance*")).

We utilized the following electronic databases: Scopus, Web of Science, Scielo, Emerald, Wiley, and ProQuest. Our search encompassed the period from 2015 to 2021. This time frame was selected in consideration of the 2016 World Bank report, which indicated that the majority of countries had implemented automated financial and customs management systems. Additionally, it noted that 159 out of the 193 United Nations member states had automated tax systems. Therefore, we deemed it pertinent to investigate how this report influenced researchers worldwide. To capture any pre-existing interests, we included the year 2015 within this scope.

We searched for August 27th to September 3rd, 2021. We applied the following inclusion criteria as filters in the databases: articles in the final stages of publication, published in scientific journals or conferences, and written in English, Portuguese, or Spanish.

Figure *1* illustrates phases 4 and 5 of the process: 'selection of studies' and 'study quality assessment'.

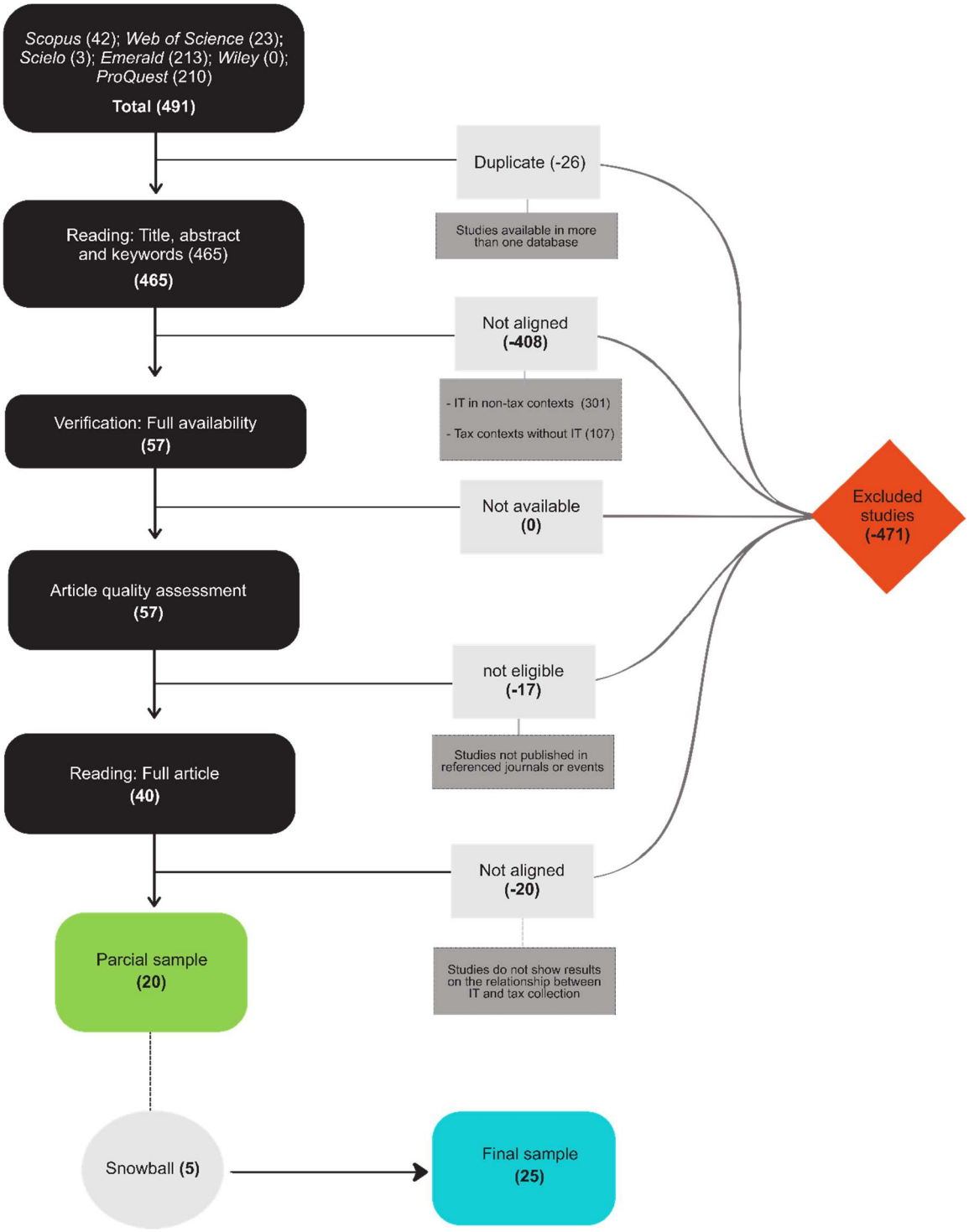

Figure 1. Reading and evaluation of articles
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In Phase 4, we initially identified and selected 42 studies from the Scopus database, 23 from Web of Science, 3 from Scielo, 213 from Emerald, none from Wiley, and 210 from ProQuest, totaling 491 studies. Subsequently, we applied exclusion criteria. The first criterion, related to duplication, led to the elimination of 26 studies. The second criterion involved an

analysis of titles, keywords, and abstracts to discard studies that were not aligned with the research focus, specifically those that did not address the relationship between IT and tax collection. consequently, 408 studies were eliminated. These excluded studies focused on IT in contexts unrelated to tax collection or discussed tax collection without mentioning the use of technological artifacts. As a result, the analysis continued with a sample of 57 studies.

Before thoroughly reviewing the studies, we assessed their quality, which also included the fourth exclusion criterion. In the field of management research, it's common for scholars to rely on the implicit quality rating of a particular journal rather than formally applying quality assessment criteria to the articles included in their reviews. This tendency arises because certain reference journals are often considered superior to others (Tranfield, Denyer & Smart, 2003). Consequently, we decided to include in our database only studies that had been published in reference journals or presented at reputable events, using Elsevier's SCImago Journal Rank (SJR) indicator as a parameter. To meet this criterion, a journal or event needed to fall within one of the quartiles (Alkhudary, Brusset & Fenies, 2020). As a result, 17 studies did not meet this criterion and were consequently excluded from the sample, leaving us with 40 studies for the application of the fifth exclusion criterion.

The fifth criterion used involved thoroughly reviewing the chosen studies, excluding those that did not contain relevant results about the research theme. Some articles addressed topics unrelated to the relationship between IT and tax collection, and they only briefly mentioned these subjects, which were distant from the study's focus. Consequently, a total of 20 studies were excluded, resulting in a reduced sample size of 20 studies. From the initial 20 studies selected, the "snowball" approach was employed to expand the sample. This technique involves recursively searching for pertinent references mentioned in the retrieved articles, a process also known as citation tracking and incorporating them into the search results (Tsafnat, Glasziou, Choong, Dunn, Galgani & Coiera, 2014). Despite being a time-consuming procedure, this approach has been demonstrated to enhance information retrieval (Horsley, Dingwall, & Sampson, 2011) and is considered a best practice (Greenhalgh & Peacock, 2005).

The implementation of this procedure led to the selection of 12 initial studies, to which the same exclusion criteria were applied. Following this process, 5 studies were included in the sample. Out of these 5 studies, four were not found in the databases we initially searched, while the last one had its final version published in a journal indexed in one of the consulted databases in 2022. As a result, the final sample for the metasynthesis comprised a total of 25 studies.

Section 3 details Phase 6 of the review protocol, the 'data extraction and monitoring progress', while Section 4 emphasizes Phase 7, 'data synthesis'. Sections 4 and 5 discuss Phase

8, the 'report and recommendations', which addresses metasynthesis and the research agenda. Metasynthesis and realistic synthesis are two interpretive and inductive methods developed to bridge the gap between narrative reviews and meta-analysis. Unlike meta-analysis, metasynthesis constructs interpretations rather than conducting analyses, revealing analogies between papers (Noblit & Hare, 1988). Finally, Section 6 presents Phase 9, 'Reporting and Dissemination', as practical recommendations.

2. 3 DESCRIPTIVE STATISTICS

Each study included in this research was assigned a unique identifier code. More details about the studies can be found in Appendix B, where partial data are extracted from the reviewed studies, including authors, year of publication, journal, development context, methodology, main research theme, and other relevant elements.

In the studied sample, there were a total of sixty-nine researchers involved, leading to an average of 2.9 authors per study. However, despite the growing interest in the topic within the literature, we did not identify any authors who significantly stood out, as only four authors contributed two studies each.

While these authors research different aspects, they share a common focus: developing countries. Figure 2 displays the geographical distribution of their studies, with numbers indicating the count of studies where the first author is affiliated with a specific country.

Figure 2. Geographic distribution of study authorship
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Most studies published in referenced journals or events come from authors originating in the United States (3), Uganda (3), Bangladesh (2), Norway (2), the United Kingdom (2), Malaysia (2), and Nigeria (2). These studies encompass a variety of research from cross-cultural and national perspectives. Interestingly, when analyzing the geographical distribution of studies, there is a significant absence of contributions from researchers in Latin America, Oceania, and the Middle East on the topic in question.

In summary, data indicates a significant concentration of research from specific countries, while lacking contributions from other important regions of the world.

The analysis of Table 1 enables us to observe the temporal evolution of publications throughout the study period.

Table 1: Years of publications

Year	Studies	#
2016	1, 2	2
2017	3	1
2018	4	1
2019	5, 6, 7, 8, 9, 10, 11	7
2020	12, 13, 14, 15, 16	5
2021	17, 18, 19, 20, 21, 22, 23, 24	8
2022	25	1

80% percent of studies about the discussed topic were published between 2019 and 2021. This underscores the current relevance and growing interest in this research field. Authors' publications are widely distributed, encompassing various academic journals and events, with no significant concentration in a specific outlet, as indicated in Table 2, showing that only two academic journals have the distinction of featuring two studies each.

Table 2: Academic journals or published events

Academic Journal/Event	Studies	#
Government Information Quarterly	1, 4	2
Sustainability	6, 11	2
3rd African Conference on Human-Computer Interaction, AfriCHI 2021	24	1
Accounting Research Journal	16	1
American Economic Journal: Economic Policy	25	1
Economic Change and Restructuring	20	1
Ejournal of Tax Research	10	1
Information Technology for Development	2	1
International Journal of Accounting & Information Management	7	1
International Journal of Enterprise Information Systems	8	1
International Journal of Law and Management	5	1
Journal of Accounting in Emerging Economies	3	1
Journal of Asian Finance, Economics and Business	21	1
Journal of Economic Behavior and Organization	17	1
Journal of Economics, Finance and Administrative Science	15	1
Journal of Electronic Commerce in Organizations	9	1
Journal of Global Operations and Strategic Sourcing	23	1
Journal of Systems and Information Technology	14	1
National Tax Journal	19	1
Technological Forecasting and Social Change	18	1
Transforming Government: People, Process and Policy	22	1
World Bank Economic Review	12	1
World Development	13	1

The contexts in which these studies were conducted are presented in Table 3. The application of scientific studies has addressed various contexts, with a particular emphasis on developing and underdeveloped countries. Comparative studies have been conducted across different nations, including three studies in Uganda, and two studies each in Bangladesh, the United States of America, Ethiopia, and India.

Table 3: Study Contexts

Country	Studies	#
Countries [a]	12, 16, 18	3
Bangladesh	9, 23	2
China	22	1
Croatia	10	1
Slovakia	6	1
United States of America	1, 7	2
Ethiopia	17, 19	2
Mauritius Islands	4	1
India	3, 20	2
Nigeria	8	1
Portugal	14	1
Romania	11	1
Thailand	2	1
Tajikistan	25	1
Tanzania	13	1
Uganda	5, 15, 24	3
Vietnam	21	1

Note: [a] refers to comparative studies conducted in more than one country.

The research contexts have involved the use of diverse methods, as indicated in Table 4. There are three prominent scientific methods with significant relevance in the context of empirical studies, specifically: structural equation modeling (32%), differences-in-differences and its variations (20%), and multiple regression and its variations (20%).

Table 4: Methods applied in studies

Method	Studies	#
Structural equation modeling	2, 3, 4, 8, 9, 14, 22, 23	8
Difference in differences	1, 12, 17, 18, 19	5
Multiple regression	5, 21, 13, 13, 20	5
Content analysis	10, 11	2
Correlation analysis	5, 15	2
Experiment	17, 25	2
Factor analysis	6, 21	2
Principal component analysis	6	1
Scattering analysis	6	1
Correspondence Analysis	6	1
System Usability Scale (SUS)	24	1
Time series	7	1
Grounded theory	16	1

Note: Some studies utilized multiple methods.

The most frequent method, 'Structural equation modeling', was exclusively used to examine the factors influencing the adoption of specific technologies. Its primary focus is to understand the relationships between complex variables that shape this adoption process. 'Difference in differences' was employed to comprehend the effects of an intervention or

treatment by comparing the changes that took place in a group exposed to the intervention with those in another unexposed control group. Finally, 'Multiple regression' has demonstrated their versatility when applied in various study contexts and different research studies.

Several studies have utilized these methods to investigate various technologies as presented in Table 5.

Table 5: Types of technology

Types of technology	Studies	#
Systems	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 14, 15, 21, 24, 25	15
Digitization (e-Gov)	10, 11, 16, 18, 20, 23	6
Sales registration machines	17, 19	2
Electronic fiscal devices	13	1
Electronic invoice	22	1

Among the technologies investigated, 'Systems' is predominant, representing around 60% of the study's focus. These systems are approached from different perspectives and contexts. Next, the 'Digitalization of governments' is explored in 24% of the research, focusing especially on the ability of these government entities to promote changes in the services offered to citizens. Devices such as sales registration machines, Electronic Fiscal Devices (EFDs), and electronic invoices are covered in four studies, totaling 16% of the scope, with special emphasis on the capacity of these instruments to improve government tax management.

In the next section, we will conduct a qualitative metasynthesis analysis of the literature following the protocol proposed by Tranfield, Denyer, and Smart (2003).

2.4 METASYNTHESIS

The clusters of analysis were categorized as follows: "Aspects related to IT and its application in tax administration", "Factors that influence adoption" and "Impacts of IT on tax collection" (Table 6). The first group comprises studies that address various aspects that tax administrations face when implementing IT, including technology adoption, associated obstacles and factors, and perceptions about IT and its usability. The cluster called "Factors influencing adoption" delves into issues related to the reasons or determinants that affect the use or intention to adopt such technologies, analyzing the perspectives of the different actors involved. The last group, "Impacts of IT on tax collection", covers the effects that the implementation of IT may have had on the collection of taxes administered by municipalities, states or countries.

Table 6: Research Clusters and year of publication

Cluster	Year	Studies	#
Aspects related to IT and its application in tax administration (n=8)	2019	5, 6, 7, 10, 11	5
	2020	15, 16	2
	2021	24	1
Factors influencing adoption (n=9)	2016	2	1
	2017	3	1
	2018	4	1
	2019	8, 9	2
	2020	14	1
	2021	21, 22, 23	3
Impacts of IT on tax collection (n=8)	2016	1	1
	2020	12, 13	2
	2021	17, 18, 19, 20	4
	2022	25	1

Studies related to the cluster "Aspects related to IT and its application in tax administration" began to emerge in 2019, with a significant concentration during that same year. In contrast, studies covering the cluster "Factors influencing adoption" have been published gradually over the years.

As for the cluster "Impacts of IT on tax collection," the first study was published in 2016 and it is in the last three years that its presence has become more prominent, indicating a growing interest among researchers in understanding the effects of IT on tax collection.

These results suggest an evolution in the field of research. Initially, there was a focus on general aspects of IT and tax administration, which has gradually shifted towards a greater emphasis on the determining factors for the adoption of these technologies. Furthermore, there is a growing interest in understanding the concrete impacts that the use of IT can have on tax collection, indicating a trend towards more specific and applied studies in this area in recent years.

2.4.1 ASPECTS RELATED TO IT AND ITS APPLICATION IN TAX ADMINISTRATION

This cluster covers issues that indirectly address various aspects of IT within tax administrations. These questions shed light on different dilemmas or advancements in this field and offer elements that are not directly connected to the other clusters. Table 7 further classifies studies in this cluster into four distinct groups: (1) factors affecting effectiveness and

performance; (2) barriers and drivers; (3) IT implementation aspects; and (4) Relationship between IT and tax compliance.

Table 7: Aspects related to IT and its application in tax administration

Group	Description	Studies
Factor affecting effectiveness and performance	Administrative competence and difficulties	6
	Postage cost savings and time	6
	Ease of collecting taxes, fees, and tariffs	6
Barriers and drivers	Underdeveloped ICTs	10
	Slow development of e-government	10
	Slow business development	10
	Problems with data security	10
	Low hardware and software prices	10
	Attracting foreign investments	10
IT implementation aspects	Online progress of delivery of declarations	7
	Usability	24
IT x Tax compliance relationship	Taxpayer attitude	5, 15
	Systemic corruption	5, 15
	Informal contributors	16
	Time spent	11
	Slowness	11
	IT infrastructure	16

The primary focus of the first group is to assess the factors influencing the effectiveness and performance of IT systems in tax administration. They emphasize three key aspects identified by Kot, Štefko, Dobrovič, Rajnoha, & Váchal in their 2019 study: administrative competence and government complexity, time and postage cost savings, and the streamlining of tax and fee collection. These factors are crucial for optimizing IT solutions in financial tax administration.

The second group consists of barriers and drivers influencing the adoption of IT by tax administrations in developed countries. The primary barriers include the underdevelopment of Information and Communication Technologies (ICT) in these countries, the slow progress of e-government initiatives, which hinders effective government control monitoring, and challenges associated with slow business growth and data security issues (Hodzic, 2019). On the other hand, drivers encompass affordable prices for hardware and software acquisition and the attraction of foreign investment. The barriers primarily stem from technical issues, while the drivers are associated with the government's capacity to foster a competitive economic environment.

In the third group, we delve into aspects related to IT implementation, encompassing two key elements of e-government analysis: the continuous improvement of statement delivery (Koong, Bai, Tejinder, & Morris, 2019) and usability (Eilu, Walyawula, & Soita, 2021), which

are interconnected. The first element pertains to the increasing use of IT. As it becomes more established, its usage naturally broadens. The second element assesses the positive impact of IT functionalities explored by users, highlighting that not all users adopt all available functionalities, often due to obligations or practicality.

The fourth and final group focuses on the relationship between IT and tax compliance. Taxpayer attitudes greatly influence IT adoption, which, in turn, is linked to significant tax compliance outcomes (Sadress, Bananuka, Orobia, & Opiso, 2019; Night & Bananuka, 2020). However, IT is not immune to the systemic corruption prevalent in many developing countries and, in some cases, can be compromised rapidly. Furthermore, IT can efficiently handle registered taxpayers, but it may not adequately address many informal taxpayers (Umar & Masud, 2020), as it surpasses the control mechanisms it offers.

Despite the challenges posed, the integration of IT into tax environments has led to a significant reduction in the time required to meet tax obligations. This has contributed to an increase in tax compliance levels, which, in turn, serves to reduce corruption (Fanea-Ivanovici, Radu-Cristian, Marius-Cristian, & Voicu, 2019). Electronic tax administration, a characteristic of advanced countries' tax systems, faces difficulties in full adoption by developing nations. In this context, a computerized tax administration alone is insufficient to achieve widespread use. Access to IT infrastructure is also essential, especially for small and medium-sized businesses, to align effectively with tax administration requirements. Unfortunately, a significant proportion of these businesses in developing countries still lack access to such infrastructure (Umar & Masud, 2020).

In summary, the adoption of IT has led to significant advancements in tax administration, as demonstrated in this study. Nonetheless, challenges have been identified, as outlined in section 4.3, which must be addressed to enhance the effectiveness of these results, enabling a more efficient utilization of the benefits brought about by IT in tax management.

2.4.2 FACTORS INFLUENCING ADOPTION

In the second cluster is dedicated to analyzing the determinants influencing the adoption of IT in tax relations. Factors were grouped into two categories: internal aspects of IT, which encompass intrinsic motivations for using technology, and external aspects of IT, which pertain to issues arising from relationships external to its functionalities. Table 8 presents these factors along with their respective classifications in the mentioned sets.

Table 8: Factors influencing adoption

	Factors	Studies	#
Internal aspects of IT	Performance expectation	2, 8, 22, 23	4
	Perceived ease of use	2, 3, 4, 8, 9, 21, 23	6
	Perceived trust	2, 9, 22, 23	4
	Perceived usefulness	2, 3, 4, 23	4
	Perceived autonomy	2, 4	2
External aspects of IT	Social Influence	2, 8	2
	Taxpayer awareness	21	1
	External compatibility	14	1
	Tax Compliance Costs	14	1
	Coercive pressure	14	1
	External knowledge	14	1

In the context of internal aspects of IT, six relevant factors have been identified. The first among these is 'performance expectation,' which encompasses the perceived benefits, usefulness, and performance of IT in executing tasks (Bhuasiri, Zo, Lee & Ciganek, 2016; Mas'ud & Umar, 2019; Qi & Che Azmi, 2021; Kabir, 2021). This factor is considered one of the primary determinants in the Unified Technology Acceptance Theory (UTAUT).

On the other hand, 'perceived ease of use' is a critical factor for realizing these benefits. It is associated with users' perception that IT systems are user-friendly, offer support for tasks, exhibit usability, reliability, adaptability, availability, and provide a responsive interface (Bhuasiri, Zo, Lee & Ciganek, 2016; Zaidi, Henderson & Gupta, 2017; Veeramoootoo, Nunkoo & Dwivedi, 2018; Mas'ud & Umar, 2019; Rifat, Nisha & Iqbal, 2019; Kabir, 2021; Le, Bui & Nguyen, 2021).

'Perceived trust' has been identified as a key determinant of the intention to adopt IT (Bhuasiri et al., 2016; Rifat et al., 2019; Kabir, 2021; Qi & Che Azmi, 2021). This factor is closely related to security and privacy concerns (Loo, Yeow & Chong, 2009; Wang, Wang, Lin & Tang, 2003) and refers to the extent to which an individual believes that the use of a given IT system is free from privacy threats (Ong, Lai & Wang, 2004) based on the belief that security measures are incorporated (Pavlou, Tan & Gefen, 2003).

The three preceding factors, namely ‘performance expectation’, ‘perceived ease of use’, and ‘perceived trust’, are interconnected with ‘perceived usefulness’, which emerges as a significant influencer in IT adoption (Zaidi, Henderson & Gupta, 2017; Kabir, 2021; Bhuasiri, Zo, Lee & Ciganek, 2016; Veeramoootoo, Nunkoo & Dwivedi, 2018). ‘Perceived usefulness’ is defined as the belief that IT enhances one's work performance (Davis, 1989) and can result in the development of habits where the user instinctively utilizes IT in response to specific situations or tasks (Limayem, Cheung & Chan, 2003; Roca & Gagne, 2008).

Another significant factor for IT adoption in ‘perceived autonomy’ (Bhuasiri, Zo, Lee & Ciganek, 2016; Veeramoootoo, Nunkoo & Dwivedi, 2018). This dimension involves the user's satisfaction with their freedom to carry out activities using IT (Deci & Ryan, 2000; Miserandino, 1996; Roca & Gagné, 2008), influenced by the various user experiences. in SDT, it is considered a fundamental element.

The second group of factors are related to six external aspects for IT adoption. The first of these pertains to 'social influence,' which is associated with an individual's perception of the opinions of significant individuals nearby who believe that he or she should use IT (Fishbein & Ajzen, 1977; Venkatesh, Morris, Gordon & Davis, 2003).

Another factor present within this group is ‘taxpayer awareness’, which has emerged as a key element in the modern world. This factor encompasses the level of knowledge and awareness regarding compliance with tax policies and the execution of tax procedures (Hofmann, Hoelzl & Kirchler, 2008). It plays a significant role in electronic tax compliance (Le, Bui & Nguyen, 2021).

Furthermore, four other factors in the second group influence the intention to adopt IT, as described by Martins and Picoto (2020): ‘external compatibility’," defined as the degree of integration or harmonization between IT and the procedures and practices existing within a company (Azmi, Sapiei, Mustapha & Abdullah, 2016); ‘tax compliance costs’, which measures the expenses associated with tax compliance activities for adoption; ‘coercive pressure’, referring to tax compliance obligations; and ‘external knowledge’, encompassing the external sources that companies rely on to acquire information about compatible IT.

In conclusion, this cluster of studies illustrates that various factors can influence the intention to adopt IT. One of the most significant factors is the ‘perceived ease of use’, which pertains to how effectively IT facilitates and simplifies task implementation. While internal factors are extensively discussed in the literature, with eight out of the nine studies in this set mentioning them, external factors are only addressed in four studies. Three out of the nine studies establish connections between internal and external factors. Consequently, there is potential for amalgamating these studies to develop models that analyze these factors across different contexts, particularly in countries that have yet to be investigated.

2.4.3 IMPACTS OF IT ON TAX COLLECTION

In our analysis, the final cluster that surfaced encompasses the effects of IT on tax collection. Table 9 illustrates the identified types of IT and the continent of study.

Table 9: Contexts of IT impacts on collection

IT	Continent	Studies	#
System	Asia	25	3
	Cross-country	12	
	North America	1	
Sales recording machines	Africa	17, 19	2
Electronic tax device	Africa	13	1
Digitization (e-Gov)	Asia	20	2
	Cross-country	18	

Three studies stand out due to their impact analysis of system usage. Two of these studies were conducted at the corporate level: one in Tajikistan (Asia) by Okunogbe and Pouliquen (2022) and another on an international scale by Kochanova, Hasnain, and Larson (2020). The former demonstrated a notable increase of TJS 25,357 (equivalent to US$3,600) in tax collection among companies classified as high-risk. Conversely, the latter study presented conflicting results, indicating an average increase of 0.75% in income tax collection as a percentage of Gross Domestic Product (GDP) and an average reduction of 0.65% in tax collection on goods and services as a percentage of GDP.

The third study, focused on the government sphere in the United States of America (North America), was conducted by Pierson and Thompson (2016). The results highlighted significant increases over the years of system implementation, notably a 161.2% increase in leisure tax after the second year and 126.8% after the third year.

Regarding the analysis of sales recording machines, two studies were conducted in Ethiopia, both at the enterprise level. Ali et al.'s (2021) study showed an increase ranging between 18% and 32% in Value Added Tax (VAT), corresponding to a 3.6% to 6.4% increase in the country's total revenue. Conversely, Mascagni, Mengistu, and Woldeyes (2021) revealed a significant 47.7% increase in net VAT collection and a 12% increase in income tax collection.

A study investigating the use of Electronic Fiscal Devices (EFDs) at the government level was conducted by Fjeldstad, Kagoma, Mdee, Sjursen, and Somville (2020). Their findings suggest that when companies interact with customers aware of their legal obligation to request receipts and perceive a real risk of punishment for not issuing receipts, there is an average increase of 24 percentage points in Value Added Tax (VAT).

Finally, two studies explored the impact of digitalization, especially on e-government implementation. One of these studies took place in India (Asia), conducted by Mallick (2021), which did not identify relevant impacts on tax revenue. In contrast, the international study by Uyar et al. (2021) demonstrated that, according to the six indicators of the Global

Competitiveness Index (GCI) issued by the World Economic Forum (WEF) in 2020, tax evasion decreased on average from 1.2% to 23%, influenced by these indicators.

In summary, most studies analyzed were conducted on the African continent (3), evenly distributed between organizational levels (4 studies each). The collective analysis of these studies suggests that the adoption of ICT has the potential to increase tax revenue, showcasing variations ranging from 0.75% to 161.2%.

2.4.4 LITERATURE REFERENCE THEORIES

We identified applications of twelve theories in the analyzed studies (Table 10), emphasizing the feasibility of addressing the phenomenon from various perspectives.

Table 10: Theories used in studies from the sample

Aspects studied	Theories used	Studies	#
Human behavior (n=10)	Technology Acceptance Model (TAM)	3, 5, 9, 15, 23	5
	Self-Determination Theory (SDT)	2, 23	2
	Theory of Reasoned Action (TRA)	5, 15	2
	Theory of planned behavior (TPB)	3	1
Context (n=11)	Information Systems Success Model (ISSM)	3, 4	2
	Technology-Organizational Environment Framework (TOE)	14, 22	2
	Institutional theory	5, 18	2
	Expectancy-Confirmation Theory (ECT)	4	1
	Hofstede's cultural values	3	1
	Competencies development model	14	1
	Modernization theory	18	1
Human behavior and Context (n=2)	Unified Theory of Acceptance and Use of Technology (UTAUT)	2, 8	2

Note: Some studies either did not employ theories or utilized multiple theories.

The categorization of the theories has been conducted based on the aspects they investigate, specifically: Human behavior; Context; and both. 'Human behavior' encompasses theories that pertain to behavioral aspects and aims to elucidate the factors influencing IT usage. 'Context' comprises theories that extend beyond human behavior, delving into elements associated with the contextual environment in which these technologies are deployed. While they incorporate some elements from 'Human behavior', these theories primarily aim to comprehend aspects related to contextual situations. 'Both' represents the intersection of the two preceding groups.

There are five theories of ‘Human behavior’, with the TAM Model being the most frequently referenced, appearing in five of the studies analyzed. The TAM Model aims to explain how individuals accept and use new technologies by considering that users' intentions are influenced by two primary beliefs: perceived ease of use and perceived usefulness. Therefore, TAM seeks to explain which external factors affect a person's internal beliefs, attitudes, and intentions regarding the use of IT (Legris, Ingham, & Collerette, 2003).

On the other hand, SDT is a scientific approach that relates to human motivation, personality development, and well-being (Ryan & Deci, 2000). SDT makes a distinction between autonomous motivation (intrinsic motivation) and controlled motivation (extrinsic motivation) (Vansteenkiste, Lens, & Deci, 2006). Intrinsic motivation refers to performing an activity for pleasure and self-interest, while extrinsic motivation refers to performing an activity for a specific purpose, such as obtaining a reward, avoiding shame, or receiving personal attention (Meyer & Gagné, 2008; Vallerand, 2000).

SDT proposes that the adoption of intrinsic motivation depends on satisfying three fundamental psychological needs: autonomy, competence, and relatedness. Autonomy represents the desire to initiate and regulate one's behavior. Competence is the belief in one's effectiveness in interactions with the environment or in performing activities. Relatedness pertains to the need to perceive connections and receive support from important individuals (Roca & Gagné, 2008; Sørebø, Halvari, Gulli & Kristiansen, 2009). Individuals who satisfy these basic psychological needs are more likely to increase their intrinsic motivation and fully internalize extrinsic motivation (Gagné & Deci, 2005).

In the same theoretical context, the TRA posits that individuals make rational decisions regarding their actions. This implies that there must be an intention to engage in a specific behavior for it to occur. The TRA model relies on two primary factors contributing to behavioral intention: attitude toward the behavior and subjective norm. Ajzen and Fishbein (1980) argue that, in addition to a deeper understanding of the factors influencing behavior, it is necessary to explore individuals' beliefs about themselves and their environment.

The TPB extends the TRA, which serves as a framework for comprehending and forecasting human social behavior (Ajzen, 1991). TPB posits that human behavior is directly shaped by interests, which, in turn, are influenced by attitudes toward behavior, subjective norms, and perceptions of behavioral control (Ajzen, 1991).

On the other hand, ECT has its foundations in the field of marketing and is often employed to study consumer satisfaction and post-purchase behavior (Houston, Grandey & Sawyer, 2018). ECT posits that consumers form initial expectations about a product or service

before using it. After the first experience, they develop expectations regarding the product or service's performance, which are then compared to their initial expectations, referred to conceptually as ‘confirmation’. Subsequently, consumers assess their level of satisfaction based on the degree of confirmation of their initial expectations. Finally, satisfied consumers are more likely to repurchase the product or service, whereas dissatisfied consumers tend to discontinue its use (Bhattacherjee, 2001).

‘Context’ presents six theories that explore human behavior and aim to comprehend the factors associated with the contextual situations in which technologies are deployed. They also establish connections with the preceding group on occasion.

The first theory is ISSM which postulates interrelationships among six Information Systems (IS) constructs: system quality, information quality, IS use, user satisfaction, individual impact, and organizational impact. The ISSM model significantly contributes to the understanding of IS success by summarizing several success factors within a single theoretical framework and proposing temporal and causal interdependencies between these categories (Wang & Liao, 2008). In response to changes in the IS environment, DeLone and McLean (2016) updated the model, introducing a new construct: service quality, which assesses the quality of service provided by the IS department, thereby complementing the measures of IS platform success (Tam & Oliveira, 2017).

Unlike the ISSM, the TOE framework is a theoretical model widely used to research the adoption of technological innovation (Iacovou, Benbasat & Dexter, 1995). The original TOE framework consists of three contextual elements that influence the process of adopting and implementing technological innovations: technological context, organizational context, and environmental context.

The technological context refers to the discernible characteristics of existing and new technologies, while the organizational context encompasses internal factors, such as the company's size, its resources, and the complexity of its management structure. The environmental context includes the external factors surrounding the company's operations, such as the industry, competitors, and government relations, all of which can impact adoption decisions.

Institutional theory suggests that the adoption and retention of organizational practices are influenced not only by technical pressures for economic performance but also by social pressures related to conformity and legitimacy. This theoretical approach, originally developed for the study of organizations, has since expanded to analyze institutional change (Meyer and Rowan, 1977). Institutional theory suggests that organizations respond to both external and

internal pressures by adopting structures and practices considered legitimate by other organizations in their respective fields.

In this context, Hofstede's (2001) cultural values are discussed, encompassing five cultural dimensions: power distance, individualism-collectivism, masculinity-femininity, uncertainty avoidance, and long/short-term orientation. These dimensions provide insights into national culture composition and have been used to predict country-level behavior, although they may not accurately predict individual behavior.

As for the internal context, the competencies development model addresses how competitive advantages that generate profit disappear over time, making it important to find new sources of competitive advantage. This process occurs within an organization and in situations where information is non-existent or difficult to understand. Competence is defined as the ability to combine the company's assets and resources to perform a given task (Teece, Pisano, & Shuen, 1997).

Finally, modernization theory focuses on macro-environmental factors, such as economic growth, political orientation, and technological progress, and their influence on social change (Nam, 2018). Barker (2003) posits that modernized societies benefit more from emerging technologies than less technologically advanced societies.

‘Both’ represents the convergence of the two preceding groups and incorporates UTAUT, an approach introduced by Venkatesh et al. (2003). UTAUT is a comprehensive model designed to integrate existing theories on IT adoption, with its primary aim being to elucidate user acceptance of this technology.

UTAUT proposes four primary factors that determine the use of information systems, which are: performance expectation, effort expectation, social influence, and facilitating conditions. Performance expectation relates to an individual's belief that using a system can effectively enhance their performance in a specific activity. On the other hand, effort expectancy pertains to the perception of how easy it is to use the information system. Social influence is defined as an individual's perception of the opinions of people close to them regarding the necessity of adopting specific behaviors or actions related to IT. This concept is supported by the theory proposed by Fishbein and Ajzen (1977). Furthermore, facilitating conditions refer to objective environmental factors that are believed to ease the performance of tasks related to IT usage. This concept is rooted in the research conducted by Thompson, Higgins and Howell (1991).

In summary, the listed theories encompass a wide array of factors, spanning behavioral, contextual, cultural, and technological dimensions, among others. These theories play a pivotal

role in quantitative studies aimed at understanding impacts and influencing factors, as well as in the qualitative analysis of knowledge. Table 11 below displays an illustrative summary of the relationships between the clusters and the associated theories and methodological approaches.

Table 11: Relationship clusters, theories, and method

Final cluster	Studies	Theories used	Methods
Aspects related to IT and its application in tax administration	5, 6, 7, 10, 11, 15, 16, 24	TRA and TAM	Quantitative (5) Qualitative (3)
Factors influencing adoption	2, 3, 4, 8, 9, 14, 21, 22, 23	TAM, UTAUT, SDT, ISSM, TOE, institutional theory, TPB, ECT, Hofstede's cultural values and competency development model	Quantitative (9)
Impacts of IT on tax collection	1, 12, 13, 17, 18, 19, 20, 25	Institutional theory and Modernization theory	Quantitative (8)

The cluster titled ‘Aspects related to IT and its application in tax administration’ contains both quantitative and qualitative approaches in a balanced number. Notably, within this cluster, only two works are grounded in specific theoretical frameworks. In contrast, the cluster ‘Factors influencing adoption’ is marked by a prevalence of quantitative studies, bolstered by ten distinct theories, with only one not relying on a specific theoretical model. The ‘Impacts of IT on tax collection’ cluster is also exclusively composed of quantitative studies, with just one work incorporating the theories, while the rest are primarily based on recent empirical research.

In summary, the analysis reveals that literature about the subject matter is dominated by quantitative research. Notably, the cluster ‘Factors influencing adoption’ stands out for its robust theoretical foundation, drawing on widely validated theories, while the cluster ‘Impacts of IT on tax collection’ lack a theoretical background.

2.4.5 KEY CHALLENGES ENCOUNTERED

This section offers a concise summary of the primary challenges encountered when adopting technologies, as outlined in the selected studies. Table 12 illustrates the three groups of key challenges identified: technical aspects; relationship with stakeholders; and risks associated with the IT implementation process.

Table 12: Key challenges

Group	Studies	#
Technical aspects	16, 19	2
Relationship with stakeholders	10, 13, 16, 19, 24	5
Risks associated with the it implementation process	9, 10, 20	3

The first set of challenges focuses on technical aspects. A notable example is the operation of vending machines, which necessitate a reliable electrical supply and adequate network infrastructure. Furthermore, effective network management demands specialized technical knowledge, which can be particularly challenging for developing countries. Another important consideration is the handling of the substantial volumes of data collected, crucial for making informed decisions. However, this task is not straightforward, as it may involve a shortage of necessary technical expertise, difficulties in coordinating government entities, and inconsistent application of tax legislation (Ali et al., 2021).

Challenges related to technical aspects are also present in the context of micro and small companies. A large proportion of these companies have inadequate IT infrastructure, which highlights the relevance of government intervention through subsidies for training and, eventually, assisting in the acquisition of IT equipment at a reasonable cost. This short-term measure can result in long-term benefits, especially in terms of improving tax collection (Umar & Mas'ud, 2020).

The effectiveness of IT initiatives requires close cooperation among users, companies, and the government to enhance technical capacity. In this context, significant challenges are associated with the second group, specifically, challenges related to relationships with stakeholders.

Especially in scenarios where institutions have limited resources, which is common in developing countries, acquiring additional information about the tax bases of individuals and companies may have a minimal impact (Ali et al., 2021). For tax authorities in these nations, the absence of accurate information about these bases poses a critical challenge (Boadway & Sato, 2009; Gordon & Li, 2009; Olken & Singhal, 2011).

Hence, the involvement of all stakeholders is vital for the realization of an efficient digital tax administration. These stakeholders encompass policymakers, tax administrators, businesses, academic institutions, accounting firms, and, naturally, the taxpayers themselves (Hodzic, 2019). It is only through this collaborative and collective effort that we can confront

the challenges and attain a more effective tax system that aligns with the demands of the current scenario.

In this context, political leaders in developing nations and advocates of international tax reform must understand that IT only plays an auxiliary role in administration and cannot replace the political determination required to eradicate corruption. When political leaders combat corruption by promoting honesty and vigorously enforcing penalties for wrongdoers, IT efficiency is enhanced. However, in cases where corruption is tolerated without restrictions, the use of IT becomes ineffective (Umar & Mas'ud, 2020).

In addition to the aspects mentioned, implementing a more modern digital tax administration requires overcoming other issues related to engagement with different stakeholders. Among these barriers, digital exclusion stands out, which refers to the situation in which some users or taxpayers do not have the necessary records in digital format to comply with tax obligations. Additionally, the lack of financial resources to acquire new software that meets the new requirements also appears to be a relevant challenge for simplifying tax declarations (Hodzic, 2019).

A concrete example of this problem can be observed in the context of Tanzania, where the acceptance and use of electronic tax devices by companies continue to be a major obstacle for tax administrations. In this scenario, it appears that VAT collection did not show the expected improvement, as highlighted by Fjeldstad et al. (2020).

In many countries other than Tanzania, the introduction of electronic tax devices has not led to an increase in VAT revenues relative to GDP (Casey & Castro, 2015). This situation prompts questions about the factors responsible for limited tax collection improvements, even after the adoption of online tax declaration services. Notably, one significant issue is the identification of usability challenges in these online tax declaration systems (Eilu, Walyawula & Soita, 2021).

For users, an additional motivation may be linked to the necessity of transmitting confidential and sensitive information, such as income data and taxes, using technology and the Internet for online tax payments (Rifat, Nisha & Iqbal, 2019). This context sheds light on our third set of challenges: the risks associated with the IT implementation process. Users harbor a latent concern regarding security and privacy, as they aim to safeguard against phishing attacks, a form of cybercrime (Hodzic, 2019). This security apprehension can also present an additional challenge to the convenience and ease of filing tax returns online (Rifat, Nisha & Iqbal, 2019).

When it comes to the risks associated with filing taxes, we encounter several challenges that can impede taxpayers' efficient use of online services. These challenges encompass the

potential for fraud, financial costs tied to IT usage, human errors during electronic filing, and the risk of server connection issues, leading to unsatisfactory performance, especially during peak tax return periods.

In this context, an intrinsic relationship can be seen between the mentioned risks and the technical aspects of the system used. It should be noted that these technical aspects are directly associated with the security, efficiency, and reliability of the online service offered for the tax declaration. Therefore, it is imperative to pay attention to the development of measures that mitigate these risks, to guarantee a safer and more effective experience for taxpayers who choose to use this method of tax declaration.

The development of innovative technologies, such as blockchain, has provided new and secure methods for record keeping. However, this same technology facilitates the use of cryptocurrencies, as they pose significant risks to tax transparency (Mallick, 2021). In this sense, it is essential to seek a balance between technological advancement and the security of standards and regulations that aim to guarantee integrity and justice in the economic system.

In summary, the implementation of an efficient digital tax administration faces technical, relational, and security challenges, especially in developing countries. Cooperation between governments, companies, and various stakeholders is essential to overcome technical obstacles, such as inadequate infrastructure and data processing. Furthermore, the digital divide and concerns about taxpayer security also need to be addressed. Technological advancement, although promising, requires caution to guarantee the expected returns, such as greater revenues, integrity, and transparency in the tax system.

2.5 RESEARCH AGENDA

As the global trend towards digitizing tax administrations at different government levels continues to grow and enterprises increasingly emphasize digital development, there is a pressing need for scientific research. This research should focus on key areas, including Information Technology (IT) management, tax evasion, and electronic government. Scholars should collaborate to establish a structured, yet adaptable research agenda aimed at enhancing our comprehension of IT's role in tax administration, considering its various aspects and characteristics.

We conducted a systematic review of the literature examining the relationship between IT and tax revenue, incorporating various determining factors and relevant findings. Our goal

was to offer a comprehensive overview for future scientific investigations in this field. Through this integration process, we developed a research suggestions map (Figure 3) inspired by the prior work of Kraus, Palmer, Kailer, Kallinger, and Spitzer (2019). This map highlights methodological approaches at the top, specific research themes in the left column, and different levels of analysis in the right column, depicting the contexts for investigating those themes. Our map represents the initial effort to establish a meaningful connection between previous IT studies and tax collection, to facilitate future research in this field.

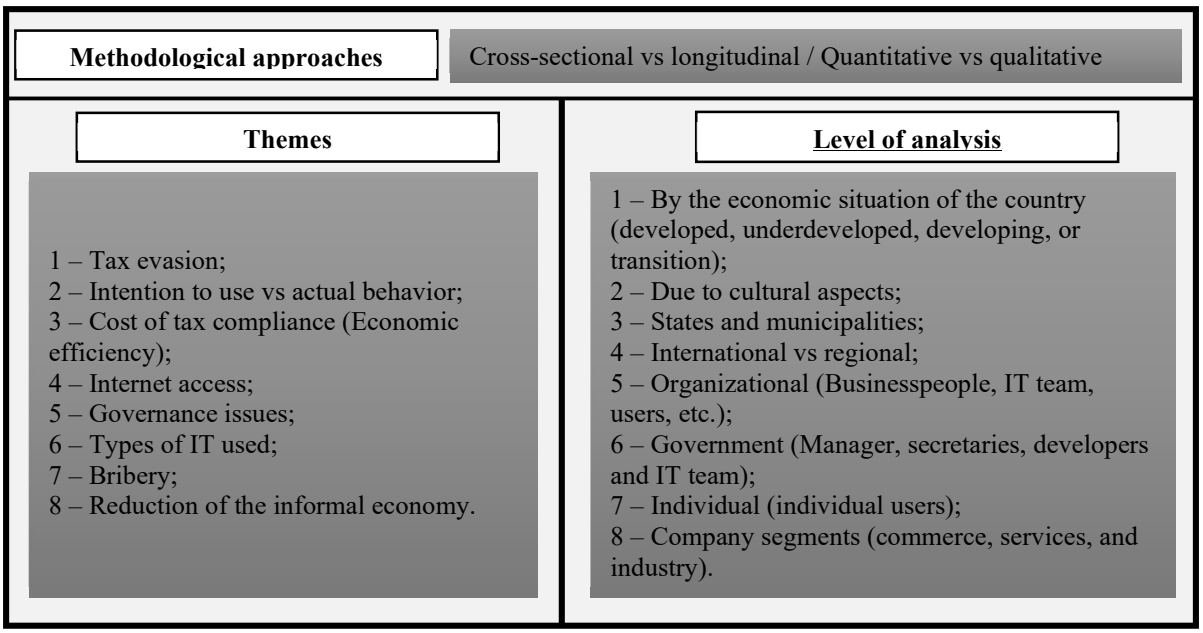

Figure 3. Search map.

Commonly, researchers acquire an in-depth understanding of specific phenomena through cross-sectional studies, in which different groups or scenarios are compared. However, when dealing with emerging topics of great relevance, longitudinal studies become the preferred research method. This type of approach allows you to monitor and analyze changes and trends over time, providing a more comprehensive and detailed understanding of the relationships between IT and tax collection. Therefore, it is essential to consider the application of longitudinal studies for more in-depth investigations in this specific field, aiming to significantly contribute to the advancement of knowledge in this area of interest.

About methodological selection, it is common for quantitative research to investigate the impacts of specific policies on variables of interest, aiming to explain the effectiveness of these policies. Our sample consists predominantly of studies of this focus, as shown in Table 11, suggesting that the field could benefit from more qualitative and mixed methods research.

In addition, the review of these articles suggests the exploration of various topics to gain a deeper understanding of the fundamental mechanisms and outcomes aimed at enhancing IT within tax administrations. Among the issues necessitating clarification, a notable focus is on studying the impact of IT usage on tax evasion. For instance, Uyar et al. (2021) recommend conducting an analysis that concentrates on tax evasion within a specific set of countries, such as developing or transitioning nations. Such an approach can yield intriguing insights, given that the utilization of Information and Communication Technologies (ICTs) and the evolution of e-government services in these countries often differ from those found in developed nations.

Several relevant questions permeate the research domain concerning the adoption of IT by individuals and organizations, as is widely discussed by several researchers in different scientific works in the sample of this systematic literature review. Distinguishing between the intended use of IT and the actual usage behaviors observed in users and business entities offers significant opportunities, as the disparity between what is planned and what occurs can provide crucial insights aimed at improving implementation strategies and promoting adoption.

Another important subject of consideration involves examining how compliance costs related to tax obligations impact IT adoption. Furthermore, it's crucial to assess the potential benefits for government entities. Investigating this relationship can shed light on the significance of fiscal factors as influencers in decision-making when it comes to adopting digital technologies. Simultaneously, analyzing whether IT adoption genuinely represents a modernization trend or if there are other underlying determinants at play can offer a critical perspective on the phenomenon.

Research on the impact of internet access on IT adoption is extremely relevant, given that the availability and quality of connectivity to the World Wide Web can have a significant influence on the incorporation of digital technologies, both by organizations and individuals. The internet is considered a fundamental facilitator in this process, becoming an essential element for the advancement and dissemination of IT.

Another relevant approach lies in the analysis of elements related to governance issues within the scope of IT implementation. This research encompasses a variety of perspectives that examine the effect of governance structures on decision-making and the use of IT.

In the context of our investigation, the main types of IT used were identified, as detailed in Table 5. A notable example is the electronic invoice, which stands out as a paradigmatic category. This technology allows the analysis of data from different nations, making it possible to make meaningful comparisons related to the impacts of cultural differences on the adoption of this technology and compliance with tax obligations.

An additional approach worthy of exploration is investigating the potential of IT in mitigating bribery among public officials and its impact on fundraising. Furthermore, it is pertinent to examine issues related to the digitalization of tax services, as this transformation can play a significant role in formalizing companies and, consequently, reducing the informal economy.

Sustainability issues also stand out, as the environmental impact resulting from the use of IT deserves special attention. This encompasses not only the reduction in paper consumption but also the growing concern about the management of technological waste. These emerging themes have been the subject of investigation in various spheres of research, reflecting the growing awareness of the need to promote more ecologically responsible practices in the digital age.

The mentioned themes can be explored at various levels of analysis. To this end, researchers in this field have employed various approaches. Firstly, one can conduct comparative studies by considering the economic status of the involved countries. Another potential perspective is to delve into cultural aspects, which have already been subject to research. Nevertheless, there is a noticeable shortage of international studies, specifically, comparative analyses between countries.

Another relatively unexplored aspect is regionalization, as illustrated in Table 3. Research that is more focused on specific groups of countries, like those comprising the Eurozone or Latin America, for instance, still requires more extensive investigation.

Existing research on the topic also considers various organizational levels. Therefore, investigating businesspeople, IT managers, and end users of companies presents a promising field of research.

In the government context, which has already been extensively covered in the literature, investigations involving public managers, executive heads, secretaries, developers, and government IT teams show promise. Moreover, studying the individual characteristics of external end users—individuals—provides research opportunities. This research can help explain why some models succeed while others fail. Understanding how these individual characteristics influence the adoption and performance of systems is crucial for advancing knowledge in this field.

The segmentation of IT adoption reveals significant diversity in both business and personal contexts, and its dynamics are significantly influenced by a variety of factors. In the business sphere, these distinctions are fundamental for understanding why certain initiatives cannot merely be transplanted from one sector, like commerce, services, or industry, to another

without overcoming specific challenges and adjusting strategies to match the particularities of each domain. This intricate interplay of contextual elements makes the IT approach a complex and strategic task, demanding careful consideration of the nuances within each sector. This complexity presents ample opportunities for further investigation.

The examples underscore the significance of adopting comprehensive approaches at various levels of analysis and themes to gain a deeper understanding of the essential mechanisms and outcomes intended to enhance IT within tax administrations. Moreover, they highlight the existing gaps in the literature and provide recommendations for future research in this field. In summary, delving into the relationship between IT and tax collection can be enhanced by integrating knowledge from general IT literature, scrutinizing tax evasion, implementing experimental policies related to tax collection, and bolstering state capabilities.

2.6 PRACTICAL RECOMMENDATIONS

In this section, we present our 'practical recommendations, which corresponds to phase 9 of the review protocol.

The evidence suggest a significant rise in tax collections when IT systems are implemented. This underscores the importance of modernizing tax structures at the federal, state, and municipal levels. Governments have a variety of tools at their disposal, from sales recording machines to electronic tax systems, to improve control over taxpayers and tax collection. The use of these resources will increase the availability of information, enabling more efficient audits and, consequently, reducing tax evasion.

The world is currently undergoing a rapid process of digitalization, largely propelled by the recent pandemic. This necessitates governments to continuously seek ways to adapt to these changes and prevent potential losses. In this regard, the standardized systems examined by Pierson and Thompson in 2016 offer a promising solution, as they have already been validated by other governments.

However, IT alone does not solve all problems, and governments must ensure that companies and users understand how it works and are part of the change process, avoiding usability or underutilization problems.

As the use of IT advances in governments and gains greater support from the stakeholders involved, it becomes essential to keep pace with these demands and prevent the provided structures from becoming insufficient to accommodate the ever-increasing data.

Losing the trust of these stakeholders can result in the obsolescence of the implemented IT, a return to previous revenue levels, and a loss of control.

Several factors can influence the intention to use IT in tax administration, including social influence, which can be exploited by governments to accelerate the adoption of deployed IT. Furthermore, wide publicity and a good government communications plan can be crucial to gaining initial buy-in.

Users expect IT to be useful, user-friendly, and empowering. When it comes to using systems, environments must feature clear and intuitive layouts with as few steps as possible to prevent a loss of interest and premature discontinuation of these systems. Perceived risks necessitate maximum transparency from administrators and adequate security measures for users.

Another crucial point is the integration of artificial intelligence (AI) into government strategies. AI offers significant advantages, such as swiftly and efficiently analyzing vast amounts of data, recognizing patterns and trends, identifying anomalies, and predicting future taxpayer behaviors. Furthermore, AI can automate mundane processes, thereby reducing the manual workload of collection teams and enabling them to focus on higher-value activities, such as specialized audits and strategic decision-making. The adoption of AI solutions can also enhance the transparency, efficiency, and effectiveness of tax systems, promoting fairer and more equitable tax collection.

Finally, implementations must have an IT governance plan that assists administrations with guidelines, skills, competencies, and responsibilities to control processes, optimize the application of resources, support decision-making, and ensure information security.

2.7 CONCLUDING REMARKS

This study aimed to provide a comprehensive analysis of the existing literature concerning the relationship between Information Technology (IT) and tax collection. The analysis identified three main clusters: Impacts of IT on Tax Collection; Factors Influencing Adoption; and Aspects of IT Application in Tax Administration.

The cluster on 'Impacts of IT on tax collection' is still in an early stage of development, whereas the 'Factors influencing adoption' cluster has garnered consistent interest over the years.

The studies examined are based on diverse theories, ranging from approaches focused on human behavior to investigations of the restrictions imposed by institutions and cultural values. The Technology Acceptance Model (TAM) used in studies within the cluster titled ‘Factors that influence adoption’ stands out.

This study makes substantial managerial contributions to the field of tax administration within the IT context. It identifies key challenges, including the absence of suitable technological infrastructure, resistance to change from both taxpayers and government agencies and concerns regarding data security and privacy. This information can serve as a guide for tax administration managers when making strategic decisions.

A relevant managerial implication is the importance of integrating information systems and raising awareness about the benefits of IT. The effectiveness and efficiency of operations can be guaranteed through the integration of existing systems, and successful strategies for dealing with resistance to change, identified in the literature, can be applied by managers.

Based on the findings of this research, several approaches for future research are recommended. It is essential to conduct more comprehensive and persuasive studies regarding the relationship between the digitization of government services and tax administration, which should encompass gathering empirical data and qualitative analyses. Additionally, exploring the economic and social implications of the successful implementation of IT in tax administration is crucial, considering its effects on collection and socioeconomic development.

Case studies that examine successful instances of IT implementation in tax management can offer valuable insights for public managers and technology companies as they develop specialized solutions for tax administrations. Additionally, it's crucial to account for the diversity of socioeconomic contexts when assessing the effects of IT adoption in tax administration. Comparative studies across countries and regions can be particularly useful in formulating specific recommendations for each unique situation.

Finally, it is suggested to explore the role of emerging technologies, such as artificial intelligence (AI), blockchain, and machine learning, in tax administration and their effects on tax collection. These technologies have the potential to bring significant advances in this field and deserve in-depth investigation.

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APPENDICES

APPENDIX A – Summary of the review protocol

1) Systematic Review Research Question

What is known in the existing literature regarding the relationship between the utilization of IT and tax revenue?

2) Objective of Systematic Literature Review

Comprehensively analyze the current literature on the intersection of Information Technology (IT) and tax collection.

3) Points to Clarify in The Systematic Literature Review

- (RQ1) What are the primary research clusters identifiable within the literature?
- (RQ2) Which reference theories are applied or referenced in the study of these topics?
- RQ3) What challenges exist in implementing IT in these contexts?

4) Protocol to Be Used

The protocol to be used is the model by Tranfield, Denyer, and Smart (2003), which was available for viewing in Figure 1.

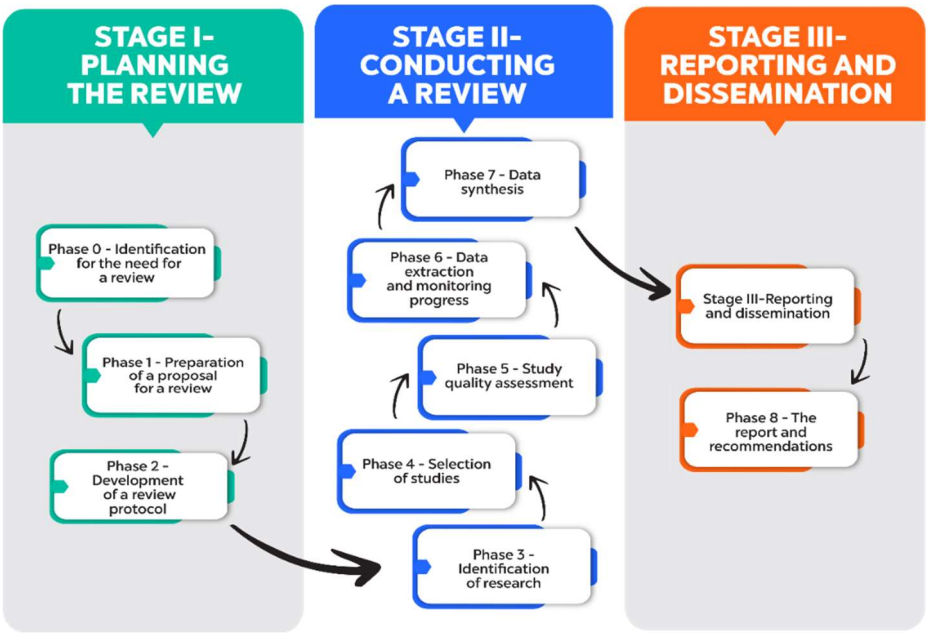

Figure 1. RSL stages

5) Reference Management

The reference management software to be used will be EndNote, version X9 (Figure 2), this choice was made because the researcher already has some familiarity with it, having used it in previous research.

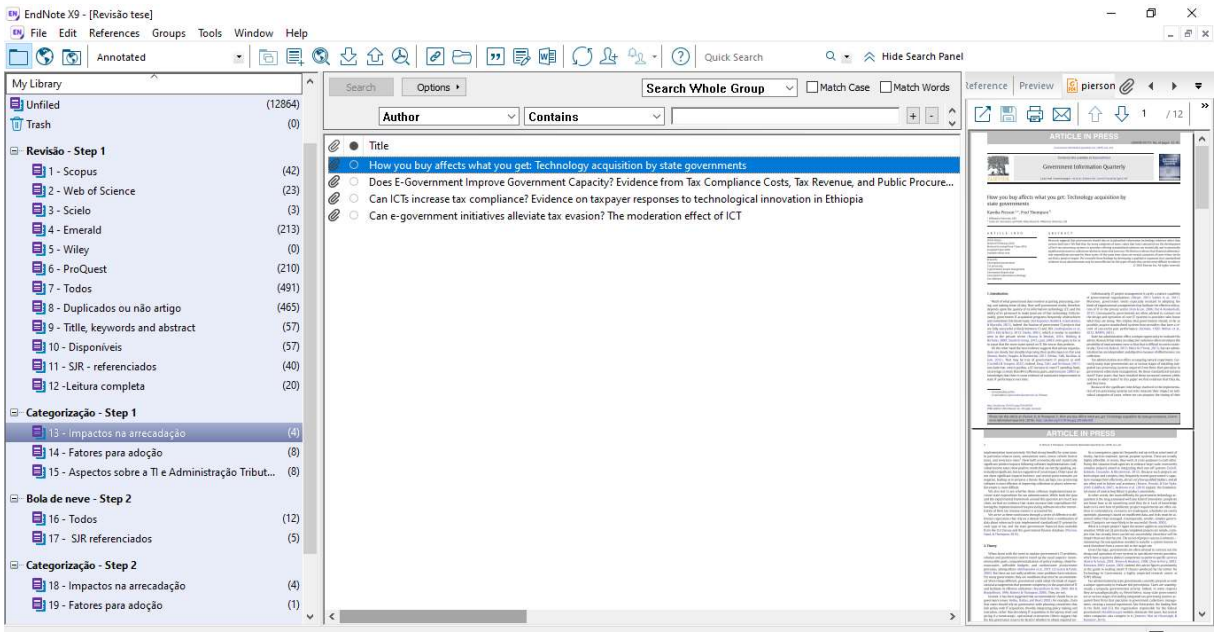

Figure 2. EndNote

6) Data Sources

The electronic databases chosen considered the criteria listed below:

- Be available on the CAPES Journal Portal;
- Allow the search to be carried out based on the constructed or adapted logical expression;
- That historically indexed journals with relevant publications about the area of this study proposal.

The chosen databases are presented: Scopus, Web of Science, Scielo, Emerald, Wiley, and ProQuest.

7) Keywords and Search Strings

The keywords taken into consideration and that will be used for the search strings have a relationship within the literature with the proposed research. The search expression to be used in the databases will be:

(("digitalizing tax collection systems" OR "e-Government" OR "e-gov" OR "electronic government" OR "electronic tax register" OR "eletrocic taxation" OR "electronic tax system" OR "e-tax systems" OR "electronic tax filing" OR "e-filing" OR "information communication technology" OR "information and communication technologie" OR "ICTs" OR "on-line tax" OR "online tax" OR "on-line tax system" OR "online tax system" OR "digital transformation" OR "digital technology") AND ("tax evasion" OR "tax collection" OR "tax revenue" OR "tax compliance"))

8) Inclusion Criteria

The inclusion criteria will continue to be applied in the databases when appropriate:

- Years: 2015 to 2021;
- Journal papers in the final stage of publication or conference;
- Languages: English, Spanish and Portuguese.

9) Exclusion Criteria

The exclusion criteria to be used will follow the order shown below:

- Duplicate search in the database;
- Reading the titles, keywords, and abstract where works that are not aligned with the research intended to be developed will be eliminated;
- Verification and exclusion of works that are not available for access to their full version;
- Checking whether the works are referenced and excluding those that are not;
- Complete reading of the works, excluding those whose results do not demonstrate contributions to the researched topic, that is, after complete reading, the article does not cover the relationship between IT and tax collection.

APPENDIX B – Data extraction from articles selected for the systematic literature review

Code: 1	
Title	How you buy affects what you get: Technology acquisition by state governments
Author(s)	Pierson, K.; Thompson, F.
Year	2016
Journal / Event	Government Information Quarterly
SJR 2020	2.12 / Q1
Context	States of the United States of America
Level	Government
Purpose of the study/Research question	Do standardized systems work better than others? Have states that implemented them experienced an increase in revenue compared to states that haven't?
Theories used	-
Type of technology	Systems
Analysis methods	Differences in differences
Final cluster	Impacts of IT on tax collection
Main topic	Impacts of Employing Standardized Systems on State Taxes

Code: 2	
Title	User Acceptance of e-government Services: Examining an e-tax Filing and Payment System in Thailand
Author(s)	Bhuasiri, W.; Zo, H.; Lee, H.; Ciganek, A.
Year	2016
Journal / Event	Information Technology for Development
SJR 2020	0.83/ Q1
Context	Thailand
Level	Users
Purpose of the study/Research question	To investigate the factors influencing citizens' willingness to embrace an electronic tax declaration and payment system in Thailand
Theories used	UTUAT and SDR
Type of technology	Systems
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Determinants of intention to use the system

Code: 3	
Title	The moderating effect of culture on e-filing taxes: evidence from India
Author(s)	Zaidi, S.; Henderson, C.; Gupta, G.
Year	2017
Journal / Event	Journal of Accounting in Emerging Economies
SJR 2020	0.44/Q2
Context	India
Level	Users
Purpose of the study/Research question	Examine the factors that affect the adoption of an electronic tax filing system in an emerging economy.
Theories used	TAM, ISSM and Hofstede's cultural values
Type of technology	Systems
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Factors Affecting System Adoption

Code: 4	
Title	What determines success of an e-government service? Validation of an integrative model of e-filing continuance usage
Author(s)	Veeramootoo, N.; Nunkoo, R.; Dwivedi, Y. K.
Year	2018
Journal / Event	Government Information Quarterly
SJR 2020	2.12/Q1
Context	Mauritius Islands
Level	Users
Purpose of the study/Research question	Validate an integrated electronic archiving continuity usage model.
Theories used	ECT and ISSM
Type of technology	Systems
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Usage Model of Factors Affecting System Adoption

Code: 5	
Title	Antecedents of tax compliance of small business enterprises: a developing country perspective
Author(s)	Sadress, N.; Bananuka, J.; Orobia, L.; Opiso, J.
Year	2019
Journal / Event	International Journal of Law and Management
SJR 2020	0.26/Q2
Context	Uganda Small Businesses.
Level	Companies
Purpose of the study/Research question	To investigate the contribution of attitude toward the e-tax system, e-tax system adoption, and isomorphic forces to the tax compliance of small businesses (SBEs) in a developing country in a single study.
Theories used	TRA, Institutional Theory and TAM
Type of technology	Systems
Analysis methods	Correlation and multiple regression analysis
Final cluster	Aspects related to IT and its application in tax administration
Main topic	The influence of attitude toward the system

Code: 6	
Title	The Main Performance and Effectiveness Factors of Sustainable Financial Administration Reform Using Multidimensional Statistical Tools
Author(s)	Kot, S.; Stefko, R.; Dobrovic, J.; Rajnoha, R.; Váchal, J.
Year	2019
Journal / Event	Sustainability
SJR 2020	0.61/Q1
Context	Slovakia
Level	Government
Purpose of the study/Research question	Assist public authorities, tax policymakers, and businesses in comprehending the perception of tax system reform. Emphasize its fundamental effectiveness and sustainable performance in the context of the non-macroeconomy, including social, and technological aspects, and processes.
Theories used	-
Type of technology	Systems
Analysis methods	Principal component analysis; Factor analysis; Scattering analysis; Correspondence analysis.
Final cluster	Aspects related to IT and its application in tax administration
Main topic	Perception about system reform

Code: 7	
Title	Advancements and forecasts of electronic tax return and informational filings in the US
Author(s)	Koong, K.; Bai, S.; Tejinder, S.; Morris, C.
Year	2019
Journal / Event	International Journal of Accounting & Information Management
SJR 2020	0.46/Q2
Context	States of the United States of America
Level	Government
Purpose of the study/Research question	Examine the longitudinal progress of total tax returns filed electronically by individuals, businesses, and “other” categories for the period 2004 to 2017 and project a timeline to achieve the target.
Theories used	-
Type of technology	Systems
Analysis methods	Time series
Final cluster	Aspects related to IT and its application in tax administration
Main topic	Electronic declaration delivery progress

Code: 8	
Title	Advancements and forecasts of electronic tax return and informational filings in the US
Title	Structural Effects of Trust in E-Filing Software on E-Filing Acceptance in Services Sector
Author(s)	Mas'ud, A.; Umar, M.
Year	2019
Journal / Event	International Journal of Enterprise Information Systems
SJR 2020	0.28/Q3
Context	Nigerian Microenterprises
Level	Companies
Purpose of the study/Research question	Examining the structural mediating effects of reliance on electronic filing software on microentrepreneurs' intention to use electronic filing systems to file their tax return
Theories used	UTUAT
Type of technology	Systems
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Effect of trust on intention to use the system

Code: 9	
Title	Predicting e-tax service adoption: Integrating perceived risk, service quality and TAM
Author(s)	Rifat, A.; Nisha, N.; Iqbal, M.
Year	2019
Journal / Event	Journal of Electronic Commerce in Organizations
SJR 2020	0.15/Q4
Context	Bangladesh
Level	Users
Purpose of the study/Research question	Identify the factors and dimensions that may impact a taxpayer's willingness to utilize the system.
Theories used	TAM
Type of technology	Systems
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Factors and dimensions that affect the intention to use the system

Code: 10	
Title	Tax administrative challenges of the digital economy: the Croatian experience
Author(s)	Hodzic, S.
Year	2019
Journal / Event	Ejournal of Tax Research
SJR 2020	0.13/Q4
Context	Croatia
Level	Government
Purpose of the study/Research question	Analyze and describe the barriers and drivers of the digital economy within the Croatian Tax Administration.
Theories used	-
Type of technology	Digitization (e-Gov)
Analysis methods	Content analysis
Final cluster	Aspects related to IT and its application in tax administration
Main topic	Barriers and drivers of digitalization

Code: 11	
Title	Fighting Corruption and Enhancing Tax Compliance through Digitization: Achieving Sustainable Development in Romania
Author(s)	Fanea-Ivanovici, M.; Radu-Cristian, M.; Marius-Cristian, P.; Voicu, C.
Year	2019
Journal / Event	Sustainability
SJR 2020	0.61/Q1
Context	Romania
Level	Government
Purpose of the study/Research question	Discuss the role of digitalization, with a focus on digital public services and e-government, in increasing tax compliance and combating corruption to improve sustainable development in Romania.
Theories used	-
Type of technology	Digitization (e-Gov)
Analysis methods	Content analysis
Final cluster	Aspects related to IT and its application in tax administration
Main topic	Scanning paper

Code: 12	
Title	Does E-Government Improve Government Capacity? Evidence from Tax Compliance Costs, Tax Revenue, and Public Procurement Competitiveness
Author(s)	Kochanova, A.; Hasnain, Z.; Larson, B.
Year	2020
Journal / Event	World Bank Economic Review
SJR 2020	1.54 / Q1
Context	Countries
Level	Companies
Purpose of the study/Research question	Investigate whether the use of information and communication technology (ICT) by e-government can strengthen its ability to collect and spend fiscal resources effectively and improve the business environment.
Theories used	-
Type of technology	Systems
Analysis methods	Differences in differences
Final cluster	Impacts of IT on tax collection
Main topic	Aumento na receita de impostos de renda em relação ao PIB

Code: 13	
Title	The customer is king: Evidence on VAT compliance in Tanzania
Author(s)	Fjeldstad, O. H.; Kagoma, C.; Mdee, E.; Sjursen, I. H.; Somville, V.
Year	2020
Journal / Event	World Development
SJR 2020	2.39/Q1
Context	Tanzanian companies
Level	Companies
Purpose of the study/Research question	Examine the (non)compliance behavior of Electronic Fiscal Devices (EFDs) and identify the factors that influence it.
Theories used	-
Type of technology	Electronic fiscal devices
Analysis methods	Probit and Logit
Final cluster	Impacts of IT on tax collection
Main topic	Impact of Electronic Fiscal Devices (EFDs) on Value Added Tax (VAT)

Code: 14	
Title	Tax compliance as a driver for adopting information technologies – effect on competencies development and on competitive advantages
Author(s)	Martins, A.; Picoto, W.
Year	2020
Journal / Event	Journal of Systems and Information Technology
SJR 2020	0.3/Q2
Context	Portugal
Level	Companies
Purpose of the study/Research question	Evaluate the effect of mandatory digital transmission of documents to the tax and customs authority on the decision to adopt the system by small and medium-sized companies
Theories used	TOE Framework and Competencies development model
Type of technology	Systems
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Factors that affect the decision to adopt the system

Code: 15	
Title	The mediating role of adoption of an electronic tax system in the relationship between attitude towards electronic tax system and tax compliance
Author(s)	Night, S.; Bananuka, J.
Year	2020
Journal / Event	Journal of Economics, Finance and Administrative Science
SJR 2020	0.29/Q2
Context	Uganda
Level	Companies
Purpose of the study/Research question	To examine the mediating effect of e-tax system adoption on the relationship between attitude towards the e-tax system and tax compliance using evidence from small businesses (SBEs) in a developing African economy.
Theories used	TRA and TAM
Type of technology	Systems
Analysis methods	Análise de correlação
Final cluster	Aspects related to IT and its application in tax administration
Main topic	Mediating effect of system adoption in relation to attitude and compliance

Code: 16	
Title	Why information technology is constrained in tackling tax noncompliance in developing countries: Nigerian tax administrators' perspectives
Author(s)	Umar, M.; Masud, A.
Year	2020
Journal / Event	Accounting Research Journal
SJR 2020	0.3/Q3
Context	Developing countries
Level	Government and companies
Purpose of the study/Research question	This study aims to investigate the reasons for the large-scale tax noncompliance prevalent in underdeveloped countries despite many years of information technology (IT)-led tax administration reforms.
Theories used	-
Type of technology	Digitization (e-Gov)
Analysis methods	Grounded theory
Final cluster	Aspects related to IT and its application in tax administration
Main topic	Reasons for tax noncompliance

Code: 17	
Title	Can ICTs increase tax compliance? Evidence on taxpayer responses to technological innovation in Ethiopia
Author(s)	Mascagni, G.; Mengistu, A. T.; Woldeyes, F. B.
Year	2021
Journal / Event	Journal of Economic Behavior and Organization
SJR 2020	1.26/Q1
Context	Addis Ababa companies of Ethiopia
Level	Companies
Purpose of the study/Research question	Report three sets of results that begin to fill the research gap in the field of technological innovation in tax administration.
Theories used	-
Type of technology	Sales registration machines
Analysis methods	Differences in differences/ Experiment
Final cluster	Impacts of IT on tax collection
Main topic	Impact of sales registration machines (SRM) without income tax and without VAT

Code: 18	
Title	Can e-government initiatives alleviate tax evasion? The moderation effect of ICT
Author(s)	Uyar, A.; Nimer, K.; Kuzey, C.; Shahbaz, M.; Schneider, F.
Year	2021
Journal / Event	Technological Forecasting and Social Change
SJR 2020	2.23/Q1
Context	Countries
Level	Government
Purpose of the study/Research question	Given the argument that digitalization of government services increases government efficiency, do e-government initiatives contribute to alleviating tax evasion? Furthermore, would the adoption of ICT by society and citizens strengthen the relationship between the digitalization of government services and the reduction of tax evasion?
Theories used	Modernization theory and institutional theory
Type of technology	Digitization (e-Gov)
Analysis methods	Panel data
Final cluster	Impacts of IT on tax collection
Main topic	Impact of the adoption of information and communication technologies (ICTs) on tax evasion in relation to GDP

Code: 19	
Title	Building fiscal capacity in developing countries: Evidence on the role of information technology
Author(s)	Ali, M.; Shifa, A. B.; Shimeles, A.; Woldeyes, F.
Year	2021
Journal / Event	National Tax Journal
SJR 2020	0.43/Q2
Context	Ethiopian companies
Level	Companies
Purpose of the study/Research question	Examine the impact of the use of electronic registration machines on tax payments by registered taxpayers and representatives of the tax base.
Theories used	-
Type of technology	Sales registration machines
Analysis methods	Differences in differences
Final cluster	Impacts of IT on tax collection
Main topic	Impact of sales registration machines (SRM) on VAT

Code: 20	
Title	Do governance quality and ICT infrastructure influence the tax revenue mobilisation? An empirical analysis for India
Author(s)	Mallick, H.
Year	2021
Journal / Event	Economic Change and Restructuring
SJR 2020	0.41/Q3
Context	Federal Government and States of India
Level	Government
Purpose of the study/Research question	Analyze whether the use of modern ICT infrastructures resulted in greater tax revenue collection, taking into account the potential contributory power of ICT infrastructures to provide transparency and accountability in the tax system
Theories used	-
Type of technology	Digitization (e-Gov)
Analysis methods	Multiple regression
Final cluster	Impacts of IT on tax collection
Main topic	Impact of ICTs on Goods and Services Tax (GST)

Code: 21	
Title	Factors Affecting Electronic Tax Compliance of Small and Medium Enterprises in Vietnam
Author(s)	Le, H.; Bui, M.; Nguyen, G.
Year	2021
Journal / Event	Journal of Asian Finance, Economics and Business
SJR 2020	0.37/Q2
Context	Vietnam
Level	Companies
Purpose of the study/Research question	Explore the factors influencing electronic tax compliance of small and medium enterprises in Vietnam.
Theories used	-
Type of technology	Systems
Analysis methods	Factor analysis and multiple regression
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Factors influencing compliance

Code: 22	
Title	Factors affecting electronic invoice adoption and tax compliance process efficiency
Author(s)	Qi, Y.; Che Azmi, A.
Year	2021
Journal / Event	Transforming Government: People, Process and Policy
SJR 2020	0.49/Q2
Context	China
Level	Companies
Purpose of the study/Research question	Examine the factors that affect the adoption of electronic invoicing and, in turn, the impact of these factors on the efficiency of companies' tax compliance process.
Theories used	TOE Framework
Type of technology	Electronic invoice
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Factors affecting the adoption of electronic invoices

Code: 23	
Title	Behavioural intention to adopt blockchain for a transparent and effective taxing system
Author(s)	Kabir, M.
Year	2021
Journal / Event	Journal of Global Operations and Strategic Sourcing
SJR 2020	0.31/Q3
Context	Bangladesh
Level	Companies
Purpose of the study/Research question	Assess the intention of tax stakeholders regarding the adoption of blockchain technology (BT) for a transparent and effective tax system.
Theories used	TAM and SDT
Type of technology	Digitization (e-Gov)
Analysis methods	Structural equation modeling
Final cluster	Factors influencing the adoption of technology in this context
Main topic	Intention to adopt blockchain technology (BT)

Code: 24	
Title	An Assessment of Usability of Online Tax Return Services in Uganda and Its Influence on Tax Revenue
Author(s)	Eilu, E.; Walyawula, C.; Soita, R.
Year	2021
Journal / Event	3rd African Conference on Human-Computer Interaction, AfriCHI 2021
SJR 2020	0.18
Context	Uganda
Level	Users
Purpose of the study/Research question	Investigate how the usability factor of these online tax filing services affected taxpayer use of the services
Theories used	-
Type of technology	Systems
Analysis methods	Escala de Usabilidade do Sistema (SUS)
Final cluster	Aspects related to IT and its application in tax administration
Main topic	System usability

Code: 25	
Title	Technology, Taxation and Corruption: Experimental Evidence from the Introduction of Electronic Tax Filing
Author(s)	Okunogbe, O.; Pouliquen, V.
Year	2022
Journal / Event	American Economic Journal: Economic Policy
SJR 2020	7.87/Q1
Context	Tajikistan companies
Level	Companies
Purpose of the study/Research question	Examine the impact of electronic filing on compliance costs, tax payments, and bribe payments using experimental variations and data from companies in Tajikistan. (I'm interested in the system's impact on revenue)
Theories used	-
Type of technology	Systems
Analysis methods	Experiment
Final cluster	Impacts of IT on tax collection
Main topic	Impact of electronic filing on tax evasion

3 ESSAY 2: DOES THE ADOPTION OF STANDARDIZED ELECTRONIC TAX SYSTEMS INCREASE TAX COLLECTION? EVIDENCE FROM A BRAZILIAN STATE

ABSTRACT

Purpose
The article aims to analyze the impact of implementing standardized electronic tax systems on tax collection in municipalities within a Brazilian state.

Method
The database comprises information from 146 municipalities in Rio Grande do Norte, from 2013 to 2018. Initially, the article employs a panel analysis with bidirectional fixed effects and subsequently applies the difference-in-differences approach with staggered adoption, as proposed by Callaway and Sant'Anna (2021).

Results
The implementation of standardized electronic systems for tax management resulted in significant average increases in the collection of Urban Property and Territorial Tax (IPTU) and Tax on Services of Any Nature (ISSQN). In the case of IPTU, there was an average increase of approximately 52%, while ISSQN experienced an average increase of approximately 43%. In terms of the temporal analysis, there was an average increase of approximately 77% in IPTU collection after the third year of system implementation. In addition, ISSQN revenue experienced an average increase of 72% after the fourth year of adopting the system above.

Originality/Contribution
This article offers evidence at the municipal level supporting the proposition that the integration of Information Technology (IT) in public administration is linked to an increase in revenue. It stands out as one of the few contributions presenting specific data at the municipal level, particularly in municipalities with a lower degree of transparency.

Keywords: Standardized electronic tax systems; Information Technology; Tax collection; Municipalities.

3. 1 INTRODUCTION

The utilization of information technology (IT) has increasingly permeated organizational processes, with a particular emphasis on information systems for management and accounting. It has also led to transformations in how governments deliver services and engage with the public. This shift spans a wide range of areas, from managing public finances and social programs to elections and more (World Bank, 2016). These initiatives, which harness information and communication technologies (ICTs), aim to enhance the efficiency of government services for citizens, employees, businesses, and agencies, while also bolstering the transparency and credibility of public administration. These efforts, which encompass

combating various forms of corruption, fall under the umbrella of electronic government (Carter & B'elanger, 2005; Zhang & Zhang, 2009; Srivastava & Teo, 2010).

As an aspect of electronic government, the electronic tax system appears 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 refund, which facilitates online transactions with tax authorities, helping them verify taxpayers' obligations as well as respond to relevant queries quickly (Le, Bui, & Nguyen, 2021).

Electronic tax systems originated in the United States, with the Internal Revenue Service (IRS) initially introducing electronic filing for tax returns, primarily for refunds (Muturi & Kiarie, 2015). This innovation was part of the Electronic Refund Filing Program, launched in 1986, to simplify the tax refund process for taxpayers. Today, these systems have been adopted in numerous countries, including Australia, Canada, Italy, the United Kingdom, Chile, Ireland, Germany, France, the Netherlands, Finland, Sweden, Switzerland, Norway, Singapore, Brazil, Mexico, India, China, Thailand, Malaysia, Turkey, Uganda, Nigeria, Rwanda, and Kenya (Muturi & Kiarie, 2015).

In an international context, it is observed that several economies have chosen to standardize their tax systems and adopt electronic invoicing models (Winn & Zhang, 2013). In Brazil, the Electronic Invoice (NF-e) project was designed to establish a national electronic tax document model, replacing the traditional process of issuing paper tax documents. Legal validity is ensured by the sender's digital signature, simplifying taxpayers' ancillary obligations, and enabling real-time monitoring of commercial operations by the Tax Authorities. This model is like the one introduced in Chile in 2002, with Chile being a pioneer in this aspect (Geron, Finatelli, Faria, & Carmo Romeiro, 2011).

Mexico also invested in developing its project, aiming to contribute significantly to its modernization (Urrutia, 2005). Similarly to Chile, Mexico was one of the first to adopt digital certification for electronic documents, regulating it through electronic identification for use in transactions (Geron et al., 2011).

In European countries, tax authorities have suggested enhancing business efficiency by implementing a large-scale electronic invoice system (Neto & Martinez, 2016). In June 2010, the European community recommended adopting a standardized invoice and data management model for both the private and public sectors. This approach resembled the one taken by the United States and led to the development of the ISO 20022 platform (Winn & Zhang, 2013).

In Brazil, the Federal Government's Growth Program (PAC), along with other mechanisms and initiatives, introduced the Public Digital Bookkeeping System (SPED). This program encompasses a collection of tax document records that are relevant to the Finance Secretariats (SEFAZ) of each state, as well as the Brazilian Federal Revenue Secretariat (SRF). It enables the monitoring and calculation of taxes resulting from the sale of products or services by taxpayers, aiming to combat the significant issue of tax evasion in Brazil (Walter & Ribeiro, 2007).

When considering Brazilian state and municipal governments, it becomes evident that they have also explored modernization options. In 2004, during the 1st National Meeting of Tax Administrators (ENAT), a collaborative effort among all three government tiers was discussed to achieve greater administrative integration, standardization, and improved data quality to reduce costs, streamline customer service, and increase revenue (Duarte, 2009). The meeting concluded with the approval of two technological cooperation protocols: one for registration (Synchronized Registration Project) and the other for Electronic Invoicing (NF-e).

Despite the widespread adoption of ICTs in tax administration and the significant changes they have brought to the tax payment process, there is limited evidence of their impact on tax administration and tax compliance in developing countries (Besley & Persson, 2013; Mascagni, Mengistu, & Woldeyes, 2021). The existing literature primarily focuses 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), which makes the exploration of municipal interventions a valuable opportunity.

Based on this, assessing these tax compliance repercussions is crucial for a complete evaluation of any policy intervention (Lopez-Luzuriaga & Scartascini, 2019). The introduction of ICT is expected to bring several benefits, including increased tax revenue, assuming challenges do not hinder the process (Mascagni, Mengistu, & Woldeyes, 2021).

The 1988 Federal Constitution of Brazil granted municipalities the authority to establish their own Municipal Organic Law, which is equivalent to a Municipal Constitution. According to this law, municipalities are responsible for managing several taxes, including the tax on Urban Property and Territorial Tax (IPTU), the tax on inter-vivos real estate transfers (ITBI), and the tax on services of any nature (ISSQN). Additionally, municipalities possess the autonomy to levy fees associated with the exercise of police power. This power is essential for public authorities to oversee and regulate individual interests, safeguarding the collective

interest. This article specifically concentrates on the two taxes deemed collectively most crucial, the IPTU and ISSQN.

Simultaneously, Brazilian municipalities have grappled with a severe fiscal crisis, largely driven by the 2015 recession. In 2021, data from the Federation of Industries of the State of Rio de Janeiro (FIRJAN) revealed, through the Firjan Fiscal Management Index yearbook (IFGF), that out of 5,229 municipalities analyzed, 3,024 were teetering on the brink of financial insolvency, facing challenging or critical fiscal circumstances. This non-compliance with expenditure limits, as stipulated by the Fiscal Responsibility Law (LRF), primarily stems from the municipalities' struggle to generate sufficient revenue from their local economies.

Electronic tax systems have been implemented in numerous Brazilian municipalities, from large capitals to municipalities further away from large urban centers, offering the population access to various services such as the taxpayer portal, online taxation, and the citizen portal, among others. Thus, governments should, whenever possible, acquire standardized systems from vendors with a track record of successful implementations (Kelman, 1990; Mithas, Tafti, Bardhan, & Goh, 2012). As a result, the electronic tax systems adopted by most Brazilian municipalities closely align with what Pierson and Thompson (2016) defined as standardized systems. These systems can be customized to meet the needs of each municipality and often come with features that allow flexibility without incurring additional development costs.

This information indicates that electronic tax systems enhance control over the registration data of citizens and companies. Yet, it remains uncertain whether they effectively boost tax collection or merely fulfill municipalities' needs to adapt to changes in modern economies, which demand more efficient tax administration measures for tax management and control. Therefore, this study aims to analyze the impact of implementing standardized electronic tax systems on tax collection in municipalities within a Brazilian state.

It is important to note that the benefits of implementing these systems grow over time, highlighting the importance of long-term investments in technology and training. This highlights the need for a sustained approach to reap the rewards of increased revenue over time.

This study aligns with the broader context of the expanding body of literature that examines the role of technology in enhancing 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). It contributes to this literature by emphasizing that standardized electronic tax systems offer an alternative for increasing tax collection in Brazilian municipalities.

Furthermore, this study is part of a rapidly growing literature that explores the use of information technology 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). This study contributes to this body of knowledge by demonstrating that the adoption of standardized electronic tax systems impacts tax administration in Brazilian municipalities.

The paper presents some of the initial evidence regarding the impact of standardized electronic tax systems at the municipal level. While prior studies have predominantly concentrated on the state level (Pierson & Thompson, 2016), this research addresses a significant gap in the literature by examining the effects of these systems on municipalities. This is valuable for comprehending regional dynamics and crafting targeted public policies for municipal governments.

In summary, this study makes a substantial contribution to the literature and carries important practical implications, highlighting the crucial role of information technology in improving tax administration and increasing state capacity at the municipal level in developing countries like Brazil. Its conclusions could influence the formulation of modernization policies and strategies worldwide.

The remainder of the article is structured as follows: The next section provides a literature review. Section 3 describes the data sources and variables. Section 4 demonstrates the empirical strategy. Section 5 presents and discusses the results, and Section 6 concludes the study.

3.2 LITERATURE REVIEW

This section of the literature review introduces the theories from existing literature that facilitate the analysis of the phenomenon under study. It then presents the primary contexts in which Information and Communication Technologies (ICTs) are utilized within organizations responsible for tax administration. Finally, it provides a summary of the most recent studies regarding the effects of using Information Technology to capture various tax categories.

3.2.1 THEORETICAL FRAMEWORK

In alignment with Uyar et al. (2021), our study deems it relevant to employ the modernization and institutional theories. This combined theoretical approach is instrumental in elucidating the influence of e-government initiatives on tax revenue. Below, we outline the core tenets of these two theories.

3.2.1.1 Modernization theory

Modernization theory, which has received contributions from several researchers (Barker, 2005; Bernstein, 1971; McClelland, 1961), plays a fundamental role in understanding the influences on social change, development, and progress. This theory focuses on macro-environmental factors, such as political enlightenment, economic development, urbanization, technological advancement, democratic institutions, levels of education, communication, and media, among others.

Although it has previously been neglected in the context of tax evasion (Uyar et al., 2021), modernization theory provides an appropriate theoretical basis for this study as it explores the impact of technological advancement on societies (Barker, 2005). Therefore, e-government initiatives and the spread of ICTs represent long-term technological progress, while changes in tax evasion symbolize the social transformation resulting from this technological progress (Uyar et al., 2021).

According to modernization theory, modern societies would use and benefit from services provided by emerging technologies, compared to less technologically sophisticated societies (Barker, 2005). In this context, considering e-government as an innovative and recent catalyst for social change, governments that have macro-environmental resources and capabilities, such as political democracy and economic capital, would be in a better position to implement e-government actions compared to their peers whose initiatives are limited to basic benefits in an early phase of e-government maturity (Azad, Faraj, Goh, & Feghali, 2010; Layne & Lee, 2001; Norris, 2001; Singh, Das, & Joseph, 2007).

Due to technological advances in government services, which result in more efficient government administration, it is plausible that social transformations will occur. For example, an increase in tax compliance and a reduction in corruption are expected, which could ultimately lead to a decrease in tax evasion (Uyar et al., 2021). Our study assumes the fight against tax evasion is one of the social consequences resulting from the adoption of electronic

tax systems. Therefore, it is expected that the implementation of these systems at the municipal level can generate significant increases in local revenue.

However, it is important to highlight that the success of modernization through adopting an electronic tax system in municipal governments depends on the availability of adequate resources, such as human resources (McClelland, 1961). Furthermore, modernization theory recognizes the influence of contextual conditions, as the impact of macroenvironmental capabilities on social progress can vary according to cultural context (Nam, 2018).

3.2.1.2 Institutional Theory

Institutional theory emphasizes the role of formal and informal institutions in driving social change (Kılıç, Uyar, & Kuzei, 2020). It suggests that organizations prioritize conformity and legitimacy over economic performance due to social pressures (Kessler, 2013; Di Maggio & Powell, 1983). Consequently, organizations often adopt structures and practices endorsed by others in their respective fields, such as standardized electronic tax systems (Di Maggio & Powell, 1983; Meyer & Rowan, 1977). Over time, organizations tend to become more similar, a concept known as institutional isomorphism (Hoffman, 1999; Meyer & Rowan, 1977; Scott, 2007).

This theory is a useful tool for understanding events involving organizational life, such as tax compliance by small businesses and citizens (Di Maggio & Powell, 1983). Companies seek to maintain and increase legitimacy through compliance with pressures from the institutional environment (Mizruchi & Fein, 1999). Therefore, strengthening isomorphic forces encourages taxpayers to meet their tax obligations and reduce tax evasion tendencies. In this study, it is assumed that municipalities that can satisfactorily integrate the pressures suffered and efficiently implement electronic tax systems will be able to increase their tax collections.

A fundamental view of institutional theory is that efficiency and effectiveness are not the only, and sometimes not even the main, activities of organizations (Brandtern & Suárez, 2021). In the specific case of this study, motivations to adopt innovations differ between municipalities, and many practices spread for reasons that have little to do with their effectiveness (Brandtern & Suárez, 2021). Therefore, while it is assumed that tax collection may be influenced by municipalities' e-government initiatives 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, it is also considered that municipalities adopting electronic tax systems may not be motivated solely by the effectiveness

of collection. Factors like operational automation, transparency, accountability, traceability, audit control, and adaptation to the global environment may not necessarily increase collections.

Hence, it is essential to recognize that motivations for implementing electronic tax systems are multifaceted, encompassing not only revenue issues but also efficiency, transparency, integrity, and adaptation to the demands of contemporary society. These factors contribute to more effective fiscal administration and strengthen relationships between the municipal government and its citizens.

3.2.2 ICT IN THE CONTEXTS OF TAX ADMINISTRATION

The scientific literature regarding the use of ICTs in the field of taxation focuses primarily on the digitalization of tax procedures. Previous studies support the idea that simplifying tax processes, from filing to payment, through ICTs, can improve the level of tax compliance (Sidani, Ghanem & Rawwas, 2014; Tjen & Evans, 2017; Night & Bananuka, 2020).

Nevertheless, it is essential to emphasize that limited capacity may lead to an inability to fully utilize available data, even when it is in electronic format (Mascagni, Mengistu & Woldeyes, 2021). Observational evidence suggests that, in many cases, tax authorities in low-income countries fail to adequately verify tax records, even when the process is relatively simple (Kangave, Nakato, Waiswa, & Zzimbe, 2016; Almunia, Gerard, Hjort, Knebelmann, Raisaro & Tian, 2017; Mascagni, Mengistu & Woldeyes, 2021). Therefore, Information and Communication Technologies (ICTs) may not deliver the expected benefits in terms of tax revenue and compliance with obligations. They may also fail to generate spillover effects along the value chain, especially if governments lack the necessary human capital, technology, and institutions to fully harness the advantages of ICTs (Yilmaz & Coolidge, 2013; Lewis-Faupel et al., 2016; World Bank, 2016).

On the other hand, several empirical studies have demonstrated that e-government improves transparency and accountability, which, in turn, increases government efficiency (Rehman, Kamal &, Esichaikul, 2016; Porumbescu, 2016; Srivastava, Teo & Devaraj, 2016). However, it is important to highlight that increased efficiency and transparency are not direct consequences of the digitalization of government services (Choi & Chandler, 2020) since historically many e-government initiatives have been poorly planned and implemented, resulting in low performance or failures (Dawes, 2008; Anthopoulos, Reddick, Giannakidou & Mavridis, 2016). Therefore, the digitalization of government services can effectively increase

efficiency and effectiveness only if the implementation of e-government innovations is successful and meets the expectations of citizens and organizations, ensuring simplification and reducing complexity (Choi & Chandler, 2020).

The implementation of electronic tax systems has been associated with a reduction in corruption levels, which, in turn, can lead to a decrease in tax evasion (Baum, Gupta & Kimani, 2017). Although corruption and tax evasion are distinct concepts, it is important to highlight that these phenomena can be interconnected, creating a vicious cycle. Therefore, controlling corruption plays a significant role in reducing tax evasion (Bejaković, 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).

3.2.3 IMPACT OF IT ON TAX COLLECTION

Following a systematic literature review (refer to Article 1), our research discovered that studies examining the effects of IT on tax collection are recent, with a primary focus on the current triennium (2020-2022). Therefore, below, we provide a summary of the studies included in this review, along with additional findings.

From a state tax perspective, Pierson and Thompson (2016) aimed to determine whether the use of standardized systems, which are less customizable, is more effective than other systems. They also investigated whether standardized systems lead to increased revenue compared to states in the United States that have chosen different types of systems. The authors' main findings indicated 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 tax on vehicles increased by 23.2% after the second year, and the tax on harvesting resources such as coal, oil, or wood increased by 51% after the third year. This study is unique as it is the only one that analyzed the particularities of this type of system in state taxes.

In the context of international studies, Kochanova, Hasnain, and Larson (2020) examined the impact of using ICTs on tax collection. Their findings revealed a 0.75% average increase in income tax collection as a percentage of Gross domestic product (GDP) after implementing transactional electronic filing systems. However, tax revenue on goods and services as a percentage of GDP decreased by an average of 0.65%.

Similarly, the work of Uyar et al. (2021) aimed to understand the role of using ICTs in reducing tax evasion, represented by the underground economy as a percentage of GDP (Schneider & Medina, 2017; Medina & Schneider, 2019). The authors utilized six indicators from the Global Competitiveness Index (GCI) issued by the World Economic Forum (WEF, 2020). They discussed that after the adoption of ICTs, tax evasion is reduced by the following indicators: 1.2% in electronic participation (E-Participation), 23% without future orientation (FutureOrient), 15% without government adaptability (GovAdaptability), 15% without government response to change (GovRespChange), 17% without a legal framework for digital business (LegalFramework), and 8.2% without the government's long-term vision (GovernVision).

In Latin America, a study conducted by Bellon, Dabla-Norris, Khalid, and Lima in 2022, focusing on Peru, examined the effects of implementing electronic invoicing on both tax compliance and company performance. According to the authors, the introduction of electronic invoicing led to a more than 5% increase in sales, purchases, and VAT obligations for companies in the first year following its adoption. Moreover, the findings suggest that the positive impact of electronic invoicing on sales and reported taxes is primarily driven by smaller businesses, with micro and small enterprises experiencing an 11.6% rise in VAT liabilities during the initial year after implementation.

In Africa, a study conducted by Ali et al. (2021) in Ethiopia analyzed the impact of using sales recording machines on tax payments by registered taxpayers and representatives of the tax base in companies. The results indicate that the use of these machines encourages companies to report higher sales, resulting in increased tax payments. Additionally, it leads to a rise in employment levels and the creation of more companies, which ultimately boosts overall fiscal capacity. The impact of these machines' ranges from 18% to 32% on VAT. Since VAT contributes to almost 20% of the total domestic revenue collection in Ethiopia, this increase corresponds to a 3.6% to 6.4% rise in overall revenue collection.

Mascagni, Mengistu, and Woldeyes (2021), examined the impact of sales recording machines on tax collection. Their findings revealed a 47.7% increase in net Value Added Tax (VAT) collections, along with a 12% increase in Income Tax collections. Furthermore, the researchers conducted an experiment demonstrating that the treatment method, which involved sending recommendation letters about joining sales recording machines, had a significantly positive effect on Income Tax liabilities. This increase in compliance amounted to approximately 16% within the control group. Notably, when analyzing a subgroup of users who

did not utilize sales registration machines, the effect nearly doubled, resulting in an over 30% increase in VAT collections, which was also more statistically significant.

From a similar perspective, Fjeldstad et al. (2020) investigated tax non-compliance behavior with electronic tax devices in Tanzanian companies and the factors that influence it. The conclusion points out that companies are more likely to be tax compliant when they transact with a customer who is aware of their legal obligation to obtain receipts and thinks there is a real risk of punishment if detected without a receipt, resulting in an average increase in compliance of 24 percentage points in VAT.

In Rwanda, Eissa and Zeitlin (2014) investigated the adoption rate and tax compliance impacts of introducing electronic invoicing machines. Although adoption rates were not as high as expected, VAT collections increased by an average of 8%. These studies, as well as the one from Ethiopia, suggest that the use of electronic tax technologies can contribute to increased tax compliance.

Studies on the impacts were still found in Asia, such as Okunogbe and Pouliquen (2022), who investigated the impact of using electronic filing systems on tax payments based on an experiment conducted with companies in Tajikistan. The results demonstrated a significant increase of TJS 25,357 (USD 3,600) in tax payments because of using the system among high-risk companies.

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

On the contrary, in India, Mallick (2021) indicated that ICT infrastructure and the quality of governance do not significantly enhance overall tax collection. This outcome may be attributed to the ease with which taxpayers can evade the tax system by conducting transactions outside the system or without relying on ICT infrastructure.

The lesson drawn from this is clear: most studies show an increase in revenue ranging from 0.65% to 161.2%. Notably, there is a concentration of studies in developing countries with national analysis perspectives, highlighting the fertile ground for new research seeking to comprehend the impact of IT on tax collection. As previously mentioned, our work aims to explore the effects of a specific technology, standardized electronic tax systems, on tax collection in Brazilian municipalities, representing an innovative approach.

3.3 DATA

3.3.1 SAMPLE

The sample for this study focused on municipalities in the state of Rio Grande do Norte, Brazil. According to the IFGF 2021 report, which pertains to the calendar year 2020, out of the 154 municipalities that were analyzed, only 15 (9.74%) exhibited excellent or good management indices, falling within the range of 1 to 0.6. This data positions Rio Grande do Norte as one of the five states with the highest proportion of municipalities facing fiscal difficulties. This situation serves as the motivation for conducting an in-depth analysis of the state's municipalities in this study.

Initially, our sample consisted of all 167 municipalities in the state, spanning the years from 2013 to 2018. During the data cleaning process, we excluded 11 municipalities due to either insufficient information or inconsistencies found in the reviewed statements. An additional 10 municipalities were removed because their system implementation dates preceded 2013, which marks the beginning of our panel data. Consequently, the sample was refined to include 146 municipalities.

3.3.2 INDEPENDENT VARIABLE

Our independent variable comprises the adoption of the standardized electronic tax system (Pierson & Thompson, 2016). Initially, we identified this variable by examining official documents available on the municipalities' websites to determine the year of implementation. When information was unavailable, we turned to inquiries and consultations via the Citizen Information Service (E-Sic). In certain instances, we encountered municipalities where the system was in place, but we received no response after six months of requesting information. In such cases, we sought assistance from the Court of Auditors of the State of Rio Grande do Norte (TCE/RN) and reviewed their records to ascertain the implementation period. As a result, the variable "system" is represented as a binary variable that indicates the presence of a standardized electronic tax system in the municipality over the years.

3.3.3 DEPENDENT VARIABLES

The dependent variables in our analysis comprise the values of revenue from IPTU and ISSQN. We chose to include only these variables, as the Real Estate Transfer Tax (ITBI) and

the fees related to the exercise of police power in the context studied present additional complexities that are beyond the direct control of the municipal system under analysis.

For example, ITBI collection is conditioned on effective communication with the registry offices. In the Brazilian context, especially in the small municipalities that make up the majority of our sample, this communication still represents a significant challenge. Furthermore, fees related to police power are also generally neglected in the smaller municipalities in our sample.

The revenue values of our dependent variables were extracted from declarations related to annual balance sheets, which are available in the Brazilian Public Sector Accounting and Fiscal Information System (SICONFI) starting from 2013, the first year in which these declarations were made available in the system.

To tackle the issue of missing data in six municipalities, particularly when the reported amounts are not provided or declarations are neglected, we employed simple imputations based on the method proposed by Engels and Diehr (2003) for longitudinal data during the initial collection inspections. In instances where data for a specific year was absent in the panel of five municipalities, we utilized the average information from the preceding and succeeding years. For a municipality lacking collection data for the year 2018, we replicated the data from 2017. It is worth noting that the results are robust even with the exclusion of these municipalities.

The values of municipal revenues in the period 2014-2018 were deflated by the Broad National Consumer Price Index (IPCA) of Brazilian Institute of Geography and Statistics (IBGE), the main Brazilian inflation index, based on the year 2013. Seeking to improve the understanding of the data, these were transformed into thousands as a unit of measurement and placed in a logarithm to better capture the effects. It is worth noting that as there are collections in which the municipalities delivered a zero value, when transforming them into their logarithmic function, one of MaCurdy and Pencavel's (1968) methods was used, adding 1 to the collection, to replace zeros and not cause missing values. Figure 1 shows the evolution of collections in municipalities over the years.

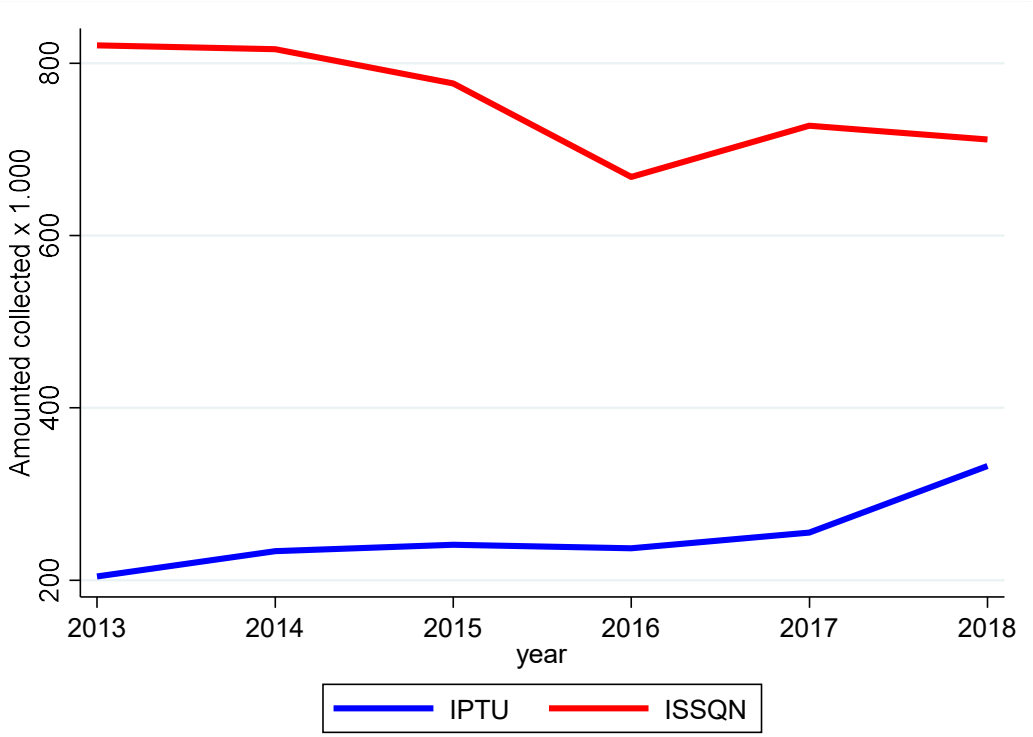

Figure 1. Evolution of collections in all municipalities
Note: The figure shows the evolution of the IPTU and ISSQN collection, the line for the first is in blue, while for the second it is in red.

First, it is important to highlight that the revenues presented in Figure 1 have been adjusted to account for inflation, as previously mentioned. It is observed, therefore, that revenue from ISSQN was in decline until 2016 but showed a recovery in 2016 and 2017, although it did not return to the levels observed in 2014. On the other hand, the IPTU collection has shown steady growth over the years.

When analyzing the relative importance of each tax on total revenue, it becomes evident that significant variations occurred over the period. Revenue from ISSQN, which represented 62.3% of total revenue in 2013, decreased to 55.4% in 2018. In contrast, the IPTU collection recorded a progressive increase. In 2013, IPTU accounted for approximately 15.5% of total revenue, increasing to about 18.6% in 2015, and reaching approximately 25.9% of total revenue in 2018.

3.3.4 CONTROL VARIABLES

The data for this study was sourced from three specific outlets at the Brazilian Institute of Geography and Statistics (IBGE). Firstly, the Gross Domestic Product (GDP) survey of the municipalities was consulted to extract their GDP per capita (Kochanova, Hasnain & Larson,

2020; Uyar et al., 2021). Next, the estimated population survey provided information about the number of inhabitants in each municipality (Uyar et al., 2021). Finally, data related to the number of companies operating in the municipality, employed personnel, and average salary was obtained through a survey of the Central Business Registry. Information regarding the latest revision of the local tax code was collected from the internet pages of the selected municipalities for the sample.

In the context of the models developed to predict IPTU collection, control variables were employed, including estimated population, employed personnel, average salary, and a dummy variable indicating the revision of the tax code. For the ISSQN revenue forecast models, the control variables comprised estimated population, the number of companies operating in the municipality, GDP per capita, and a dummy variable indicating the revision of the tax code.

It is important to note that some control variables were based on previous studies, aligning with existing literature. However, the inclusion of additional variables, such as the number of active companies, represents an original contribution to this study. We believe that this variable plays a significant role as a control factor in the investigated context, possibly correlating with ISSQN collection.

Furthermore, it is crucial to highlight that modernization theory identifies relevant macro-environmental factors, such as economic development, which may be linked to the GDP per capita of municipalities and the number of active companies. Similarly, the macroenvironmental factor of urbanization, representing the concentration of the population in urban areas and the growth of cities, is depicted in this study by the variable referring to the number of inhabitants in each municipality.

3.3.5 CONTROL AND TREATMENT GROUPS

The treatment group consists of municipalities that operated a system continuously throughout a full year. In contrast, the control group comprises municipalities that either operated the system partially during the year or did not have it at all. Figure 2 illustrates the transition of municipalities to the treatment group, specifically those that maintained uninterrupted operation for a full year between 2013 and 2018, in comparison to those that did not implement the system. The sample includes 146 municipalities.

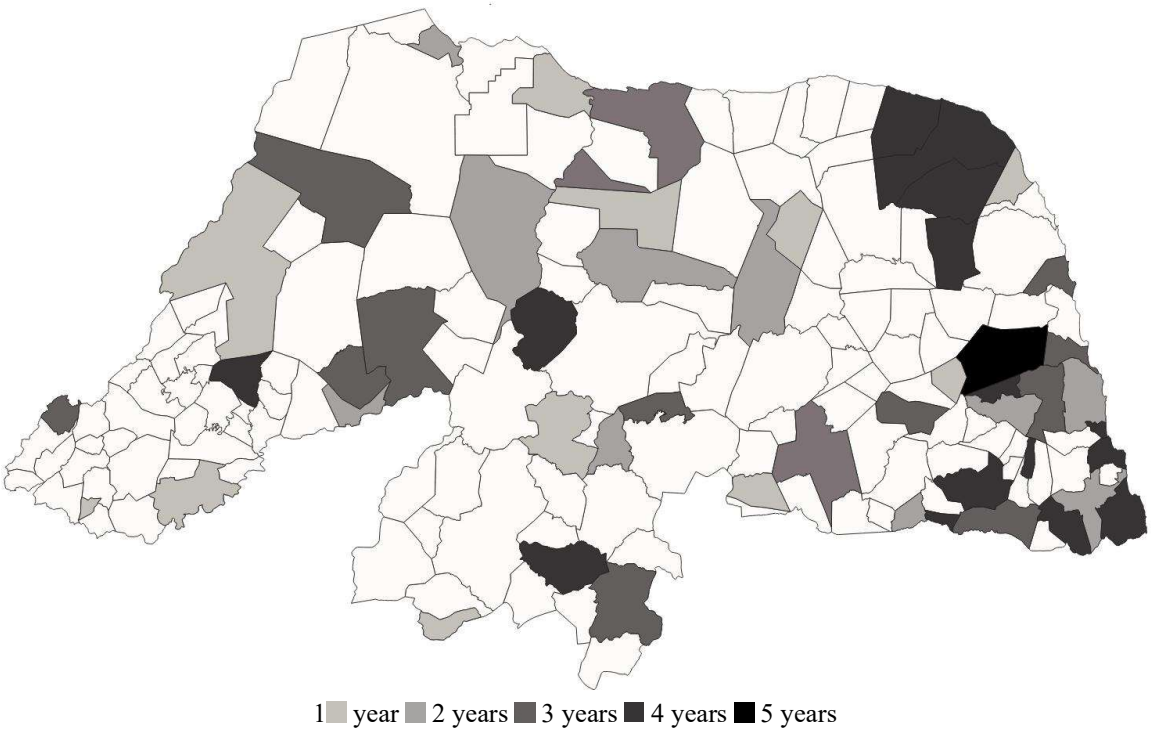

Figure 2. Municipalities with Systems in functioning
Note: This figure displays a map of the state of Rio Grande do Norte in Brazil, highlighting municipalities that have implemented the system by using a darker shade

Figure 2 illustrates that in 2013, only 0.68% (equivalent to 1 municipality) had implemented the system. However, in 2014, the following year, adoption surged to 10.96%, with 16 municipalities embracing the system. Over the subsequent years, adopting an electronic tax system grew, peaking at approximately 34.93% with 51 municipalities in 2018. As a result, the municipalities were grouped as follows: 2014 (15), 2015 (11), 2016 (3), 2017 (10), and 2018 (11). Table 1 provides additional details on these groups.

Table 1: Characteristics of the groups

GROUP: 2014	
Size of municipalities	Small Size I (13); Small Size II (2)
Types of systems	A(1); B(1); C(1); D(5); E(7)
GROUP: 2015	
Size of municipalities	Small Size I (4); Small Size II (4); Medium Size (2); Large Size (1)
Types of systems	B(1); D(1); E(8); F(1)
GROUP: 2016	
Size of municipalities	Small Size I (1); Small Size II (2)
Types of systems	D(1); E(1); F(1)
GROUP: 2017	
Size of municipalities	Small Size I (7); Small Size II (2); Medium Size (1)
Types of systems	A(3); E(6); G(1)
GROUP: 2018	
Size of municipalities	Small Size I (10); Small Size II (1)
Types of systems	A(1); B(1); E(3); G(1); H(1); L(1); J(1)

Note: The table displays the distribution of municipalities into groups based on size and system types for various years from 2014 to 2018. Municipalities are categorized as Small Size I, Small Size II, Medium Size, and Large Size, and by system types A, B, C, D, E, F, G, H, J, and L.

Table 1 provides a description of municipalities categorized based on their size according to the IBGE classification. The municipality's size classification considered the population in 2013. The groups for the years 2014, 2016, and 2018 exclusively consist of municipalities classified as Small Size I or Small Size II. However, the 2017 group includes medium-sized municipalities in addition to the ones mentioned earlier. Furthermore, the group for 2015 includes not only medium-sized municipalities but also a Large-sized municipality.

During the analysis, we identified and coded ten types of systems implemented in these municipalities, represented by the letters A to J. Among these, systems coded as A, D, E, F, and G stood out for their simplicity and efficiency in guiding payments. The 2018 group witnessed the implementation of the largest number of different system types, whereas the 2015 group was notable for predominantly implementing the type E system in eight out of the eleven municipalities, representing the highest proportion within a single group.

Table 2 presents descriptive statistics for the variables used in the research models. It includes three years of panel data, along with tests comparing means between the treatment and control groups.

Table 2: Descriptive statistics

	2014			2016			2018		
	(1)	(2)	t-test	(1)	(2)	t-test	(1)	(2)	t-test
	Treatment	Control	Difference	Treatment	Control	Difference	Treatment	Control	Difference
Variable	Mean/Standard erros	Mean/Standard erros	(1)-(2)	Mean/Standard erros	Mean/Standard erros	(1)-(2)	Mean/Standard erros	Mean/Standard erros	(1)-(2)
IPTU collection deflated (x 1,000 R$)	259.405	230.327	29.078	898.902	65.850	833.052***	832.686	63.840	768.846*
	[137.941]	[139.434]		[617.541]	[30.929]		[539.005]	[37.762]	
ISSQN collection deflated (x 1,000 R$)	704.970	829.879	-124.909	1744.936	389.336	1355.600***	1501.311	287.662	1213.649***
	[309.928]	[222.553]		[580.544]	[111.934]		[509.104]	[55.001]	
Estimated population in the municipality (x 1,000)	16600.250	12921.246	3679.004	29636.800	9514.009	20122.791***	23354.431	8457.105	14897.326***
	[4388.227]	[2064.157]		[8254.204]	[1031.207]		[5199.151]	[1086.633]	
Number of companies operating in the municipality (x 1,000)	200.313	156.208	44.105	452.600	94.672	357.928***	320.255	76.442	243.813***
	[59.001]	[34.272]		[148.832]	[12.070]		[90.202]	[10.256]	
Personnel employed in the municipality	2130.875	1566.900	563.975	4180.067	822.940	3357.127***	3085.608	815.579	2270.029***
	[735.261]	[376.178]		[1511.041]	[147.740]		[911.475]	[168.177]	
Average salary in minimum wages	1.700	1.731	-0.031	1.727	1.683	0.044	1.804	1.747	0.057
	[0.039]	[0.024]		[0.051]	[0.023]		[0.040]	[0.022]	
Value of GDP Per Capita	10383.175	10388.764	-5.589	14190.258	10439.379	3750.880**	17210.327	12890.987	4319.340
	[1160.576]	[670.055]		[1291.596]	[700.432]		[2705.304]	[1255.269]	
Tax code reform	0.125	0.031	0.094*	0.233	0.060	0.173***	0.412	0.189	0.222***
	[0.085]	[0.015]		[0.079]	[0.022]		[0.070]	[0.040]	
N	**16**	**130**		**30**	**116**		**51**	**95**	
Number of observations			**146**			**146**			**146**

Note: The value displayed for t-tests are the differences in means between groups, ***, ** and * indicate significance at the 1, 5 and 10 percent critical level, respectively.

For the year 2014, when analyzing the results of the t-test for the difference between means for the group that adopted the system (Treatment) and the group that had not adopted it (Control), we observed that there is no statistically significant difference between the variables. This lack of significance is attributed to the presence of only a few municipalities in the treatment group during that year.

However, in contrast, in 2016, except for the variable related to the average salary, which shows minimal variation according to IBGE data, the other variables exhibited statistical significance in the differences between the averages of the two groups. For instance, the difference in the IPTU collection for that year amounts to R$833,052.00.

In 2018, except for the average salary, GDP per capita also fails to demonstrate statistical significance in the differences in averages between the groups. Notably, the differences in average IPTU and ISSQN collections between the two groups decreased between 2016 and 2018, which aligns with expectations due to the gradual adoption of the system by municipalities over the years.

In 2018, approximately 41% of the municipalities in the treatment group, roughly equivalent to 21 municipalities, had reformed their tax codes. In contrast, only about 20% of the municipalities in the control group, or approximately 18 municipalities, had implemented similar reforms.

3.4 EMPIRICAL STRATEGY

To determine the causal effect of adopting the system on municipal revenues, we initially employed a panel model with two-way fixed effects. This choice was influenced by the growing literature utilizing similar regressions (Sun & Abraham, 2020), which motivated us to investigate the necessary assumptions for producing causally interpretable estimates (Athey & Imbens, 2018; Borusyak & Jaravel, 2017; Callaway & Sant'Anna, 2021; Chaisemartin & D'Haultfœuille, 2020; Goodman-Bacon, 2018).

To facilitate a comparison with the primary method we selected, Callaway and Sant'Anna (2021, which will be discussed later), we opted for two-way fixed effects without conducting any additional tests. The following section outlines the model proposed for the municipality's revenue collection at the current stage:

$$LogCollection_{it} = X_{it}\beta + \gamma_t + \alpha_i + u_{it},$$

In this study, we treat the logarithm of individual revenues from Urban Property and Territorial Tax (IPTU) and Tax on Services of Any Nature (ISSQN) as dependent variables. Each of these revenue sources is estimated independently. Additionally, we utilized the X_{it}, matrix, which encompasses the time-varying characteristics of the municipality.

To analyze taxation, we developed three different models for IPTU. The first model excludes control variables. In the second model, we incorporate the estimated population, employed personnel, and average salary as control variables. The third model introduces a dummy variable representing the reform of the tax code among the control variables.

As for ISSQN, the first model also excludes control variables. In the second model, we include the estimated population, the number of active companies, and GDP per capita as control variables. The third model integrates the dummy variable related to the tax code reform into the control variables. A table with the description of all variables used in the model is available in Appendix A.

The variable γ_t is a dummy variable for year t. The variable α_i represents unobserved characteristics of municipality I that remain constant over time. Finally, the term u_{it} represents the model error for municipality i in year t.

Our two-way fixed effects models extend beyond two periods and account for variations in the timing of treatment entry, deviating from a typical difference-in-differences model. Recent and emerging literature suggests that in scenarios involving treatment heterogeneity and staggered adoption of a policy, β is a weighted average of these treatment effects that vary across both time and units (Athey & Imbens, 2022; Borusyak & Jaravel, 2022; Callaway & Sant'Anna, 2021; Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2021).

As a result, in such situations, β may not accurately represent the causal parameter of interest when evaluating a policy change, such as the implementation of an electronic tax system. This is because the sources of bias can vary depending on the specific context under study.

While there is no single universally applicable method for adjusting bidirectional fixed effects and estimating the parameter of interest, which, in our case, is the effect of adopting these systems on municipal revenue, our approach in this study aligns with the one outlined by Callaway and Sant'Anna (2021). Their approach represents a natural extension of the Average Treatment Effect of Treated (ATT) and is particularly suited for datasets with multiple treatment groups and multiple periods. Clean comparisons are obtained by focusing on units that were never protected or have not yet undergone treatment, forming the control group.

Specifically, the ATT for a given period is defined as individuals who are treated for the first time during that period.

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

where $Y_t(1)$ is the potential result, in our case of collecting IPTU and ISSQN at time t if treated, $Y_t(0)$is the potential result at time t if not treated and $G_g = 1$ is a binary variable that indicates that the individual belongs to the group whose treatment begins in period g. $ATT(g,t)$ allows us to analyze how the average treatment effect varies across different dimensions in a unified way.

To identify $ATT(g,t)$ and understand its functionality, the main assumptions of the model include the irreversibility of treatment, which assumes that once a unit is treated, it will remain treated in the subsequent period. In other words, no municipality has ceased using the system; the limited anticipation of treatment for all 'eventually treated' groups implies that there is no expectation of treatment. This means that companies and citizens do not change their behavior in the hope that treatment will be adopted in municipalities in the future; conditional parallel trends are based on a 'never treated' or 'not yet treated' group. This condition, when considering control variables, ensures that the average outcomes for the group first treated in period g and the 'never treated' or 'not yet treated' group follow parallel paths in the absence of treatment. All these assumptions are pertinent to the context of our work.

Callaway and Sant'Anna (2021) propose three approaches for estimating $ATT(g,t)$: outcome regression (OR), inverse probability weighting (IPW), and doubly robust (DR). In this study, we employ the DR approach, which combines both OR and IPW methods. It only requires one of these methods, not necessarily both, to accurately specify the outcome evolution for the comparison group or the propensity score model. For our standard error estimation models, we used the WildBootstrap multiplicative procedure with 999 repetitions, employing the "Mammen" approach for standard output.

Pretreatment control variables can play a crucial role in our analysis. The assumption of conditional parallel trends, based on a 'never treated' or 'not yet treated' group, suggests the need to include pre-treatment control variables that may be associated with the evolution of outcome $Y_t(0)$ during post-treatment periods. It's important to note that our model explicitly excludes the incorporation of post-treatment control variables, as they may be influenced by the treatment.

To summarize the results obtained from the estimated $ATT(g,t)$, the approach introduced by Callaway and Sant'Anna in 2021 considers aggregation schemes. These schemes provide a single overall treatment effect parameter similar to ATT in both periods and two case groups, which we refer to as 'simple ATT.'

Additionally, they offer partial aggregations that highlight heterogeneity along certain dimensions, such as (i) variations in average treatment effects across treatment groups by the date of policy adoption (effect group-specific); (ii) how average cumulative treatment effects change over calendar time (calendar time effects); and (iii) how average treatment effects vary with the duration of treatment exposure (dynamic effects).

3.5 ANALYSIS AND DISCUSSION OF RESULTS

In this section, we start by presenting Table 3, which displays the results of the fixed effects model applied to all collection types. It's important to note that we used three different models for each collection category. The first model had no control variables, the second model included three control variables, and the third model featured four control variables, with the last one being a dummy variable related to the tax code reform.

Table 3: Bidirectional Two-way fixed effects models

VARIABLE	(1) IPTU logarithm	(2) IPTU logarithm	(3) IPTU logarithm	(4) ISSQN logarithm	(5) ISSQN logarithm	(6) ISSQN logarithm
Adoption of standardized electronic tax systems	**0.469*** **	**0.467*** **	**0.465*** **	0.238	**0.277***	0.263
	(0.138)	(0.140)	(0.141)	(0.160)	(0.163)	(0.164)
2014	0.0168	0.0306	0.0304	0.0194	0.0660	0.0671
	(0.107)	(0.108)	(0.108)	(0.125)	(0.129)	(0.129)
2015	-0.0359	-0.0310	-0.0319	-0.0623	-0.0253	-0.0285
	(0.109)	(0.109)	(0.109)	(0.127)	(0.130)	(0.130)
2016	-0.133	-0.129	-0.131	-0.645***	-0.603***	-0.608***
	(0.110)	(0.111)	(0.111)	(0.128)	(0.131)	(0.131)
2017	-0.0524	-0.0389	-0.0440	-0.166	-0.118	-0.145
	(0.113)	(0.114)	(0.117)	(0.131)	(0.137)	(0.141)
2018	-0.0934	-0.0564	-0.0616	-0.118	-0.0671	-0.0951
	(0.116)	(0.118)	(0.122)	(0.135)	(0.144)	(0.148)
Constant	2.612***	3.502***	3.507***	5.272***	5.552***	5.555***
	(0.0752)	(0.679)	(0.680)	(0.0874)	(0.561)	(0.561)
Controls						
Estimated population in the municipality	No	Yes	Yes	No	Yes	Yes
Number of companies operating in the municipality	No	No	No	No	Yes	Yes
Personnel employed in the municipality	No	Yes	Yes	No	No	No
Average salary in minimum wages	No	Yes	Yes	No	No	No
Value of GDP Per Capita	No	No	No	No	Yes	Yes
Tax code reform	No	No	Yes	No	No	Yes
R-squared	0.018	0.023	0.023	0.052	0.055	0.056
Number of ID	146	146	146	146	146	146

Notes: Standard errors are shown in parentheses. Significance levels: *** for 99% ($p < 0.01$), ** for 95% ($p < 0.05$), and * for 90% ($p < 0.1$).

These preliminary results demonstrate that the adoption of the systems has a positive impact on IPTU and ISSQN revenues. It is important to highlight that in models 2 and 5, which do not incorporate the reform of the tax code as a control variable, we obtained a statistically significant coefficient for IPTU collection, showing an average increase of approximately 47%, and a significant effect only at the 10% level for ISSQN collection, demonstrating an average increase of around 28%.

On the other hand, in models 3 and 6, which include the reform of the tax code as a control variable, although the results for IPTU and ISSQN are like the models that do not include it, only the model referring to IPTU presents statistical significance. It is important to note that the coefficients for models without controls are comparable to models with controls; however, only the coefficient related to IPTU has statistical significance.

Below, in Table 4, we present the results of the methodology developed by Callaway and Sant'Anna (2021). This methodology comprises Average Treatment Effects (ATTs) in a simplified model, covering all groups and periods evaluated. It also includes ATTs segmented

by groups, providing insights into the specific effects for the group that implemented the system in the respective year.

Table 4: Single and group ATTs

VARIABLE	(1) IPTU logarithm	(2) IPTU logarithm	(3) IPTU logarithm	(4) ISSQN logarithm	(5) ISSQN logarithm	(6) ISSQN logarithm
ATT	0.541**	**0.506****	**0.516****	0.199	**0.426****	**0.408****
	(0.223)	(0.243)	(0.248)	(0.123)	(0.199)	(0.198)
G2014	0.472	0.444	0.453	0.371**	**0.407*****	**0.384****
	(0.394)	(0.409)	(0.394)	(0.151)	(0.155)	(0.173)
G2015	0.817	**0.758***	**0.776****	0.424**	0.493	0.497
	(0.503)	(0.412)	(0.378)	(0.167)	(0.559)	(0.556)
G2016	0.837**	0.520	0.543	-0.905**	0.620	0.757
	(0.358)	(0.450)	(0.492)	(0.436)	-1.344	-1.344
G2017	0.403	**0.509***	0.425	-0.241	0.475	0.473
	(0.255)	(0.295)	(0.296)	(0.452)	(0.488)	(0.589)
G2018	-0.0858	-0.101	0.0418	-0.159	0.115	-0.0509
	(0.271)	(0.282)	(0.352)	(0.313)	(0.359)	(0.405)
			Controls			
Estimated population in the municipality	No	Yes	Yes	No	Yes	Yes
Number of companies operating in the municipality	No	No	No	No	Yes	Yes
Personnel employed in the municipality	No	Yes	Yes	No	No	No
Average salary in minimum wages	No	Yes	Yes	No	No	No
Value of GDP Per Capita	No	No	No	No	Yes	Yes
Tax code reform	No	No	Yes	No	No	Yes
Test parallel trends	0.0001	**0.6784**	**0.4240**	0.0100	**0.2442**	**0.1954**
Observations	870	870	870	870	870	870

Notes: Standard errors are shown in parentheses. Significance levels: *** for 99% ($p < 0.01$), ** for 95% ($p < 0.05$), and * for 90% ($p < 0.1$).

In simple ATTs, the results related to the IPTU collection forecast models exhibit some variations; however, they are relatively close to the results presented in Table 3. Furthermore, these results are statistically significant and do not violate the parallel trend test for the period before treatment, as they do not show statistical significance in the p-value. The observed increase is approximately 51% in model 2 and 52% in model 3, both with a significance level of 5%. These findings align with the results obtained by Mascagni, Mengistu, and Woldeyes (2021) in their research on the effects of sales registration machines on tax collection. In their study, they observed a 47.7% increase in the net collection of Value Added Tax (VAT).

In many municipalities, IPTU serves as the only officially managed tax, meaning it is compulsorily imposed on the population. However, in several cases, the absence of an effective control system has resulted in inefficient collection, rendering it susceptible to the implementation of a more efficient system. In this context, the e-government initiative, as per

modernization theory, signifies a significant technological advancement. Conversely, the substantial increase in IPTU collection is emblematic of the social transformation resulting from this technological progress, specifically the adoption of an electronic taxation system (Uyar et al., 2021).

In the ISSQN collection models, a notable disparity is observed in the fixed-effect models, emphasizing the relevance of the approach proposed by Callaway and Sant'Anna (2021). Additionally, the models with controls do not exhibit violations in the parallel trends test, indicating an average increase in ISSQN collection of approximately 43% in model 5 and 41% in model 6, both significant at a 10% confidence level. These results support the existing literature, which suggests an increase in tax collection due to 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).

This evidence points to the possibility that the system in question could be an effective tool to improve the management of this important tax, helping both municipalities to optimize their tax administration and companies that offer services. Furthermore, the use of this system has the potential to significantly contribute to reducing tax evasion by micro and small companies, which frequently fail to issue service invoices and, therefore, fail to pay the taxes due. This phenomenon is in line with the findings of Fjeldstad et al. (2020), who pointed to the fact that taxpayers may now fear possible sanctions imposed by the tax administration, which represents auspicious news for local government authorities.

From this point onwards, our analysis will focus on statistically significant results with appropriate controls, ensuring that they do not violate the parallel trends test. This last aspect became evident during the assessment of simple ATTs and will now be further explored through the analysis of ATTs by groups.

In the first stage, we analyzed the impact on ISSQN (Municipal Service Tax) revenue. It was found that only the group that implemented the system in 2014 achieved positive and statistically significant results. This result was obtained with a 1% significance level in the model that excludes the reform of the tax code as a control variable. In the model that includes it, the significance level is 5%. For this group, we observed approximately 41% and 38% increases in ISSQN collection. In the groups from 2015, 2017, and 2018, although the results were positive, they did not reach statistical significance.

Consequently, the 2014 group appears to be better positioned to adopt this innovation in e-government (Azad, Faraj, Goh, & Feghali, 2010; Layne & Lee, 2001; Norris, 2001; Singh,

Das, & Joseph, 2007), which allows it to capture revenue that was previously uncollected. This fact reinforces one of the arguments of modernization theory, which postulates that social changes result in greater tax compliance and lower levels of corruption. These factors can, ultimately, reduce tax evasion (Uyar et al., 2021).

In terms of capturing IPTU revenue, we observed that among taxpayers who initially adopted the system in 2015, there was an average increase of about 76% in model 2, without incorporating the tax code reform as a control variable, and this increase was statistically significant at 10%. In model 3, where we included the tax code reform as a controlling factor, the average increase was approximately 78%, and it was statistically significant at 5%.

Similarly, the group that started using the system in 2017 showed an average increase of approximately 51%, with a statistical significance of 10% according to model 2. These results are worth highlighting and, according to the literature consulted, only Pierson and Thompson (2016) documented operational increases in collection that exceeded the 50% mark.

However, these results prompt reflection on potential underlying factors contributing to these findings. Upon analyzing the websites of the mentioned municipalities, a common emerging characteristic is the simplification of the process for citizens to issue IPTU charges. Therefore, it's plausible to argue that one of the reasons behind this remarkable improvement in tax compliance is closely linked to the simplification of tax procedures facilitated by electronic tax collection systems (Sidani, Ghanem & Rawwas, 2014; Tjen & Evans, 2017; Night & Bananuka, 2020).

It's important to note that in 2014, the group achieved its highest number of system subscribers in a single year, encompassing fifteen municipalities. This phenomenon can be interpreted through the lens of institutional theory, which underscores the reciprocal influence among institutions. It's worth highlighting that all these municipalities had populations of fewer than thirty thousand inhabitants, with the majority of them in the second year of their respective chief executive's first term.

This implies that the introduction of the system represented an innovation in the new municipal administration, potentially contributing to the fight against corruption. This finding aligns with one of the macro-environmental factors of modernization theory, which addresses the strengthening of political institutions.

Given that municipal management represents a politically significant institution, the willingness to introduce information technologies with the potential to alter the behavior patterns of both businesses and citizens, even if this initiative is considered unpopular,

underscores the reinforcement of this institution. This finding also supports the argument presented by Baum, Gupta, and Kimani (2017).

This is because the implementation of e-government systems, which can help reduce corruption, may result in a decrease in tax evasion. Furthermore, as described by Barker (2005), modernization theory emphasizes the influence of contextual conditions.

Furthermore, it is essential to provide justifications that explain the disparities between the groups in question. Initially, when examining the data set for the year 2014, there is a notable difference compared to the other groups. In Table 1, we observe a higher level of homogeneity among the municipalities included. All fifteen of these municipalities are categorized as small, with thirteen falling into the "small size I" classification. Importantly, none of these municipalities made any changes to their tax codes either before the system's implementation or during the implementation year.

Additionally, these municipalities stand out for their concentration on adopting two specific types of systems, setting them apart from the other groups in our study. This concentration on systems brings us back to the concept emphasized in institutional theory, which addresses the influence of one institution on another.

A closer examination of this group reveals that most of the municipalities are part of a municipal consortium. In this context, it becomes evident that the presence of the system, within these circumstances, and this municipal profile, results in an immediate and substantial increase in the collection of the ISSQN tax. This enhanced effectiveness can be attributed to the system's ability to facilitate more efficient management of service provider registrations and the issuance of electronic service invoices.

In contrast, the 2015 dataset presents contrasting results concerning IPTU and ISSQN revenues. While both show positive trends, only IPTU revenues exhibit statistical significance. The absence of statistical significance in the models related to ISSQN can be attributed to the inherent heterogeneity within this group. As illustrated in Table 1, we identified at least four distinct supplier systems, and the municipalities encompass various size categories, including small (I and II), medium, and large sizes.

Another reason for the lack of significant results concerning the ISSQN is associated with citizens' perceptions of the electronic tax collection process. If the system does not meet their expectations, particularly in terms of simplification and reducing complexity, as pointed out by Choi & Chandler (2020), there is a possibility that these individuals may explore alternatives, which could include resorting to corruption among professionals involved in the process.

This more efficient result in IPTU collection for the 2015 group can be attributed to enhanced transparency and accountability (Rehman, Kamal, Esichaikul, 2016; Porumbescu, 2016; Srivastava, Teo, and Devaraj, 2016). This, in turn, suggests a reduction in factors contributing to tax evasion, such as corruption (Bejaković, 2014; Alm, Martinez-Vazquez & McClellan, 2016; Faridy, Freudenberg, Sarker & Copp, 2016; Ivanyna, Moumouras & Rangazas, 2016; Rosid, Evan & Tran-Nam, 2016; Marriott, 2017; Swanepoel & Meiring, 2017; Máchova, Volejníková & Lněnička, 2018).

However, in the 2016 dataset, a significant reduction in dimension is evident, as shown in Table 1. This distinct characteristic may help explain the absence of statistical significance, despite the positive findings.

Another possible explanation for the lack of these results could lie in the lack of positions for tax auditors or tax inspectors in municipalities, even after the implementation of systems. This is in line with what academic literature highlights about the scarcity of qualified human resources and effective institutions to take advantage of the benefits of ICTs (McClelland, 1961; Yilmaz & Coolidge, 2013; Lewis-Faupel et al., 2016; World Bank, 2016).

The 2017 group presents positive and statistically significant results, except in the case of the IPTU model, which does not incorporate the reform of the tax code as a control variable. It is worth mentioning that in this specific group, in addition to simplifying the tax procedures of standardized electronic tax systems, we must consider another specific factor: all systems implemented in these municipalities, when they do not cover all taxes, are at least dedicated to IPTU management. It is important to highlight that this year marked the beginning of a new municipal management and all municipalities in the group were in the process of transition, which may explain the differences observed.

The completeness of the system also underscores another element of great relevance in the macro-environmental context of modernization theory: technological progress. Furthermore, in this group, there is a concentration of two types of systems, namely E and A. When examining the microregions where these municipalities are located, mutual influences become evident between the six municipalities that implemented the type E system, as well as among the three municipalities that adopted the type A system. This finding emphasizes the importance of institutional theory regarding the interactions and reciprocal influences of institutions on each other.

The fact that it is the first year of the administration also denotes the strengthening of the macro-environmental factor in the democratic institution, since, if the administration was

able to implement such a significant modernization right at the beginning of the mandate, this demonstrates its robustness.

Finally, the 2018 group does not exhibit positive and/or statistically significant coefficients in the models with control variables. Out of the eleven municipalities within this group, ten are classified as small municipalities I according to IBGE. In these areas, at least seven distinct types of systems were identified, without the predominance of a single type, as the most frequent types are present in just two municipalities.

This raises a question: when a group exhibits a high concentration of small municipalities with this profile, and there is no specific concentration in one or two types of systems, as was the case in the 2014 group, the obtained results may become contradictory. If this occurs, it contradicts one of the perspectives of institutional theory, which suggests that organizations are not always focused on efficiency and effectiveness (Brandtern & Suárez, 2021). Consequently, this can lead to inadequate planning, resulting in poor performance or failures (Dawes, 2008; Anthopoulos, Reddick, Giannakidou, & Mavridis, 2016).

The presence of a high concentration of small municipalities, defined as those with up to 20,000 inhabitants, within this group, prompts us to contemplate the urbanization aspect discussed in modernization theory. However, the lack of consistent results may be attributed to the absence of significant urban concentrations that foster technological advancements.

Given the absence of relevant findings using the approach proposed by Callaway and Sant'Anna (2021), which considers Average Treatment Effects on the Treated (ATTs) per calendar year, we have opted not to include them in this context. To conclude the presentation of our results, Table 5 illustrates the impact dynamics in treated municipalities. Here, ATTs are estimated for each period in comparison to the initial treatment period, encompassing all cohorts.

Table 5: ATT by dynamic effects

VARIABLE	(1) IPTU logarithm	(2) IPTU logarithm	(3) IPTU logarithm	(4) ISSQN logarithm	(5) ISSQN logarithm	(6) ISSQN logarithm
T-4	-0.111	-0.203	-0.204	-0.272**	-0.192	**-0.204***
	(0.304)	(0.328)	(0.330)	(0.137)	(0.118)	(0.111)
T-3	0.123	0.0851	0.0862	-0.0306	-0.0695	-0.0719
	(0.259)	(0.265)	(0.268)	(0.223)	(0.228)	(0.251)
T-2	0.0493	0.0327	0.0210	-0.0111	-0.0248	0.00801
	(0.214)	(0.216)	(0.216)	(0.454)	(0.533)	(0.559)
T-1	0.00589	0.119	0.126	0.533*	0.383	0.350
	(0.289)	(0.343)	(0.371)	(0.295)	(0.407)	(0.401)
T+0	0.195	0.188	0.209	-0.174	0.00507	-0.0117
	(0.151)	(0.168)	(0.169)	(0.214)	(0.232)	(0.229)
T+1	0.656***	**0.613****	**0.637****	0.315*	**0.660***	**0.661***
	(0.246)	(0.274)	(0.269)	(0.166)	(0.396)	(0.399)
T+2	0.703**	0.608	**0.635***	0.614***	**0.714****	**0.664****
	(0.335)	(0.375)	(0.372)	(0.186)	(0.320)	(0.294)
T+3	0.789**	**0.766***	**0.729***	0.237	0.399	0.399
	(0.351)	(0.398)	(0.389)	(0.177)	(0.540)	(0.522)
T+4	0.650	0.640	0.621	0.276	**0.722***	**0.686***
	(0.504)	(0.494)	(0.514)	(0.200)	(0.379)	(0.390)
			Controls			
Estimated population in the municipality	No	Yes	Yes	No	Yes	Yes
Number of companies operating in the municipality	No	No	No	No	Yes	Yes
Personnel employed in the municipality	No	Yes	Yes	No	No	No
Average salary in minimum wages	No	Yes	Yes	No	No	No
Value of GDP Per Capita	No	No	No	No	Yes	Yes
Tax code reform	No	No	Yes	No	No	Yes
Test parallel trends	0.0001	**0.6784**	**0.4240**	0.0100	**0.2442**	**0.1954**
Observations	870	870	870	870	870	870

Notes: Standard errors are shown in parentheses. Significance levels: *** for 99% ($p < 0.01$), ** for 95% ($p < 0.05$), and * for 90% ($p < 0.1$).

In Table 5, when analyzing IPTU collection, it is observed that one year after the implementation of the system (T+1), IPTU collection increases, on average, by 61% in model 2 and 64% in model 3 for the municipalities. These results are statistically significant at a 10% confidence level. The T+1 period spans the years 2014, 2015, 2016, and 2017, encompassing a total of thirty-nine municipalities. These findings support the conclusions of Bellon, Dabla-Norris, Khalid, and Lima (2022), who also found that some taxes experience increases in the first year after system implementation.

About IPTU collection, after two years of system implementation (T+2), only model 3, which includes a dummy variable representing the reform of the tax code as a control variable,

demonstrates statistical significance, with a level of 10% confidence. This result indicates that, after two years, municipalities increased IPTU collection by around 64%, a result like that observed in the T+1 period. The T+2 period encompasses the years 2014, 2015 and 2016. This conclusion is in line with previous studies in the literature that point to an increase in revenue through the adoption of technologies in tax administration it is in line with the findings from Pierson and Thompson (2016), which highlighted the existence of significant results in the second year.

The results related to IPTU indicate that three years after implementing the system (T+3), the increase in revenue collection continues to rise, reaching 77% in node 2 and 73% in node 3, both statistically significant at a 10% confidence level. The T+3 period only covers the years 2014 and 2015. These findings are consistent with those of Pierson and Thompson (2016), who observed revenue increases in tobacco, leisure, and resources from coal, oil, or wood after the third year of system usage.

The results obtained within the scope of ISSQN collection indicate that the benefits of this tax become evident in the first year (T+1) after the implementation of the system. Our findings suggest that, in both models that incorporate control variables, an increase in revenue of approximately 66% is observed, which is statistically significant at a confidence level of 10%. This finding, in the first year, differs from the conclusions of Mallick (2021), who did not identify positive and significant effects of the adoption of Information and Communication Technologies (ICTs) in tax management. However, our results are in line with previous studies that showed positive effects in the first year of implementing the system, such as the works of Pierson and Thompson (2016), Kochanova, Hasnain, and Larson (2020), and Bellon, Dabla-Norris, Khalid, and Lima (2022). This highlights the importance of ICTs in the modernization and efficiency of tax administration.

In the second year (T+2) of system implementation, an average increase of approximately 71% was observed in the model that does not include the reform of the tax code and around 66% in the model that incorporates it. Both results are statistically significant at a 5% confidence level. These findings support the thesis that revenue continues to increase with the adoption of the system, corroborating the argument presented by Eissa and Zeitilin (2014), which suggests that the use of tax technologies can effectively contribute to improving tax compliance.

In the models for ISSQN collection, the data also reveal that starting from the fourth year (T+4), there is an approximately 72% increase in collections, with a significance level of 10% in model 5, which does not account for changes to the tax code. In model 6, an increase of

around 69% is observed, also with a significance level of 10%. It's important to highlight that these findings apply exclusively to the group of municipalities from the year 2014, which consists of fifteen municipal entities.

These results, like the findings of Pierson and Thompson (2016) regarding this type of collection, support the notion that in certain studies, some types of taxes only yield positive results after the second year of implementing the tax system.

Revenue from the ISSQN tax is generated through the provision of services by companies. In this context, it is reasonable to argue that, due to technological advancements, citizens now expect to receive tax documents for the services they acquire. This expectation can be seen as a form of social pressure for compliance and legitimacy, as emphasized by Kessler (2013), and is also in line with institutional theory, as discussed by Di Maggio and Powell (1983).

This change in citizens' expectations regarding fiscal transparency represents a relevant element in the context of municipalities' organizational structures. As citizens demand appropriate tax documentation from service providers, municipalities, as institutions, are expected to adjust their structures to meet these new requirements. This not only reinforces tax compliance but also encourages improvements in municipal administrative practices, resulting in greater efficiency and effectiveness in public management.

In summary, when focusing exclusively on bidirectional fixed effects models, it was observed that the implementation of standardized electronic tax systems results in a statistically significant increase in total IPTU and ISSQN collections. However, statistical significance only appears for ISSQN in the model that excludes the reform of the tax code. By employing the methodology proposed by Callaway and Sant'Anna (2021), statistically significant results were obtained for these same collections, without any violation of the parallel trend test. However, the results differ from the two-way fixed effects models, especially in the case of ISSQN. Furthermore, Callaway and Sant'Anna's (2021) approach reveals notable results, such as group effects on collections and dynamic effects with a substantial impact.

It is important to highlight that in the models that incorporate a dummy variable for the reform of the tax code, the results are remarkably similar to the models that exclude it, suggesting that the mere adoption of the system is capable of boosting revenue, thus obviating the need for reforms in the corresponding local tax codes.

3.6 CONCLUDING REMARKS

This study aims to analyze the impact of implementing standardized electronic tax systems on tax collection in municipalities within a Brazilian state. The results obtained indicate that the adoption of electronic tax systems can assist municipalities in increasing revenue collection. A noteworthy that the impacts on individual taxes may vary and might not be uniform across all municipalities.

As for social contributions, the results of this study offer support for enhancing municipal fiscal management. The findings demonstrate improvements in revenue collection, which can subsequently lead to better service provision for both citizens and civil society. Moreover, it is well-known that most Brazilian municipalities encounter challenges in adhering to the LRF (Fiscal Responsibility Law), and the results suggest that the use of these systems can assist them in improving this process.

Recent studies have already identified that the use of Information and Communication Technologies (ICTs) helps improve revenue collection (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). Additionally, other studies have identified relational issues in the use of these 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 work is pioneering as it seeks to analyze the collection of specific taxes by municipalities, particularly in the interior regions of the country, thus contributing to the advancement of the literature.

At the same time, we propose a critical reflection on modernization theory, considering the results we obtained. This theory assumes that modern societies take advantage of the services offered by emerging technologies, compared to less technologically advanced societies (Barker, 2005). However, our findings demonstrate that there are groups of municipalities with lower population density that have experienced significant benefits from adopting recent technologies, in contrast to larger or similarly sized municipalities. This leads us to consider that urbanization, a characteristic often associated with modernization, is not necessarily the only determinant of success in the adoption of technology.

In this context, it is plausible to argue that the degree of modernization of society, if we can define it unequivocally, may not be the only determining factor. On the contrary, the influence of institutional factors involving a given society, together with its level of urbanization, can play a crucial role in the results of the exercises.

The primary managerial implication of this study is associated with presenting evidence that supports the notion that integrating technology into public administration not only enhances control over activities but can also serve as an effective tool to boost municipal tax revenue. Additionally, it is observed that the type of system employed can impact collection levels; more comprehensive systems tend to yield more efficient results.

From a practical standpoint, it would be highly relevant for municipal authorities to consider not only the implementation of technological systems but also the formulation of strategies that promote actions such as citizens requesting service invoices. Furthermore, incentivizing municipal officials to increase inspections could further contribute to achieving this objective.

Such actions could trigger a significant increase in municipal revenues when combined with the implementation and effective use of the technological system, resulting in a synergistic approach to optimizing public revenue.

Among the limitations of this study, it is important to note that these results are applicable specifically to the state of Rio Grande Norte and should not be extrapolated to other states. Additionally, the pathways employed by municipalities to enhance revenue collection, as well as the influence of different types of systems on this process, represent further limitations.

Regarding future research suggestions, we propose conducting a more comprehensive municipal-level analysis, which could involve comparing municipalities between states or grouping those with similar characteristics at the state level. This approach would enable a more accurate comparison between municipalities. Additionally, we recommend conducting a qualitative study involving municipal managers who are responsible for implementing these systems. This study can help identify differences in the approaches adopted and the challenges they face.

Furthermore, it is essential to emphasize that 'tax management modernization policies' represent a promising research field, especially considering the expected national-level tax reform.

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APPENDICES

APPENDIX A – Variables description summary

Variable	Description	Type
Adoption of the standardized electronic tax system.	Indicates whether the standardized electronic tax system is in operation in the municipality throughout the year.	Independent.
Revenue from IPTU.	Log revenue from IPTU.	Dependent.
Revenue from ISSQN.	Log revenue from ISSQN.	Dependent.
Estimated population in the municipality.	Estimated population number of the municipality in the year.	Control.
Number of companies operating in the municipality.	Number of active companies in the municipality in the year.	Control.
Personnel employed in the municipality.	Number of people employed in the municipality in the year.	Control.
Average salary in minimum wages.	Average salary in minimum wages of the municipality's population in the year.	Control.
Value of GDP Per Capita.	Value of GDP per capita in the municipality in the year.	Control.
Tax code reform.	Dummy showing whether the municipality revised the municipal tax code in the year of implementing the standardized electronic tax system or in the previous year.	Control.

4 ESSAY 3: DOES MUNICIPALITY SIZE MATTER? THE IMPACT OF INTRODUCING THE ELECTRONIC CONSUMER INVOICE (NFC-E)

ABSTRACT

Purpose
This study aims to analyze the NFC-e project's impact on the Tax on Circulation of Goods and Services (ICMS).

Method
The database comprises 4,652 municipalities in Brazil, covering information from 2013 to 2016. The article employs the difference-in-differences approach with staggered adoption, as proposed by Callaway and Sant'Anna (2021).

Results
The research findings suggest that the adoption of NFC-e has varying impacts on municipalities based on their size. Larger municipalities experienced more substantial increases in the transfer of participation installment in the ICMS per person. Specifically, large size municipalities witnessed an average increase of about 3.6% per person, while medium size municipalities experienced an increase of approximately 2.7% per person. In terms of the effects over time, the largest municipalities exhibited an average per-person increase of approximately 18.6% two years after the states implemented the project.

Originality/Contribution
The study provides evidence supporting the idea that implementing policies aimed at modernizing state tax management leads to increased revenue, marking it an important initiative. These policies not only serve to ensure security, control, and transparency in the management process but also serve as upgrades to enhance tax collection within specific groups of municipalities.

Keywords: Electronic invoice; Electronic consumer invoice; Information Technology; Tax collection.

4.1 INTRODUCTION

The electronic invoice is a document that electronically records transactions for goods or services, storing and exchanging this information digitally. Considered an emerging practice, electronic invoices offer a valuable source of information across various domains (Kieckbusch, Filho, Di Oliveira & Weigang, 2023). They serve as an information system service, gathering data on business transactions and transmitting it across networks (Lian, 2015).

Hence, the electronic invoice has emerged as a product of the information age (Tang, Qiu, Huang, Chen, Yan, Lian, & Li, 2020), with its origins traced back to the development of electronic data interchange (EDI) systems in the 1960s. Initially, EDI systems were utilized by

companies to exchange electronic documents like purchase orders, invoices, and bills of lading. However, during the 1990s, the adoption of electronic invoicing gained momentum as governments recognized its potential benefits (OECD, 2019; Bellon, Dabla-Norris, Khalid, & Lima, 2022).

NF-e has become a prevalent invoicing method across numerous countries, prompting governments to enforce electronic invoicing regulations. These measures encourage NF-e adoption among companies, facilitating compliance with tax laws, saving time and money, and streamlining invoicing and tax reporting processes (OECD, 2022). For instance, Mexico established a legal framework for electronic invoicing in 2005, Brazil mandated a system in 2010, Peru introduced a mandatory electronic invoicing system in 2013, and Chile followed suit in 2014 (Koch, 2014). The European Union set forth directives on electronic invoices in 2004, advocating for their use in public procurement, while Italy implemented regulations for business-to-business (B2B) electronic invoices in 2016 (European Commission, 2004). In 2019, India introduced B2B e-invoicing regulations, and in 2020, Saudi Arabia initiated a mandate for B2B e-invoicing (Taxmann, 2019).

Specifically in Brazil, the Public Digital Bookkeeping System (SPED) is a project designed to modernize and simplify tax and accounting obligations. One of its pivotal components is the electronic invoice, known as NF-e. This invoice is mandatory for all Brazilian companies engaged in product sales and is required across all states (Receita Federal do Brasil, 2022a).

In Brazil, studies on electronic tax document projects have primarily focused on the pioneering NF-e project, which profoundly influenced the entire market ecosystem. This research delves into various aspects, including perspectives from state tax authorities (Bonfim, Moraes, Machado, Amorim & Raimundini, 2012), anticipated benefits, and challenges for accounting professionals (Silva Filho, Leite Filho & Pereira, 2015; Oliveira, Teodoro & Bonfin, 2021). It also explores regional revenue increases exemplified by Vieira, Pimenta, Cruz, and Souza (2019), who investigated whether the NF-e program led to a revenue surge in the State of Goiás. Furthermore, it evaluates the program's impacts on daily business operations (Correia & Santos, 2011; Eckert, Santos, Mecca, & Biasio, 2011; Borba, Petrini & Wiednhoft, 2013; Flores, Rosa, Bianco, & Bernardo, 2014).

In alignment with previous studies on electronic invoices, our research focused on the utilization of electronic consumer invoices. Despite the global trend of adopting electronic invoices to enhance tax compliance and reduce costs (Barreix & Zambrano, 2018), our results primarily emphasize their significance in larger urban areas. This correlation is consistent with

recent investigations that explore diverse aspects related to electronic invoices, ranging from analyzing tax compliance costs across various national contexts (Poel, Marneffe & Vanlaer, 2016; Ramírez, Oliva & Andino, 2018) to identifying corporate resistance to implementation (Olaleye & Sanusi, 2017), inefficiencies in emission systems (Guanaratne & Pappel, 2020), regulatory challenges, advancements, and factors influencing adoption (Linh, 2020; Qi & Azmi, 2021; Nguyen, Nguyen & Dang, 2020).

Moreover, our study contributes to the discourse of examining revenue increases in a hundred different countries (Bellon et al., 2022; Ramírez-Álvarez, Oliva & Andino, 2018). Specifically, our research underscores the prevalence and utilization of electronic consumer invoices in larger urban environments, enriching discussions on the spatial distribution and impact of electronic invoices within municipal settings.

Considering the limited empirical evidence on the global impact of electronic tax document initiatives in Brazil and the absence of comprehensive studies on various initiatives, this research focuses on examining the NFC-e project. The primary goal of this project was to introduce a nationwide electronic tax document model, replacing traditional paper documents (Receita Federal do Brasil, 2022b). These paper documents, known as tax coupons for final consumers, differ from NF-e since they do not require specific personal details of individuals or legal entities. The selection of this project is based on its direct influence on the interaction between sellers and end consumers, an aspect that prior studies have yet to explore. Hence, this study aims to analyze the NFC-e project's impact on transferring participation installment in the Tax on Circulation of Goods and Services (ICMS) from states to municipalities.

The ICMS participation installment constitutes a portion of the tax revenue collected by states from the circulation of goods and services, directed towards municipalities (Bregman, 2011). Transferring this share aims to decentralize tax collection and facilitate the utilization of resources for local development.

ICMS, the primary tax in terms of revenue collected by Brazilian states, is partially allocated to municipalities within the state of collection. As per the 1988 Federal Constitution (Brazil, 1988), 25% of the ICMS collected must be forwarded to the respective municipalities (Bregman, 2011), establishing the ICMS participation installment as a form of intergovernmental transfer.

Intergovernmental transfers involve the allocation of resources between various government levels—federal to state and state to municipal. One of the key reasons for these transfers is the disparity between decentralized public policy execution and tax collection among different government tiers. Hence, intergovernmental transfers serve as a mechanism to

alleviate this imbalance and redistribute resources among regions with varying income and developmental disparities (Mendes, 2004).

Out of the designated 25%, at least three-quarters, i.e., 75%, must be distributed based on the derivation principle, which distributes a segment of the tax based on where the tax event occurred. This principle is commonly known as Fiscal Added Value (VAF). Its essence lies in ensuring that municipalities significantly contributing to ICMS collection receive a proportionately larger share during the transfer (Sasso, Varela, and Righeto, 2021).

Since ICMS is imposed on the circulation of goods and services, municipalities with higher population densities tend to generate greater amounts compared to less populated ones. The remaining portion allocated to municipalities—up to a quarter, or 25%—is subject to state laws for transfer. Consequently, there is discretion in distributing this fraction (Mendes, 2004). Sasso, Varela, and Righeto (2021) scrutinized state legislation, identifying this discretionary allocation within each state.

Hence, if a municipality boosts its ICMS collection through the introduction of NFC-e or any other dynamic commercial activity, it stands a better chance of receiving a larger share of the transfer.

From a managerial perspective, our research provides a comprehensive analysis that supports the implementation of policies aimed at modernizing state tax management. Our investigation shows that these policies are effective in optimizing tax collection, especially in municipalities with specific socioeconomic characteristics. They not only benefit public resources but also strengthen the ability of local governments to provide essential services to the population.

This study contributes to the expanding literature that evaluates the effects of various innovative policies on tax collection, leveraging the increasing availability of administrative tax records in developing countries (Kleven & Waseem, 2013; Best, Brockmeyer, Kleven, Spinnewijn, & Waseem, 2015; Gupta, Keen, Shah, & Verdier, 2017; Pomeranz & Vila-Belda, 2019). Additionally, this study complements recent research that analyzed the effects of digitizing tax data in developing nations. For instance, Okunogbe and Pouliquen (2022) demonstrate, using data from Tajikistan, that electronic tax reporting reduces tax evasion, lowers compliance costs, and decreases bribe payments. Eissa and Zeitlin (2014) report that the adoption of electronic invoicing machines by companies in Rwanda increased VAT collection. Similarly, Fan, Li, Qian, and Wen (2018) found that the digitalization of invoices increased VAT collection in China.

Moreover, this study adds to the growing body of work on the role of technology in enhancing 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). Finally, it provides some of the earliest evidence of the causal impact of technology use on local tax collection.

The remainder of the article is structured as follows: The next section contextualizes NFC-e in Brazil. Section 3 presents the literature review. Section 4 describes the data sources and variables. Section 5 outlines the empirical strategy. Section 6 presents the results, while section 7 discusses them. Finally, section 8 concludes the study.

4.2 A ELETRONIC CONSUMER INVOICE (NFC-e)

The Electronic Consumer Invoice (NFC-e) was introduced in Brazil in 2013 and is governed by the National Economic and Fiscal Information System (SINEFI) (BRASIL, 2023). NFC-e represents a technological advancement enabling the substitution of traditional paper invoices with digital documents. Notably, its technological features include standardized documentation issued in XML format, facilitating seamless integration with company management systems.

Furthermore, NFC-e incorporates Digital Certification technology, ensuring document authenticity and thwarting forgery attempts. This aspect safeguards commercial transactions and aids in curbing tax evasion. Another pivotal attribute of NFC-e is its capability to transmit documents via a QR code, easily scannable by consumers. This feature grants customers immediate access to invoices, enhancing transparency in transactions and fostering increased trust in the relationship between consumers and businesses.

NFC-e enables real-time transmission of information to the State Treasury Department, offering greater control over commercial operations. This is pivotal for monitoring and preventing tax fraud, thereby enhancing the country's business environment.

In essence, NFC-e's technological features, including standardization, Digital Certification, QR code-based transmission, and real-time reporting to the Treasury Department, ensure security, transparency, and control in commercial transactions. NFC-e stands as a technological innovation that benefits both companies and consumers, ultimately fostering an improved business environment nationwide.

The implementation of NFC-e projects in various states was implemented trought their specific legislation. Based on states documents, Table 1 outlines specific state peculiarities during the project implementation, while comprehensive documentary research is available in Appendix A.

Table 1: NFC-e mandatory start in the states

State	Abbreviation	Region	Compulsory start date	Sytem type	Voluntary membership
Acre	AC	North	06/01/2014	Technology transfer	Yes
Alagoas	AL	Northeast	10/01/2016	Technology transfer	Yes
Amapá	AP	North	01/01/2017	Technology transfer	Yes
Amazonas	AM	North	03/01/2014	Own	Yes
Bahia	BA	Northeast	08/22/2017	Technology transfer	Yes
Ceará	CE	Northeast	02/01/2017	Technology transfer	No
Distrito Federal	DF	Center-West	01/01/2016	Technology transfer	Yes
Espírito Santo	ES	Southeast	01/01/2016	Technology transfer	Yes
Goiás	GO	Center-West	01/01/2017	Technology transfer	Yes
Maranhão	MA	Northeast	03/01/2017	Technology transfer	Yes
Mato Grosso	MT	Center-West	02/01/2014	Own	Yes
Mato Grosso do Sul	MS	Center-West	03/01/2017	Technology transfer	Yes
Minas Gerais	MG	Southeast	03/01/2019	Technology transfer	No
Pará	PA	North	06/01/2015	Technology transfer	Yes
Paraíba	PB	Northeast	07/01/2015	Technology transfer	Yes
Paraná	PR	South	07/01/2015	Own	Yes
Pernambuco	PE	Northeast	08/01/2017	Technology transfer	No
Piauí	PI	Northeast	11/01/2015	Technology transfer	Yes
Rio de Janeiro	RJ	Southeast	10/01/2014	Technology transfer	Yes
Rio Grande do Norte	RN	Northeast	01/01/2017	Technology transfer	Yes
Rio Grande do Sul	RS	South	09/01/2014	Own	No
Rondônia	RO	North	03/01/2015	Technology transfer	Yes
Roraima	RR	North	07/01/2015	Technology transfer	Yes
Santa Catarina	SC	South	-	-	-
São Paulo	SP	Southeast	07/01/2015	Own	Yes
Sergipe	SE	Northeast	11/01/2014	Technology transfer	Yes
Tocatins	TO	North	07/01/2018	Technology transfer	No

Table 1 illustrates that approximately 81% of states opted for voluntary membership (allowing companies to join before the legally required period) as a means of encouraging participation. This form of membership prevailed in most states, with only five states not offering it. This variation may be attributed to differences in each state's implementation capacity, public awareness of the system's benefits, or political pressures favoring mandatory adoption. Many states chose to adopt what we refer to as a technology transfer system (Pierson

& Thompson, 2016), derived from technology originating in Rio Grande do Sul. Only five states chose to develop their systems, showcasing a customized approach to meet local needs.

Another significant aspect is the variation in mandatory start dates across states. Some, like Acre and Rio Grande do Sul, implemented the requirement as early as 2014, while others, including Minas Gerais, adopted it more recently in 2019. These differences could reflect resource availability, infrastructure readiness, and the political priorities of each state. For instance, in Amazonas, the obligation started in March 2014 for certain taxpayers, whereas in Tocatins, it commenced in July 2018. As of our data collection in September 2022, only Santa Catarina had not yet joined the project, although discussions were ongoing.

Each state had the autonomy to establish its criteria for setting the mandatory NFC-e (Nota Fiscal do Consumidor eletrônica) schedule. For instance, Paraná organized deadlines based on taxpayers' National Classification of Economic Activities (CNAE) code, while Rio Grande do Sul used annual revenue as a segmentation criterion.

4.3 LITERATURE REVIEW

The literature review section first introduces the theories discovered, enabling us to analyze the phenomenon under study. It then provides a synthesis of recent studies regarding the impacts of IT usage on various types of collections, concluding with a discussion on the motivations and challenges associated with utilizing electronic invoices.

4.3.1 THEORIES

4.3.1.1 TOE Framework

The Technology-Organizational Environment (TOE) Framework, developed by Tornatzky and Fleischer in 1990, is widely utilized in examining the adoption of technological innovations (Iacovou, Benbasat, & Dexter, 1995). This framework originally encompasses three contextual elements that impact the adoption and implementation of technological innovations: technological context, organizational context, and environmental context. The technological context revolves around the perceptual characteristics of both existing and new technologies (Zhu, Kraemer, & Xu, 2006; Henderson, Sheetz, & Trinkle, 2012). The organizational context pertains to internal factors such as the company's size, scope, internal

resources, and the complexity of its management structure (Zhu et al., 2006; Henderson et al., 2012). Conversely, the environmental context encompasses factors external to the company's operations (industry, competitors, and government relations) that can influence adoption decisions (Zhu et al., 2006; Henderson et al., 2012). In this study, we draw upon support from the environmental context.

According to Iacovou, Benbasat, and Dexter (1995), the adoption of information technology (IT) by micro and small companies is primarily influenced by external pressures. Particularly, coercive pressures, which represent the forces exerted by other organizations upon which companies rely (DiMaggio & Powell, 1983), are considered the primary source of influence on IT adoption. Studies by Iacovou, Benbasat, and Dexter (1995), Kuan and Chau (2001), Sila (2013), and Teo, Wei, and Benbasat (2003) have noted that companies might follow similar IT adoption patterns due to these coercive pressures.

In the scenario involving micro and small companies issuing Electronic Consumer Invoices (NFC-e), the use of a compatible automation system authorized by the state finance department is imperative for the registration and issuance of the NFC-e. In instances where these companies rely on others to issue NFC-e, larger corporations might exert pressure on them to register and generate NFC-e to claim the entire ICMS credit on purchases, thereby cutting down their operational expenses. This demonstrates how coercive pressures can impact the adoption of IT within a specific context of the supply chain.

According to DiMaggio and Powell (1983), mimetic pressures are a factor that can lead organizations to follow other successful organizations in their sector. These pressures are driven by competitive forces and may result in similar adoption decisions to those of successful rivals. Teo, Wei, and Benbasat (2003) identified two ways in which mimetic pressures manifest. Firstly, if many companies in the same sector adopt an automation system compatible with NFC-e, others in the sector will also adopt it to avoid the risk of being seen as less innovative. Secondly, organizations may imitate competitors who have succeeded in adopting an automation system compatible with NFC-e, seeking to follow perceived best practices to remain competitive.

Finally, it is important to highlight that regulatory pressure plays a significant role in companies' adoption of Information Technology (IT) (Kuan & Chau, 2001; Zhu et al., 2006). This pressure comes from regulatory authorities, such as state treasury departments, which require for companies to adopt an automation system compatible with NFC-e issuance. This regulatory requirement may, in turn, encourage the adoption of an automation system compatible with NFC-e for other business purposes. According to Kuan and Chau (2001), the

imposition of government regulations has exerted a positive influence on the level of IT adoption by micro and small businesses. These organizations believe they will reap significant benefits by adopting these technologies, surpassing potential advantages provided to the government itself.

4.3.1.2 Modernization theory

Barker (2005) postulated that modernization theory holds relevance in analyzing fiscal issues by encompassing the impact of technological innovations on social structures. Nevertheless, Uyar et al. (2021) highlighted historical neglect among scholars in researching the interactions between modernization theory and advancements in combating tax evasion.

Modernization theory emphasizes social transformation stemming from transitioning from traditional to modern contexts, driven by macro-environmental factors like technological progress, political advancement, economic growth, urbanization, democratic institutions, educational levels, communication, and media (Nam, 2018). Hence, we consider this theory an adequate theoretical framework for our study. For instance, if economic growth, such as GDP per capita, is influenced by a technology adoption policy like NFC-e, we believe it's a significant aspect of modernization theory.

According to Uyar et al. (2021), technological improvements in government services leading to more efficient public administration can yield significant social effects, including increasing tax compliance levels and reducing corruption. These changes hold the potential to curtail tax evasion, considered an achievement of social change.

While technological advances facilitate social changes and modernization, previous literature demonstrates that more developed societies tend to gain greater benefits than less developed ones (Barker, 2005; Nam, 2018; Uyar et al., 2021). Consequently, the diffusion of technologies in societies plays a pivotal role in social transformation (Kock & Gaskins, 2014). Here, the mandate to issue the NFC-e represents a social change resulting from policy implementation.

Nam (2018) underscored the importance of developing e-government in reducing corruption, which is related to pre-existing cultural traits within a country. Electronic government tends to support anti-corruption initiatives in culturally consolidated countries but may diminish in societies with power inequality and aversion to uncertainty. Considering that more populous municipalities often possess better structures to combat corruption, it's expected

that these municipalities will benefit more from NFC-e implementation than small municipalities.

4.3.2 IMPACTS OF INFORMATION TECHNOLOGY (IT) ON TAX COLLECTION

Through a systematic literature review (Essay 1), it was noted that research exploring the effects of IT on tax revenues is currently in an emerging and evolving stage. Presented below is a summary of studies included in this review along with some additional discoveries.

Several researchers have delved into various aspects related to the use of standardized and customizable systems for state tax collection in the United States. Pierson and Thompson (2016) conducted a notable study investigating whether the adoption of standardized systems increased revenue compared to other systems. Their findings indicated a 26% increase in tobacco tax in the year of implementation, followed by a 43% and 38.8% increase in subsequent years. Similarly, leisure tax surged by 161.2% in the second year and 126.8% in the third year. Vehicle tax saw a 23.2% increase after the second year, while taxes on coal, oil, or wood resources rose by 51% after the third year.

In an Asian context, Okunogbe and Pouliquen (2022) examined the impact of electronic filing systems on tax payments in Tajikistan. Their results demonstrated a significant increase of TJS 25,357 (USD 3,600) in high-risk companies upon the adoption of such systems.

Beyond systems, studies have focused on Information and Communication Technologies (ICTs) for tax collection. Kochanova, Hasnain, and Larson (2020) explored the enhancement of tax collection capabilities using ICTs. Their findings suggested an average increase of 0.75% in income tax collection relative to GDP after adopting transactional electronic filing systems.

Uyar et al. (2021) investigated the role of ICTs in reducing tax evasion in developing countries using indicators from the Global Competitiveness Index. They observed a reduction in tax evasion, ranging from 1.2% to 23%, across different indicators following the adoption of ICTs. Conversely, Mallick (2021) indicated that ICT infrastructure and governance quality did not significantly boost overall tax collection, especially when taxpayers could circumvent the tax system.

Jemiluyi and Jeke (2023) explored ICTs' role in mobilizing tax revenue in the Southern African Development Community (SADC), comprising developing countries. They found that employing ICTs in tax collection could lead to variable increases ranging from 0.002% to 0.18%, contingent on the efficiency of the technology employed.

The introduction of electronic invoicing has been pivotal in tax compliance and company performance. Bellon, Dabla-Norris, Khalid, and Lima (2022) analyzed the impact of electronic invoice adoption in Peru and noted over a 5% increase in sales, purchases, and Value Added Tax (VAT) obligations within companies in the first post-adoption year. This impact was notably pronounced for micro and small companies, witnessing an 11.6% rise in VAT liabilities.

In China, Fan et al. (2018) scrutinized the effect of adopting electronic invoice encryption on VAT revenues. Their estimates suggested that this reform contributed to 27.1% of VAT revenue and 12.9% of all government revenue between 2002 and 2007.

In Ecuador, Ramírez-Álvarez, Oliva, and Andino (2022) analyzed the electronic invoicing system's role in curbing tax evasion. They observed a substantial increase in VAT collection in the years following the system's introduction, reaching 19.4% in the first year and 28.1% in the second year.

Regarding sales recording machines, Ali et al. (2021) conducted a study in Ethiopia and found that their usage led companies to report increased sales, subsequently resulting in higher tax payments ranging from 18% to 32% in VAT, contributing to an overall fiscal capacity increase.

Mascagni, Mengistu, and Woldeyes (2021) investigated the effects of sales recording machines on tax collection. They observed a 47.7% increase in net VAT collection and a 12% increase in Income Tax collection. Additionally, they found that sending recommendation letters significantly boosted tax compliance, increasing it by about 16%.

Fjeldstad et al. (2020) investigated tax non-compliance behavior with electronic tax devices in Tanzanian companies. They noted that companies were more likely to comply with tax obligations when transacting with clients aware of the necessity to obtain receipts. This resulted in an average 24 percentage-point increase in VAT compliance.

Eissa and Zeitlin (2014) scrutinized the adoption rate and impacts on tax compliance following the introduction of electronic billing machines in Rwanda. Though adoption rates didn't meet expectations, VAT revenue increased by an average of 8%, suggesting that the use of electronic fiscal technologies can contribute to enhanced tax compliance.

Digitalization has also been studied concerning tax revenue generation. Kowal-Pawul and Przekota (2021) examined the significance of Value Added Tax (VAT) digitalization in the construction and wholesale/retail sectors in revenue disclosure. They observed an 18.75% increase in the second year compared to the first in the construction sector and a 31.88% increase in the third year compared to the second in the retail sector.

Frățilă, Păunescu, Nichita, and Lazăr (2023) investigated the effects of digitalizing the Romanian public sector on local tax revenue. Over the years, they noted average revenue increases ranging from 0.943% to 6.587%.

These studies underscore that utilizing standardized systems, adopting ICTs, implementing electronic invoicing, and employing sales recording machines contribute to increased tax revenue and reduced tax evasion, fostering greater tax compliance and strengthening government revenue collection capacities. In summary, a notable increase in revenue is evident across most studies. It's worth highlighting that in various tax types and contexts studied, revenue variations oscillate positively between 0.75% and 161.2%.

4.3.3 MOTIVATIONS AND CHALLENGES OF UTILIZING ELECTRONIC INVOICES

Recent studies have delved into understanding the intricacies of electronic invoice development and maturity. Poel, Marneffe, and Vanlaer (2016) identified both barriers and facilitators associated with electronic invoices. They revealed that companies perceive their use as reducing printing costs, saving time, enhancing storage efficiency, and enabling better process control. However, these companies also highlight security concerns as a critical point, although larger and more experienced companies tend to better appreciate the benefits.

On the other hand, Gunaratne and Pappel (2020) emphasized the inefficiencies of electronic invoices. They pointed out that users and experts identify three main themes contributing to a negative perception of this tool: operational aspects related to functionalities and standards in daily operations; technological aspects, such as system suppliers and the use of outdated technologies; and information security, echoing the concerns of Poel, Marneffe, and Vanlaer (2016).

Contrary to the security issues highlighted by these authors, Hernandez-Ortega and Jimenez-Martinez (2013) argued that habitual use of electronic invoices enhances companies' confidence in this technology. They also indicated that habit explains why these factors improve companies' performance when using it because frequent usage creates a positive feedback loop of information, improving confidence and allowing companies to benefit from its advantages.

Despite habit generating a positive perception of the usefulness of this technology, Olaleye and Sanusi (2017) demonstrated that resistance to using electronic invoices persists due to factors such as performance risk (concerns about the communication channel's functionality) and financial risk (concerns about potential monetary loss), which contribute to anxiety surrounding their use.

This resistance to adopting electronic invoices, highlighted by Haag, Born, Kreuzer, and Bernius (2013), is particularly higher among small companies, especially micro-enterprises, due to their lack of knowledge on the subject and the necessary procedures. Larger companies, in contrast, anticipate significant change management efforts.

Regarding the mandatory adoption of electronic invoices, Linh and Phuong (2020) pointed out three main issues that can affect their viability: regulatory issues (related to accounting and tax standards), information technology issues (including IT infrastructure such as internet access, hardware, and software), and issues related to psychology and market habits, like the preference for cash payments and the use of paper documents.

Addressing the factors influencing the adoption of electronic invoices, Lian (2015) indicated that expectation of effort, social influence, trust in e-government, and perceived risk significantly affect the intention to use. Additionally, trust in e-government and perceived risk mediate the relationship between behavioral intention and security concerns regarding e-government. A similar study conducted by Qi and Che Azmi (2021) found that perceived trust, like Lian (2015), and perceived benefits positively influence electronic invoice adoption. They noted that adoption positively impacts the overall efficiency of the tax compliance process, suggesting that factors influencing adoption may have a mediating effect on the efficiency of that adoption and the tax compliance process.

However, Jutumaa and Oorni (2011) suggested that a positive attitude towards adoption and intention to adopt are insufficient for complete adoption. Consumers do not generalize positive experiences related to partially adopted technology to all usage situations. Instead, they anticipate service providers to actively guide them on how, when, and where to change their behavior. This underscores the importance of providers taking responsibility for adoption, a characteristic that may be more prevalent in larger municipalities.

In summary, while electronic invoices highlight benefits and motivations, there are still lingering questions, particularly concerning their utilization in micro and small companies and the overall awareness level among companies and users.

4.4 DATA

4.4.1 SAMPLE

This dataset primarily focuses on municipal-level data due to the policy analysis conducted at the state level, which also influences the revenue transferred from states to

municipalities, as previously discussed in this study. Initially, the sample comprised 5,568 municipalities in Brazil, encompassing data from 2013 to 2016. To determine the initial year for our panel, we considered information from the Brazilian Public Sector Accounting and Tax Information System (SICONFI) at the municipal level, available from 2013 onwards. Given our interest in assessing the impact of NFC-e adoption on the ICMS share transfer from states to municipalities, it was crucial to balance the sample. Thus, we stopped our data collection in 2016 to ensure a balanced representation between treated and untreated cases. This decision was made to prevent bias in the results and subsequent analysis, as post-2016 data would include all states implementing the policy.

During the data refinement process, 880 municipalities were excluded due to inconsistencies in ICMS quota declarations. Most of these municipalities reported zero values for more than two years, leading to a reduced sample of 4,688 municipalities. However, for estimating the statistical model, as described in the empirical strategy section, we opted to exclude municipalities classified as metropolis (cities with more than 900,001 inhabitants) by the Brazilian Institute of Geography and Statistics (IBGE). This decision was made to facilitate finding municipalities similar enough to carry out the analysis required by the empirical strategy. Consequently, the final sample consisted of 4,662 municipalities.

4.4.2 INDEPENDENT VARIABLE

Our independent variable pertains to the adoption of NFC-e at states. It is noteworthy that in certain states, taxpayers were given the option of voluntary adherence. However, for our study, we focused on the initiation date of the obligation, irrespective of the criteria applied, as outlined in Table 1. Hence, the '*nfce'* variable is a dummy variable signifying the existence of the project in municipalities based on the legislation implemented by the state over the years.

4.4.3 DEPENDENT VARIABLE

The dependent variable in this study focuses on the transfer of the participation installment ICMS from states to municipalities per person. Data for the years 2014 to 2016 were gathered from the Public Sector Accounting and Fiscal Information System (SICONFI) and adjusted based on the Broad National Consumer Price Index (IPCA) from 2013, a key economic indicator in Brazil. These adjusted values were then divided by the estimated population of each

municipality for the respective years, obtained from the Brazilian Institute of Geography and Statistics (IBGE) population estimation survey.

To enhance clarity, these values are transformed using a logarithmic function. Therefore, the dependent variable in this study represents the logarithm of the ICMS participation portion transferred per inhabitant of the municipality. We chose to use the value of the participation installment ICMS portion per person, as one of the assumptions of the modernization theory refers to the macro-environmental factor of urbanization, which refers to population concentration in urban areas and the growth of cities. Therefore, capturing this variation can represent a better interpretation of the result at the local level.

4.4.4 CONTROL VARIABLES

In this study, two control variables were used in their logarithmic form. We consulted sources from the Brazilian Institute of Geography and Statistics (IBGE), specifically the Gross Domestic Product (GDP) survey of municipalities, to obtain information on GDP per capita, as used in previous studies by Kochanova, Hasnain and Larson (2020) and Uyar et al. (2021). In addition, we consulted the Central Business Register survey to obtain data on the number of companies operating in the municipality.

Therefore, one of the variables considered is based on recent empirical research, while the other variable, related to the number of active companies, is our addition. We believe that, within the scope of our research, this variable plays a crucial role as a control parameter. For example, variations in the number of local companies that issue NFC-e to consumers can directly impact the distribution of the ICMS portion.

Modernization theory identifies several relevant macro-environmental factors, such as economic progress, which may be associated with municipalities' GDP per capita and the number of companies in operation.

4.4.5 CONTROL AND TREATMENT GROUPS

We identified the year of NFC-e operation initiation in the state for our panel, following the criteria outlined by Pierson and Thompson (2016). Any adoption that commenced with at least one-third of the state's fiscal year remaining was considered implemented within that specific fiscal year. If an adoption was completed by the end of the state's fiscal year, it was

marked as not implemented until the subsequent fiscal year. Figure 1 demonstrates the progression of NFC-e project adoption across different states over the years.

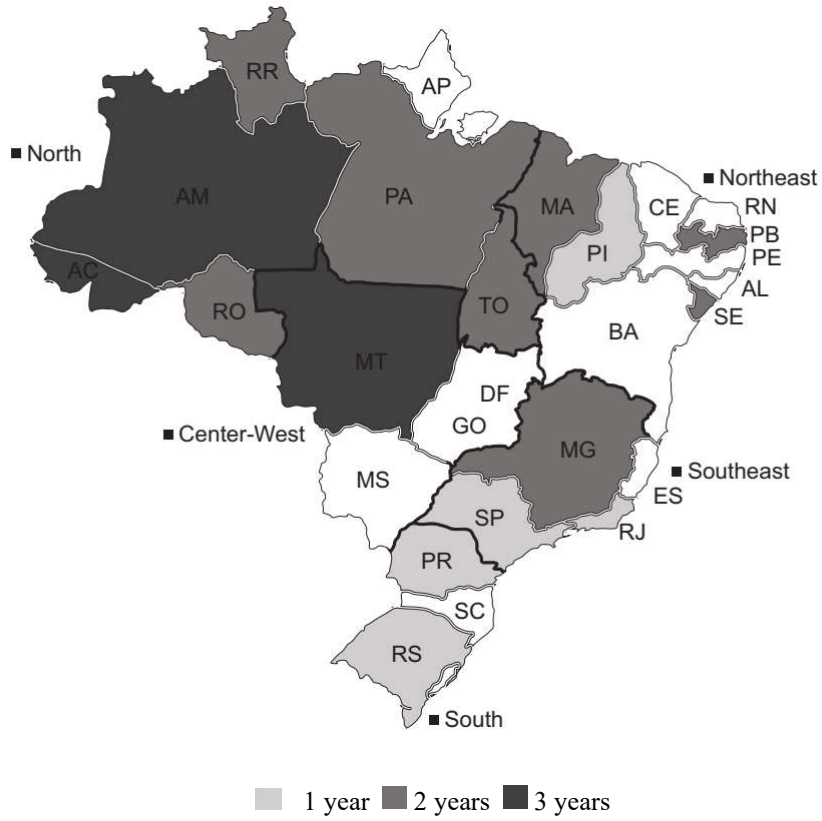

Figure 1. States with NFC-e operation
Note: This figure displays a map of Brazil showcasing the progression of NFC-e adoption across different states. The shaded areas indicate states that have implemented the NFC-e project.

By 2014, three states had implemented the project, encompassing 180 municipalities. Subsequently, in 2015, nine additional states joined, significantly increasing the coverage to 2,062 municipalities. This expansion was primarily attributed to the inclusion of states such as Paraná, Rio Grande do Sul, and São Paulo. In 2016, the NFC-e project further expanded to include Piauí, resulting in a total coverage of 2,411 municipalities due to state-level initiatives.

In our analysis, the treatment group comprised municipalities where the NFC-e project was operational in their respective states. The control group consisted of municipalities where the states began implementing the project in the last quarter of the year or where the innovation had not yet been adopted.

Table 2 presents descriptive statistics of the dependent variable and other variables. Notably, results from 2013 were excluded because no municipalities were subjected to treatment at that time. Hence, data from 2015 and 2016 are presented to compare the differences between the initial year of adoption (2014) of the treated municipalities.

Table 2: Descriptive statistics

	2014			2015			2016		
	(1)	(2)	t-test	(1)	(2)	t-test	(1)	(2)	t-test
	Treatment	Control	Difference	Treatment	Control	Difference	Treatment	Control	Difference
Variable	Mean/Standard erros	Mean/Standard erros	(1)-(2)	Mean/Standard erros	Mean/Standard erros	(1)-(2)	Mean/Standard erros	Mean/Standard erros	(1)-(2)
Participation installment ICMS per person	601.627	524.987	76.640*	651.383	379.686	271.697***	596.528	403.988	192.540***
	[31.594]	[7.953]		[13.250]	[8.914]		[10.312]	[9.427]	
Number of companies operating in the municipality	501.228	718.878	-217.651	978.502	524.028	454.474***	866.965	543.572	323.392***
	[124.262]	[31.099]		[55.954]	[32.440]		[50.603]	[34.003]	
GDP per capita	22678.585	19673.905	3004.680	28461.227	15909.275	12551.952***	26252.697	17634.620	8618.077***
	[1489.025]	[368.749]		[838.847]	[360.665]		[475.591]	[361.979]	
N	180	4472		2062	2590		2241	2411	
Number of observations			4652			4652			4652

Note: The value displayed for t-tests are the differences in means between groups, ***, ** and * indicate significance at the 1, 5 and 10 percent critical level, respectively.

In 2014, the average difference in Participation installment ICMS per person between municipalities with and without NFC-e was relatively small, around R$ 76.64 per person, without a significant discrepancy. However, by 2015, this difference increased significantly to approximately R$271.70 per person, indicating a more notable impact of NFC-e presence. Nevertheless, in 2016, there was a reduction in this difference to an average of R$179.20 per person, suggesting a weakening of the effect compared to the previous year. All differences in means between the groups are statistically significant.

Regarding number of companies operating in the municipality, in 2014, the average difference between municipalities with and without NFC-e was negative, indicating an average of approximately -217.65 companies in municipalities with the technology. However, by 2015, this difference significantly reversed to approximately 454.47 companies, indicating a substantial increase in the number of companies in municipalities that adopted NFC-e. By 2016, this difference stood at 323.39 companies. Although the 2014 difference was not statistically significant, the change in sign emphasizes the importance of the number of companies as a relevant variable.

The average difference in GDP per capita between the groups in 2014 was approximately R$3,004.68, without reaching statistical significance. However, in 2015, this difference significantly increased to approximately R$12,551.95, declining to approximately R$8,618.08 in 2016. Both 2015 and 2016 results are statistically significant at the 1% level.

These findings indicate a correlation between the adoption of NFC-e and the increase in ICMS participation share, the number of active companies in the municipalities, and GDP per capita. The analysis highlights significant changes over the studied years, emphasizing the influence of NFC-e on municipal economic variables.

4.5 EMPIRICAL STRATEGY

In formulating our empirical strategy, we utilized the classifications provided by the Brazilian Institute of Geography and Statistics (IBGE) to define our subsamples. IBGE categorizes municipalities based on population size into the following groups: Small Size I, encompassing up to 20,000 inhabitants; Small Size II, ranging from 20,001 to 50,000 inhabitants; Medium Size, comprising 50,001 to 100,000 inhabitants; Large Size, with 100,001 to 900,000 inhabitants; and Metrópole, consisting of 900,001 inhabitants or more.

We opted to establish this distinction by examining aspects associated with modernization theory, including urban concentration, which serves as the theoretical lens through which we assess the policy in question. Recognizing that population figures can fluctuate over time, we determined a municipality's classification group based on the population it had in the initial year of our panel. For instance, if a municipality had 20,000 inhabitants in 2013 but grew to 20,001 inhabitants in 2014, it would consistently be categorized as Small Size I across all years.

Our model's estimations were based on four distinct subsamples. Initially, the first subsample consisted of municipalities categorized as Small Size I (3,198). The second subsample comprised municipalities classified as Small Size II (912). The third subsample referred to medium-sized municipalities (299). Finally, the fourth subsample included the municipalities of Grande Porte (251). We intentionally excluded metropolises due to their limited number—only 16—and their high population density.

Therefore, in this work, we chose to follow the approach presented by Callaway and Sant'Anna (2021) as an empirical strategy. These authors' approach considers a natural generalization of the Average Treatment Effect on the Treated (***ATT***), based only on "clean"

comparisons, which is suitable for data with staggered adoption of the policy over time. The comparisons are said to be clean, as they focus on units that have never been treated or units that have not yet been treated to form the control group. Specifically, the ***ATT*** for time ***t*** is defined for individuals first treated in time ***g*** as:

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

where $Y_t(1))$ is the potential result, in our case, the value transferred from the ICMS share by the states to the municipalities at time t if treated, $Y_t(0)$ is the potential result at time t if not treated, and $G_g = 1$ is a binary variable that indicates that the individual belongs to the group whose treatment begins in period g. The $ATT(g,t)$ is a basic unit of analysis of the treatment effect, disaggregated by group of municipalities according to the initial treatment data and the period. A table with the description of all variables used in the model is available in Appendix B.

To ascertain $ATT(g,t)$ and its functionality, our model's primary provisions revolve around several key assumptions. First, it assumes the irreversibility of treatment, implying that once a unit receives treatment, it remains treated in subsequent periods, assuming no withdrawal from the project. Second, it presupposes limited anticipation of treatment for all groups eventually treated, meaning that companies do not alter their behavior in anticipation of future treatment approval. Lastly, it relies on conditional parallel trends based on a 'never treated' or 'not yet treated' group. This assumption states that, given control variables, the average outcomes for the group initially treated in period 'g' and the 'never treated' or 'not yet treated' group followed parallel paths in the absence of treatment. These assumptions are pertinent to the context of our work.

Callaway and Sant'Anna (2021) suggest three approaches to estimate $ATT(g,t)$: Outcome Regression (OR), Inverse Probability Weighting (IPW), or Doubly Robust (DR). In this work, we employed a DR approach, which combines both OR and IPW methods. It requires only one of these methods (OR or IPW) to properly specify the evolution of the outcome for the comparison group or the propensity score model—not necessarily both. To estimate standard errors, we adopted the WildBootstrap procedure with standard output, using 999 repetitions and applying the "Mammen" approach.

Pretreatment control variables may play a crucial role in the analysis. Therefore, in the results section, we provide outcomes with and without these control variables. The assumption

of conditional parallel trends, relying on a 'never treated' or 'not yet treated' group, highlights the necessity of including pre-treatment control variables potentially linked to the evolution of outcome $Y_t(0)$ during the post-treatment periods.

To assess this, the results display the p-values of the pre-treatment parallel trends test, which should not be statistically significant at any level when using the 'never treated' parameter. Additionally, the model explicitly excludes post-treatment control variables to prevent potential influence from the treatment.

To summarize the estimated $ATT(g,t)$ results, we employ the method outlined by Callaway and Sant'Anna (2021), which encompasses various aggregation approaches. These methods yield a unified treatment effect parameter, termed the simple ATT, akin to the two-period, two-group ATT.

Moreover, we conduct partial aggregations to highlight heterogeneity along specific dimensions, including (i) Variances in average treatment effects among treatment groups based on policy adoption data (group-specific effect); (ii) Trends in average cumulative treatment effects over time (calendar time effects); (iii) Variances in the average treatment effects based on the duration of exposure to the treatment (duration effects). These analyses enable us to explore different facets of the treatment effect while addressing variations in outcomes along these dimensions.

4.6 RESULTS

In this section, the results obtained from the application of the methodology proposed by Callaway and Sant'Anna (2021) for the aggregation of simple ATTs, by groups, calendar year, and dynamic effects will be presented. For each subsample, two models were considered: the first without the inclusion of control variables and the second with the inclusion of the two previously mentioned variables. The results regarding simple ATTs are presented in Table 3.

Table 3: Simple ATT

VARIABLE	(1) Small Size I	(2) Small Size I	(3) Small Size II	(4) Small Size II	(5) Medium Size	(6) Medium Size	(7) Large Size	(8) Large Size
ATT	0.0125***	0.00436	-0.0249***	-0.0239*	0.0118	**0.0273***	0.0245*	**0.0355****
	(0.00445)	(0.00955)	(0.00800)	(0.0133)	(0.0142)	(0.0154)	(0.0136)	(0.0146)
Controls								
Logarithmic GDP per capita	No	Yes	No	Yes	No	Yes	No	Yes
Logarithmic number of active companies	No	Yes	No	Yes	No	Yes	No	Yes
Test parallel trends	0.0001	**0.1815**	0.0301	0.0328	**0.1734**	**0.6940**	0.0000	**0.3083**
Observations	12,760	12,760	3,648	3,648	1,196	1,196	1,004	1,004

Notes: standard errors in parentheses. ***99% significance level (p<0.01), **95% significance level (p<0.05), *90% significance level (p<0.1).

In municipalities Small Size I, there exists a statistically significant and positive association in the model without controls. Nevertheless, this model fails the parallel trends test, which is an indication of the validity of one the assumptions adopted in our empirical approach. The model that includes controls also demonstrates a positive association, but it does not achieve statistical significance, despite meeting the assumption of parallel trends. In the case of municipalities Small Size II, both the models with and without controls reveal negative associations. Despite exhibiting statistical significance, both violate the parallel trends test.

For medium size municipalities, both models satisfy the parallel trends test. However, only the model with controls shows a statistically significant result, with a confidence level of 10%. This outcome suggests that, on average, the transfer of the participation installment ICMS increases by around 2.7% per person in these municipalities.

Regarding large size municipalities, the model without controls fails the parallel trends test, displaying a statistically significant positive association. Conversely, the model with controls does not violate parallel trends, and the results are statistically significant at a 1% level of significance. These findings indicate that, on average, these municipalities increase the transfer of the participation installment ICMS by approximately 3.6% per person. Detailed results of the ATTs by groups are presented in Table 4.

Table 4: ATT by groups

VARIABLE	(1) Small Size I	(2) Small Size I	(3) Small Size II	(4) Small Size II	(5) Medium Size	(6) Medium Size	(7) Large Size	(8) Large Size
G2014	0.0292**	0.0150	-0.0709***	-0.109***	-0.0355	-0.0291	0.0704***	**0.0865*** **
	(0.0129)	(0.0149)	(0.0201)	(0.0273)	(0.0368)	(0.0452)	(0.0187)	(0.0232)
G2015	0.00852*	0.00189	-0.0170*	-0.00798	0.0176	**0.0344** **	0.0221	**0.0329** **
	(0.00509)	(0.00940)	(0.00873)	(0.0142)	(0.0156)	(0.0142)	(0.0136)	(0.0149)
G2016	0.0399***	**0.0206***	0.0346**	0.0284*	0.0644	0.0832	0.0219	0.0140
	(0.00907)	(0.0105)	(0.0174)	(0.0163)	(0.0433)	(0.0523)	(0.0146)	(0.0130)
Controls								
Logarithmic GDP per capita	No	Yes	No	Yes	No	Yes	No	Yes
Logarithmic number of active companies	No	Yes	No	Yes	No	Yes	No	Yes
Test parallel trends	0.0001	**0.1815**	0.0301	0.0328	**0.1734**	**0.6940**	0.0000	**0.3083**
Observations	12,760	12,760	3,648	3,648	1,196	1,196	1,004	1,004

Notes: standard errors in parentheses. ***99% significance level (p<0.01), **95% significance level (p<0.05), *90% significance level (p<0.1).

Moving forward, the discussion will focus on results associated with control variables that adhere to the parallel trends test. The significance of understanding parallel trends and utilizing control variables became apparent during the analysis presented in Table 3 and the discussion of the empirical strategy.

In the subset consisting of Small Size I municipalities, only the 2016 group demonstrates a statistically significant positive result, reaching a significance level of 10%. These findings indicate that municipalities, where states implemented the NFC-e project, witnessed an average increase of around 2.1% in the transfer of the participation installment ICMS per person. Conversely, no statistically significant results were observed in the 2014 and 2015 groups.

Among medium-sized municipalities, solely the 2015 group displays a positive and statistically significant outcome at a 5% level. This discovery reveals that municipalities where states implemented the NFC-e project in 2015 experienced an average increase of approximately 3.4% in the transfer of the participation installment ICMS per person.

Regarding large municipalities, we observed positive and statistically significant outcomes at 1% and 5% levels for the 2014 and 2015 groups, respectively. In the 2014 group, there was an average increase of approximately 8.7% in the transfer of the participation installment ICMS per person, whereas in the 2015 group, this increase averaged about 3.3% per person. Subsequently, Table 5 highlights the dynamic effects. This implies the accumulation of ATTs over the time of exposure to treatment for all municipalities served.

Table 5: ATT by dynamic effects

VARIABLE	(1) Small Size I	(2) Small Size I	(3) Small Size II	(4) Small Size II	(5) Medium Size	(6) Medium Size	(7) Large Size	(8) Large Size
	(0.00788)	(0.0129)	(0.0143)	(0.0182)	(0.0235)	(0.0285)	(0.0184)	(0.0196)
Tm2	0.0448***	-0.0560	0.0210	0.0243	-0.00138	-0.00548	0.0287***	-0.00770
	(0.0114)	(0.0605)	(0.0226)	(0.0220)	(0.0172)	(0.0147)	(0.00821)	(0.0137)
Tm1	-0.00309	-0.00305	-0.0188**	-0.0364**	-0.0130	-0.0107	-0.0163	-0.0106
	(0.00477)	(0.00717)	(0.00786)	(0.0149)	(0.0130)	(0.0142)	(0.0121)	(0.0143)
Tp0	0.0257***	**0.0137****	0.00465	0.00394	**0.0255***	**0.0358****	0.0351***	**0.0421*****
	(0.00428)	(0.00663)	(0.00665)	(0.0117)	(0.0137)	(0.0150)	(0.00993)	(0.0108)
Tp1	-0.00379	-0.00657	-0.0455***	-0.0392**	0.00558	0.0267	0.00905	0.0236
	(0.00618)	(0.0138)	(0.0108)	(0.0160)	(0.0188)	(0.0178)	(0.0191)	(0.0183)
Tp2	0.0309	0.0109	-0.111***	-0.139***	-0.0823	-0.0686	0.160***	**0.185*****
	(0.0193)	(0.0239)	(0.0360)	(0.0392)	(0.0576)	(0.0696)	(0.0403)	(0.0392)
Controls								
Logarithmic GDP per capita	No	Yes	No	Yes	No	Yes	No	Yes
Logarithmic number of active companies	No	Yes	No	Yes	No	Yes	No	Yes
Test parallel trends	0.0001	**0.1815**	0.0301	0.0328	**0.1734**	**0.6940**	0.0000	**0.3083**
Observations	12,760	12,760	3,648	3,648	1,196	1,196	1,004	1,004

Notes: standard errors in parentheses. ***99% significance level (p<0.01), **95% significance level (p<0.05), *90% significance level (p<0.1).

When analyzing the subsets of municipalities in Table 6, we noticed increases in the transfer of the participation installment ICMS during the year of project implementation across all subsets that passed the parallel trends test. In small size municipalities I, the average increase was approximately 1.4% per person, significant at a 5% level. Medium size municipalities experienced an average increase of approximately 3.6% per person, statistically significant at level 5%, while large size municipalities saw an average increase of approximately 4.2% per person, statistically significant at 1%. The analysis period spans across all groups from 2014 to 2016.

In the second-year post-implementation, a positive and statistically significant result was only found in large size municipalities. The data reveals that these municipalities, exposed to the adoption of NFC-e projects by the states, increased the transfer of the participation installment ICMS by an average of approximately 19% per person, which also holds statistical significance at a 1% confidence level. During this period, only municipalities in states that implemented the NFC-e project in 2014 were included.

4.7 DISCUSSION

Upon analyzing the results outlined in the preceding section, a notable observation emerges. Across all aggregated measures of Average Treatment Effects (ATTs), municipalities categorized as large size and medium size demonstrated statistically significant positive effects. Conversely, in municipalities classified as small size I, a clear positive effect wasn't initially evident in the analysis of simple ATT. Nevertheless, there was evidence of a positive and statistically significant effect in certain subsets of other aggregate analyses. As for municipalities classified as small size II, they did not consistently exhibit positive and statistically significant results aligned with the specifics of the adopted empirical strategy.

The evidence presented suggests that larger municipalities tend to yield more significant outcomes compared to smaller ones. This observation aligns with a fundamental principle of modernization theory, positing that more advanced societies possess a greater ability to attain superior benefits compared to less developed ones (Barker, 2005; Nam, 2018; Uyar et al., 2021). Hence, given that municipalities with larger populations are typically linked to higher levels of modernity, it is reasonable to anticipate that they would achieve more significant outcomes through technological advancement and economic growth.

Modernization theory offers a valuable interpretative lens for understanding differences in performance between municipalities of different sizes. She suggests that the population size of a municipality can be a relevant marker of its degree of modernity, associating it with a broader spectrum of resources and opportunities. This theoretical perspective assumes that more populous municipalities tend to be more advanced due to a series of factors, such as the availability of more sophisticated infrastructure, easier access to technological innovations, a greater diversity of economic activities, and a more robust educational base.

Considering the intrinsic link between modernization, technological development, and economic growth, it's reasonable to anticipate that municipalities with larger populations will exhibit better performance in these areas. The concentration of resources and talent in these areas typically fosters an environment favorable to innovation and progress, resulting in comparative advantages in economic development, job creation, and technological advancements.

Larger municipalities, as they successfully assimilate and disseminate new technologies, tend to become more efficient in combating corruption. This phenomenon aligns with the principles outlined in modernization theory (Nam, 2018; Kock & Gaskins, 2014), where it represents a notable aspect of social change and transformation.

Conversely, smaller and less populated municipalities often exhibit a delay in adopting these new technologies. According to modernization theory, this delay stems from power inequality and a reluctance to navigate uncertainty (Nam, 2018). This trend is particularly prevalent in smaller municipalities, where companies are more inclined to postpone the implementation of mandatory technologies due to the lack of rigorous oversight.

The theme of oversight relates to the theoretical framework of the TOE (Technology-Organization-Environment) model, particularly emphasizing regulatory pressures within the environmental sphere (Kuan & Chau, 2001; Zhu et al., 2006). This suggests that densely populated municipalities are inclined to accommodate a higher concentration of companies and possess a greater capacity to integrate technologies, as proposed by modernization theory. As a result, it is anticipated that state governments will prioritize regulating companies situated in these municipalities, subsequently leading to an increased likelihood of technology adoption among these companies, as observed by Kuan and Chau (2001).

The interconnected nature of the market, influenced by the adoption of technologies due to regulatory pressures, is closely linked to the pursuit of efficiency and competitiveness. Standardizing the adoption of technologies reflects the quest for a competitive edge and cost reduction across the production chain (DiMaggio & Powell, 1983). This push to embrace technology is further emphasized by its direct impact on the operations and costs of the involved companies (Iacovou, Benbasat, & Dexter, 1995; Kuan & Chau, 2001; Sila, 2013; Teo, Wei, & Benbasat, 2003).

These technological adoption patterns mirror a business strategy, influenced by economic and regulatory factors. In larger municipalities, the presence of stricter regulations is evident, leading to a multiplier effect of technological coercion throughout the production chain. This is due to heightened visibility and regulatory scrutiny in these areas, which increases the pressure on companies to adopt technologies aligned with established standards (DiMaggio & Powell, 1983). This standardized approach to technology adoption not only fulfills regulatory requirements but also enhances operational efficiency and competitive advantage in an increasingly interconnected and dynamic business landscape.

Municipalities face various pressures beyond regulatory and coercive impositions. Larger municipalities influence smaller ones not just by setting examples but also by exerting mimetic pressure. In such scenarios, businesses situated in highly developed municipalities encounter an environment where they experience both the necessity to adopt similar practices and competitive pressures simultaneously.

Moreover, according to Lian (2015), companies are significantly influenced by the social dynamics of their operational environment. The pursuit of acceptance and validation within a business community often drives the adoption of practices aligned with social norms and performance expectations.

Consequently, mimetic pressures not only influence business decision-making but also play a pivotal role in establishing and upholding practices within a specific municipal context. This reflects the interplay between competition and social influences on businesses.

Large population centers experience a more immediate impact from the rapid dissemination of technologies. These areas concentrate most medium and large companies in Brazil, leading to higher rates of business concentration overall. In this context, it is assumed that companies situated in these centers are better positioned to reap the benefits resulting from the adoption of Electronic Consumer Invoices (NFC-e), as underscored in prior studies such as those conducted by Poel, Marneffe, and Vanlaer (2016) and Qi and Che Azmi (2021). These advantages encompass cost reduction linked to printing, time savings, optimized storage, and enhanced control of internal processes.

Poel, Marneffe, and Vanlaer (2016) highlighted significant disparities in how electronic invoice benefits are perceived, particularly concerning a company's size. A discernible trend shows that larger companies tend to comprehend and capitalize on these benefits more effectively, primarily due to their access to substantial budgetary resources. Conversely, micro and small companies, predominant in smaller municipalities, encounter challenges in leveraging these advantages due to insufficient human and technical resources required to address data security issues.

The events mentioned above illustrate two key points emphasized by Gunaratne and Pappel (2020) regarding operational and technological aspects. Smaller municipalities are situated farther from the hubs where technological advancements and human capital development take place. Consequently, they encounter challenges concerning operational functionality, daily standards, and access to software. Primarily, smaller municipalities lack access to locally available technologies and often lack professional software developers in their vicinity. Consequently, these municipalities encounter difficulties in modernizing their infrastructure as they rely on the spread of these technologies and the availability of developers in smaller towns, following the saturation observed in major urban centers.

Nevertheless, the absence of technology and the underdevelopment of software do not solely account for the issues affecting small municipalities. In many of these areas, businesses tend to be small in scale and have historically shown resistance to adopting electronic invoices

(Haag, Born, Kreuzer, and Bernius, 2013). This resistance may be attributed to the factors outlined by Gunaratne and Pappel (2020). However, it could also be linked to a lack of familiarity with the system. Regular usage has the potential to build trust in information technologies, consequently enhancing the perception of their usefulness and security (Hernandez-Ortega and Jimenez-Martinez, 2013).

However, beyond considering factors like familiarity, usefulness, and perceived security, there are additional concerns regarding performance, particularly concerning the functionality of electronic invoicing. Small businesses tend to avoid adopting regulatory mechanisms (Linh & Phuong, 2020) related to accounting and taxation, likely due to apprehension about extending state oversight into their operations. Financial concerns also emerge, connected to the risk of monetary losses. This could arise, for instance, from excessive tax charges or the potential scenario of issuing an invoice without receiving the corresponding payment from the consumer (Olaleye & Sanusi, 2017).

There are several persistent factors influencing the adoption of technology in smaller areas, as highlighted by Linh and Phuong (2020). Software availability is just one aspect; these municipalities also grapple with challenges related to internet accessibility, the local availability of hardware equipment, and the entrenched culture of barter transactions. The latter presents potential hurdles to implementing electronic invoicing. For instance, when consumers opt to pay via card (debit or credit), it necessitates the company to issue the NFC-e. This situation contrasts with urban centers, where, due to public safety concerns, individuals often avoid cash transactions.

The impact on the acceptance and spread of NFC-e in small municipalities can be influenced by various factors. One of these factors is associated with consumer perception. Because local companies may face potential limitations in accessing technology, consumers might not universally apply positive experiences related to technology. Instead, they might anticipate that the service providers they engage with take the lead in adopting such technology (Jutumaa & Oorni, 2011).

This viewpoint has prompted numerous states and municipalities to introduce fiscal education programs. These initiatives aim to bridge this perception gap by offering information and guidance to consumers and local businesses regarding the significance and advantages of embracing NFC-e.

Upon analyzing the results based on various forms of aggregating average treatment effects (ATTs), we commence with a discussion concerning the behavior of the simple ATT. The data presented in Table 3 reveal an uptick in the transfer of participation installment ICMS

portion allocated to medium size and large size municipalities that implemented the NFC-e project. This result contradicts the findings of Mallick (2021), which indicated a lack of increases in tax revenue. Nevertheless, this outcome aligns with other studies, such as those by Fjeldstad et al. (2020), Kochanova, Hasnain, and Larson (2020), Ali et al. (2021), Okunogbe, and Pouliquen (2022), showcasing enhancements in tax collection through the adoption of technologies.

Analyzing the ATTs grouped by years showed an uptick in participation installment ICMS transfer among large size municipalities that adopted the NFC-e project in their states in 2014. This discovery corroborates the findings outlined in studies by Fan et al. (2018) and Mascagni, Mengistu, and Woldeyes (2021). Both studies illustrated that introducing reforms via the integration of information technology resulted in significant enhancements in tax collection.

However, within the 2015 group, both medium size and large size municipalities showed positive outcomes regarding the increase in the transfer of the participation installment ICMS. Notably, among large size municipalities, a comparatively lower outcome was discovered when juxtaposed with the 2015 group in contrast to the 2014 group. These findings align with the study conducted by Ramírez-Álvarez, Oliva, and Andino (2022), which reported positive and significant results associated with using the electronic invoice system to enhance VAT collection.

In the case of large size municipalities, it was noted that only the subset associated with 2016 group did not exhibit statistical significance. This outcome could be attributed to the exclusive inclusion of municipalities from a single state, Piauí, within the 2016 group, while the 2014 group comprised three states, and the 2015 group encompassed nine states.

Conversely, in the small size I municipalities of the 2016 group, positive and significant results were observed, albeit with coefficients that were smaller than those found in the other groups. These findings align with the conclusions drawn by Ali et al. (2021) and Frățilă et al. (2023).

The dynamic effects revealed a positive increase in the transfer of the participation installment ICMS in small size I, medium size I, and large size municipalities during the year of project implementation. This strengthens the preceding discussion, suggesting that larger municipalities yield greater results. This aligns with Pierson and Thompson's findings (2016), which showed positive and statistically significant results for tobacco taxes in the initial year of a standardized system's implementation. Similar results were obtained by Bellon et al. (2022) in Peru, where the introduction of electronic invoices led to increased revenue.

The positive surge in participation installment ICMS transfer to large municipalities continued to rise in subsequent years. In the second year following the NFC-e project's introduction, a noteworthy increase in positive variation was observed. This trend corresponds to Pierson and Thompson's (2016) findings, noting a positive and significant impact in the system's second year, particularly concerning taxes linked to tobacco, entertainment, and vehicles. Additionally, it corroborates the conclusions of Ramírez-Álvarez, Oliva, and Andino (2022), who found advantageous results in Value Added Tax (VAT) collection after the second year, as well as the research by Kowal-Pawul and Przekota (2021), which observed an increase in VAT after the system's digitalization in the second year.

This trend also aligns with one of the findings of Uyar et al. (2021), showcasing the reduction in tax evasion through a long-term governmental vision. Hence, it is plausible that the observed increase, notably from the second year onwards, can be attributed to this perspective. State policies favoring the adoption of NFC-e primarily concentrate on larger urban centers, where a higher volume of consumer transactions and, theoretically, more significant modernization exists. Therefore, it's understandable that this result would take time to establish itself.

In summary, our findings indicate that medium size and large size municipalities benefit the most from participation installment ICMS transfer increase due to technological innovation policies like the NFC-e project. This emphasizes that various factors, as discussed earlier, can positively influence this transfer to smaller municipalities.

4.8 CONCLUDING REMARKS

This study aimed to analyze the impacts resulting from the adoption of the Electronic Consumer Invoice (NFC-e) project on the collection of the Tax on Circulation of Goods and Services (ICMS), focusing especially on how state policies regarding NFC-e implementation influenced the distribution of the ICMS share from states to municipalities. Our results indicate that larger municipalities were able to assimilate this policy more effectively, resulting in a significant increase in resource transfers.

The primary social contribution of this study underscores the necessity to modernize smaller municipalities so they can benefit from the innovation policies implemented by the states. If these municipalities could adopt these innovations more effectively, they could reduce their dependence on external resources and enhance the services provided to the community.

Previous studies have highlighted the potential of Information and Communication Technologies (ICTs) in improving tax revenue at the state level. Therefore, our work contributes to expanding scientific knowledge in the field of research investigating the relationship between the use of technology and fundraising performance.

From a management perspective, this study highlights the importance of states committing to implementing innovation policies in tax documents in all regions, not solely in large urban centers. Our results suggest that smaller municipalities may be less impacted by inspection compared to larger ones. If innovation policies could be successfully implemented in these smaller municipalities, an increase in ICMS collection would be expected, leading to an increase in transfers to these municipalities.

A fundamental limitation of this study is related to the lack of comprehensive data availability on ICMS share transfers for all Brazilian municipalities, leading to the reduction of our sample. Furthermore, due to the different implementation periods of the projects in the states, it was not possible to carry out a regional analysis due to the lack of sufficient observations to validate the empirical strategy adopted. Another limitation is the limited understanding of the mechanisms through which Information Technology in public management is influenced by politics. It is crucial to consider political factors to better understand IT adoption, including political interests, party dynamics, and institutional structures. A more comprehensive approach can significantly contribute to identifying effective IT adoption strategies.

For future quantitative research, it is recommended to explore other technological projects aimed at improving tax management in states and analyzing inter-regional data or by groups of states, considering other regional development characteristics not addressed in this study. From a qualitative perspective, it is suggested to investigate the challenges faced in the implementation of these state policies, from the development or acquisition of information technologies to the implementation process, including available resources, whether financial, structural, or human.

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APPENDICES

APPENDIX A - Document analysis

State: Acre	
Group	2014
Electronic website	http://sefaznet.ac.gov.br/nfce/
State legislation	Decree No. 5,257/2013; Decree No. 6,596/2013.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	06/01/2014
Initial obligated companies	Taxpayers listed in the single annex to decree 6,596/2013 (Named the taxpayers, do not follow an economic activity parameter).

Estado: Alagoas	
Group	-
Electronic website	http://www.sefaz.al.gov.br/nfce
State legislation	Decree No. 43,606/2015; Normative Instruction No. 23/2017; Normative Instruction No. 46/2015.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	10/01/2016
Initial obligated companies	Taxpayers who: a) have earned, in the previous calendar year, in the sum of their establishments, gross revenue equal to or greater than R$ 15,000,000.00 (fifteen million reais); b) at the beginning of its activity, whose annual gross revenue is expected to exceed R$ 120,000.00 (one hundred and twenty thousand reais).

State: Amapá	
Group	-
Electronic website	http://www.sefaz.ap.gov.br/detalhe?id=9
State legislation	Decree nº 2970/2016.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	01/01/2017
Initial obligated companies	As of 01/01/2017 for the taxpayers provided for in Article 2 of Annex XXIII of regulation (Establishments that carry out the sale or resale of goods at retail and companies providing services and that have annual gross revenue above R $ 120,000.00 (one hundred and twenty thousand reais) is required to use Fiscal Coupon Issuer (ECF) equipment, which is capable of printing, in its basic software, obligatorily, the credit or debit receipt relating to the use of electronic transfer of funds – TEF).

State: Amazonas	
Group	2014
Electronic website	http://portalnfce.sefaz.am.gov.br/
State legislation	GSEFAZ Resolution No. 22/2013; Decree No. 34,459/2014.
The type of system adopted	Own
Voluntary membership	Yes
Compulsory start date	03/01/2014
Initial obligated companies	From March 1, 2014, for taxpayers listed in Annex I of GSEFAZ Resolution No. 22/2013 (Named taxpayers, does not follow an economic activity parameter)

State: Bahia	
Group	-
Electronic website	https://www.sefaz.ba.gov.br/scripts/default/nfiscalconsumidor.asp
State legislation	Articles 107-A to 107-I of the RICMS.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	08/22/2017
Initial obligated companies	I - 08/22/2017, in each new establishment registered in the CAD-ICMS of this State; II - 01.03.2018, in establishments registered in the taxpayer register of the State of Bahia that calculate tax using the tax current account regime.

State: Ceará	
Group	-
Electronic website	1) http://nfce.sefaz.ce.gov.br/pages/index.jsf 2) https://cfe.sefaz.ce.gov.br/mfe/informacoes/legislacao-estadual#/
State legislation	Decree No. 31,922/2016; Normative Instruction No. 10/2017.
The type of system adopted	Technology transfer
Voluntary membership	No
Compulsory start date	01/02/2017
Initial obligated companies	Taxpayers falling into one of the following subclasses of the National Classification of Economic-Fiscal Activity (CNAE Fiscal): a) 4771-7/01 - Retail trade of pharmaceutical products, without formula manipulation; b) 4771-7/02 - Retail trade of pharmaceutical products, with manipulation of formulas; c) 4771-7/03 - Retail trade of homeopathic pharmaceutical products; d) 4771-7/04 - Retail trade of veterinary medicines. From May 1, 2017, for all new retail establishments registered in the General Tax Registry (CGF), independent of CNAE-Fiscal.

State: Distrito Federal	
Group	-
Electronic website	https://receita.fazenda.df.gov.br/
State legislation	Ordinance nº 234/2014.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	01/01/2016
Initial obligated companies	Art. 1. They are obliged to issue the Electronic Consumer Invoice - NFC-e, model 65, provided for in articles 79 and 88-C of Decree No. 18,955, of December 22, 1997, and in article 76 of Decree No. 25,508, of January 19, 2005, all taxpayers who carry out sales operations or provision of services, in retail, aimed at final consumers, in person or for home delivery.

Sate: Espiríto Santo	
Group	-
Electronic website	https://sefaz.es.gov.br/consulta-nfce
State legislation	Ordinance No. 08-R/2017; Decree No. 1,090-R/2002.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	01/01/2018
Initial obligated companies	Art. 2 From January 1, 2018, the accreditation referred to in art. 1st will be required for all retail establishments located in this State.

State: Goiás	
Group	-
Electronic website	https://www.economia.go.gov.br/receita-estadual/documentos-fiscais/nfce.html
State legislation	Art. 167-S-A to 167-T of the RCTE-GO; Art. 114, XXXIV and XXXV of RCTE-GO; IN 1,278/2016-GSF.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	01/01/2017
Initial obligated companies	a) for taxpayers whose economic activity falls within the following codes of the National Classification of Economic Activities - CNAE: 1. 4731-8/00 of CNAE, retail trade of fuels for motor vehicles; 2. 4732-6/00 from CNAE, retail investment trade; b) for taxpayers registered in the State Taxpayer Registry - CCE as of January 1, 2017.

State: Maranhão	
Group	-
Electronic website	https://sistemas1.sefaz.ma.gov.br/portalsefaz/jsp/pagina/pagina.jsf?codigo=1693
State legislation	Administrative Resolution No. 02/2017; Administrative Resolution No. 19/2016; Administrative Resolution No. 18/2013.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	03/01/2017
Initial obligated companies	I – March 1, 2017, with annual revenue equal to or greater than R$ 10,000,000.00 (ten million reais); II – May 1, 2017, with annual revenue equal to or greater than R$7,500,000.00 (seven million and five hundred thousand reais) and less than R$10,000,000.00 (tem million reais); III – September 1, 2017, with annual revenue equal to or greater than R$3,600,000.00 (three million and six hundred thousand reais) and less than R$7,500,000.00 (seven million and five hundred thousand reais); IV – November 1, 2017, with annual revenue equal to or greater than R$ 1,800,000.00 (one million and eight hundred thousand reais) and less than R$ 3,600,000.00 (three million and six hundred thousand reais); V – December 1, 2017, other taxpayers, regardless of the amount of revenue.

State: Mato Grosso	
Group	2014
Electronic website	https://www.sefaz.mt.gov.br/portal/nfce/
State legislation	Section XIII-D of the RICMS; Ordinance No. 77/2013.
The type of system adopted	Own
Voluntary membership	Yes
Compulsory start date	02/01/2014
Initial obligated companies	The legislation does not make it clear how the mandatory schedule worked. It only asks questions that share the effect.

State: Mato Grosso do Sul	
Group	-
Electronic website	https://www.nfce.ms.gov.br/
State legislation	Decree No. 14,508/2016 and amendments; Sub-Annex 20 of Annex 015 and amendments.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	03/01/2017
Initial obligated companies	I - from March 1, 2017, in cases where the annual gross revenue, in the year 2016, is greater than R$6,000,000.00 (six million reais).

State: Minas Gerais	
Group	-
Electronic website	http://www.sped.fazenda.mg.gov.br/spedmg/nfce/
State legislation	Decree No. 47,562/2018; Resolution No. 5,234/2019; Resolution No. 5,313/2019; Resolution No. 5,379/2020; RICMS - Section III of Chapter IV of Part 1 of Annex V.
The type of system adopted	Technology transfer
Voluntary membership	No
Compulsory start date	03/01/2019
Initial obligated companies	I - March 1, 2019, for taxpayers who register in the Taxpayer Registry of this State from that date onwards; II - April 1, 2019, for taxpayers: a) classified under code 4731-8/00 of the National Classification of Economic Activities - CNAE - (retail trade of fuels for motor vehicles); b) whose annual gross revenue earned in the base year 2018 is greater than the amount of R$100,000,000.00 (one hundred million reais), subject to the provisions of §§ 4 to 6.

State: Pará	
Group	2015
Electronic website	http://nfce.sefa.pa.gov.br/
State legislation	Decree nº 1088/2014; Normative Instruction No. 11/2014; Normative Instruction No. 28/2014; Normative Instruction No. 19/2015; Normative Instruction No. 23/2016; Normative Instruction No. 02/2017; Normative Instruction No. 07/2017; Normative Instruction No. 08/2017; Ordinance No. 58/2014.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	06/01/2015
Initial obligated companies	I - June 1, 2015, for establishments linked to the Special Executive Coordination of Tax Administration for Large Taxpayers - CEEAT-GC that sell or supply goods to natural or legal entities that are not ICMS taxpayers.

State: Paraíba	
Group	2015
Electronic website	https://www.sefaz.pb.gov.br/info/notas-fiscais/nfc-e
State legislation	Ordinance No. 259/2014.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	07/01/2015
Initial obligated companies	As of July 1, 2015, retail establishments with revenue exceeding R$ 25,000,000.00 (twenty-five million reais) in 2013 will be required to issue an Electronic Consumer Invoice (NFC-e), if it falls within the provisions of art. 338 (ECF obligation) of the ICMS-PB Regulation.

State: Paraná	
Group	2015
Electronic website	https://sped.fazenda.pr.gov.br/NFCe/Pagina/Apresentacao
State legislation	Tax Procedure Rule No. 100/2014; SEFA Resolution No. 145/2015.
The type of system adopted	Own
Voluntary membership	Yes
Compulsory start date	07/01/2015
Initial obligated companies	I - July 1, 2015: 4731-8/00 - RETAIL TRADE OF MOTOR VEHICLE FUEL. It followed a monthly schedule by segments until January 2016.

State: Pernambuco	
Group	-
Electronic website	https://www.sefaz.pe.gov.br/Servicos/Nota-Fiscal-de-Consumidor-Eletronica/Paginas/default.aspx
State legislation	Decree No. 44,650/2017 - arts. 147 to 149; SF Ordinance No. 192/2017.
The type of system adopted	Technology transfer
Voluntary membership	No
Compulsory start date	08/01/2017
Initial obligated companies	I – for taxpayers registered with Ccepe as of August 1, 2017; and II – from January 1, 2018, for other taxpayers, observing the schedule established in the Sefaz ordinance (by the ordinance linked to food).

Estado: Piauí	
Group	2016
Electronic website	https://portal.sefaz.pi.gov.br/documentoseletronicos/portal/nfce/
State legislation	GSF Ordinance No. 606/2015.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	11/01/2015
Initial obligated companies	I - those obliged to use the ECF who have not complied with this requirement by the effective date of the Ordinance and those who adhere voluntarily under the terms of art. 3rd.

State: Rio de Janeiro	
Group	2015
Electronic website	http://www.fazenda.rj.gov.br/sefaz/faces/menu_structure/servicos/navigationContribuinte/conluna1/menu_servico_icms/ICMS-DFE?_adf.ctrl-state=kngzmb6qv_5&_afrLoop=85608948060554132
State legislation	Book VI of RICMS/2000, Decree nº 27,427/2000; Annex II-A of Part II of SEFAZ Resolution No. 720/2014; SAF Ordinance No. 2155/2016; SAF Ordinance No. 2047/2016; SAF Ordinance No. 1959/2015; SAF Ordinance No. 1814/2015.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	10/01/2014
Initial obligated companies	Those required to use ECF have not requested authorization to use the equipment by September 30, 2014, observing the provisions of §§ 1 and 10 of this article.

State: Rio Grande do Norte	
Group	-
Electronic website	https://www.set.rn.gov.br/contentProducao/aplicacao/set_v2/nfce/gerados/inicio.asp
State legislation	Decree No. 26,002/2016.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	01/01/2017
Initial obligated companies	Mandatory for new taxpayers, except those who had at least one ECF establishment registered with the CCE-RN before that date, and for taxpayers who carry out activities (main or secondary) in 453 – Sale of parts and accessories for motor vehicles; 454 – Sale, maintenance and parts of motorcycles, parts and accessories; 475 – Retail trade of computer and communication equipment; household equipment and articles; 476 – Retail trade of cultural, recreational and sporting goods.

State: Rio Grande do Sul	
Group	2015
Electronic website	https://www.rs.gov.br/carta-de-servicos/servicos?servico=1724
State legislation	Updates from: Decree nº 37,699/1997 (RICMS), Book II, Art. 26-C; DRP Normative Instruction No. 045/1998, Title I, Chapter XI, Section 29.0; Decree No. 37,699/1997 (RICMS), Book II, art. 8th, Section I, "j" and "k"; Decree No. 37,699/1997 (RICMS), Appendix XLIV.
The type of system adopted	Own
Voluntary membership	No
Compulsory start date	09/01/2014
Initial obligated companies	Taxpayers included in the general modality who jointly promote wholesale and retail trade operations.

State: Rondônia	
Group	2015
Electronic website	https://www.nfce.sefin.ro.gov.br/legislacao.jsp
State legislation	Normative Instruction No. 003/2014.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	03/01/2015
Initial obligated companies	From March 1, 2015, taxpayers who, in the sum of their establishments, have earned, in the calendar year 2014, gross revenue equal to or greater than R$ 12,000,000.00 (twelve million Reais).

State: Roraima	
Group	2015
Electronic website	https://www.sefaz.rr.gov.br/nfc-e
State legislation	Ordinance No. 768/2014
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	01/07/2015
Initial obligated companies	From July 1, 2015, for taxpayers located in the Capital, except those opting for Simples Nacional.

Estado: Santa Catarina	
Group	-
Electronic website	https://www.sef.sc.gov.br/servicos/servico/136/NFC-e_-_Nota_Fiscal_de_Consumidor_Eletr%C3%B4nica
State legislation	Annex 11 of the RICMS/SC (from art. 93); DIAT Act nº 022/2020; DIAT Act nº 38/2020; DIAT Act nº 53/2020.
The type of system adopted	-
Voluntary membership	-
Compulsory start date	-
Initial obligated companies	-

State: São Paulo	
Group	2015
Electronic website	http://www.nfce.fazenda.sp.gov.br/NFCePortal/
State legislation	Decree No. 61,084/2015; CAT Ordinance No. 147/2012; CAT Ordinance No. 12/2015.
The type of system adopted	Own
Voluntary membership	Yes
Compulsory start date	07/01/2015
Initial obligated companies	I - replacing the Tax Coupon issued by Tax Coupon Issuing equipment - ECF, from the date of registration in the ICMS Taxpayer Register, for establishments that will be registered from 07/01/2015.

State: Sergipe	
Group	2015
Electronic website	http://nfce.se.gov.br/
State legislation	Ordinance No. 312/2014; Decree No. 29,108/2013.
The type of system adopted	Technology transfer
Voluntary membership	Yes
Compulsory start date	11/01/2014
Initial obligated companies	The state provided an annex with the names of companies that would be required from this date, without defined criteria.

State: Tocatins	
Group	-
Electronic website	http://www.sefaz.to.gov.br/nfce/index.jsf
State legislation	SEFAZ Ordinance No. 510/2018 revoked by No. 262/2022
The type of system adopted	Technology transfer
Voluntary membership	No
Compulsory start date	01/07/2018
Initial obligated companies	I - July 1, 2018, for establishments just starting their activities.

APPENDIX B – Variables description summary

Variable	Description	Type
Adoption of NFC-e at states	Indicates whether the nfc-e project is being implemented in the state to which the municipality belongs.	Independent.
Transfer of the participation installment ICMS.	Transfer of the value of the ICMS participation portion from states to municipalities per person.	Dependent.
Logarithmic number of companies operating in the municipality.	Log number of active companies in the municipality in the year.	Control.
Logarithmic GDP per capita	Log value of the municipality's GDP per capita in the year.	Control.

5 GENERAL CONCLUSIONS

Information Technology (IT) plays a fundamental role in restructuring tax administrations, offering numerous opportunities to enhance the collection and analysis of information, efficiently manage workloads and available resources, promote collaborative engagement, and standardize the treatment of taxpayers. This thesis investigated the use of IT in tax administrations, presenting the results obtained in three distinct essays.

Throughout this research, the strategic significance of IT in optimizing tax processes has been emphasized. Technological advances enable not only the modernization of data collection methods but also the implementation of more sophisticated analytical tools, capable of extracting valuable insights from available information. This, in turn, enhances the ability to understand tax patterns, identify areas of risk, and make informed decisions to improve the effectiveness of tax administrations.

Moreover, effective workload and resource management, facilitated by IT, stand out as crucial factors contributing to the operational effectiveness of tax administrations. Automating routine tasks and deploying integrated systems foster a more efficient utilization of human and technological resources, enabling a targeted focus on activities of greater complexity and added value.

In the realm of cooperative engagement, information technology (IT) plays a pivotal role in establishing platforms and systems that foster collaboration among tax administrations and between them and taxpayers. Promoting a secure and efficient digital environment contributes to cultivating a more transparent and collaborative relationship, reducing potential conflicts, and enhancing tax compliance.

Standardization in the treatment of taxpayers, facilitated by IT, ensures a more equitable and consistent application of tax policies. Computerized systems and standardized protocols decrease the likelihood of disparities in the treatment of taxpayers, promoting tax fairness, and bolstering trust in tax administration.

In the first essay, a systematic literature review (SLR) was conducted to analyze how researchers have explored the relationship between the use of IT and tax revenue. The SLR revealed the existence of three research clusters: the impacts of IT on tax collection; the factors that influence technology adoption in this context; and aspects related to IT and its application in tax administration. However, it was found that research in this area is still in its early stages, suggesting the need for further studies to deepen the understanding of the role of IT in tax

collection. Additionally, the main challenges of IT implementation in governments were identified, and an agenda for future investigations in this field was provided.

Among the technologies identified in the systematic literature review, the standardized electronic tax system, explored in the second essay, stands out. This study analyzed the effects of adopting this system on the tax collection of Brazilian municipalities, using a database composed of 146 municipalities in the state of Rio Grande do Norte from 2013 to 2018. The results revealed that Urban Property and Territorial Tax (IPTU) had an average increase of around 52%, while the Tax on Services of Any Nature (ISSQN) showed an average increase of approximately 43%. When analyzing the effects over time, an average increase of approximately 77% in IPTU collection after the third year and an average increase of approximately 72% in ISSQN collection after the fourth year were observed.

In the third essay, the Electronic Consumer Invoice (NFC-e) and its impact on the Tax on Circulation of Goods and Services (ICMS) were discussed. Utilizing a database comprising 4,652 municipalities in Brazil from 2013 to 2016, the study applied the difference-in-differences approach proposed by Callaway and Sant'Anna (2021). The results indicated varying effects of NFC-e adoption on municipalities, contingent upon their size. Larger municipalities demonstrated more significant increases in the participation installment in the ICMS per person transfer by the states. On average, large municipalities experienced a 3.6% per capita increase, while medium-sized municipalities achieved a 2.7% per capita increase. Over time, large municipalities exhibited an average 18.6% per capita increase in the participation installment in the ICMS.

These essays emphasize the significance of employing IT in tax administrations to enhance tax collection. The implementation of standardized electronic tax systems and the adoption of NFC-e have proven to be effective in enhancing municipal collection, thereby contributing to increased revenue from taxes such as IPTU and ISSQN. Our results suggest that these technologies offer significant advantages, including the reduction of tax evasion, simplification of tax collection processes, and improvement in administrative efficiency.

Nonetheless, it is essential to highlight that the integration of IT into tax administrations extends beyond the mere implementation of systems and technologies. Equally crucial is the focus on training public servants, fostering awareness, engaging taxpayers, and ensuring the security and protection of tax data, as exposed in the challenges found in the results of the first essay. Furthermore, there is a necessity to formulate policies and strategies that promote digital inclusion and mitigate socioeconomic disparities, allowing all segments of society to enjoy the advantages of IT-driven enhancements.

Given the results obtained in this thesis, the need for continuous investment in the IT area in tax administrations becomes evident. Governments must prioritize the modernization of tax systems, promoting the integration of advanced technologies, such as artificial intelligence and data analysis, to strengthen the efficiency and effectiveness of tax collection. Furthermore, it is essential to encourage cooperation between governments, sharing good practices and experiences in IT implementation.

In conclusion, leveraging Information Technology (IT) in tax administrations presents a valuable opportunity to enhance tax collection, foster tax justice, and propel socio-economic development. The conducted essays in this thesis underscore the advantages stemming from the adoption of standardized electronic tax systems and the utilization of NFC-e. Nevertheless, there exists a scope for further advancement and in-depth research on this subject, particularly concerning the challenges of IT implementation and its impacts on various contexts and groups of taxpayers. The pursuit of innovative solutions and investment in training professionals in this field are crucial steps toward maximizing the benefits of IT in tax administrations, ensuring a more efficient and equitable tax environment.

As future directions, this thesis aims to be continued through other experimental approaches. Our systematic literature review (SLR) revealed the existence of three clusters, one of which is dedicated to factors that influence adoption. Therefore, we intend to carry out a quantitative study involving users and companies, to investigate the factors that lead to the adoption of standardized electronic tax systems, such as electronic invoices. This study should employ structural equation modeling, a method widely used in the articles analyzed in our RSL.

Furthermore, through RSL, we have identified the primary challenges that governments face when implementing technologies in tax administration. Consequently, we plan to conduct a qualitative study with municipal and state managers to explore these challenges in detail. Additionally, we intend to evaluate the feasibility of other studies, including the analysis of statewide projects, as well as electronic invoices and electronic consumer invoices.

During the data collection phase, we gathered information on states' expenditures on investments in information technology. Subsequently, we contemplated conducting a study to analyze the efficiency of these investments, specifically focusing on the returns in tax revenue obtained. Additionally, a national project has been underway since 2022 to standardize the electronic service invoice (NFS-e). As of January 5, 2024, it has garnered the participation of 1,015 entities, including 18 capitals and 997 municipalities. In this context, assessing the impact of this new project on the collection of the Tax on Services of Any Nature (ISSQN) is also a viable consideration.

In summary, the essays conducted in this thesis underscore the significance of information technology in tax administrations, emphasizing the advantages brought about by the implementation of electronic systems and the adoption of new technologies. Nevertheless, it is crucial to acknowledge that the integration of IT extends beyond mere system implementation, necessitating ongoing investments, proper training, taxpayer awareness, and the safeguarding of tax data. Simultaneously, promoting digital inclusion and mitigating socioeconomic inequalities is essential to ensure that everyone can reap the benefits of these advancements.