30º Prêmio Tesouro de Finanças Públicas

Revista
Cadernos de Finanças Públicas

2026

Edição Especial

TESOURONACIONAL

Impact of the Implementation of NFC-E and the Nota Premiada Bahia Program on Tax Collection in the State of Bahia

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ABSTRACT

In order to analyze auxiliary policies to combat tax evasion, this work evaluated, for the State of Bahia (Brazil), the implementation of the Electronic Consumer Invoice (NFC-e), a digital tax document that is mandatory for transactions with final consumers. In a complementary way, it also evaluated the impact of a state program of tax lotteries for consumers (Nota Premiada Bahia - NPB). The mandatory determination of NFC-e increased, in Bahia, the revenue reported by companies by 6.75%. For companies that are not subject to tax substitution, this value reaches up to 10.7%. The NPB program awards increased the request for invoices by up to 12.8% for small municipalities in Bahia.

Keywords: tax evasion; invoice technologies; e-invoicing; tax lotteries; differences-in-differences.
JEL Classification: D22, H26, H27

SUMMARY

1. INTRODUCTION 4
2. INSTITUTIONAL ASPECTS 5
2.1 Tax Evasion 5
2.2 Tax on the Circulation of Goods and Services (ICMS) 8
2.3 Incentives in Tax Enforcement Policies 9
2.4 Electronic Tax Receipt (NF-E) and Electronic Consumer Tax Receipt (NFC-E) 11
2.5 Bahia Award Program (NPB) 12
2.6 Tax Substitution 13
3. METHODOLOGY AND DATA 15
3.1 Potential Results and Differences-in-Differences 15
3.2 Company Data – Revenues and Registrations 18
3.3 Data from Tax Invoices and the Bahia Award-Winning Invoice Program 22
4. RESULTS 25
4.1 Impact of NFC-E Implementation – DiD by Companies 25
4.1.1 Heterogeneity Analysis – Effect by Municipality Size 29
4.2 Impact of the Bahia Premium Invoice Program 31
5. CONCLUSION 34
BIBLIOGRAPHICAL REFERENCES 36
APPENDICES 39

1. INTRODUCTION

Tax evasion is a problem that affects governments in general, especially in developing countries. Gordon and Li (2009) estimate that developing countries collect, as a fraction of GDP, only two-thirds or less of the average tax revenue collected by developed countries. In the context of Value Added Tax (VAT), the main complication of tax evasion is concentrated at the end of the chain, in sales to the final consumer, as they have no financial incentive to correctly record the transaction.

To combat this obstacle, over the past decade, Brazilian tax authorities have developed and instituted the Electronic Consumer Invoice (NFC-e), a document that must be issued in transactions with end consumers. In addition, several states have also implemented state programs offering tax incentives to consumers via lotteries or prizes based on the tax paid on their transactions. Both programs are useful tools for increasing tax collection through a logic distinct from *enforcement* itself.

Given the importance of such programs in the country's scenario, this study aims to identify, based on Difference-in-Differences models, the impact of the implementation of the NFC-e on the revenue reported by Bahian companies to the state tax authorities. In addition, it aims to analyze whether tax lottery prizes, under the Nota Premiada Bahia program, have changed the behavior of Bahian consumers in relation to the issuance of invoices in their municipalities.

Similar to Naritomi (2019), the DiD model uses the differentiation of companies by IBGE's National Code of Economic Activities (CNAE) into a treatment group (retail sector) and a control group (wholesale sector).

Based on an individual model of the companies, it was identified that the implementation of the NFC-e in the state of Bahia led to an increase of up to 10.7% in the revenue reported by companies in Bahia. For companies less subject to tax substitution (ST), it is possible to identify a significant increase in the impact of NFC-e (between 50% and 70%). This result may be indicative in favor of the ST institute in combating tax evasion. Tax substitution consists of a form of advance payment, at the beginning of the commercial chain, of the tax due on sales to the final consumer.

It should be noted that the impact identified by the implementation of NFC-e probably represents a floor for the program's effect, since the wholesale sector (control group) is affected to a lesser extent by the implementation of the policy. Even wholesale companies can carry out commercial operations subject to the issuance of NFC-e.

In addition, the effect on companies was not uniform across all municipalities in Bahia. Companies in municipalities with a population of less than 20,000 inhabitants showed no change in reported revenue, unlike companies in other locations with larger populations.

With regard to the Bahia Prize Note program, a change in consumer behavior was identified in municipalities that received prizes for the first time. It was found that, in the six months after having a first winner of the draw, municipalities with a population of less than 20,000 inhabitants had an increase of about 7.6% in the value issued in NFC-e. For municipalities between 20,000 and 50,000 inhabitants, this increase reached 12.8%.

It is worth noting that these policies were evaluated for a state with socioeconomic conditions that differ from other Brazilian entities. Bahia has labor market indicators below the Brazilian average. In 2023, for example, it had an unemployment rate of 13.2% and an informality rate of 53.7%, while these figures for Brazil averaged 7.8% and 39.2%, respectively.

This discussion is also quite relevant to the current Brazilian scenario. The tax reform will establish a new dynamic in the relationship between taxpayers, consumers, and tax authorities. New technologies for issuing tax documents and recording transactions between taxpayers and consumers will likely be implemented. In addition, Complementary Law No. 214/25 provides for the possibility of creating tax compliance incentive programs financed by up to 0.05% of the revenue from the new taxes created (tax and contribution on goods and services - IBS and CBS). At current prices, such initiatives could reach R$ 500 million per year.

This study is divided as follows: Section 2 deals with institutional aspects related to tax evasion, the implementation of tax documents, and the Bahia Prize Note program; Section 3 discusses the methodology and data used for this study; Section 4 shows the results of the proposed models; and Section 5 concludes this study by highlighting the importance of auxiliary *enforcement* policies as efficient means of increasing tax collection.

2. INSTITUTIONAL ASPECTS

2.1 Tax Evasion

On a daily basis, people treat the term tax evasion as any action in which the taxpayer fails to pay taxes illegally or apparently legally, but with loopholes in tax laws. However, this term has a different meaning in tax law. Alexandre (2016) identifies and illustrates the three means of evading tax payments:

• **Tax evasion:** The taxpayer uses illegal means to escape taxation, such as not issuing invoices or falsifying accounting records.

• **Tax avoidance:** The taxpayer uses legal means to escape taxation or make it less burdensome, such as deducting health and education expenses from personal income tax.

• **Tax avoidance:** The taxpayer's behavior is not strictly illegal, but it takes an artificial form (a simulation). For example, in a case where two parties, instead of signing a contract for the purchase and sale of land, create a company in which A contributes the capital and B contributes the land. Shortly thereafter, the company is dissolved, with B retaining the capital and A retaining the land. There is a clear simulation of the purchase and sale to avoid paying the Real Estate Transfer Tax (ITBI).

The approach of this study is more economic than legal, and any form of avoiding paying taxes that is illegal (evasion) or simulated (avoidance) will be treated as tax evasion.

Tax evasion has several negative impacts on the economy: a reduction in the provision of public goods and services due to the loss of government revenue; unfair competition between companies, mainly generated by economic or informational asymmetry between different entities; and an increase in socioeconomic inequality, since various instruments used in tax evasion are more accessible to individuals and companies with higher incomes.

It is important to highlight tax evasion on two types of taxes: income/wealth taxes and consumption taxes. Regarding the former, most evasion occurs due to the possibility of investing funds in tax havens. The *Global Tax Evasion Report 2024 - EU Tax Observatory* indicates that, by 2022, approximately US$ 12 trillion had been allocated to tax havens (corresponding to about 12% of global GDP). In 2022 alone, approximately US$ 1 trillion was sent to tax havens. Of these *offshore* amounts, it is estimated that around 25% remain untaxed. These estimates take into account both the personal transfer of funds to *offshore* accounts and the transfer of assets by multinationals to countries with low corporate tax rates[1] (Alstadsaeter et al., 2023).

With regard to consumption taxes, tax evasion occurs mainly due to the lack of registration or notification to the tax authorities of transactions that have taken place. According to the *Tax Foundation Center*, one method for verifying the efficiency of a country's Value Added Tax (VAT) is based on the "*VAT Gap*." The *VAT Gap* is given by the difference between the VAT re-

1 Evidence suggests that multinational companies transfer their assets to their own subsidiaries in countries with low corporate tax rates. This can be done through intragroup manipulation of exports and imports. In this way, subsidiaries located in countries with high tax rates can purchase services (managerial or financial) from other subsidiaries located in countries with low tax rates. Among the locations with the highest transfers of "profits" received are: Puerto Rico, Ireland, Luxembourg, Hong Kong, Switzerland, Singapore, and the Netherlands. (Alstadsaeter et al., 2023)

venue actually collected and the difference between the revenue that could have been obtained with an ideal VAT applied at an average rate on all final consumption. The difference in actual and potential revenues from this tax is mainly due to: non-compliance with VAT (tax evasion) and political choices to exempt certain goods and services or to tax them at reduced rates. The European Union has an average VAT gap of 15.84%, but among the countries with the highest rates are Cyprus (29.26%), Spain (26.97%), Poland (26.09%), and Italy (23.17%) (Asen, 2021).

The population's perception of the level of efficiency and corruption in a government directly impacts how much society is willing to pay taxes (Brockmann; Herschel; Seelkopf, 2016).

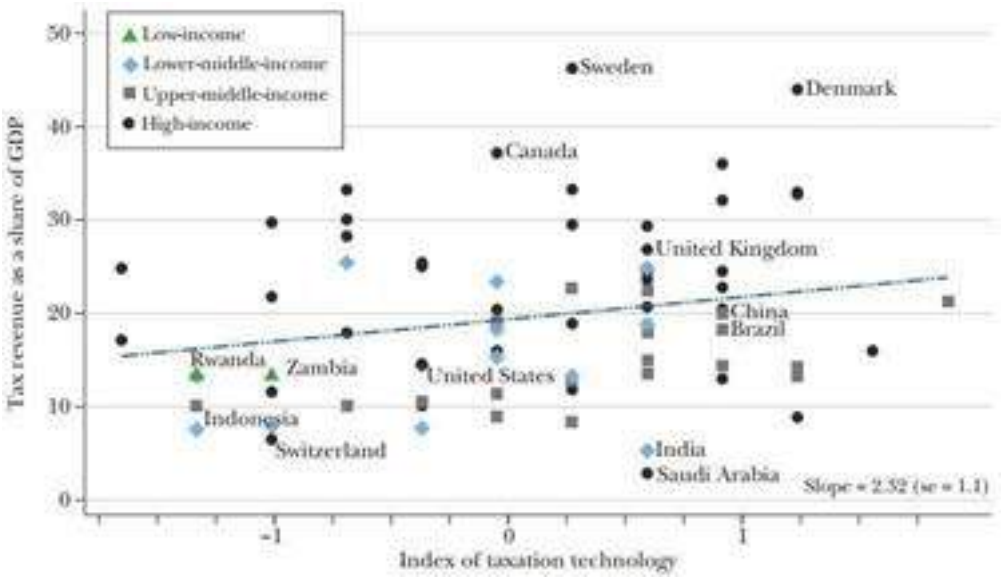
In addition, tax evasion is much higher in poorer countries. According to Gordon and Li (2009), developing countries collect, on average, only two-thirds or less of the amount of tax revenue collected, as a fraction of GDP, than developed countries. To better illustrate the difficulty of obtaining tax revenue by less developed countries, in 2019, the average ratio of tax revenue to GDP for low-income countries was 12%, for lower-middle-income countries 18%, for upper-middle-income countries 21%, and for high-income countries 30% (Okunogbe; Tourek, 2024).

Much of this problem is due to the informality present in poorer countries. Formalization generates economic incentives, as it provides companies and their employees with access to better bank financing, social services, medical services, technical expertise, wage balances, among others. As developed countries offer these benefits with better quality, the incentive for companies to formalize is lower in developing countries (Gordon; Li, 2009).

Furthermore, informality directly undermines the tax information available to the tax authorities. Informal companies are invisible to the government and have no incentive to submit the required tax documentation. On the other hand, *third*-party information greatly benefits tax compliance when this information from companies is not automatically accessible to the tax authority (Pomeranz, 2015).

Okunogbe and Tourek (2024) report that a country's tax collection capacity is also intrinsically related to the technologies employed in the tax system. The authors catalogued tax technologies employed by 75 countries to capture the correlation between these procedures and their tax revenues. The authors evaluated the technologies by creating "scores" for three distinct dimensions (identification capacity; detection capacity; collection capacity). In Figure 2.1, it is possible to see a positive correlation between countries that apply more available technologies and their tax revenues collected as a percentage of GDP.

Figure 2.1 – Relationship between Tax Technologies and Revenue Collection by GDP



Source: Okunogbe and Tourek (2024)

Note: The authors use the following technologies to calculate the score based on instruments from three areas. ***Identification capacity:*** digital identification with a unique identity number; ID based on government-issued documents (or biometric information); possibility of online registration. ***Detection Capacity:*** tax authority receives data from third parties; submission of electronic invoices by taxpayers; use of artificial intelligence to detect tax evasion. ***Collection Capacity:*** taxpayers can pay online; requests for installment payments and deferrals can be made online.

2.2 Tax on the Circulation of Goods and Services (ICMS)

Taxes on companies' goods usually take two forms: value added tax (VAT) or retail sales tax. Fabbri and Hemels (2013) characterize the former as a tax levied on the production chain, with the tax rate only being applied to the "value added" to production. For example, taxpayers can deduct the amount of tax due on the entry of goods (tax credit) from the amount of tax due on the exit of goods (tax debit). Thus, in simple terms, the tax charged is given by the difference between the tax due on the exit and the tax due on the entry of goods.

The second form of tax, on the other hand, is levied only at the end of the commercial chain, that is, it is levied only at the time of sale to the final consumer on the sale price.

According to Lindholm (1970), VAT has the advantage of encouraging greater tax compliance, since the company that purchases goods must keep records of what tax was previously paid in order to credit its final debt to the Internal Revenue Service. However, the Achilles' heel of this type of taxation lies with the end consumer, who has no incentive to request an invoice, which increases the possibilities of tax evasion by the taxpayer (merchant) at the end of the

chain.

The ICMS is a state tax created by the Federal Constitution of 1988 with a provision for non-cumulative taxation, i.e., the tax due in previous stages can be offset in later stages, when the product leaves the factory.

This tax has similar foundations to VAT in other countries. However, international experience shows that VAT is mostly national in nature. According to Alexandre (2016), in Brazil, based on the desire to divide a very important tax among all federal entities, the constitution created three taxes that the rest of the world combines into one (state ICMS, federal IPI, and municipal ISS).

Although it increased the tax autonomy of the states, the creation of this tax, with its different regulations in each state, generated excessive bureaucracy, a low degree of transparency, and a lack of comparability of taxpayers' economic and fiscal data (Mattos; Rocha; Toporcov, 2013).

Tax revenues are the main source of income for Brazilian federal entities. According to the 2024 General Government Gross Tax Burden Estimate report prepared by the National Treasury, the general government's gross tax burden (CTB) was 32.32% of GDP (BRAZIL, 2025). This indicator, for each federal sphere, was: 21.4% for the central government; 8.5% for state governments; and 2.4% for municipal governments.

Also, according to this report, the ICMS is the second highest tax in terms of revenue, R$ 805.16 billion, behind only income tax (IR), which totals R$ 813.91 billion. In addition, this tax is the largest source of revenue for Brazilian states. For illustrative purposes, when looking at the Summary Budget Execution Report (RREO) for the state of Bahia, we see that in 2024, ICMS revenue was the most significant source of total primary revenue (36.15%).

2.3 Incentives in Fiscal Policies

Individuals' choices are influenced by the incentives (financial or otherwise) they may receive from making the corresponding decision.

Tax incentives are usually financial in nature: as lower tax payments or as direct monetary returns. However, Antinyan and Asatryan (2019) expose other types of tax policy incentives present in individuals' behavior, such as ***deterrent incentives*** (related to enforcement), ***moral incentives*** (related to moral ethics), and ***simplification or information incentives*** (related to facilitating the administrative process for tax payment).

Fabbri and Hemels (2013) analyze the situation of requesting invoices as a problem of public goods asymmetry. The consumer is a potential contributor to a specific public good (tax enforcement). The rational buyer evaluates the private costs and benefits of requesting an invoice. For any transaction, the benefit to the buyer of requesting a receipt is almost zero, since they are hardly directly affected by the tax paid by the seller to the government. Thus, consumers do not internalize the full benefit of tax payment in their decision. This is because goods financed through taxes are usually public goods and, by definition, are non-excludable. Thus, consumers in the transaction and other citizens share the benefit generated by the payment of taxes on any transactions.

On the other hand, by not requesting an invoice, consumers can obtain an economic benefit if they manage to negotiate a discount with the seller (Fabbri; Hemels, 2013). The seller may also have incentives to collect the financial benefit for themselves by not issuing the required tax documentation and, consequently, not paying the tax on the transaction. Thus, even if requesting invoices is the optimal social choice, the dominant individual strategy of agents becomes not to request invoices in their own transactions and to "free ride" on the provision of public goods.

Without any government intervention policy, consumers not only lose the benefits of requesting invoices, but may also face a high social and moral cost when requesting such documentation when the social culture is not to request receipts (Fabbri; Hemels, 2013). A possible solution to this scenario may be the introduction of fines or penalties for consumers themselves if they do not request invoices in transactions. In this case, the benefits obtained by buyers remain unchanged, but the costs of their decisions increase. However, in addition to the low efficiency of these policies, they may generate a feeling of dissatisfaction among citizens. Such policies have already been implemented in Portugal, Italy, and Belgium, but due to strong popular dissatisfaction, they were quickly canceled (Fabbri and Hemels, 2013), (Wilks, Cruz, and Sousa, 2019).

In order to encourage tax compliance, an alternative solution was found in the form of benefit programs and/or lotteries aimed at one of the parties to the transactions. Initiatives in this regard can be found in several countries, such as Argentina, Chile, China, Slovenia, Slovakia, the Philippines, Georgia, Greece, Malaysia, Malta, Mongolia, Peru, Portugal, Puerto Rico, Poland, Romania, and Taiwan (Fooken; Hemmelgarn; Herrmann, 2015), (Wan, 2010), (Fabbri; Hemels, 2013), (Burger; Schoeman, 2021), (Wilks; Cruz; Sousa, 2019).

If the invoice serves as a lottery ticket, then consumers have incentives and reasons to

request such documents (Fooken; Hemmelgarn; Herrmann, 2015). In addition, the lottery can generate positive externalities by instilling in citizens, in the long term, the habit of requesting invoices, so that the prize itself loses value in the future or is even abolished (Fabbri; Hemels, 2013).

Such programs are also in line with the findings of Tversky and Kahneman (1992) who, based on *Cumulative Prospect Theory (CPT)*, identified that individuals tend to overvalue the possibility of extreme events, which contributes to the popularity of lotteries.

It is worth noting that tax compliance also depends on economic, social, cultural, moral, and ethical aspects that vary from country to country. Therefore, successful tax lottery policies adopted in other locations would not necessarily guarantee the same result if adopted in other locations, especially in Brazil.

2.4 Electronic Tax Invoice (NF-E) and Electronic Consumer Tax Invoice (NFC-E)

In order to improve tax enforcement and compliance, SINIEF Adjustment No. 07/05 instituted the Electronic Tax Receipt (NF-e) in 2005, a document that must be issued in transactions between companies when IPI or ICMS taxes are levied. This instrument mainly covered purchases in *Business to Business (B2B)* transactions.

The NF-e is a file in *Extended Markup Language (XML)* format that is sent to the tax authorities to record the transaction of goods. This document was an important milestone in the fight against tax evasion, as it introduced the mandatory issuance of a digital document in the wholesale sector, which is stored in the information systems of the State Tax Authorities.

As the ICMS is a non-cumulative tax, which allows the tax due in previous stages of the chain to be credited, in transactions between companies (wholesale) there is, theoretically, less incentive for tax evasion.

As seen, the greatest weakness of VAT is at the end of the commercial chain (*Business to Consumer - B2C* transactions), since end consumers generally receive no additional benefit for demanding the correct documentation of the commercial transaction.

In this vein, in 2013, SINIEF Adjustment No. 01/13 (later supplemented by SINIEF Adjustment No. 19/16) instituted the Electronic Consumer Invoice (NFC-e), a document that must be issued in transactions with end consumers. In simplified terms, the NF-e mainly affected the wholesale sector and the NFC-e, the retail sector. Similar to the NF-e, the NFC-e is a standard *XML* digital file that will be sent to the tax authorities to record the transaction of the goods.

The State of Bahia, based on its ICMS Regulation (Decree No. 13,780/2012), instituted the mandatory issuance of NFC-e in transactions for end consumers as of the end of 2017. It should be noted that this requirement was staggered over time for different taxpayers:

• August 22, 2017: for new establishments registered in the State ICMS Registry[2];

• March 1, 2018: for establishments registered in the State of Bahia taxpayer registry that calculate tax using the fiscal current account regime[3];

• January 1, 2019: for establishments opting for Simples Nacional.

Prior to NFC-e, merchants were required to issue tax receipts via a Tax Receipt Issuer (ECF). This was a commercial automation device capable of issuing physical tax documents and storing records of these issuances. However, this device was quite susceptible to fraud and also required a physical inspection by the tax authority, since there was no direct transmission of electronic documentation related to the transaction.

2.5 Bahia Award-Winning Receipt Program (NPB)

In 2017, the Government of Bahia created the Bahia Award-Winning Receipt Program (NPB), which consists of an initiative to encourage citizens to demand and check electronic receipts (NFC-e and NF-e) for purchases made in establishments in Bahia (BAHIA, 2017).

The program offers monetary incentives to consumers through tax lotteries. Each year, R$ 13 million in prizes are distributed, with 91 monthly prizes: 1 prize worth R$ 100,000 and 90 prizes worth R$ 10,000. In addition, there is a special prize of R$ 1 million each year.

To participate in the draw, consumers must first register on the NPB website. Consumers compete based on the CPFs indicated on the NF-e and NFC-e related to the sale; CNPJs are not valid. As of September 3, 2025, there were 871,073 citizens registered on the NPB website.

In Bahia, NFC-e must be issued with consumer identification (CNPJ or CPF) in the following cases (Bahia, 2012): home delivery; value equal to or greater than R$ 500 and value less than R$ 500 when requested by the purchaser.

Despite the requirement to issue NFC-e with identification for amounts equal to or greater than R$ 500, it is possible to have the NFC-e authorized and issued without this identification information. In the case of Bahia, the NFC-e issuance system only prevents issuance without

2 The original version of the Regulation stipulated that companies listed in a list published by SEFAZ should issue NFC-e as of July 2016. This list included about 400 companies. In addition, new establishments registered with the ICMS in the state as of January 2017 were required to issue NFC-e.

3 Initially, this deadline was set for November 1, 2017, but it was postponed on October 26, 2017, to March 1, 2018.

consumer identification for amounts above R$ 10,000.

The raffle tickets are generated randomly on a monthly basis, after the end of the month to which they refer. They take into account the sum of the values of the invoices that are authorized monthly with the citizen's CPF. To make the process more equitable, there are staggered ranges of ticket quantities eligible to participate in the program in relation to monthly consumer invoice spending, as indicated in Table B.1 of Annex B.

For the draws, a "lucky number" is used as a reference, which will be related to the five federal lottery prizes. The payment of the prize to the winner must be made within 90 days after the citizen returns with their personal data for approval and transfer of the amounts.

2.6 Tax Substitution

The institution of tax substitution is something quite peculiar and specific to the Brazilian tax system. It consists of a differentiated regime of tax inspection and collection in which payment is made by a substitute and not by the taxpayer himself.

In a "normal" scenario, the sellers themselves are the taxpayers and are also required to pay the ICMS on the sale. Figure 2.2 illustrates this general scenario. Imagine that A is the producer, B is the supermarket, and C is the end consumer. Thus, normally, A collects the ICMS due on sales to B, while B collects the ICMS due on sales to C.

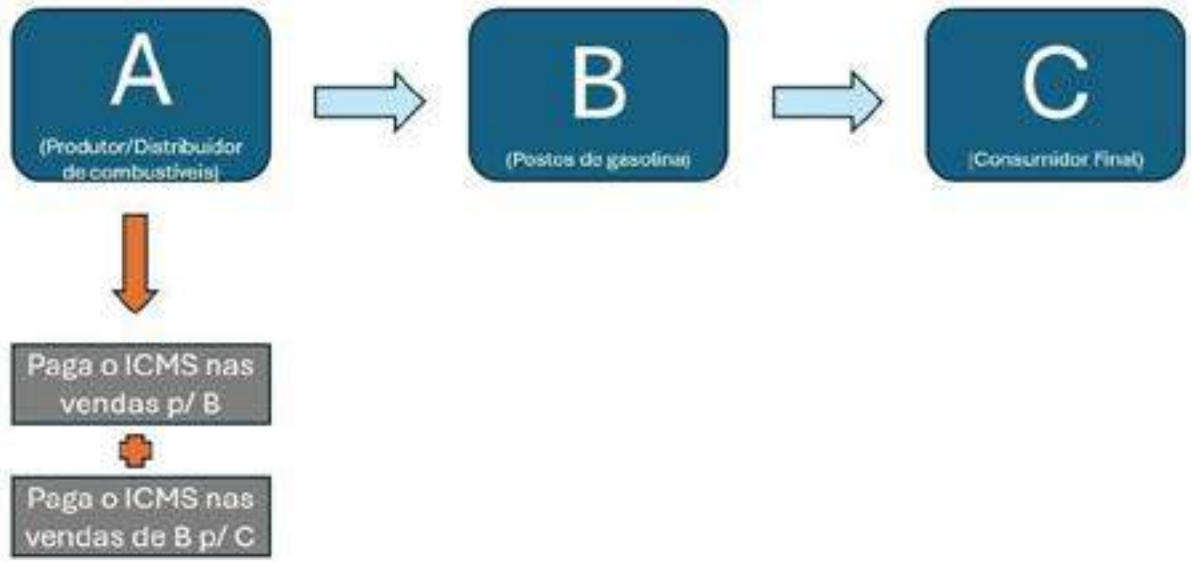
However, Brazilian legislation, especially in the case of ICMS, has created a differentiated collection regime called Tax Substitution (ST). There are two distinct forms of tax substitution: forward (or progressive) ST and backward (or regressive) ST.

Figure 2.2 – General flow of the tax chain

Source: Own elaboration (2025)

The most common form of ST in practice is known as forward ST. It occurs in cases where those occupying positions further down the production chain are replaced, in terms of their tax liability, by those occupying positions further up the chain (Alexandre, 2016). Figure 2.3 illustrates this case. In order to centralize oversight in less fragmented stages of the commercial cycle, it is defined, for example, that fuel producers and distributors are tax substitutes for gas stations and must collect the ICMS that would be due on sales from gas stations to end consumers. The ICMS in this operation is calculated based on an estimate of the sale price of operations between B and C.

Figure 2.3 – Forward ST flow



Source: Own elaboration (2025)

Backward ST, a less common form, occurs in cases where those occupying earlier positions in the production chain are replaced, in their duty to pay tax, by those occupying later positions in the same chain (Alexandre, 2016). Figure A.1 in Annex A illustrates this case.

ST aims to centralize enforcement efforts in more concentrated stages of the commercial chain. For example, instead of inspecting each gas station selling fuel, the tax authorities can concentrate their efforts on controlling product outflows from large producers and distributors. Furthermore, this institution places less of a burden on small producers and sellers, since they do not need to maintain accounting and financial logistics to arrange for tax collection.

However, the ST is often criticized for adding complexity and exceptions to the ICMS tax model. In addition, the estimated final prices of products are often significantly lower than the actual market price, which favors lower tax payments.

Theoretically, one can imagine that the implementation of the NFC-e has a different impact on sectors subject to tax substitution, since this tax is already collected at another, more centralized stage of the production chain.

3. METHODOLOGY AND DATA

3.1 Potential Results and Differences-in-Differences

Cunningham (2021) and Angrist and Pischke (2009) discuss the potential outcomes model for defining causation based on a comparison between a factual and a counterfactual.

Imagine, for example, that you want to measure whether going to the hospital actually has a positive impact on a person's health based on some health indicator (suppose, as an indicator, life expectancy).

Thus, in the real world, it is only possible to examine two groups of people: those who went to the hospital and those who did not. How could we verify whether being hospitalized increases a person's life expectancy? A common answer might be: "just compare the life expectancy of people who went to the hospital with that of people who did not go to the hospital." However, there is already a problem here: completely different groups of people are being analyzed. People who go to the hospital may be predisposed to disease and may be in poorer health. People who do not go to the hospital do so for a variety of reasons, including not having regular illnesses. Thus, it can be assumed that people who go to the hospital already have a shorter life expectancy, even if they go to the hospital.

Note that to answer the question of whether hospitals increase life expectancy, one must compare identical groups of people who have been hospitalized and those who have not. However, the necessary counterfactual cannot be observed in the real world. It is not possible for an identical group of individuals to be hospitalized and not hospitalized at the same moment in time.

Mathematically, the problem can be explained as follows. Imagine two distinct groups of people, those who went to the hospital and those who did not.

The treatment (going to the hospital) is a binary variable defined as $D_i = \{0, 1\}$. That is, if the individual goes to the hospital $D_i = 1$ and if they do not, $D_i = 0$.

The outcome of interest, the life expectancy of this individual, is denoted by Y_i. Thus, Y_i^0 is the expectation of the individual if he did not go to the hospital. Y_i^1 is the expectation of this

same individual if he goes to the hospital. The potential outcomes equation for this individual can be given in Equation 3.1.

$$Y_i = Y_i^0 + (Y_i^1 - Y_i^0).\ D_i \#3.1$$

$Y_i = Y_i^1$ if the person went to the hospital ($D_i = 1$), otherwise, $Y_i = Y_i^0$. From this, it is possible to expand the analysis to causal inference in a given population in Equation 3.2.

$$ATE = E[Y_i^1] - E[Y_i^0] \#3.2$$

The difference $E[Y_i^1] - E[Y_i^0]$ is called the *average treatment effect (ATE)* and determines exactly the causal effect of the treatment, that is, the real impact of the policy implementation. It should be noted, therefore, that this variable is not observable, as it depends on the measurement of two states that cannot occur at the same time: measuring the life expectancy of individuals if they are hospitalized and measuring the life expectancy of those same individuals if they are not hospitalized.

However, in the real world, it is sometimes possible to estimate two other ways of identifying the average treatment effect, based on inferences from sample data.

The *Average Treatment Effect for the Treatment Group (ATT)* is the average effect for the group of units that were selected to receive the treatment. The *ATT* analyzes the average treatment effect for the group randomly selected as the treatment group (which was subjected to the policy in question).

$$ATT = E[D_i=1] - E[D_i=1] \#3.3$$

The *Average Treatment Effect for the Untreated Group (ATU)*, on the other hand, analyzes the average effect for the group of units that were not selected to receive the treatment.

$$ATU = E[D_i=0] - E[D_i=0] \#3.4$$

Cunningham (2021) demonstrates that the simple difference between the means can be given by Equation 3.5.

$$\underbrace{\frac{1}{N_T}\sum_{i=1}^{n}(d_i = 1) - \frac{1}{N_C}\sum_{i=1}^{n}(d_i = 0)}_{\text{Simples Diferenças de Médias}} = \underbrace{E[Y^1] - E[Y^0]}_{ATE} + \underbrace{E[D = 1] - E[D = 0]}_{\text{Viés de Seleção}} + \\ + \underbrace{(1 - \pi)(ATT - ATU)}_{\text{(Viés de efeito de tratamento heterogêneo)}} \quad \#3.5$$

The left side of Equation 3.5 represents the simple observation of the difference in means between the life expectancy of the two distinct groups. That is, it would be the same as comparing the observable mean of the group that goes to the hospital and the observable mean of the group that does not go to the hospital. The first term on the right side of the equation represents what we actually want, that is, what the difference in means between the two distinct groups would be if both were subject to treatment and if they were not subject to treatment.

It is clear that the simple difference in observable averages is not equal to the parameter of interest for inferring the causality of a given policy. The second and third terms on the right side of the equation represent biases that cause this differentiation.

The second term on the right side, called selection bias, represents an inherent difference between the two groups if they had never received treatment. In the example in question, it would be the inherent difference between the groups of people who would go to the hospital and the group of people who would not go to the hospital. These are not similar groups, as stated earlier, there may be a predisposition to receive treatment due to the inherent characteristics of the group of people. For example, people who go to the hospital are usually those with poorer health.

The third term, called heterogeneous treatment effect bias, represents another form of bias when identifying the *ATE*.

Therefore, it is possible to see that the evaluation of the average effect of hospitalization cannot be simply assessed by the first term, that is, the simple difference in means between the observable groups, in most cases, is not sufficient to evaluate the causal effect.

To circumvent the problems of measuring causal effect, certain estimation strategies can be applied. The Differences-in-Differences model is an initial quasi-experimental identification strategy for estimating the causal effect of a policy's impact. Given the implementation of public policy in period t, according to Cunningham (2021), a simple Difference-in-Differences model, with treated group k and untreated group *U*, can be specified in Equation 3.6.

$$\delta_{kU}^{2\times2} = (E[Após] - E[Pré]) - (E[Após] - E[Pré]) \quad \#3.6$$

The first two terms on the right-hand side show the average effect of the treated unit before and after the policy implementation. The last two terms show the average difference of the control unit before and after the policy implementation. This equation can be rewritten as Equation 3.7.

$$\delta_{kU}^{2\times2} = E[Após] - E[Após]_{\smile ATT} +$$

$$+ [E[Após] - E[Pré]] - [E[Após] - E[Pré]]_{\smile Viés\ de\ tendência\ não\ paralela\ no\ caso\ 2x2} \quad \#3.7$$

According to Equation 3.7, the Difference-in-Differences estimator corresponds to the Average Treatment Effect for the Treated Group (*ATT*) added to the non-parallel trend bias term. According to Cunningham (2021), this second term indicates, in simpler terms, whether a control group was found that approximates the path of the treatment group and that the treatment is not endogenous. Thus, assuming the parallel trend hypothesis between the control and treatment groups, the second term is zero and the Difference-in-Differences estimator equals the *ATT*.

This dissertation employs a strategy similar to that proposed by Naritomi (2019). The author uses a Difference-in-Differences model to assess the impact of the implementation of the Nota Fiscal Paulista program in the state of São Paulo. As the implementation of the program had a greater impact on *B2C* commerce, the author estimates the *ATT* by the post-treatment difference between the treated group (retail sector) and the control group (wholesale sector).

3.2 Company Data – Revenues and Registrations

With regard to ICMS, companies in the state of Bahia, during 2016 to 2023, basically had three ways of transmitting information related to revenues obtained and taxes due: Monthly Assessment Statement (DMA); Digital Tax Bookkeeping (EFD); and Simples Nacional Collection Document (DAS).

The first two are issued by taxpayers who do not opt for Simples Nacional. In the State of Bahia, the tax regime for those who do not opt for Simples is called Conta Corrente Fiscal (Tax Current Account). During this period, taxpayers in Bahia under the Conta Corrente Fiscal regime were required to submit their monthly information through both DMA and EFD.

In the state, the DMA was instituted before the EFD and is a simpler declaration, with less information reported by the taxpayer. As of January 1, 2024, taxpayers in Bahia are no longer

required to issue the DMA, and only the EFD needs to be submitted. Simples Nacional, on the other hand, is a differentiated regime established by Complementary Law No. 123/06, which created simplified calculation rules for certain companies. Taxpayers under this regime report their information through the Simples Nacional Collection Document (DAS).

In short, Simples is an optional regime that has a certain revenue limit for entry. Until 2016, this limit consisted of an annual gross revenue of R$ 3.6 million; as of 2018, this limit increased to R$ 4.8 million.

Based on the information contained in the EFD, DMA, and DAS, the Bahia State Finance Department was asked to generate a database with the revenue and ICMS information reported between 2016 and 2023 by the companies listed in its ICMS registration system.

In accordance with Law No. 13,709/18, commonly referred to as the General Data Protection Law (LGPD), all personal data made available was previously anonymized by the Information Production Directorate (DPI) of the Finance Department. The data anonymization process was carried out by generating random numbers. This study did not use identified taxpayer data, which was stored in the aforementioned directorate[4].

From the monthly information contained in the documents, the following was made available for the period from 2016 to 2023: anonymized company identifier (based on the CNPJ); indicator of opting for the Simples Nacional regime or the Fiscal Current Account regime; revenue and ICMS reported by the companies listed in the tax documents (EFD, DMA, and DAS); company's registered CNAE; municipality where the company is registered; indicator of the proportion of Tax Replacement for the company's purchases.

Analysis period – The period for analyzing and studying company behavior was limited to January 2016 to February 2020. It is important to mention that the analysis was restricted to the pre-pandemic period, as this event had a significant impact on commerce in general. Possibly, the wholesale and retail sectors suffered different economic effects. The restrictions on trade and the lockdown policy were not uniformly adopted by municipalities in Bahia.

Identification of establishments – Anonymized identifiers were provided based on the CNPJs (Corporate Taxpayer IDs) of establishments registered in the ICMS (Value-Added Tax) Registry of the State of Bahia. The analysis was restricted to 107,984 companies that submitted tax reports during this period and had a CNAE (National Classification of Economic Activities)

4 In addition, all data were processed and analyzed in a specific environment and equipment belonging to Sefaz/BA itself. It is important to note that this work does not necessarily reflect the views of the institution. Furthermore, there is no financial interest in the research, only an interest in contributing to and advancing the scientific debate on economic and tax literature.

registered in the database. In this study, a company is defined as a set of establishments under the same base identifier. Thus, the same company may have several branch establishments. In addition, as there may be tax planning and centralization of tax accounting between the company and its branches, the entire perspective addressed in the data processing will be aggregated by company and not by each of its establishments.

Tax Regime – To ensure uniform treatment, all companies that changed their tax regime during the period were excluded, i.e., companies that opted for Simples Nacional and also for the Fiscal Current Account regime between 2016 and 2020 were excluded from the analysis. As these regimes have very different rules, both in terms of accounting obligations and tax rates, a simple change in the tax regime option could impact taxpayer behavior.

Reported revenue and ICMS – As discussed, companies under the Tax Current Account regime transmit their information via DMA and EFD, while companies opting for Simples Nacional transmit their information via DAS. Thus, the maximum amount stated in these documents was assigned as reported revenue and ICMS. In the case of companies that submitted both DMA and EFD, there are some rare cases of differences in the information contained in these sources. It makes sense to use the maximum amount reported, since the taxpayer's return constitutes the tax credit and divergent amounts may generate alerts for the tax administration.

Activity sector – One of the main working variables for identifying the sector in which the company operates is the IBGE National Code of Economic Activities (CNAE). This code structure is defined by the IBGE to record the economic activity to which the establishment is linked. The CNAE consists of 7 digits that have the following hierarchy: Division, Group, Class, Subclass.

Due to the possible centralization of accounting and tax records, companies were assigned the CNAE of the establishment with the highest reported revenue in the period and which had a CNAE registered in the database. Based on these codes, companies in the retail and wholesale sectors were identified, as shown in Table B.2 of Annex B. At the end of this assignment, for the period from January 2016 to February 2020, 107,984 companies were identified, divided into 99,302 retail companies and 8,682 wholesale companies. The economic sectors total 218 CNAEs, 126 of which are wholesale and 92 are retail.

Tax Replacement – As explained in Section 2.6, tax replacement (ST) is a differentiated tax collection regime, the most common type being ST, which anticipates tax collection at earlier stages of the production chain. In theory, companies subject to ST may be less impacted by the implementation of NFC-e, since the tax is collected at the beginning of the production chain

anyway. Therefore, it is important to have an indication of which companies are most subject to ST. Based on an indicator of the proportion of purchases by ST for each company in relation to compras totais, a single ST benchmark was created for each company that weighs this monthly ST indicator in relation to the reported revenue for each month throughout the analyzed period. For example, an ST Factor of 15 indicates that purchases subject to tax substitution for that company represented 15% of its total purchases.

Table 3.1 shows the total descriptive statistics for the period analyzed, using raw data from 107,894 companies.

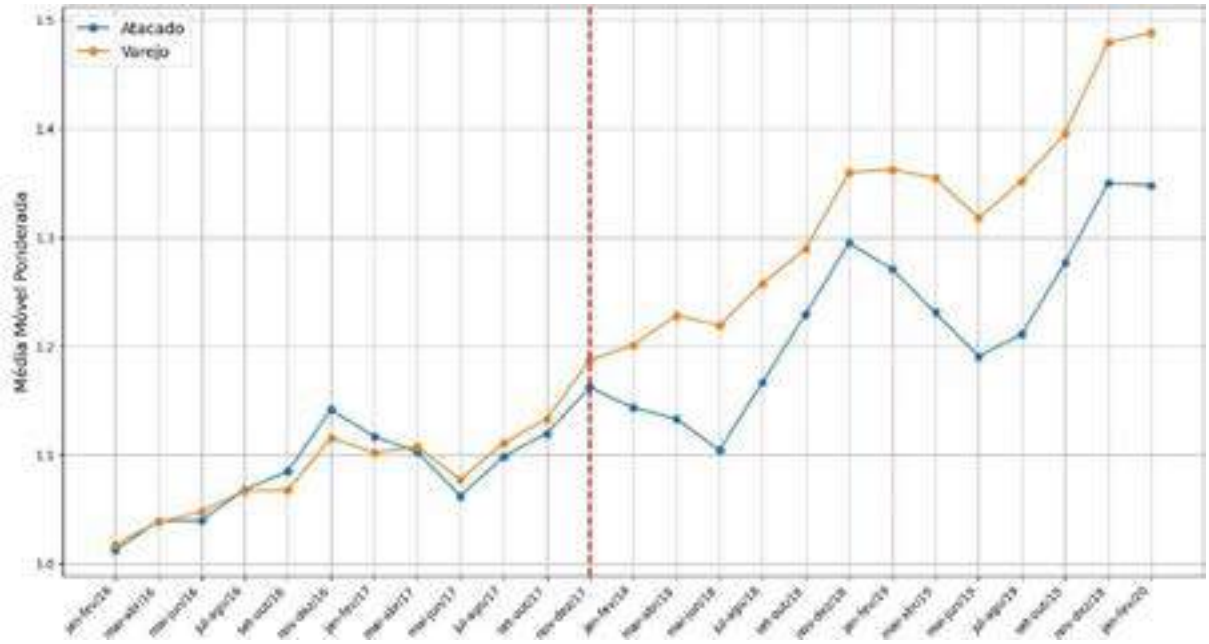
Figure 3.1 shows the evolution of reported revenue for the 218 sectors, aggregated by wholesale and retail, based on the moving average of the last three two-month periods. The analysis is weighted by their pre-treatment averages. As the data for wholesale and retail are asymmetrically distributed, the revenues for each aggregated sector were limited to their 98.5th percentile. About 60% of total accumulated wholesale and retail revenue is concentrated in the largest 1.5% of companies, so extraordinary revenues could, in isolation, distort the results and the robustness of the causal analysis. Thus, based on this cutoff per period, all retail and wholesale companies that collected above this percentile would have this value as their attributed revenue.

Table 3.1 – Descriptive Statistics – Wholesale vs. Retail

	ATACADO			VAREJO		
	Receita Total	Receita Mensal	Icms Mensal	Receita Total	Receita Mensal	Icms Mensal
Qtd de Empresas	8.682	8.682	8.682	99.302	99.302	99.302
Média	78.117.283	831.035	6.820	4.212.674	44.816	870
DP	779.417.847	8.291.679	103.223	82.917.090	882.097	16.049
Min	0	0	0	0	0	0
25%	176.249	1.875	0	97.079	1.033	13
50%	1.291.979	13.744	63	422.623	4.496	77
75%	10.231.636	108.847	826	1.356.762	14.434	311
Máx	38.610.138.614	410.746.155	5.328.914	16.513.956.691	175.680.390	2.432.676

Source: Own elaboration (2025)

Figure 3.1 – Weighted Moving Average for the last 3 two-month periods – Wholesale vs. Retail



Source: Own elaboration (2025)

It should be noted that the implementation deadline for NFC-e for taxpayers under the tax current account regime was set for early November 2017. However, this requirement was postponed at the end of October to March 2018. During this period, it is reasonable to assume that there will be some anticipation of the effects, since the implementation of NFC-e in daily routines requires adaptation of systems and company activities. In addition, several taxpayers used the November 2017 deadline as a reference to operate correctly. The graph shows that, before the last two months of 2017 (the NFC-e implementation period), wholesale and retail revenues behaved similarly. However, since the NFC-e implementation period, there has been an increase in the gap between the two sectors.

On the other hand, Figure A.2 in Appendix A shows the same analysis, but now for companies with tax substitution indicators of less than 15%. It can be seen that for companies less subject to ST, the impact of NFC-e implementation on retail, at least visually, appears to be more significant.

3.3 Data from Tax Invoices and the Bahia Premium Invoice Program

As seen, several governments have instituted tax education programs based on the financial return of the tax collected from the taxpayer, either by refunding a percentage of the tax

paid (cashback) or by holding tax lotteries.

In addition to the data described in Section 3.2, the Bahia Finance Department provided another database related to the Bahia Prize-Winning Receipt Program and the issuance of NF-e and NFC-e during the period from 2016 to 2023. It should be noted that the anonymization and security processes described in Section 3.2 were also replicated for the preparation and analysis of this information.[5]

The following monthly information was made available for the period from 2016 to October 2023: Anonymized company identifier; aggregate value and quantity of NFC-e and NF-e invoices issued per company; municipality where the invoice was issued; anonymized identifier of NPB program participants; participant's municipality; date of registration in the NPB program; anonymized identifier of the winners of the draws; reference identifier of the draw (date and value); number of invoices of participants in each draw; total value of the invoices of participants in each draw.

The NPB program began accepting registrations in December 2017, but the first draw did not take place until February 2018. Table 3.2 and Figure A.3 in Appendix A show the evolution of the number of registrations in the campaign. Record registration occurs in the first months of the program and then tends to level off over time.

Table 3.2 – Registrations per Year

Ano	Cadastros por ano	Cadastros Acum.	Var (%)
2017	37.435	37.435	-
2018	357.566	395.001	955,16
2019	130.565	525.566	33,05
2020	53.021	578.587	10,09
2021	62.500	641.087	10,80
2022	47.257	688.344	7,37
2023	55.429	743.773	8,05

Source: Own elaboration (2025)

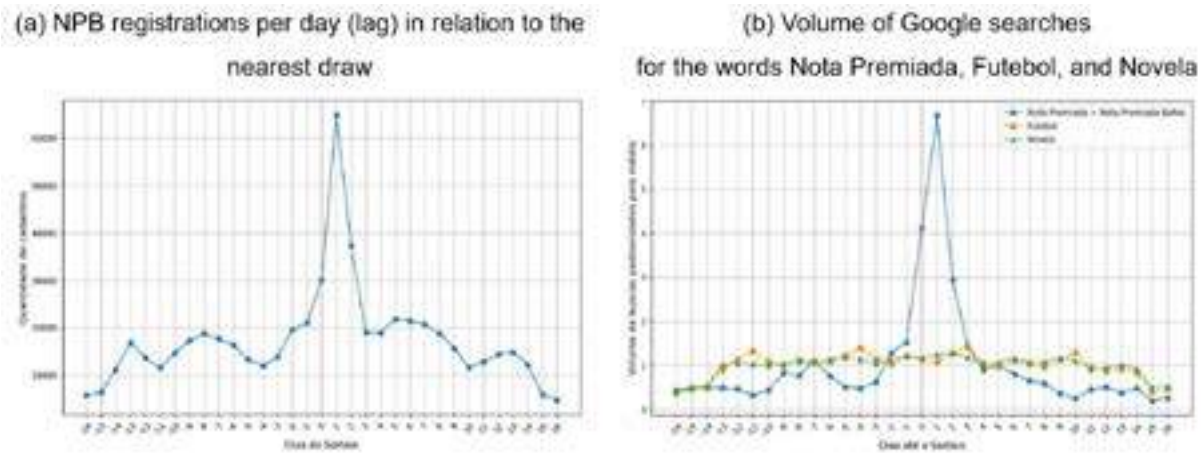
Based on each individual's registration date and the date of each draw, Figure 3.2.a shows a graph that identifies the number of registrants in relation to the dates of the nearest draws. It is possible to see the concentration of registrations on dates close to the draws, especially on

5 The data was anonymized, in accordance with Law No. 13,709/18, by the Information Production Directorate (DPI). In addition, the processing and analysis was carried out using equipment and in an environment specific to the Department of Finance.

the day after.

Another interesting point to analyze is internet searches related to the program. It is unlikely that consumers will directly access the program's website (*https://www.npb.sefaz.ba.gov.br/*), so many are likely to use search engines to find information, as well as to access the aforementioned website. Figure 3.2.b shows the volume of Google searches for the words “Nota Premiada” and “Nota Premiada Bahia,” only for the state of Bahia during the period from 2018 to 2023. It can be seen that the searches follow a similar pattern to that identified in the number of registrations, i.e., they are concentrated on the days closest to the program’s implementation. For comparison purposes, searches during this period for the words “Futebol” (soccer) and “Novela” (soap opera) are also shown. It can be seen that there is no clear pattern, unlike searches for the program. These values were normalized by the respective averages for the period.

Figure 3.2 – Registrations and Google searches per day (lag) in relation to the nearest draw



Source: Own elaboration (2025)

Table 3.3 shows the cities with the highest proportion of registrations per inhabitant. The following nomenclature was agreed upon to specify the size of the municipalities: "Small I" (population less than 20k), "Small II" (population between 20k and 50k), "Medium" (population between 20k and 100k) and "Large" (population greater than 100k).

In addition, Figure A.4 in Annex A shows the heat map with indicators of the registered population by number of inhabitants in each municipality. To highlight the differences between regions, a threshold of 10% was used for the heat map, with only five municipalities in Bahia having a coefficient above this threshold (Ipiaú, Ibirataia, Salvador, Lauro de Freitas, and Ita-

buna).

Among the 15 cities with the highest proportion of registered population, there are 6 cities with a population of less than 50,000 inhabitants. In fact, all 6 of these municipalities have already had winners of the R$ 10,000 prize. Three of them: Ipiaú, Ibirataia, and Nazaré have also had winners of the R$ 100,000 prize.

Table 3.3 – Registrations by Municipality

Município	Nº Cadastros	%Pop. Cadastrada	Pop. Município	Tamanho
Ipiaú	13.665	33,57	40.706	Pequeno II
Ibirataia	5.204	27,69	18.792	Pequeno I
Salvador	392.303	16,23	2.417.678	Grande
Lauro de Freitas	25.342	12,46	203.331	Grande
Itabuna	18.944	10,15	186.708	Grande
Jequié	15.742	9,91	158.813	Grande
Simões Filho	10.231	8,93	114.559	Grande
Itagibá	1.314	8,58	15.310	Pequeno I
Camaçari	24.804	8,26	300.372	Grande
Barra do Rocha	474	8,21	5.775	Pequeno I
Ubatã	1.315	8,17	16.094,00	Pequeno I
Cruz das Almas	4.554	7,55	60.348	Médio
Teixeira de Freitas	9.545	6,57	145.216	Grande
Feira de Santana	40.337	6,55	616.272	Grande
Nazaré	1.713	6,33	27.060	Pequeno II

Source: Own elaboration (2025)

Table 3.4 – Prizes by Municipality Size

Tamanho	R$ 10.000	R$ 100.000	R$ 1.000.000
Pequeno I	89	7	0
Pequeno II	243	13	0
Médio	195	8	0
Grande	3402	236	5

Source: Own elaboration (2025)

4. RESULTS

4.1 Impact of NFC-E Implementation – DiD by Companies

First, an estimate of Differences-in-Differences is made at the company level. Based on this analysis, it is verified whether the implementation of NFC-e had an impact on the reported revenue of the treatment groups (retail companies) in relation to the control group (wholesale companies).

It is worth noting that, for the control group, similar to Naritomi (2019), companies registered in the wholesale sectors described in Table B.2 of Annex B were used.

The regression at the company level, presented in Equation 4.1, is performed based on the grouping of the period into semesters ***t***. In total, eight semesters from January to June and July to December between 2016 and 2019 are used. The policy began in the July to December 2017 semester. The grouping by semester aims to mitigate the problem of the lack of revenues reported for firms on a monthly or even bimonthly basis. According to Naritomi (2019), grouping can also avoid several serial correlation problems in the calculation of standard errors.

Each observation is weighted by its values from the pre-implementation period of the NFC-e to better represent the scale ratio of each company in the market.

$$Ln(R)_{ist} = \alpha_i + \gamma_t + \beta \, . \, D_{ist} + \epsilon_{ist} \quad \#4.1$$

Where: $Ln(R)_{ist}$ is the logarithm of the average revenue reported by company ***i*** per semester ***t*** and per sector ***s***; α_i is the fixed effect per company; γ_t is the fixed effect per semester; β is the estimated Difference-in-Differences coefficient; D_{ist} is a time-varying treatment dummy, which will be equal to 1 if the company is in retail and if semester ***t*** is from Jul-Dec/17; it will be 0 otherwise; ϵ_{ist} is the robust and clustered error term at the company level.

The results of the econometric model are shown in Table 4.1. Column (1) shows the overall assessment of the model at the company level, with an increase in reported revenue of approximately 6.76%.

However, as explained in Section 2.6, Brazil has a rather peculiar tax collection system called tax substitution (ST). In these cases, since ICMS is collected anyway by large producers and distributors, companies subject to ST at the end of the chain may theoretically be less impacted by the implementation of NFC-e.

Columns (2) to (4) show the results of the econometric model excluding companies with ST indicators above 20%, 15%, and 10%, respectively. It should be noted that, when analyzing only companies less subject to tax substitution, there is an increase in the DiD coefficient. After the NFC-e implementation period, the revenue reported by the sectors increases to 9.54% to

10.7%. This is an increase of 41% to 58% compared to the general analysis with all companies.

It is important to note that the analysis of the model by company applied only to companies complementary to these ST indicator exclusions, that is, only for companies with ST factors greater than 20%, 15%, and 10%, returned, in all cases, DiD coefficients not significantly different from zero.

This shows that companies with less exposure to tax substitution were more impacted by the implementation of NFC-e. In addition, it may indicate that the ST institute is an efficient instrument for ensuring the proper payment of taxes in transactions with the final consumer.

Table 4.1 – Results of the DiD model by Companies

	Log da receita reportada (cutoff 98,5°)			
Variáveis	(1)	(2)	(3)	(4)
DiD	0,0676***			
	(0,0218)			
DiD (st <20)		0,101***		
		(0,0274)		
DiD (st <15)			0,0954***	
			(0,0265)	
DiD (st <10)				0,107***
				(0,0292)
EF Empresa	X	X	X	X
EF Semestre	X	X	X	X
Observações	529.268	273.531	251.337	230.980
R^2 ajustado	0.946	0.935	0.935	0.932
Empresas Atacado	8.549	6.648	6.345	5.891
Empresas Varejo	98.254	52.094	47.922	44.240

Erros padrões robustos e cluesterizados por empresas em parenteses

*** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration (2025)

Note: Table 4.1 shows the main coefficients of the Difference-in-Differences model of Equation 4.1 at the company level. The DiD variable is defined based on the interaction between a dummy variable if the company is part of the retail sector and if the semester analyzed begins in the semester of NFC-e implementation (Jul-Dec/17). The coefficients with indicators (st <20), (st<15), and (st <10) show the DiD model estimate based on the exclusion of companies with a higher proportion of tax substitution purchases in relation to the indicated factor. For example, (st<20) excludes all companies that had more than 20% of their total purchases subject to tax substitution. Thus, in columns (2) to (4), the model is estimated by excluding companies that are more subject to tax substitution and

that, theoretically, are less subject to the direct impact of NFC-e implementation at the end of the chain.

It is worth noting that the estimate of the impact of the implementation of NFC-e probably represents a floor for the effect of the program, since the control group (wholesale sector) was also possibly affected by the implementation of these invoices. In addition, due to possible registration problems of companies, which often register CNAEs (National Classification of Economic Activities) that differ from the actual operations of the companies, the control group may have companies that actually belong to the treatment group (retail sector). These problems may contribute to an underestimation of the average effect of the impact of NFC-e.

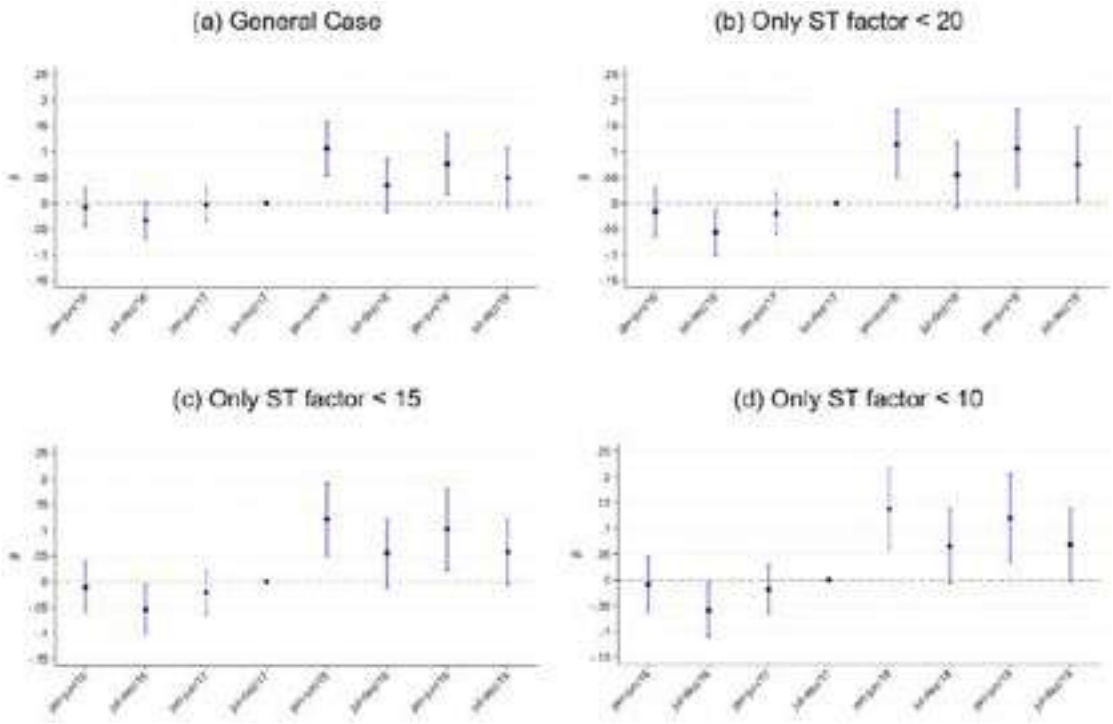
Using Equation 4.2, with a flexible DiD with seven half-yearly dummies, it is possible to test the parallel trend hypothesis between the treatment and control groups of the econometric models in columns (1) to (4). Figure 4.1 shows the *event study* tests for this model with a 95% confidence interval.

$$Ln(R)_{ist} = \alpha_i + \gamma_t + \sum_{k=-3}^{4} \beta^k \left(Tratado_s \cdot Semestre_t^k \right) + \epsilon_{ist} \#4.2$$

Where: $Ln(R)_{ist}$ is the logarithm of the average revenue reported by company ***i*** per semester ***t*** and per sector ***s***; α_i is the fixed effect per company; γ_t is the fixed effect per semester; β^k is the Differences-in-Differences coefficient estimated for each semester; ($Tratado_s$. $Semestre_t^k$) is the time-varying dummy variable, which will be equal to 1 if the company is in retail and if semester ***t*** is from Jul-Dec/17; it will be 0 otherwise; ϵ_{ist} is the robust and clustered error term at the company level.

Appendix C shows, as a robustness test, an analysis similar to that performed by Naritomi (2019) of the regression at the company level, but with the periods aggregated only in pre- and post-treatment. This strategy avoids the log zero of companies' revenues at the monthly level and helps to solve several serial correlation problems in the calculation of standard errors. The results of the robustness test are consistent with those found for the six-month period.

Figure 4.1 – Event Study of the Econometric Model by Company - CI (95%)



Source: Own elaboration (2025)

In addition, Annex D also shows the impact of NFC-e implementation by aggregate sector. According to Naritomi (2019), sector-by-sector analysis can mitigate specific problems of zero logarithmic values in the revenue reported by firms. Furthermore, from an aggregate perspective, it can mitigate the imperfections in companies' registration data. The results found are in line with the findings for individual companies.

4.1.1 Heterogeneity Analysis – Effect by Municipality Size

Using modeling similar to Equation 4.1, we analyze the impact of NFC-e implementation by municipality size where the company is registered.

The same nomenclature as in Section 3.3 was agreed upon to specify the size of the municipalities: “Small I” (pop. less than 20k); “Small II” (pop. between 20k and 50k); “Medium” (pop. between 50k and 100k) and “Large” (pop. greater than 100k)

Table 4.2 identifies the average half-yearly revenue figures reported by companies for the pre-treatment period (Jan/16 to Jul/17) for each municipality size.

Table 4.2 – Average Half-Yearly Revenue by Municipality Size

SETOR	TAMANHO			
	Pequeno I	Pequeno II	Médio	Grande
ATACADO	R$ 262.700	R$ 967.960	R$ 768.922	R$ 1.219.873
VAREJO	R$ 32.401	R$ 38.767	R$ 46.264	R$ 61.914

Source: Own elaboration (2025)

The results of the econometric model in Equation 4.1, taking into account heterogeneity by municipality, are described in Table 4.3, showing only the regression of the general case (without excluding companies) and the case of excluding companies with a tax substitution factor above 15%.

Based on the results found, it can be seen that, both in the analysis of the general case and in the exclusion of companies subject to tax substitution, there is a convergence of results. It is not possible to say, at a 10% significance level, that municipalities with a population of less than 20,000 inhabitants were impacted by the implementation of the NFC-e. One possible explanation may be the low level of enforcement in these sparsely populated areas. Custom and low enforcement continue to allow the non-issuance of invoices to be the norm for these companies and, consequently, the practice of tax evasion to continue.

However, as the municipality increases in terms of population, there is already a tendency toward greater oversight (both by consumers and the tax authorities). For "Small II," "Medium," and "Large" municipalities, there is an increase of 8.82%, 9.10%, and 6.05%, respectively, in the revenue reported by firms in the general case analysis. Excluding companies with an ST factor greater than 15%, these values reach 9.74%, 14.7%, and 8.96%, respectively.

Table 4.3 – Results of the DiD model – Heterogeneity by Municipality

	Log da receita reportada (cutoff 98,5°)			
Variáveis	(1)	(2)	(3)	(4)
DiD	0,0692	0,0882*	0,0910*	0,0605**
	(0,0614)	(0,0460)	(0,0484)	(0,0291)
EF Empresa	X	X	X	X
EF Semestre	X	X	X	X
Observações	89.474	120.678	69.549	240.276
R^2 ajustado	0,939	0,966	0,97	0,932
Empresas Atacado	654	1.255	806	4.882
Empresas Varejo	16.119	22.199	12.678	46.619
	Log da receita reportada (cutoff 98,5°)			
Variáveis	(1)	(2)	(3)	(4)
DiD (ST<15)	0,123	0,0946*	0,147**	0,0896**
	(0,0752)	(0,0540)	(0,0677)	(0,0372)
EF Empresa	X	X	X	X
EF Semestre	X	X	X	X
Observações	31.141	49.370	32.803	129.262
R^2 ajustado	0,921	0,958	0,972	0,922
Empresas Atacado	464	884	521	3.555
Empresas Varejo	6.003	9.594	6.333	25.413

Erros padrões robustos e clusterizados por empresas em parenteses

*** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration (2025)

Note: Table 4.3 shows the main coefficients of the Difference-in-Differences model of Equation 4.1, taking into account the heterogeneity of the size of the municipalities. The DiD variable is defined based on the interaction between a dummy variable if the company is part of the retail sector and if the semester analyzed begins in the semester of implementation of the NFC-e (Jul-Dec/17). The coefficient with indicators (st <15) excludes all companies that had more than 15% of their total purchases subject to tax substitution.

4.2 Impact of the Nota Premiada Bahia Program

In order to analyze the impact of the Nota Premiada award on consumer behavior, the NFC-e issued in small municipalities can be evaluated. For such cities, it is possible to find a control group of cities that have never had winners and a treatment group of cities that have had winners for the first time. For larger municipalities, however, this process is hampered, since

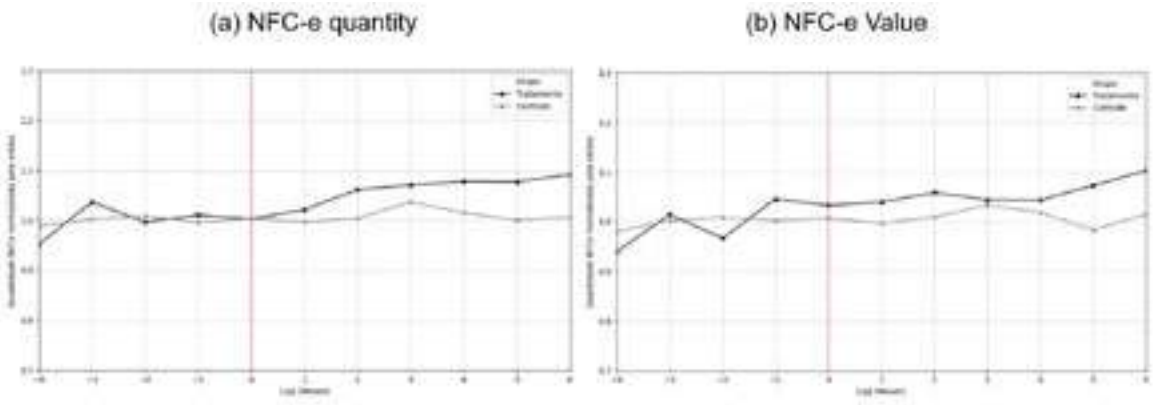
there are fewer municipalities and virtually all of them have already had several winners.

To perform a graphical analysis of the impact of the prize draws, we compare "treatment" groups, municipalities that have had winners of R$ 10,000 prizes, and "control" groups, municipalities that have never had winners. Cities that have had winners of R$ 100,000 and R$ 1 million prizes are excluded from the evaluation. Given the significant value of these prizes, we chose to exclude them to mitigate the effect of the prizes themselves on the values of NFC-e issued in the municipality.

In Figures 4.2 and 4.3, the x-axis shows the lag in relation to the month of the first prize in cities with winners. The y-axis indicates the evolution of the quantity and value of NFC-e issued in these cities during the period analyzed. These values were normalized by the average for each municipality before the prize. Figure 4.2 shows the analysis for municipalities with a population of less than 20,000 inhabitants, and Figure 4.3 shows the analysis for municipalities with between 20,000 and 50,000 inhabitants.

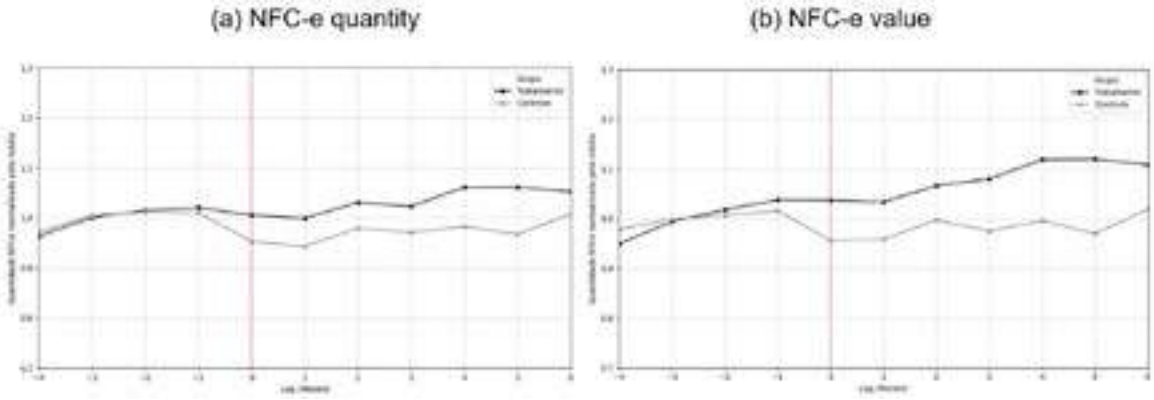
The lag $k \in [-4, 6]$ on the x-axis is constructed as follows: for municipalities with first-time winners, the lag will be equal to the 4 months prior to and 6 months after the month of the award; for municipalities that have never had winners, lag indicators [-4, 6] are randomized for all months that are in the same lag interval as the winning municipality.

Figure 4.2 – NFC-e Quantity and Value Municipalities with less than 20k inhabitants



Source: Own elaboration (2025)

Figure 4.3 – NFC-e Quantity and Value Municipalities with between 20k and 50k inhabitants



Source: Own elaboration (2025)

To identify the average effect of the award on the behavior of individuals in municipalities with winners, the DiD model of Equation 4.3 is applied.

$$Ln(NFCe)_{mk} = \alpha_m + \theta_k + \beta.D_{mk} + \epsilon_{mk} \quad \#4.3$$

Where: $Ln(NFCe)_{mk}$ is the logarithm of the quantity (or value) of NFC-e issued by municipality m for each lag k; α_m is the fixed effect per municipality; θ_k is the fixed effect per lag; β is the estimated Differences-in-Differences coefficient; D_{mk} is the treatment dummy variable per lag, which will be equal to 1 if the municipality had a winner and the period is after the award (including the month of the draw) and will be 0 otherwise; ϵ_{mk} is the clustered error term at the municipality level.

The month of the award is included in the post-treatment period. As seen, the number of registrations and searches for the program increases in the days following the award. Thus, the month of the award itself may already affect consumer behavior in requesting invoices. Table 4.4 shows the regression results for the municipalities "Small I" (pop. less than 20k) and "Small II" (pop. between 20k and 50k). For "Small I" municipalities, having a winner in the city increases the average value of NFC-e invoices issued over the next six months by 7.6% and the number of NFC-e invoices issued by 7.3%. For "Small II" municipalities, these figures reach 12.8% and 9.7%, respectively.

Table 4.4 – Results of the DiD model for NPB

	Log do Valor Emitido em NFC-e		Log da Qtd Emitida de NFC-e	
VARIÁVEIS	(1)	(2)	(3)	(4)
DiD (Pequeno I)	0.0759**		0.0729*	
	(0.0327)		(0.0377)	
DiD (Pequeno II)		0.128**		0.0968*
		(0.0516)		(0.0509)
EF por Município	X	X	X	X
EF por Defasagem	X	X	X	X
Observações	2,728	1,176	2,728	1,176
R^2 ajustado	0.772	0.832	0.773	0.842
Nº Municipios com Ganhadores	51	47	51	47
Nº Municipios sem Ganhadores	201	62	201	62

Erros padrões robustos e clusterizados por município

*** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration (2025)

5. CONCLUSION

As seen, access to commercial transaction information is essential to improve taxpayer compliance and oversight by tax authorities.

Based on microdata provided by the Bahia State Finance Department, we analyzed the impact of the implementation of new electronic tax documents on taxpayer behavior. The NFC-e, an innovative document in the Brazilian scenario, enabled real-time and digital information for each transaction. The mere requirement to register was enough to change companies' behavior and increase their reported revenues. This impact can reach up to 17.7% in the aggregate analysis by sector and up to 10.2% in a more granular view by companies.

The greater effect of the NFC-e's impact on companies less subject to the tax substitution regime strengthens this instrument as an efficient means of preventing tax evasion. However, this result does not prevent discussion of various problems with the ST and possible improvements. Often, estimated prices are perceived as significantly out of step with the current market value of products. This adds complexity to the already complicated Brazilian tax system.

Furthermore, growing initiatives to encourage tax compliance are capable of affecting consumer behavior through a logic distinct from *enforcement*. Lottery policies can be used as complementary instruments to tax authority oversight, elevating consumers themselves to the

status of overseers and encouragers of invoice issuance.

The findings of this study, therefore, highlight the impact of new *enforcement* support policies on tax evasion. The increase in tax revenue resulting from these efforts may favor a better allocation of public services offered by federal entities. In addition, it may also mitigate the problem of asymmetric information and unequal conditions in the Brazilian commercial environment, since there are companies with greater incentives and resources to commit tax evasion.

Brazil is a country with several problems of social inequality and tax evasion. The analyses presented in this dissertation aim to provide evidence of policies capable of mitigating such problems.

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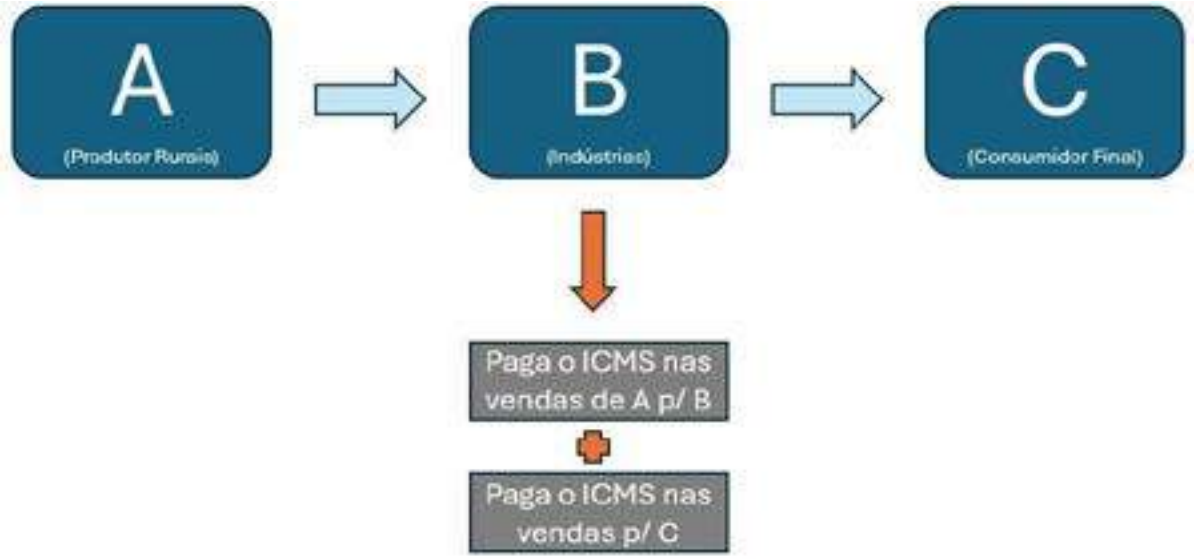
APPENDICES

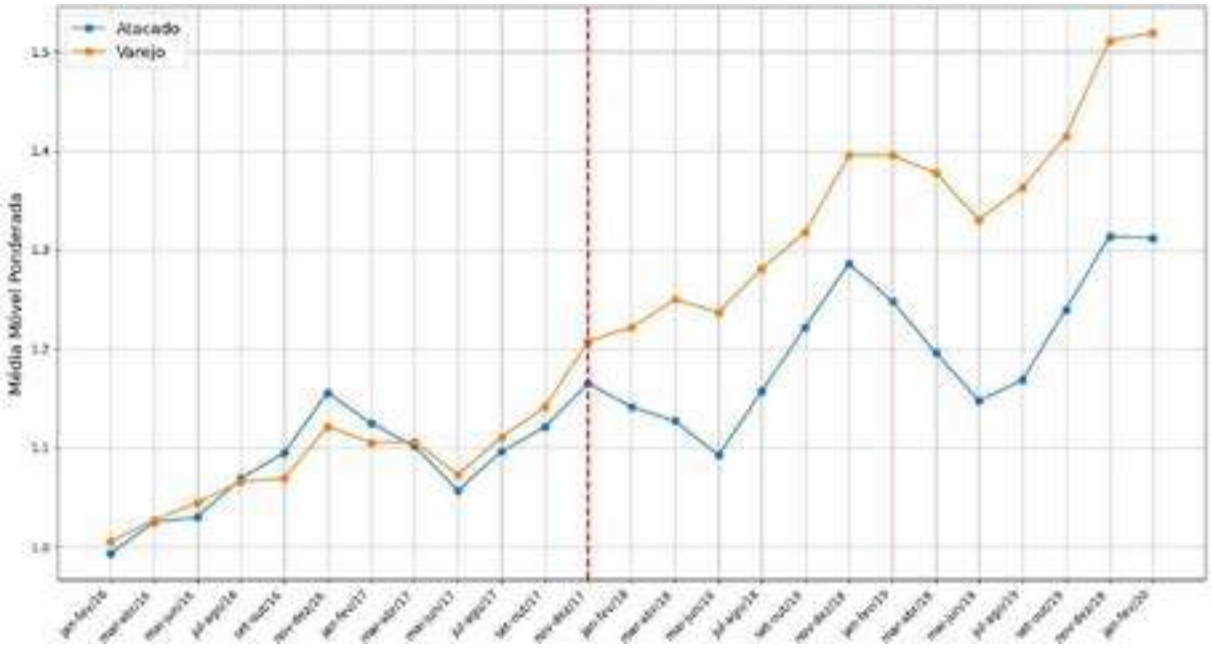
Appendix A – Auxiliary Figures

Figure A.1 – Backward ST flow



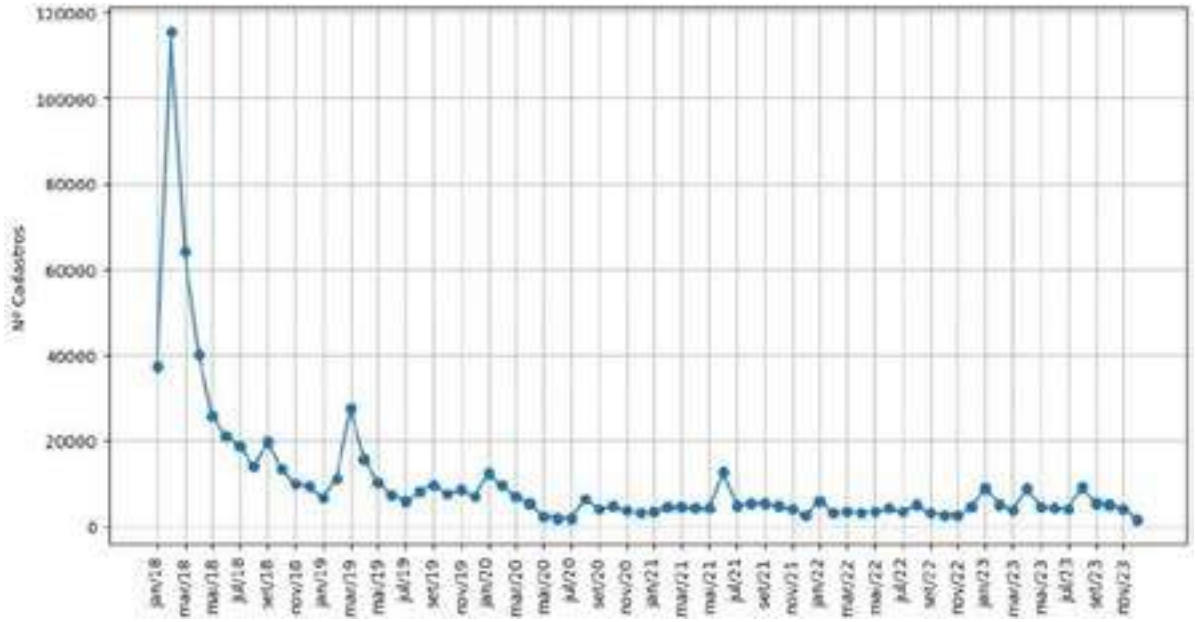
Source: Own elaboration (2025)

Figure A.2 – Weighted Moving Average for the last 3 two-month periods (Companies with ST factor < 15%) – Wholesale x Retail



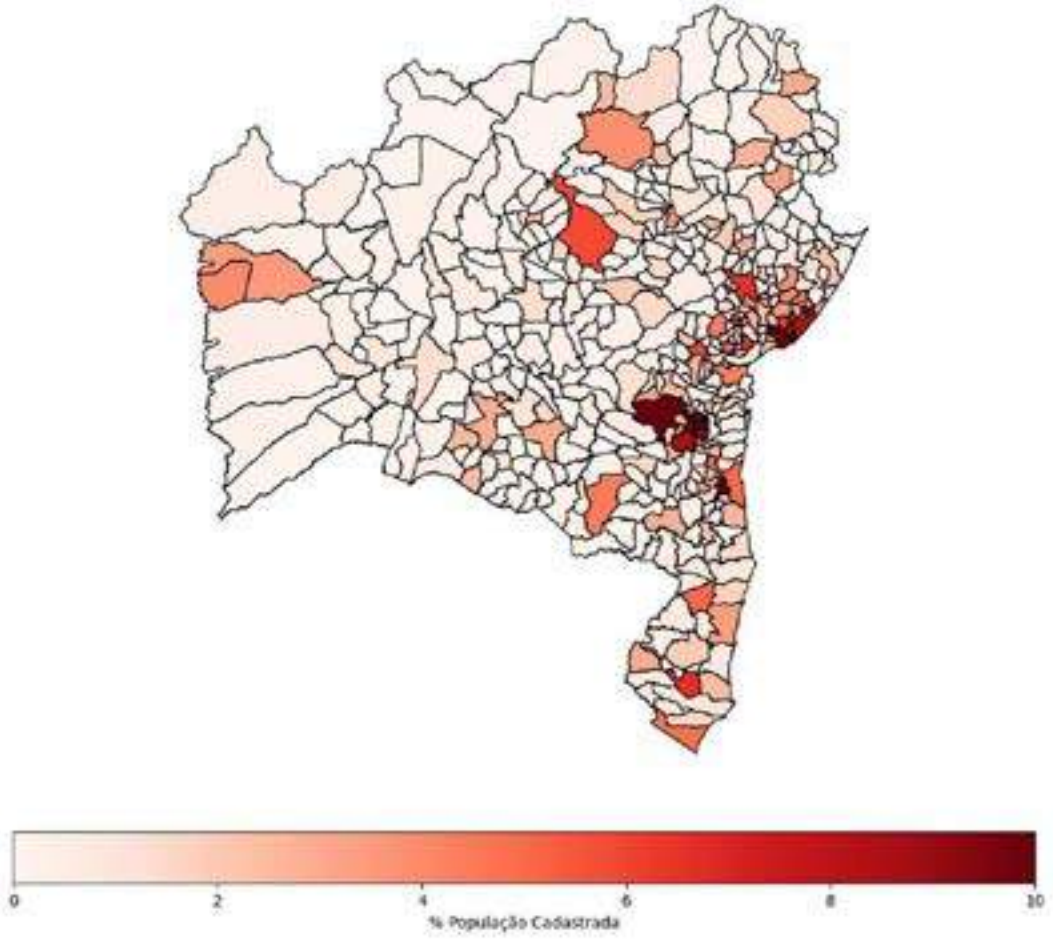
Source: Own elaboration (2025)

Figure A.3 – Monthly NPB Registrations



Source: Own elaboration (2025)

Figure A.4 – Proportion of the registered population per inhabitant



Source: Own elaboration (2025)

Appendix B – Auxiliary Charts and Tables

Table B.1 – Number of Tickets Generated per Consumer – NPB

Faixa	Soma dos Valor das Notas Mensais (R$)	Quantidade de Bilhetes
1	0,01 - 100,00	10
2	100,01 - 200,00	15
3	200,01 - 400,00	20
4	400,01 - 800,00	25
5	800,01 - 1.200,00	30
6	1.200,01 - 1.600,00	35
7	1.600,01 - 2.000,00	40
8	Acima de 2.000,00	45

Source: BAHIA (2019)

Table B.2 – Identification of Retail and Wholesale CNAEs

Setor	Cnae	Descrição
Varejo	Início 47...	Comércio Varejista
Varejo	Início 56...	Alimentação (Bares e Restaurantes)
Varejo	45111/01... /02	Comércio a varejo de automóveis, camionetas e utilitários novos e usados
Varejo	45307/03... /04	Comércio a varejo de peças e acessórios novos e usados para veículos automotores
Varejo	45307/05	Comércio a varejo de pneumáticos e câmaras de ar
Varejo	45412/03... /04/05/07	Comércio a varejo de motocicletas e acessórios (novos ou usados)
Atacado	Início 46...	Comércio por Atacado, exceto veículos automotores e motocicletas
Atacado	45111/03... /04/05/06	Comércio por atacado de automóveis, camionetas, caminhões, ônibus, reboques e utilitários novos e usados
Atacado	45307/01	Comércio por atacado de peças e acessórios novos para veículos automotores
Atacado	45307/02	Comércio por atacado de pneumáticos e câmaras de ar
Atacado	45412/01.. /02	Comércio por atacado de motocicletas, peças e acessórios

Source: Own elaboration (2025) based on IBGE data (2019)

Appendix C – Robustness Test: DiD by Companies (Aggregate Analysis between Pre- and Post-Treatment)

According to the methodology proposed by Naritomi (2019), it is also possible to verify the impact of the implementation of NFC-e at the company level *i* using the DiD estimator in Equation C.1.

The regression at the company level is performed based on two grouped periods (before and after treatment). The pre-treatment period is from January 2016 to October 2017 (variable *After* = 0), while the post-treatment period is from November 2017 to February 2020 (variable *After* = 1). According to (Naritomi, 2019), this strategy avoids the log zero of companies' monthly revenues and helps to solve several serial correlation problems in the calculation of standard errors. Another reason for grouping the periods between only before and after treatment is due to data imbalance. Several companies do not have declared revenues every month, so grouping the data avoids excluding such companies from the analysis.

Each observation is weighted by its values from the pre-implementation period of the NFC-e to better represent the scale ratio of each company in the market.

$$Ln(R)_{ist} = \alpha_i + \gamma \,.\, Apos_t + \beta \,.\, D_{ist} + \epsilon_{ist} \quad \#C.1$$

Where: $Ln(R)_{ist}$ is the logarithm of the average revenue reported by company *i* in the pre- and post-treatment periods; α_i is the fixed effect per company; γ is the fixed effect in the period grouped between Before and After treatment; β is the estimated Differences-in-Differences coefficient; D_{ist} is the time-varying treatment dummy, which will be equal to 1 if the company's sector is in retail and if the period t is after October 2017, and will be 0 otherwise; ϵ_{ist} is the clustered error term at the company level.

The results of the econometric model are shown in Table C.1. In the evaluation of the model at the company level, there is still an increase in the reported revenue of firms, reaching 10.2% in the case of companies with an ST factor of less than 10. The exclusion of companies with relevant tax substitution indicators increases the estimated coefficient by about 70% to 90%. It can be seen that the range of estimates of the impact of the implementation of NFC-e at the aggregate level over time is consistent with that observed for companies at the half-yearly level.

Table C.1 – Results of the DiD model by Companies

	Log da receita reportada (cutoff 98,5°)			
Variáveis	(1)	(2)	(3)	(4)
DiD	0,0530***			
	(0,0198)			
DiD (st <20)		0,0918***		
		(0,0227)		
DiD (st <15)			0,0898***	
			(0,0225)	
DiD (st <10)				0,102***
				(0,0246)
EF Empresa	X	X	X	X
EF Setor	X	X	X	X
EF Bimestre	X	X	X	X
Observações	144.304	75.070	68.954	63.366
R^2 ajustado	0,962	0,959	0,960	0,958
Empresas Atacado	8.682	6.766	6.463	6.005
Empresas Varejo	99.302	52.759	48.538	44.823

Erros padrões robustos e clusterizados por empresas em parenteses

*** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration (2025)

Note: Table C.1 shows the main coefficients of the Difference-in-Differences model of Equation C.1 at the company level. The DiD variable is defined based on the interaction between a dummy if the company is part of Retail and if the period t is after October 2017; it will be 0 otherwise. The coefficients with indicators (st <20), (st <15), and (st <10) show the DiD model estimate based on the exclusion of companies with a higher proportion of purchases subject to tax substitution in relation to the indicated factor. For example, (st<20) excludes all companies that had more than 20% of their total purchases subject to tax substitution.

Appendix D - Impact of NFC-E Implementation - DiD by Sector

The proposed Difference-in-Differences model for the 218 distinct sectors ***s*** per two-month period ***t*** is shown in Equation D.1.

$$Ln(R)_{st} = \alpha_s + \gamma_t + \beta \, . \, D_{st} + \epsilon_{st} \quad \#C.1$$

Where: $Ln(R)_{st}$ is the logarithm of the revenue reported by sector in the two-month period ***t***; α_s is the fixed effect per sector, γ_t is the fixed effect per two-month period; β is the estimated Difference-in-Differences coefficient; D_{st} is a time-varying treatment dummy, which will be

equal to 1 if the sector is in retail and if the two-month period ***t*** is after October 2017, and will be 0 otherwise; ϵ_{st} is the clustered error term by sector.

The results of the econometric model are shown in Table D.1. Column (1) shows the results without any exclusions of companies after the treatments already mentioned in Section 3.2. Thus, the implementation of NFC-e increased the revenue reported by the retail sectors by 9.6% in relation to the wholesale sectors.

Columns (2) to (4) show the results of the econometric model with the exclusion of companies with ST indicators below 20%, 15%, and 10%, respectively. It should be noted that, when analyzing companies less subject to tax substitution, the impact per aggregate economic sector increases significantly. After the NFC-e implementation period, the revenue reported by the sectors increases from 15.5% to 17.7%. This represents an increase of 60% to 83% compared to the overall analysis of all companies.

In line with the individual analysis by companies in Section 4.1, the analysis of the Differences-in-Differences model by sector applied only to companies with ST factors greater than 20%, 15%, and 10% returned, in all cases, DiD coefficients not significantly different from zero. This reinforces the evidence that companies with less exposure to tax substitution were more impacted by the implementation of NFC-e.

Table D.1 – Results of the DiD model by Sector

	Log da receita reportada (cutoff 98,5°)			
Variáveis	(1)	(2)	(3)	(4)
DiD	0,0966**			
	(0,0393)			
DiD (st <20)		0,177***		
		(0,0650)		
DiD (st <15)			0.173***	
			(0,0644)	
DiD (st <10)				0,155**
				(0,0667)
EF Setor	X	X	X	X
EF Bimestre	X	X	X	X
Observações	5.403	5.354	5.300	5.271
R^2 ajustado	0,9686	0,9542	0,9584	0,9588
CNAEs Atacado	126	125	123	122
CNAEs Varejo	92	92	92	92

Erros padrões robustos e clusterizados por setor em parenteses

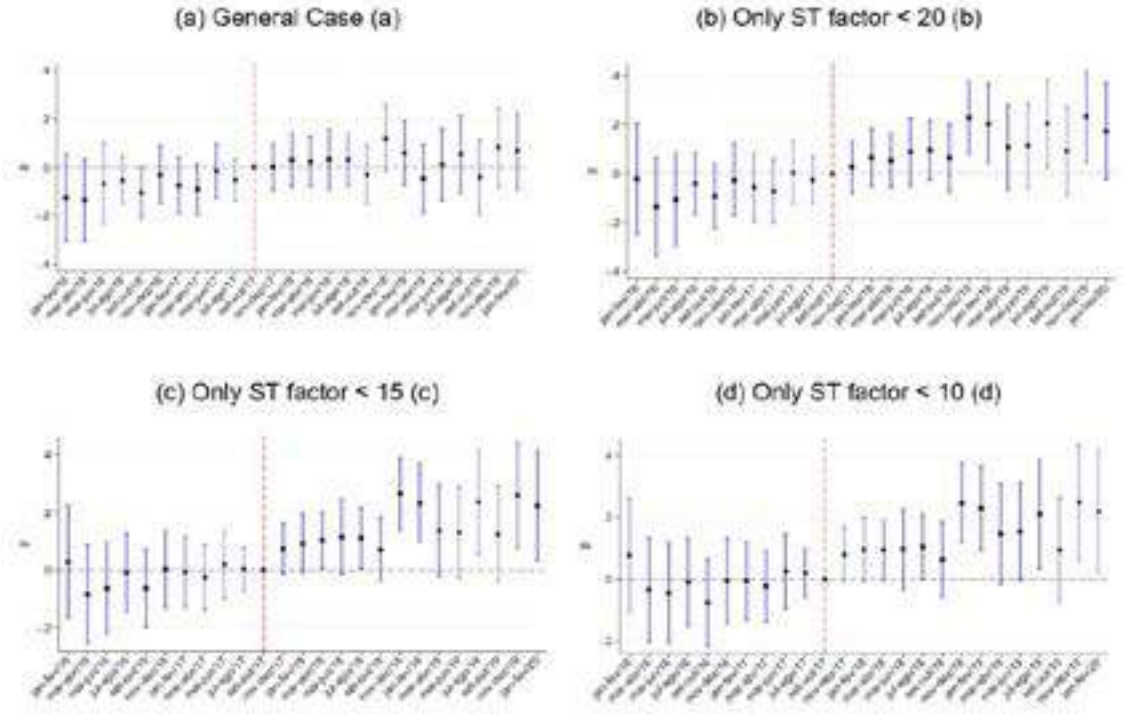
*** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration (2025)

Note: Table D.1 shows the main coefficients of the Difference-in-Differences model of Equation 5.3 at the sector level. The DiD variable is defined based on the interaction between a dummy variable if the sector is part of Retail and if the two-month period analyzed is after the implementation of NFC-e (October 2017). The coefficients with indicators (st <20), (st <15), and (st <10) show the DiD model estimate based on the exclusion of companies with a higher proportion of tax substitution purchases in relation to the indicated factor. For example, (st<20) excludes all companies that had more than 20% of their total purchases subject to tax substitution. Thus, in columns (2) to (4), the model is estimated by excluding companies that are more subject to tax substitution and that, theoretically, are less subject to the direct impact of the implementation of NFC-e at the end of the chain.

To test the hypothesis of a parallel trend between the treatment and control groups of the econometric models in columns (1) to (4), Figure D.1 shows the event study graphs of the regressions at the sector level, with a 95% confidence interval. Note that the treatment group approximates the characteristics of the control group at the pre-treatment level, with the exception of companies most affected by tax substitution.

Figure D.1 – Event Study of the Econometric Model by Sector – CI (95%)



Source: Own elaboration (2025)