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Evidence from Brazil

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Abstract*

A large body of research has estimated the effects on tax collection of informing taxpayers of their obligations. This paper examines the effects on voluntary tax payments of providing taxpayers with information on their obligations that is collected through massive information cross-checking rather than traditional auditing. This information is inexpensive to collect, but may not be sufficiently accurate to promote taxpayer compliance. We conducted a randomized controlled trial to evaluate the effectiveness of self-regularization interventions on tax compliance among simplified tax regime firms. We examine the treatments that use this information in three different ways: messaging, providing tax compliance manuals, and assisted regularization, in which tax auditors assist taxpayers in the self-regularization process. We find that assisted regularization increased the reported monthly income by 20 percent (US$1,160), which also nearly closed the tax evasion gap and reduced inconsistencies in tax declarations by 67 percent (37-point reduction). The manual and message interventions had positive, albeit smaller, effects. While the assisted regularization intervention had the largest effects, a cost-effectiveness analysis reveals that this intervention is not optimal for smaller firms because of the costs incurred by the tax authority. No effects were observed on firms' tax compliance in declarations filed in the post-intervention periods.

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Introduction

Traditional public finance research assumes that the enactment of tax obligations in legislation leads directly to revenue collection. However, practical implementation often reveals a significant gap between theory and reality (Slemrod, 2007, 2018). Higher audit penalties often deter tax noncompliance (Allingham and Sandmo, 1972), but the resources of the tax authority (TA) may not be sufficient for effective auditing. Moreover, the literature suggests that the impact of more audits and penalties on tax compliance follows a nonlinear relationship: the deterrent effect may diminish as the volume of audits and fines becomes too large (Alm, 2012). An alternative approach by TAs that is supported by new technologies and coupled with the effective use of fiscal information can play a crucial role in closing this gap (OECD, 2020).

Accurately accessing the amount of taxes owed is a major challenge for TAs, especially in developing countries (Gordon and Li, 2009). Partnerships between researchers and TAs have helped advance understanding and reduce the gap between taxes owed and taxes collected (Pomeranz and Vila-Belda, 2019). In 1995, the first experiment using letters sent by a TA was conducted in Minnesota (Coleman, 1996; Blumenthal, Christian, and Slemrod, 2001; Slemrod, Blumenthal, and Christian, 2001). Such experiments often include deterrence messages that emphasize the risk of detection or the severity of punishment and appeal to tax morale by highlighting aspects such as the social norm or the benefits to society (Pomeranz and Vila-Belda, 2019). The literature emphasizes the importance of providing clear communication supported by evidence and avoiding unfounded threats (Carrillo, Pomeranz, and Singhal, 2017). The combination of effective use of tax information and the ability to ensure enforcement is crucial for tax compliance.

The digitization and the introduction of the electronic invoice in Brazil in 2007 has provided the Brazilian TA with a vast amount of data. This data can be used to strengthen the TA's fiscal capacity through massive auditing and self-regularization. The so-called *malha fiscal* (plural form *malhas fiscais*)[1] is a computerized system that performs centralized processing of various sources of information, such as electronic invoices, accounting records, and tax declarations. These systems cross-check the data from different sources to identify possible irregularities and then encourage self-regularization by notifying the taxpayer, resulting in significantly lower costs compared to traditional auditing methods. These electronic systems have introduced a new form of auditing in which tax auditors devote part of their time to online monitoring of detected inconsistencies, advising taxpayers on how to amend declarations, and, as a last resort, carrying out in-person audits. This paper evaluates the effectiveness of three different self-regularization interventions to improve tax compliance among micro and small firms registered as simplified tax regime taxpayers in the state of Bahia, Brazil. The evidence shows that these interventions can effectively increase reported income, reduce tax evasion, and improve tax compliance.

[1] *Malha fiscal* can be translated as a “fiscal net” or “fiscal mesh” and refers to massive cross-checks of data from different sources.

Self-regularization reduces TAs' costs because the TA does not need to prove irregularities through the administrative process. In practice, self-regularization focuses on taxpayers with declarations showing evidence of error or fraud and is seen as a last attempt at a friendly settlement between the TA and the taxpayer (Biderman, 2023). Self-regularization also contributes to strengthening and transforming the relationship between the citizen-taxpayer and the government. The benefits include greater transparency and openness in the relationship between the TA and taxpayers, greater tax certainty, and lower compliance and litigation costs (Calijuri and Oliveira, 2023).

Although there is no official estimate of the tax gap in Brazil, studies show a significant gap between the tax revenue that should be collected and the tax revenue actually collected. The National Union of Treasury Prosecutors (SINPROFAZ, 2023) estimates that tax evasion in the country reached R$626.8 billion in 2022 (approximately US$125 billion[2]), representing 6.2 percent of the gross domestic product (GDP) and 58 percent of the revenue collected by state and municipal governments (National Treasury Secretariat, 2023).[3]

In partnership with the state of Bahia TA (Secretary of Finance of Bahia, SEFAZ-BA), in 2022 we conducted a randomized controlled trial (RCT) to investigate the impact of different self-regularization interventions. SEFAZ-BA implemented massive cross-checking of information and auditing of tax declarations through *malhas fiscais*, followed by self-regularization. Three interventions were implemented: (i) sending messages informing taxpayers about detected inconsistencies, (ii) providing a manual explaining tax compliance and the self-regularization process, and (iii) offering assisted or supervised regularization in which tax auditors assist taxpayers through the self-regularization process. The evaluation design made it possible to estimate the differential effect of three interventions of different intensities and to assess which is the most cost-effective. The study sample consisted of 3,400 simplified regime Simples Nacional (SN) taxpayers with detected inconsistencies in tax declarations filed in 2020 and 2021. The taxpayers were stratified according to the level of evasion and randomly assigned into four treatment groups and one control group. The outcome indicators were collected monthly in six follow-ups.

The results show that assisted regularization is the most effective intervention, followed by providing a tax compliance manual and then sending messages. In the preferred specification, the declared monthly income increased by about R$5,800 (US$1,160) in the last follow-up in the group that received assisted regularization; this represents almost 20 percent of the average revenue declaration of R$30,007. The impact is positive and statistically significant from the second follow-up onward, with the increase in declared monthly income ranging from R$4,900 (US$980) to R$6,100 (US$1,220). The

[2] An exchange rate of R$ 5.00/US$ is used here and throughout the paper.
[3] Specifically for the Tax on the Circulation of Goods and Services (ICMS)—a tax similar to a value-added tax (VAT)—Chiarelli de Sousa and Rezende (2023) calculate that the ratio between the ICMS collected and its potential revenue is only 49.2 percent. The average performance of ICMS revenue is below the average of the Organisation for Economic Co-operation and Development (OECD) countries for VAT.

results are also positive for the manual and message interventions;[4] in this case the increase in declared monthly income ranges from R$2,100 (US$420) to R$5,800 (US$1,160).

The amendments in tax declarations resulted in an almost complete elimination (94 percent, at Follow-Up 5) of tax evasion[5] in the assisted regularization group and a reduction of up to 76 percent and 63 percent, respectively, in the manual and message groups.[6] The results also show a drop in the probability of having inconsistencies detected by the *malha fiscal* for all treatment groups of 37 percentage points (pp) (68 percent compared to the pre-treatment average), 15 pp (27.5 percent), and 10 pp (18.3 percent), respectively.

The heterogeneity analyses show that the firms with higher tax evasion at baseline made larger corrections in the declared monthly revenue. The manual treatment had larger effects in the group of taxpayers with fewer inconsistencies detected at baseline, and assisted regularization had larger effects in the group of taxpayers with more inconsistencies. The effects of the interventions were higher in the subsets of firms that are larger, have fewer years of operation, and are situated outside of the state capital (Salvador).

Despite assisted regularization yielding the largest effect, it is not cost-effective when applied to smaller firms (with annual revenues of up to R$180,000). This is because the revenue obtained from smaller firms does not compensate for the costs incurred by the TA in assisted regularization, which requires the direct intervention of tax auditors. No effects were detected on tax compliance in declarations filed in the post-intervention period, and there is no evidence of spillover effects among firms with the same accountant.

The study contributes to the public finance literature by investigating the role of the effective use of new digital technologies and the information available to the TA. This is particularly relevant to the literature focused on massive auditing and regularization of simplified regime taxpayers (Coolidge and Yilmaz, 2016; Bando et al., 2021; Dom et al., 2022). This study also assesses the effects of self-regularization interventions of different strengths, given previous results showing differential effects (Antinyan and Asatryan, 2019; Pomeranz and Vila-Belda, 2019; Ortega and Scartascini, 2020; Mogollon, Ortega, and Scartascini, 2021). The interventions evaluated in this study range in strength from sending a message, to providing a tax compliance manual, to regularization assisted by tax auditors. In addition, this study performs a cost-effectiveness analysis from the perspective of the TA. This study is distinctive in that it compares the effects of the different self-regularization interventions over time through six monthly follow-ups.

[4] The effect is not statistically significant at the final follow-up for the message group because of control contamination (see Section 5.2 Compliance with Treatment for details) and comparison with the least strong treatment.
[5] Here "tax evasion" is defined as the difference between the revenue declared by the taxpayer and the revenue calculated by the TA using third-party information.
[6] The estimated impact on tax evasion of the message and manual treatments is not statistically significant in the last two follow-ups.

In contrast to the findings in previous studies (Kleven et al., 2011; Advani, Elming, and Shaw, 2023; DeBacker et al., 2015, 2018), our results show that the self-regularization interventions do not alter taxpayers' behavior with respect to declarations filed in later periods. A key difference between this study and the existing literature is that previous studies focused on traditional tax audits, while this study evaluates self-regularization interventions that do not include imposing a fine on taxpayers detected as tax evaders. Section III of this paper shows that self-regularization interventions encourage taxpayers to declare an optimal value of income for the specific declaration for which they receive the notification. However, given that there is no fine for evading, taxpayers do not change their behavior regarding future declarations.

This paper is organized as follows: Section II discusses the background of the Brazilian fiscal system, the SN tax regime, and the massive system for cross-checking information and auditing (*malha fiscal*). Section III outlines the conceptual framework. Section IV describes the study sample and the methodology. Section V presents and discusses the main results, while Section VI presents the additional results. Finally, Section VII concludes. Tables with additional information and results are presented in Annex A, and Annex B provides a cost-effectiveness analysis.

1. Institutional Context

Brazil is a federative republic comprising three levels of government: the union (federal government), states, and municipalities. Each of these levels has the autonomy to collect taxes and carry out public spending. Strengthening the fiscal capacity of subnational governments is important for Brazil because state and municipal revenue accounts for more than 30 percent of tax revenue and approximately 20 percent of national GDP (National Treasury Secretariat, 2023). Tax on the Circulation of Goods and Services (ICMS) is the most important tax in Brazil in terms of revenue. It is a state tax and accounts for approximately 7 percent of GDP and 80 percent of the state's own revenue (National Treasury Secretariat, 2023).

The state of Bahia, situated in the northeast of the country, faces significant social and economic challenges. Despite being the fourth most populous state (IBGE, 2022), it ranks only seventh in terms of GDP, and its GDP per capita is below the national median. Furthermore, 51.6 percent of the population of Bahia lives below the poverty line (IBGE, 2022). This context makes it imperative for the state TA to optimize tax collection and guarantee fiscal capacity to meet spending needs.

Approximately 180,000 firms are registered in Bahia, with 80 percent of them being micro and small businesses registered in the SN tax regime. This tax regime unifies and simplifies the monthly payment of eight taxes[7] through a single tax document. The tax liability is calculated based on a firm's total gross revenue. The SN uses reduced tax rates schedules applied according to the firm's economic activity and revenue, which results in less tax liability. For instance, the general value-added tax (ICMS) in Bahia was 18 percent in 2022. However, for companies subject to SN, the ICMS portion tax rate varied from 1.25 percent to 3.95 percent of their total gross revenue (see Table A1 in Annex A).

[7] State tax (ICMS), a municipal tax on services (ISS), and federal taxes on income (IRPJ), profits (CSLL), industrial products (IPI), imports (PIS/Pasep, COFINS), and social security contribution (CPP).

Firms with an annual gross revenue of up to R$4.8 million[8] (US$960,000) are eligible for the SN simplified tax regime.

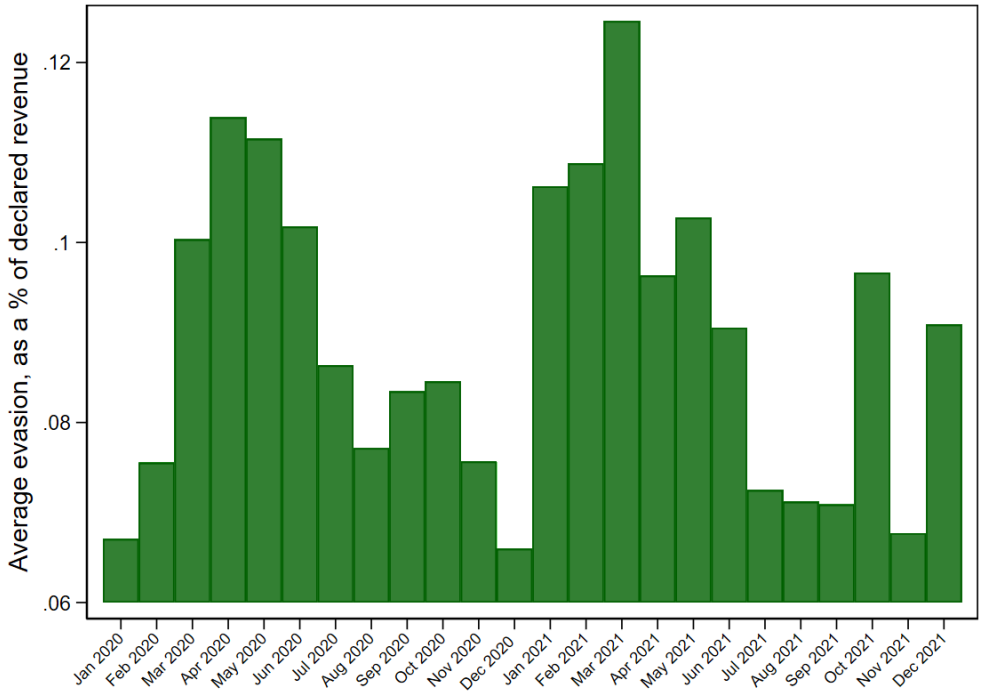
Although the individual revenue of each SN taxpayer is relatively low, the aggregate amount becomes large when considering the universe of all SN taxpayers, which includes a high percentage of taxpayers with tax irregularities. These irregularities can be attributed to intentional tax evasion or a lack of knowledge of tax regulation (Bando et al., 2021). In the sample of 15,441 SN taxpayers analyzed in this study, the average discrepancy between the declared and calculated revenue was R$3,524 (Figure 1). Multiplying this amount by 15,441 firms and applying a conservative average tax rate of 2.33 percent (see Table A1 in Annex A) yields a tax gap of R$30.4 million (approximately US$6 million) over a 24-month period. These funds could be utilized, for example, to construct three new schools or four emergency health care units in the state of Bahia.

Figure 1. Tax Gap for SN Retail Companies in 2020–2021

1(a). Average revenue calculated versus declared per month

[8] In the case of companies in the retail sector, a sublimit of R$3.6 million in annual revenue is permitted for ICMS taxation under the SN regime. Any additional revenue is subject to the general ICMS tax regime.

1(b). Average evasion per month



Notes: Panel 1(a) illustrates the monthly gross revenue of 15,441 SN firms. Calculated revenue is the value obtained by the TA based on third-party information (credit card transactions, accounting records, digital tax accounting, and electronic documents). The declared revenue corresponds to the values in taxpayers' declarations. Panel 1(b) shows the average tax evasion calculated as the percentage difference between the calculated and the declared revenue. All monetary values are in current Brazilian reais (R$).

The limited number of tax auditors[9] in the state of Bahia makes it unfeasible to audit all firms. As a result, efforts are focused on auditing larger firms with greater tax revenue potential. Small firms of the SN regime whose individual tax revenue is low are promising candidates for massive auditing through self-regularization systems called malhas fiscais. These systems have the potential to make a substantial contribution to improving tax compliance and increasing tax revenue at a lower cost.

The Inter-American Development Bank (IDB) provides financing and technical assistance in support of the modernization of the subnational TA in Brazil, including SEFAZ-BA. Activities include the development and implementation of the *malha fiscal* system. This massive auditing system performs cross-checking of information from different sources, identifies discrepancies between the information in tax declarations and third-party information, sends notifications, and allows amendment of declarations.

[9] The ratio of tax auditors to residents in the state of Bahia is 1:21,891 and the national average for Brazil is 1:18,289. In contrast, the ratio for all of Latin America and the Caribbean is 1:3,706 (Morán and Díaz, 2021).

This study leveraged the information cross-checking of the SEFAZ-BA *malha fiscal*, which detected SN firms with declared revenue lower than the revenue calculated by the TA based on third-party information. The taxpayers were notified about the detected discrepancies via their electronic tax mailbox (called the DT-e) and given the option to amend the declaration (self-regularize) by a specified deadline.

2. Conceptual Framework

This section presents a conceptual model that rationalizes the expected effects for taxpayers who received any of the treatments for self-regularization (T1–T4), both in terms of the declarations that received the treatment to increase compliance and those taxpayers declarations filled in the post-treatment period.. This framework considers a version of the seminal model by Allingham and Sandmo (1972) with the introduction of the concept of tax audit salience.[10]

Consider a taxpayer who is risk averse and whose utility function, $U(y)$, is a function of their net revenue. The decision between declaring and evading taxes is made under uncertainty. In other words, the taxpayer does not know if not declaring their full income for tax purposes will result in a penalty. Only the taxpayer knows their actual revenue ex ante, $\bar{y}$, and decides how much revenue y to declare to the TA ($y \leq \bar{y}$). The declared revenue y is subject to taxation at a constant rate θ. With probability p(.), the taxpayer is subject to a tax audit by the TA, who then knows $\bar{y}$. In the original model proposed by Allingham and Sandmo (1972), in the event of an audit, the difference between actual and declared revenue ($\bar{y} - y$) is subject to a rate π greater than θ, which can be interpreted as a penalty for evasion. It should be noted that the self-regularization interventions evaluated in this study do not entail a penalty. However, they do increase the audit salience of this declaration, defined by β, without affecting future declarations.

The taxpayer's problem is to choose the revenue that maximizes the following utility function:

$$\max_{y} E[U(y)] = (1 - \beta p)U(\bar{y} - \theta y) + \beta p U(\bar{y} - \theta y - \pi(\bar{y} - y)) = (1 - \beta p)U(Y) + \beta p U(Z),$$

where Y is the revenue available if there is no audit and Z is the revenue available if there is an audit. The first-order condition for an interior maximum can be written as:

$$-\theta(1 - \beta p)U'(Y) - (\theta - \pi)\beta p U'(Z) = 0.$$

With complete differentiation of the first-order condition with respect to the audit salience β and rearrangement of the terms, because $\pi > \theta$ we have:

[10] The concept of audit salience should not be confused with the idea of tax salience, as discussed by Chetty, Looney, and Kroft (2009). While the latter refers to the visibility of taxation for the consumer, reflected in the price of the product, and the effects on their consumption behavior, audit salience focuses on the perception and importance attributed to tax audits by taxpayers in their decision to declare or evade taxes. Moreover, it is essential to differentiate the concept addressed in this article from the literature on "fiscal illusion," which examines how the visibility of taxation to voters affects their behavior and the size of government, as discussed by Mill (1848).

$$p[\theta U'(Y) + (\pi - \theta)U'(Z)] > 0.$$

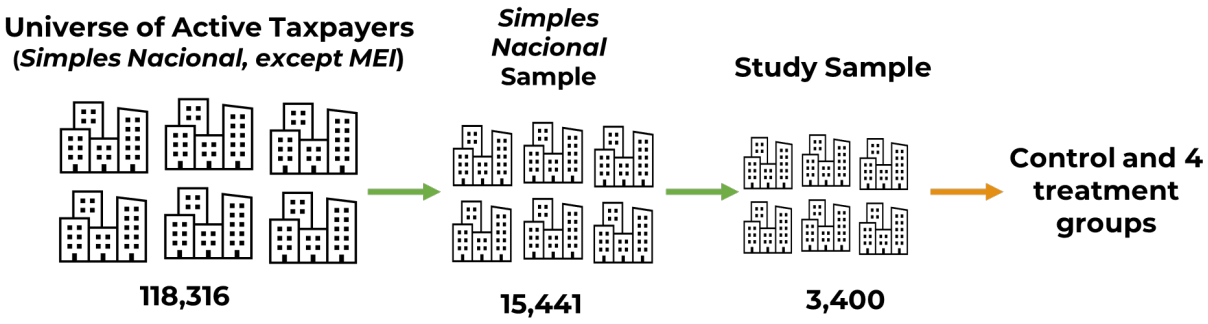
Consequently, in this study, self-regularization intervention results in an increase in the salience of the TA's actions on a specific declaration and hence encourages a taxpayer to declare an optimal value of income for this particular declaration. However, the interventions do not alter taxpayers' behavior regarding future declarations; because there is no penalty for providing inaccurate tax information, taxpayers figure they are better off declaring real income only when they are "caught" by the massive auditing system.

3. Methodology and Data

4.1 Construction of the Study Sample

Figure 2 illustrates the construction of the study sample. The universe of active SN taxpayers in the state of Bahia comprises 118,316 micro and small firms.[11] From this population we obtained a sample of 15,441 taxpayers, which we call the "Simples Nacional sample." This sample is restricted to taxpayers that have positive declared revenue, have an active DT-e for communication, are supervised by the Inspectorate for Medium and Small Retail Trade Companies (INFAZ VAREJO), and have economic activities susceptible to being taxed by ICMS.[12] Finally, the "study sample" of 3,400 taxpayers consists of firms prioritized by SEFAZ-BA based on its own criteria.[13]

Figure 2. Construction of the Study Sample



Notes: "MEI" refers to individual microentrepreneurs. The figure shows the number of taxpayers in the universe of active Simples Nacional taxpayers, the Simples Nacional sample, and the study sample. The study sample was randomly divided into five groups: one control group and four treatment groups.

For each taxpayer, we examined monthly revenue data—both the figures declared by the taxpayer and those calculated by the SEFAZ-BA *malha fiscal* based on third-party information—for 2020 and 2021. Table 1 presents the descriptive statistics for the three groups: the universe of active SN taxpayers, the Simples Nacional sample, and the study sample. The differences between these groups are mainly explained by sample

[11] This does not include individual microentrepreneurs.
[12] The National Classification of Economic Activities (CNAE) includes activities that are not taxed by the ICMS. The list of excluded activities is available on request from the authors.
[13] For example, SEFAZ-BA excluded companies with subsidiaries; the goal was to prevent all divisions receiving notifications even if only one of them exhibited inconsistencies in tax declarations. The study sample also focused on taxpayers with at least one detected inconsistency during the analysis period.

construction. For instance, the reported revenue[14] remains relatively consistent between the universe of SN taxpayers and the study sample, with values ranging from R$318,000 to R$337,000 in 2020 and from R$398,000 to R$406,000 in 2021. However, reported revenue is about 30 percent higher in the Simples Nacional sample. On the other hand, the average evasion is larger in the study sample, reaching 21 percent of the declared revenue, while in the universe of taxpayers and the Simples Nacional sample it corresponds to approximately 10 percent of the declared revenue. The companies in the study sample are larger, have fewer years in operation, and are predominantly located in the municipality of Salvador, the capital of Bahia state.

Table 1. Comparison between the Universe of Active SN Taxpayers, the Simples Nacional Sample, and the Study Sample

	Universe of active taxpayers (1)	Simples Nacional sample (2)	Study sample (3)
Reported revenue Current values, in R$			
2020	337,786	417,507	318,346
2021	398,306	520,220	406,395
Tax evasion Current values, in R$			
2020	36,739	42,455	68,174
2021	40,625	48,022	87,027
Calculated purchases Current values, in R$			
2020	257,754	222,647	245,054
2021	300,089	271,336	317,794
Number of periods with irregularities	7.6	7.7	13.2
Municipality of Salvador	0.2	0.7	0.7
Size (share capital)	924,604	1,986,106	6,259,002
Age (registered years)	10.1	9.8	8.2
Number of taxpayers	118,316	15,441	3,400

Notes: This table shows descriptive statistics for the universe of active Simples Nacional taxpayers, the Simples Nacional sample and the Study sample. The values for revenue, evasion, and purchases are the sum of the average monthly values over the year. "Reported revenue" corresponds to the gross revenue in taxpayers' declarations. "Tax evasion" is calculated as the difference between the reported revenue and the revenue calculated based on third-party information. The variable "Number of periods with irregularities" is the count of periods for which irregularities were detected (i.e., the taxpayer was "caught" by *malha fiscal*) throughout 24 months between January 2020 and December 2021. The variable "Municipality of Salvador" indicates the proportion of companies located in Salvador, the Bahia state capital.

[14] The amount of monthly gross revenue reported in the SN tax declaration.

4.2 The Intervention

The 3,400 taxpayers in the study sample were randomly assigned to the treatment and control groups. The random assignment was done by strata defined by quartiles of evasion at baseline. Within each stratum, taxpayers were ordered randomly and then divided into five groups:

- Treatment 1 (T1): The 1,000 taxpayers in this group received a message via DT-e informing them of the detection of inconsistencies in their declarations.
- Treatment 2 (T2): The 1,000 taxpayers in this group received a message as in T1, but the message also included the link to a manual explaining the self-regularization process.
- Treatment 3 (T3) and Treatment 4 (T4): These 400 taxpayers received assisted regularization in which SEFAZ-BA auditors assisted taxpayers throughout the self-regularization process. Because of operational constraints, this treatment was implemented in phases for two groups of 200 taxpayers each.
- Control group: The 1,000 taxpayers in this group did not receive any intervention.

Figure A1 in Annex A shows an example of a message sent to taxpayers in the T1 and T2 groups. The message for T1 is concise, informs about detected inconsistencies, and encourages taxpayers to amend their declaration (self-regularize). The message for T2, in addition to the contents of the T1 message, also included the link to an explanatory manual on how to use the *malha fiscal* system for self-regularization, as well as a way to contact the TA via email if they have doubts or questions. For T1 and T2, the message sender is the TA, and there is no interaction with a tax auditor.

Figure A2 in Annex A shows an example of a communication for T3 and T4. In these treatments, the message states that the sender is the responsible tax auditor. The message also indicates that taxpayers can engage in a dialogue with the tax auditor and provides instructions on how to start this interaction. Furthermore, for T3 and T4 tax auditors were permitted to contact taxpayers via telephone and email if the taxpayer did not react to the communication sent via the DT-e. The communication also indicates that the taxpayer is required to regularize or present appropriate justification within five days, and that noncompliance can result in the suspension of the taxpayer's registration[15] and initiation of the administrative process with fines and penalties.

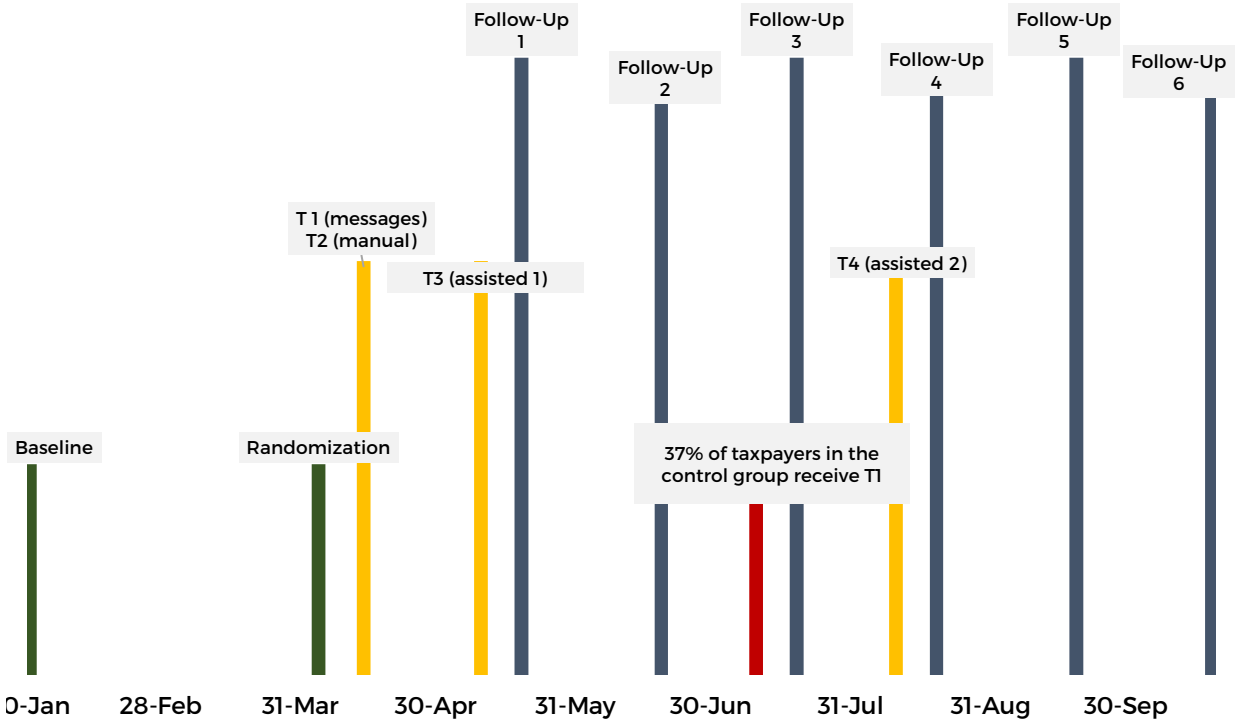
4.3 Empirical Model

In this study, the effect estimates are based on comparing the information in monthly declarations filed in 2020 and 2021 before the treatment and the information in these declarations at different follow-ups. In other words, the study compares a “photograph” of the declarations filed in 2020 and 2021 taken at baseline (January 2022) with the “photographs” of these same (amended) declarations at each of the six follow-ups, in

[15] In the event of registry suspension, several limitations are imposed on the firm including the inability to issue electronic tax documents, make financial transactions, obtain tax and financial incentives, take part in public tenders, enter into contracts or agreements, or carry out credit operations with public funds.

May, June, July, August, September, and October 2022.[16] Figure 3 presents the study timeline.

Figure 3. Study Timeline



Source: Authors' elaboration.
Note: "Assisted 1" and "assisted 2" refer to assisted regularization treatments T3 and T4, respectively.

The messages for T1 and T2 were sent in April 2022, the first assisted regularization group (T3) received communications in May 2022, and the second assisted regularization group (T4) received communications in August 2022. The experimental evaluation design in this study faces an imperfect compliance challenge, mostly because 37 percent of the control group taxpayers received T1 treatment in July 2022, which we deal with in econometric models.

The key outcome variables in this study are: (i) the amendment or correction of the declared revenue; (ii) tax evasion, calculated as the difference between the reported and calculated revenue; and (iii) the probability of the tax declaration to have inconsistencies detected by *malha fiscal* (or, as we refer to it, the probability of the taxpayer being "caught" by *malha fiscal*).

The causal effect of each treatment is defined as the difference between the value observed at the follow-up and the value observed at the baseline in the treated group

[16] We do not observe differential attrition throughout the follow-ups (see Tables A2 and A3 in Annex A).

in relation to the same difference in the control group. Formally, for each treatment (T1–T4) and follow-up (F1–F6), we estimate the following equation 1:

$$Y_{i(s)t} = \beta Z_{i(s)t} + \phi_s + \varepsilon_{i(s)t}, \quad (1)$$

where $i(s)t$ denotes a monthly tax declaration of taxpayer i, (s) is the random assignment stratum, t denotes the declaration time period (year-month), $Y_{i(s)t}$ represents the outcome of interest, β measures the Intent-to-Treat (ITT) or reduced form effect, $Z_{i(s)t}$ is the indicator of assignment to treatment (either T1, T2, T3, or T4), and ϕ_s are strata fixed effects. The estimates take into account the correlation between the standard errors $\varepsilon_{i(s)t}$ at the taxpayer level.

To address the imperfect compliance, we employ a two-stage least squares (2SLS) strategy, which is our preferred econometric specification. In this approach, in the first stage, the random assignment to the treatment group $Z_{i(s)t}$ is used as an instrument to estimate an endogenous indicator "message read."[17] The instrument affects the probability of treatment (message read) but has no direct effect on the outcome, except through treatment. In the second stage, the prediction obtained in the first stage is used to estimate the effect of the treatment on the variable of interest. Formally, for each treatment and follow-up, the 2SLS estimation takes the following form:

$$Y_{i(s)t} = \gamma \hat{T}_{i(s)t} + \phi_s + \epsilon_{i(s)t} \quad \text{(Second stage) (2)}$$

$$T_{i(s)t} = \alpha Z_{i(s)t} + \phi_s + \eta_{i(s)t}, \quad \text{(First stage) (3)}$$

where γ measures the effect, $\hat{T}_{i(s)t}$ is the prediction of the actual treatment variable from the first stage, $Z_{i(s)t}$ denotes the assignment to the treatment group, and ϕ_s is the strata fixed effect. The standard errors $\epsilon_{i(s)t}$ e $\eta_{i(s)t}$ are clustered at the taxpayer level.

4. Main Results

5.1 Baseline Balance Tests

To verify the experimental design validity, we perform the balance tests for pre-treatment characteristics. Table 2 presents the control group means in column (1) and the estimated differences between the control group means and the means of each treatment group, as well as the statistical significance of these differences and standard errors, in columns (2)–(5).

[17] Results for the indicator "message sent" are presented in Table A4 in Annex A.

Table 2. Balance in Pre-Treatment Characteristics, Control versus Treatment Groups

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Reported revenue Current values, in R$					
2020	316,416.85	-6,880.63	9,972.58	41,581.24	-23,857.13
		(21,659.69)	(21,609.44)	(42,517.38)	(35,836.28)
2021	403,759.75	-6,154.12	13,901.34	49,637.17	-43,572.81
		(26,903.25)	(26,699.49)	(51,770.15)	(43,318.49)
Tax evasion Current values, in R$					
2020	69,644.19	1,031.39	-1,262.85	-12,630.88*	-10,991.56
		(6,482.11)	(5,950.31)	(7,646.42)	(8,063.79)
2021	87,190.90	-822.09	1,157.55	-428.39	-4,034.87
		(10,156.96)	(9,873.78)	(15,285.65)	(16,621.70)
Calculated purchases Current values, in R$					
2020	243,489.02	-11,905.80	6,811.76	28,256.95	23,557.04
		(17,820.50)	(18,555.01)	(30,607.64)	(36,919.99)
2021	316,086.67	-20,561.90	12,846.67	45,379.89	22,219.83
		(22,316.36)	(23,694.41)	(45,629.79)	(43,306.51)
Number of periods with detected irregularities	13.09	0.12	0.10	0.40	0.35
		(0.25)	(0.25)	(0.45)	(0.45)
Municipality of Salvador	0.72	0.00	0.01	-0.01	0.02
		(0.02)	(0.02)	(0.04)	(0.03)
Size (share capital)	1,068,567.94	-954,779.55	-995,517.85	-998,308.02	98,987,169.07
		(1,001,185.22)	(999,954.60)	(1,000,286.62)	(99,837,646.95)
Age (registered years)	8.29	-0.19	-0.06	0.11	0.28
		(0.34)	(0.35)	(0.58)	(0.61)
Number of taxpayers	1,000	1,000	1,000	200	200

Notes: This table presents the statistics and estimated differences between the treatment and control means from the reduced-form regressions of pre-treatment characteristics on treatment assignment. T1–T4 denote respective treatments. When the year is not specified, the values in columns (1)–(5) are for observations in 2020 and 2021. The values for revenue, evasion, and purchases are the sums of the monthly values over the year. Column (1) shows the control group means and columns (2)–(5) show the estimated differences in means. The standard errors are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

The results in Table 2 show no statistically significant differences between the control group and the treatment groups on pre-treatment characteristics. These results suggest no systematic bias in the assignment into different groups, with the groups being comparable before treatment.

5.2 Compliance with Treatment

To assess the impact of self-regularization interventions on final outcomes, it is first necessary to verify compliance with the different treatments. In the case of this study, this means verifying that taxpayers are actually accessing the DT-e and reading the notifications sent by the TA. Table 3 shows the treatment compliance estimates with the results for two endogenous treatment take-up indicators: "message sent" (Panel A) and "message read" (Panel B). In the case of T3 and T4, the "message read" indicator also takes a value of 1 when a taxpayer is contacted by a tax auditor.

Table 3. Compliance with Treatment

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Results for the indicator "message sent"					
F1: May	0.000	0.999***	0.998***	0.990***	0.000
		(0.001)	(0.001)	(0.003)	(0.000)
F2: June	0.000	0.999***	0.998***	0.990***	0.000
		(0.001)	(0.001)	(0.003)	(0.000)
F3: July	0.369	0.635***	0.634***	0.629***	-0.366***
		(0.014)	(0.014)	(0.030)	(0.030)
F4: August	0.369	0.632***	0.630***	0.627***	0.615***
		(0.014)	(0.014)	(0.030)	(0.030)
F5: September	0.369	0.631***	0.629***	0.626***	0.614***
		(0.014)	(0.014)	(0.030)	(0.030)
F6: October	0.369	0.630***	0.629***	0.626***	0.614***
		(0.014)	(0.014)	(0.030)	(0.030)
Panel B:					
Results for the indicator "message read"					
F1: May	0.000	0.326***	0.319***	0.357***	0.000
		(0.015)	(0.015)	(0.015)	(0.000)
F2: June	0.000	0.348***	0.335***	0.518***	0.000
		(0.015)	(0.015)	(0.016)	(0.000)
F3: July	0.085	0.282***	0.263***	0.643***	-0.084***
		(0.018)	(0.017)	(0.024)	(0.020)

F4: August	0.120	0.261***	0.258***	0.709***	0.215***
		(0.019)	(0.019)	(0.026)	(0.027)
F5: September	0.124	0.270***	0.273***	0.720***	0.534***
		(0.019)	(0.019)	(0.026)	(0.027)
F6: October	0.132	0.277***	0.275***	0.722***	0.623***
		(0.019)	(0.019)	(0.026)	(0.027)
Number of taxpayers	1,000	1,000	1,000	200	200

Notes: This table presents the statistics and estimated differences between the treatment and control group means from the reduced-form regressions of treatment assignment on "message sent" and "message read" indicators at different follow-ups. T1–T4 denote respective treatments. Follow-ups are denoted by F1–F6 including months. Column (1) shows the control group means and columns (2)–(5) show the estimated differences. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

At the first and second follow-ups, compliance with treatment defined as "message sent" was nearly perfect; however, by the third follow-up, about 37 percent of control group taxpayers received a T1 treatment message. The messages were sent to the control group taxpayers before T4 started, which resulted in negative estimates for this group at Follow-Up 3. For the "message read" indicator, the parameter estimate reaches 0.35 for T1 and T2 and surpasses 0.7 for T3 and T4 in some estimations.

5.3 ITT Effect Estimates

The reduced-form estimates (equation 1) of the effects of self-regularization interventions on corrections in declared revenue, change in tax evasion, and change in the probability of being caught by *malha fiscal* are presented in Table 4. Column (1) shows the control group means and columns (2)–(5) present the equation (1) estimation results. As seen in Table 4, throughout the follow-ups, there is a general upward trend in reported revenue, a decrease in tax evasion, and a reduction in the probability of being caught by *malha fiscal* compared to the baseline.

Table 4. Reduced-Form Estimates

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Change (correction) in reported revenue					
Current values, in R$					
F1: May	319.88	795.41***	992.68***	405.03	-
		(268.27)	(241.02)	(307.18)	
F2: June	456.45	1,209.79***	1,550.61***	2,484.94***	-
		(292.48)	(299.90)	(577.00)	
F3: July	485.66	1,194.04***	1,515.39***	2,622.36***	-
		(292.79)	(300.16)	(582.25)	
F4: August	973.86	863.28***	1,129.31***	4,080.90***	-307.15
		(316.43)	(322.23)	(726.78)	(260.95)
F5: September	1,323.31	579.53*	817.50**	4,354.44***	1,019.97***
		(326.49)	(333.46)	(744.36)	(379.00)
F6: October	1,576.72	398.37	1,009.93**	4,105.30***	2,600.20***
		(335.49)	(398.96)	(745.11)	(705.92)
Panel B:					
Change in tax evasion					
Current values, in R$					
F1: May	6,967.78	-890.44*	-908.84*	-710.10	-
		(482.34)	(470.01)	(747.93)	
F2: June	6,830.96	-1,169.74**	-1,334.78***	-2,629.99***	-
		(479.96)	(460.67)	(670.41)	
F3: July	6,801.68	-1,151.06**	-1,286.41***	-2,755.84***	-
		(480.61)	(461.24)	(663.93)	
F4: August	6,334.89	-810.19*	-945.94**	-4,233.43***	-408.26
		(481.80)	(461.67)	(597.59)	(775.22)
F5: September	5,944.64	-543.86	-607.31	-4,417.45***	-1,693.19**
		(478.57)	(457.69)	(571.29)	(766.50)
F6: October	6,286.16	-430.81	-608.25	-4,506.24***	-3,588.81***
		(502.54)	(490.92)	(583.23)	(617.12)
Panel C:					
Change in the probability of being caught by *malha fiscal*					
In percentage points					
F1: May	0.02	-0.03***	-0.03***	-0.03***	-
		(0.01)	(0.00)	(0.01)	
F2: June	0.02	-0.04***	-0.05***	-0.12***	-
		(0.01)	(0.01)	(0.02)	
F3: July	0.02	-0.04***	-0.05***	-0.13***	-

		(0.01)	(0.01)	(0.02)	
F4: August	-0.00	-0.03***	-0.04***	-0.25***	0.00
		(0.01)	(0.01)	(0.02)	(0.01)
F5: September	-0.01	-0.03***	-0.03***	-0.25***	-0.07***
		(0.01)	(0.01)	(0.02)	(0.02)
F6: October	-0.03	-0.03***	-0.04***	-0.26***	-0.22***
		(0.01)	(0.01)	(0.02)	(0.02)
Number of taxpayers	1,000	1,000	1,000	200	200
Observations	23,269	46,649	46,496	27,932	27,952

Notes: This table presents the statistics and estimated differences between the treatment and control groups for changes observed between the baseline and each follow-up from a reduced-form specification (equation 1). T1–T4 denote respective treatments. Follow-ups are denoted F1–F6 and include months. Column (1) shows the control group means and columns (2)–(5) show the estimated coefficient β from equation (1). Reported revenue corresponds to the amount in taxpayers' declarations. Tax evasion is calculated as the difference between the revenue reported by the taxpayer and the revenue calculated by the TA based on third-party information. Estimates for T4 are reported starting in Follow-Up 4 when this group started receiving treatment. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

As seen in Table 4, the effects on corrections in reported revenue are larger in the T3 assisted regularization group, with values ranging from R$2,500 (US$500), equivalent to an increase of 8.3 percent with respect to the average declared value,[18] to R$4,400 (US$880), representing 15 percent with respect to the average declared revenue. Among groups T1 and T2, the effect is larger in T2 with an estimate ranging from R$817 (US$163) to R$1,550 (US$310), while the estimates for T1 are between R$580 (US$116) and R$1,200 (US$240). A similar pattern emerges when examining the change in tax evasion and in the probability of being caught by *malha fiscal*. For these outcomes, the coefficient estimates decline through follow-ups, with the greatest impact observed in T3, followed by T2 and, finally, T1. For corrections and evasion indicators, the effect estimates for T1 and T2 gradually become smaller from Follow-Up 3 onwards because of the control group contamination with T1 treatment in July 2022 and the relative weakness of these two treatments in comparison to T3 and T4.

5.4 2SLS Effect Estimates

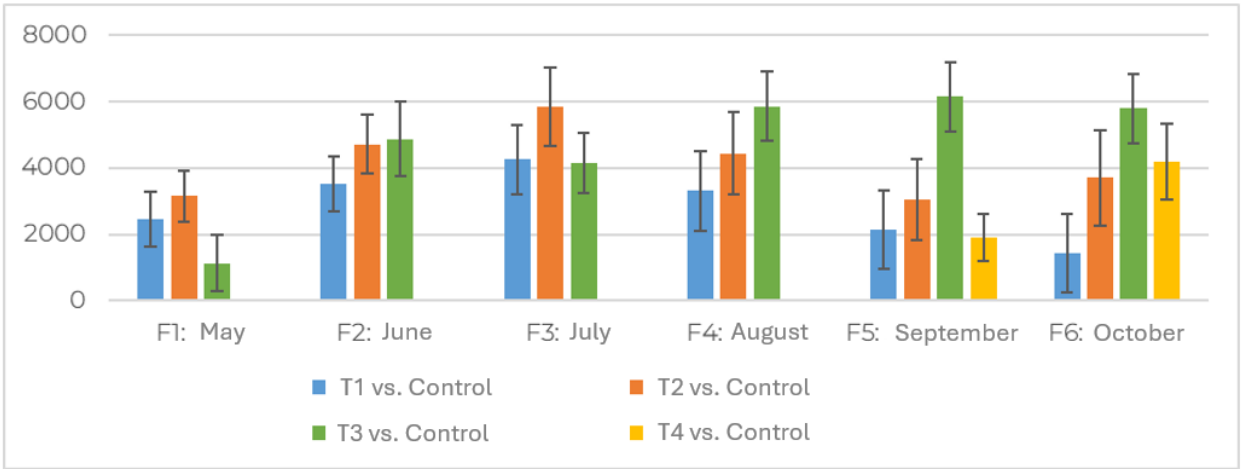
Figures 4(a), (b), and (c) and Table 5 show the 2SLS estimates where "message read"[19] is the endogenous variable instrumented with the assignment to treatment indicator. These estimates take into account the imperfect treatment compliance (see Table 3).

[18] The value of monthly revenue declared by taxpayers is R$30,007, which is the average of the amounts declared in 2020 and 2021 (R$316,416.85 + R$403,759.75 divided by 12). The annual averages are shown in Table 2.

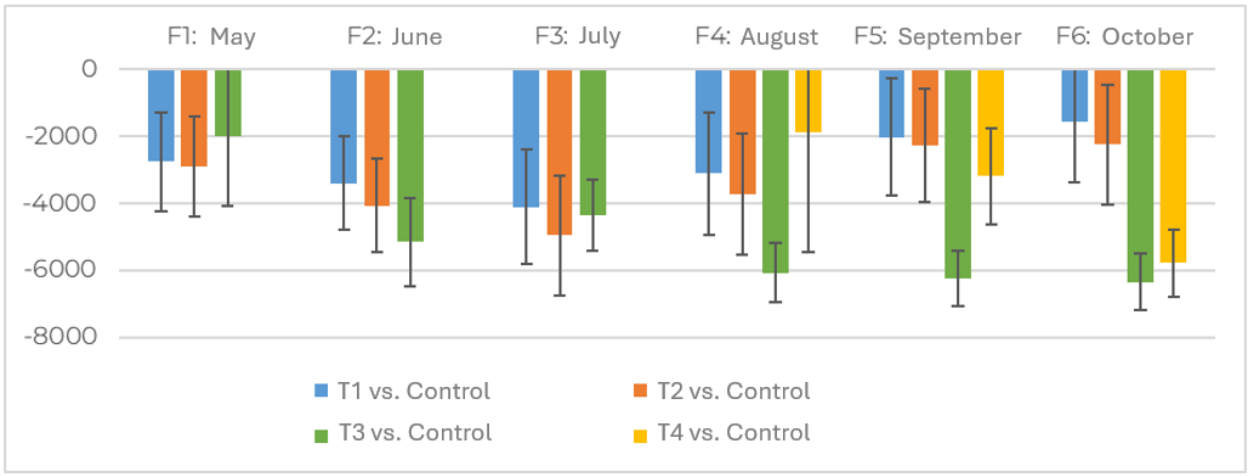
[19] Qualitatively similar results are obtained for the "message sent" indicator (Table A4 in Annex A).

Figure 4. Two-Stage Least Squares Estimates

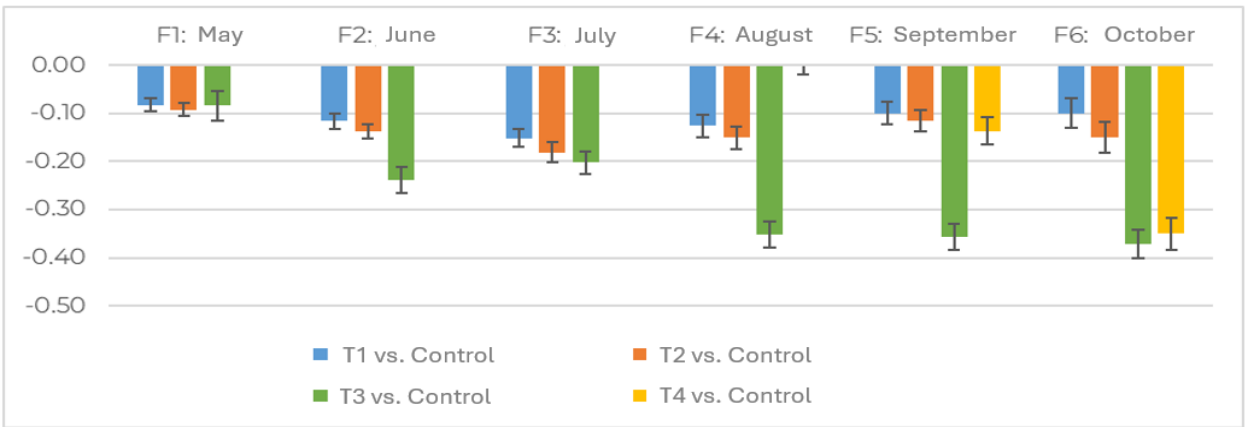
4(a). Correction in Declared Revenue (in current Brazilian reais [R$])



4(b). Change in Tax Evasion (in current Brazilian reais [R$])



4(c). Change in the Probability of Being Caught by *Malha Fiscal* (in percentage points)



Notes: This figure shows the 2SLS coefficient estimates with the "message read" endogenous indicator instrumented by the assignment to treatment indicator. The colored bars indicate the impact estimates from equation (2) for each treatment and outcome.

For T1 and T2, the effects are observed starting at the first follow-up and are larger in the T2 group. Specifically, in the T2 group the estimates for revenue correction reach R$5,800 (US$1,160) at Follow-Up 3, equivalent to approximately 20 percent of the average declared value. However, the coefficient estimates decline to R$3,700 (US$740) at Follow-Up 6. In the T1 group, the estimate for revenue correction varies between R$2,100 (US$420) and R$4,200 (US$840) and loses significance over time. This is because part of the control group received notifications in July 2022 and because T1 and T2 are weaker treatments in comparison to T3 and T4.

The same pattern is observed for tax evasion and the probability of being caught by *malha fiscal*. In the case of T1 and T2, tax evasion is reduced by up to R$4,100 (US$820) for the T1 group and R$4,900 (US$980) for T2, representing 63 percent and 76 percent, respectively, in relation to the average evasion.[20] The effect becomes not significant in the last two follow-ups. The change in the probability of being caught by *malha fiscal* is persistently significant in all follow-ups, indicating a reduction of 10 pp (18 percent compared to the baseline) and 15 pp (27.5 percent compared to the baseline) in the last follow-up for T1 and T2, respectively.

In groups T3 and T4, the effect is larger and remains stable over the follow-ups. The impact is positive and significant starting in the follow-up following the intervention, with a coefficient estimate ranging between R$4,900 (US$980) and R$6,100 (US$1,220). The coefficient estimate for the T3 group is the largest in the last follow-up and reaches approximately R$5,800 (US$1,160), equivalent to almost 20 percent of the average declared revenue. The revenue corrections resulted in a near-complete elimination of tax evasion.[21] The probability of being caught by *malha fiscal* also declined by up to 37 pp in Follow-Up 6 (68 percent, compared to the pre-treatment average of 0.55[22]).

[20] The average monthly evasion is R$6,534.80. This value is computed as an average of the amounts evaded in 2020 and 2021 (R$69,644.19 + R$87,190.90 divided by 12). The total annual evasion is shown in Table 2.
[21] In Follow-Up 5, the estimate of R$6,142.31 represents 94 percent of the average evasion; in Follow-Up 6, the estimate of R$5,785.64 represents 89 percent of the average evasion.
[22] The average probability of being caught by *malha fiscal* is 13.09/24 (see Table 2).

Table 5. 2SLS Estimates

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Change (correction) in reported revenue					
Current values, in R$					
F1: May	319.88	2,459.83***	3,152.46***	1,132.95	-
		(821.20)	(755.84)	(849.40)	
F2: June	456.45	3,514.20***	4,714.77***	4,870.95***	-
		(833.38)	(894.25)	(1,110.15)	
F3: July	485.66	4,249.54***	5,840.19***	4,140.31***	-
		(1,033.19)	(1,161.43)	(909.15)	
F4: August	973.86	3,305.06***	4,442.29***	5,855.79***	-1,408.15
		(1,190.13)	(1,251.02)	(1,031.67)	(1,209.59)
F5: September	1,323.31	2,148.85*	3,041.92**	6,142.31***	1,920.56***
		(1,189.99)	(1,218.24)	(1,039.88)	(705.05)
F6: October	1,576.72	1,434.13	3,705.53**	5,785.64***	4,189.17***
		(1,193.60)	(1,440.97)	(1,040.44)	(1,130.21)
Panel B:					
Change in tax evasion					
Current values, in R$					
F1: May	6,967.78	-2,753.72*	-2,886.20*	-1,986.27	-
		(1,486.23)	(1,493.62)	(2,081.89)	
F2: June	6,830.96	-3,397.87**	-4,058.52***	-5,155.29***	-
		(1,389.00)	(1,399.05)	(1,308.71)	
F3: July	6,801.68	-4,096.57**	-4,957.73***	-4,351.05***	-
		(1,709.74)	(1,786.49)	(1,066.87)	
F4: August	6,334.89	-3,101.80*	-3,720.97**	-6,074.66***	-1,871.74
		(1,835.76)	(1,811.05)	(882.47)	(3,585.46)
F5: September	5,944.64	-2,016.59	-2,259.80	-6,231.19***	-3,188.19**
		(1,762.55)	(1,692.12)	(821.23)	(1,438.68)
F6: October	6,286.16	-1,550.95	-2,231.73	-6,350.68***	-5,781.90***
		(1,799.19)	(1,792.17)	(845.24)	(1,003.21)
Panel C:					
Change in the probability of being caught by *malha fiscal*					
In percentage points					
F1: May	0.02	-0.08***	-0.09***	-0.09***	-
		(0.01)	(0.01)	(0.03)	
F2: June	0.02	-0.12***	-0.14***	-0.24***	-
		(0.02)	(0.02)	(0.03)	

F3: July	0.02	-0.15***	-0.18***	-0.20***	-
		(0.02)	(0.02)	(0.02)	
F4: August	-0.00	-0.13***	-0.15***	-0.35***	0.02
		(0.02)	(0.02)	(0.03)	(0.04)
F5: September	-0.01	-0.10***	-0.12***	-0.36***	-0.14***
		(0.02)	(0.02)	(0.03)	(0.03)
F6: October	-0.03	-0.10***	-0.15***	-0.37***	-0.35***
		(0.03)	(0.03)	(0.03)	(0.03)
Number of taxpayers	1,000	1,000	1,000	200	200
Observations	23,269	46,649	46,496	27,932	27,952

Notes: This table presents the statistics and estimated differences between the treatment and control groups for changes observed between the baseline and each follow-up from a 2SLS specification (equations 2 and 3) where the endogenous "message read" variable is instrumented with the assignment to treatment indicator. T1–T4 denote respective treatments. Follow-ups are denoted F1–F6 and include months. Column (1) shows the control group means and columns (2)–(5) show the estimated coefficient β from equation (2). Reported revenue corresponds to the amount in taxpayers' declarations. Tax evasion is calculated as the difference between the revenue reported by the taxpayer and the revenue calculated by the TA based on third-party information. Estimates for T4 are reported starting in Follow-Up 4 when this group started receiving treatment. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

5.5 Future Tax Compliance Behavior

A question of interest for the TA is whether, following the self-regularization intervention, taxpayers would "learn" and become aware of SN tax obligations, thereby altering their future tax compliance behavior. In the context of the Allingham and Sandmo (1972) model, a tax action can influence the taxpayer's perception of the probability of being audited and the penalty for noncompliance, prompting a change in future tax compliance behavior.

There are two opposing expectations regarding the effect of tax audits on the likelihood of being audited in the future. Taxpayers may update the perceived probability of being audited upward and therefore increase their tax compliance. Alternatively, they may, correctly or incorrectly, infer that tax auditors rarely repeat the fiscal action on the same firm in the short run, and that it is safe to evade taxes immediately after an audit. Furthermore, firms may form their perception of the likelihood of being caught in the future based on the magnitude of the tax evasion detected at present. If an audit does not detect the total amount evaded, the perception of detection in the future may be reduced, potentially resulting in lower compliance.

The empirical literature presents mixed results. In the study of individual income tax in the United States, DeBacker et al. (2018) found that audits significantly increased tax payments in subsequent years. However, this effect was short-lived for self-reported income. Similarly, Kleven et al. (2011) demonstrate a positive deterrent effect of audits on evasion in the subsequent year for individual income tax in Denmark. This effect is entirely composed of changes in self-reported income, with no effect found on income

reported by third parties. In the case of individual income tax audits in the United Kingdom, Advani, Elming, and Shaw (2023) find significant positive dynamic effects. The results indicated that taxpayers declare higher levels of tax for a period of five to eight years following the audit.

Conversely, DeBacker et al. (2015) utilized data on the tax behavior of companies in the United States and concluded that companies tend to pay less in taxes after audits. These findings can be attributed to an informed response to audit risk and a strategic Bayesian updating process. Gemmell and Ratto (2012) demonstrate that future behavior is contingent upon the outcome of the audit. In contrast, the findings of DeBacker et al. (2015) indicate that companies that are audited and found to be noncompliant tend to increase their future compliance, whereas those that are audited and found to be compliant tend to reduce their subsequent compliance. Advani, Elming, and Shaw (2023) demonstrate that audits influence the future behavior of only those who have made incorrect declarations.

Other studies on the effect of audits on future declarations have not found significant impacts. Long and Schwartz (1987) examined the Taxpayer Compliance Measurement Program in the United States, in which taxpayers were aware that the selection into the program was random and that the audit was part of a particular study. The authors found no effect on future behavior, which is consistent with the Allingham and Sandmo (1972) model, given that taxpayers had no incentive to update their probability of being audited. The study by Erard (1992), which focused on common audits, also found that there was no change in the future behavior of taxpayers.

A fundamental distinction between this study and existing literature is the type of fiscal action employed by the TA. Previous studies focused on traditional tax audits, whereas this study evaluates the impact of self-regularization interventions that do not imply fines or penalties. This distinction is relevant in light of the Allingham and Sandmo (1972) model, particularly with regard to the noncompliance penalty, which is pivotal in the decision between evading and not evading. In this study, taxpayers may perceive an increase in the TA capacity to detect irregularities in current declarations, but this is not accompanied by an immediate imposition of penalties. Self-regularization alters the salience of current fiscal action, but this alteration does not persist over time. This has an important policy implication: for self-regularization interventions to be effective, it is necessary for the TA to implement them consistently and continuously. Otherwise, taxpayers may adopt opportunistic behavior and keep evading until they “get caught” and are asked to self-regularize.

Table 6 presents the results of the reduced-form estimates for the impact of self-regularization interventions on tax declarations filed in the months following the intervention (May–August 2022). Column (1) shows the control means and columns (2)–(5) show the estimated effects.

Table 6. Post-Treatment Behavior Effect Estimates (reduced form)

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Reported revenue					
Current values, in R$					
F3: July	42,586.67	-4,913.01	-686.94	3,257.19	-
		(3,076.07)	(3,205.07)	(5,924.87)	-
F4: August	38,650.99	-2,492.78	1,083.94	3,069.46	-2,767.00
		(2,777.45)	(2,800.32)	(4,918.40)	(4,839.73)
F5: September	38,505.25	-3,342.30	2,778.36	3,046.35	-2,046.92
		(2,864.08)	(3,029.73)	(5,213.21)	(5,163.19)
F6: October	39,139.92	-2,482.31	2,603.84	6,571.37	-632.85
		(3,013.84)	(3,053.63)	(5,537.84)	(5,395.34)
Panel B:					
Tax evasion					
Current values, in R$					
F3: July	9,156.07	-1,321.66	-899.79	-861.24	-
		(1,563.08)	(1,455.98)	(2,969.08)	-
F4: August	5,981.37	888.99	-755.40	-757.59	791.37
		(1,347.69)	(1,048.40)	(2,006.34)	(2,169.19)
F5: September	5,508.07	134.76	-1,129.32	21.55	434.34
		(1,107.17)	(1,004.64)	(2,048.30)	(2,170.62)
F6: October	5,709.87	-572.97	-1,643.71	-1,602.79	-921.40
		(1,763.96)	(1,729.74)	(3,602.40)	(3,658.69)
Panel C:					
The probability of being caught by *malha fiscal*					
F3: July	0.48	-0.01	0.00	-0.01	-
		(0.02)	(0.02)	(0.04)	-
F4: August	0.39	0.01	-0.01	0.00	0.02
		(0.02)	(0.02)	(0.04)	(0.04)
F5: September	0.34	0.01	0.02	0.02	-0.04
		(0.02)	(0.02)	(0.04)	(0.04)
F6: October	0.30	-0.01	0.00	0.00	0.00
		(0.02)	(0.02)	(0.04)	(0.04)
Number of taxpayers	1,000	1,000	1,000	200	200
Observations	23,269	46,649	46,496	27,932	27,952

Notes: This table shows the statistics and reduced-form effects estimates (equation 1) for tax declarations filed in the post-treatment period from May to August 2022. Each follow-up contains information on tax declarations with a two-month lag, so the first and second follow-ups contain information on monthly declarations prior to the application of the treatment. Follow-Ups 3–6 are indicated by F3–F6, followed by the month. Column (1) shows the control group means and columns (2)–(5) show the estimated coefficient β from equation (1). Reported revenue corresponds to the amount in taxpayers' declarations. Tax evasion is calculated as the difference between the revenue reported by the taxpayer and the revenue calculated by the TA based on third-party information. Estimates for T4 are reported starting in Follow-Up 4 when this group started receiving treatment. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

The results in Table 6 show that, in all treatment groups and variables of interest, the estimates do not differ statistically from 0. This suggests that self-regularization interventions focused on declarations filed in the past do not influence the taxpayer's behavior in relation to future declarations, in the sense of reporting more or less income differently from the control group. The absence of a penalty appears to be the key explanation for this result in post-treatment behavior.

5. Additional Results

6.1 Heterogeneous Effects

Do the effects of self-regularization interventions affect differently across different groups of taxpayers? From a public policy perspective, identifying which group of taxpayers responds most to self-regularization is crucial to informing the targeting of the interventions. Furthermore, it is essential to understand whether taxpayers with different characteristics respond differently to various self-regularization strategies adopted by the TA.

Table 7 presents heterogeneous effect estimates for the correction of reported revenue in Follow-Up 6[23] for different subsamples. Each cell in Table 7 corresponds to one 2SLS estimation for a subsample shown in the row name. The subsamples were constructed using the following pre-determined or pre-treatment characteristics: tax evasion at baseline, the probability of being caught by *malha fiscal* in a 24-month period between January 2020 and December 2021, firm's size (share capital), company age, and registration in the capital city of Salvador.

[23] Results for other outcomes and follow-ups are qualitatively similar and can be provided upon request.

Table 7. Heterogeneous Effects on Correction of Reported Revenue at Follow-Up 6

	Average control	T1 vs. control	T2 vs. control	T3 vs. control	T4 vs. control
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Annual tax evasion at baseline (2021)					
High (> R$24,456)	2,897.62	3,330.47	5,873.61*	10,821.52***	7,513.26***
		(3,591.98)	(3,437.65)	(2,173.27)	(2,310.55)
		23,535	23,498	14,111	14,094
Low (≤ R$24,456)	233.27	534.39*	2,537.16**	1,635.86***	1,141.14***
		(302.38)	(1,198.51)	(353.80)	(230.89)
		23,114	22,998	13,821	13,858
Panel B:					
Probability of being caught by *malha fiscal* (2020–2021)					
High (> 0.459)	1,799.29	1,883.02	2,461.08	6,647.45***	5,712.85***
		(1,934.35)	(1,871.80)	(1,803.97)	(2,015.09)
		22,862	22,930	13,760	13,928
Low (≤ 0.459)	1,357.30	947.50	4,822.58**	5,010.32***	2,452.56***
		(1,339.81)	(2,156.56)	(1,107.74)	(705.02)
		23,787	23,566	14,172	14,024
Panel C:					
Firm size (share capital)					
Large (> R$45,000)	2,012.34	2,428.88	3,750.13*	7,552.72***	5,894.83**
		(1,947.82)	(2,149.93)	(1,711.70)	(2,312.20)
		23,383	23,072	14,283	13,808
Small (≤ R$45,000)	1,137.76	359.93	3,926.15*	3,731.55***	2,827.14***
		(1,241.37)	(2,005.93)	(1,031.54)	(790.02)
		23,266	23,424	13,649	14,144
Panel D:					
Firm age (years registered)					
> 5.4 years	1,177.20	272.87	2,885.68	4,707.85***	5,321.54***
		(1,276.91)	(1,794.91)	(1,276.90)	(2,011.14)
		23,606	23,077	14,187	14,259
≤ 5.4 years	1,990.26	2,549.91	4,281.78*	6,996.27***	2,986.95***
		(1,988.51)	(2,192.85)	(1,687.24)	(959.46)
		23,043	23,419	13,745	13,693
Panel E:					
Firm location					
Salvador	1,677.74	633.61	2,585.39*	5,515.16***	4,327.08***
		(1,343.44)	(1,559.20)	(1,280.36)	(1,417.93)
		33,765	33,690	20,176	20,310

Outside Salvador	1,311.16	3,296.80	6,675.97**	6,535.35***	3,756.40***
		(2,565.99)	(3,342.49)	(1,675.14)	(1,247.34)
		12,884	12,806	7,756	7,642

Notes: This table presents statistics and estimated differences between the treatment and control groups for changes observed between the baseline and each follow-up from a 2SLS specification (equations 2 and 3) where the endogenous "message read" variable is instrumented with the assignment to treatment indicator for subsamples shown in table rows names. The subsamples in Panels A-D were constructed by division at median value. T1–T4 denote respective treatments. All estimations are for results observed at Follow-Up 6. Column (1) shows the control group means and columns (2)–(5) show the estimated coefficient β from equation (2). Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

The results in Table 7 show that the effect on correction in declared revenue is greater for taxpayers with higher evasion at the baseline. The impact is larger in groups T3 and T4. Group T2 stands out with the highest effect estimate among taxpayers with smaller evasion at baseline. The effect of T3 and T4 is larger for taxpayers with a higher probability of being caught by *malha fiscal* in the periods previous to self-regularization interventions but is lower for taxpayers in the T2 group. These results suggest that taxpayers with fewer potential irregularities in declarations, as detected by the *malha fiscal*, are more responsive to providing additional information on the self-regularization process (T2), while taxpayers with more potential irregularities are more responsive to assisted regularization (T3).

The effect on correction in declared revenue appears to be related to the size of firms in the case of assisted interventions, with the effect being greater in the subsample of larger companies. The relationship between the age of the firm and the correction in declared revenue is less clear. Regarding heterogeneous effects by firm location, the effects vary across treatments. Firms registered outside Salvador, potentially with more limited access to information from the TA, exhibit a stronger response to T2 (providing a manual). In contrast, the effects of T3 and T4 appear to be less dependent on firm location.

6.2 Falsification Test

The self-regularization interventions evaluated in this study did not aim to change taxpayers' behavior regarding input purchases. While SN declaration does not include information on a firm's purchases, nor does the value of purchases affect the tax base and tax liability of SN taxpayers, SEFAZ-BA computes SN taxpayers' purchases based on the information from electronic invoices. As falsification tests, we estimate the effect of the intervention on the value of purchases calculated by SEFAZ-BA. Given that SN tax liability is based exclusively on the declared gross revenue, we expect that the value of purchases would not be affected by the interventions. The results of falsification tests for 2SLS estimates are presented in Table 8.[24] For all follow-ups and treatment groups, the change in calculated purchases is not statistically different from the change in the control group.

[24] The results of the reduced form specification are qualitatively similar and can be made available upon request.

Table 8. Falsification Test (change in calculated purchases)

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
F1: May	23,838.84	-4,454.07	2,869.92	9,095.79	-
		(4,997.09)	(5,369.23)	(8,512.75)	-
F2: June	23,838.84	-4,183.69	2,747.83	6,374.07	-
		(4,693.57)	(5,140.56)	(6,017.39)	-
F3: July	23,838.84	-5,125.83	3,482.85	5,134.04	-
		(5,779.57)	(6,499.15)	(4,845.85)	-
F4: August	23,838.83	-5,514.02	3,554.76	4,665.55	9,127.81
		(6,239.38)	(6,621.82)	(4,420.35)	(14,838.62)
F5: September	23,837.71	-5,339.99	3,373.01	4,742.41	3,746.86
		(6,042.34)	(6,265.69)	(4,370.98)	(6,151.04)
F6: October	23,856.87	-5,250.67	3,255.12	4,701.61	3,186.22
		(5,867.94)	(6,183.44)	(4,360.94)	(5,278.52)
Observations	23,269	46,649	46,496	27,932	27,952

Notes: This table presents the statistics and estimated differences between the treatment and control groups for changes observed between the baseline and each follow-up from a 2SLS specification (equations 2 and 3) where the endogenous "message read" variable is instrumented with the assignment to treatment indicator. T1–T4 denote respective treatments. Follow-ups are denoted F1–F6 and include months. Column (1) shows the control group means and columns (2)–(5) show the estimated coefficient β from equation (2). The outcome variable is the value of monthly purchases calculated by SEFAZ-BA based on information from electronic invoices. Estimates for T4 are reported starting in Follow-Up 4 when this group started receiving treatment. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

6.3 Accountant Externality

Another relevant aspect for fiscal policy decisions is the understanding of the role of accounting professionals in the possible spillover of self-regularization effects. The public finance literature has advanced in analyzing externalities generated through these professionals. Battaglini et al. (2019) identified a robust correlation between a taxpayer's tax evasion and the evasion of other clients of the same accounting professional, based

on informational externalities that impact tax compliance. Boning et al. (2020) indicate that spillover effects are especially relevant in the case of small companies, which often share external accountants rather than having in-house professionals.

To explore possible spillovers of self-regularization interventions through accounting professionals, we identified the subset of control group taxpayers who did not receive the T1 treatment message and for whom we had information on the accounting professional. From 1,000 control group taxpayers, we identified 610 firms with such characteristics. Consequently, we created an indicator showing that the control group firm shared their accountant with at least one treated firm. This resulted in 353 control group firms that shared accountants, and 275 control group firms that do not share their accountant with treated firms. For this subsample of 610 control group taxpayers, we run a regression in which the outcome correction in the declared revenue is regressed on the indicator of whether the taxpayer shares an accountant with at least one treated taxpayer.

The results are presented in Table 9. They show no statistically significant difference in corrections in declared revenue in control group firms with and without shared accountants, suggesting accountant spillover plays a limited role. These results are consistent with the literature that finds accountant spillover effects in interventions such as audits and in-person visits (Boning et al., 2020; Battaglini et al., 2019), but no accountant spillover effects in treatments such as information letters (Boning et al., 2020).

Table 9. Analysis of the Accountant Spillover Effect

	Parameter estimate on the indicator of shared accountant
F1: May	411.5
	(307.0)
F2: June	221.8
	(358.1)
F3: July	214.6
	(358.2)
F4: August	346.6
	(383.8)
F5: September	406.1
	(441.3)
F6: October	478.5
	(492.6)
Observations	12,976

Notes: This table shows the parameter estimates from the regression of correction in declared revenue on the indicator of shared accountant in the subsample of 610 control group firms. The regressions include strata fixed effect. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

6.4 Cost-Effectiveness Analysis

As shown in Tables 4 and 5, the assisted regularization intervention had the largest effect on tax compliance. However, this intervention requires the time of tax auditors who guide taxpayers through the regularization process. For public policy decision-making, it is important to know whether the benefits achieved are worth the costs incurred. In this section we present the analysis in which we compare the costs and effects of two interventions that showed the largest effects: the assisted regularization (T3) treatment and the tax regularization manual (T2) treatment.

Table 10 presents a summary of the results of the cost-effectiveness analysis.[25] The effectiveness was calculated using the effect estimates from the 2SLS specification for corrections of reported revenue for T2 and T3 in Follow-Up 6 (see Table 5). Two scenarios were considered for the SN tax rate. The lowest tax rate scenario (α=1.25% for the state of Bahia and α'=4.00% for the total tax revenue[26]) and the highest tax rate scenario (β=3.95% for the state of Bahia and β'=11.61% for the total tax revenue).[27] With regard to costs, the analysis covers variable costs, excluding fixed system development costs, which are incurred only once and are diluted over the system's useful life. Details of calculations are provided in Annex B.

The cost-effectiveness ratio is positive for both treatments. When considering solely the potential revenue for the state of Bahia, T2 is more advantageous when applied to firms in the lower revenue bracket (up to R$180,000), subject to the α tax rate. In this scenario, the TA would obtain a net revenue 58 percent lower had they chosen T3 (R$320.76 less per company). However, when considering the total revenue, including all levels of government, even in the case of firms with lower revenue (rate α'), T3 has a net revenue potential of up to 21 percent more (R$365.68 more per firm), making it the most advantageous option.

[25] This analysis considers the lower bound of the potential effectiveness (TA revenue); it does not consider the revenue from the application of a higher tax rate to those taxpayers who, because of declaring more revenue, could eventually be subject to a higher tax rate according to the SN tax schedule.
[26] The total tax revenue includes the tax revenue for the state of Bahia and other levels of government.
[27] See Table A1 in the Annex for details.

Table 10. Cost-Effectiveness Analysis: Comparison of T2 and T3

		T2	T3	Difference T3 vs. T2 (2)–(1)
		(1)	(2)	(3)
Scope	Simples Nacional rate	Cost-effectiveness per firm		
State of Bahia	α = 1.25%	R$555.83	R$235.07	-R$320.76
	β = 3.95%	R$1,756.42	R$2,109.62	R$353.20
General government	α' = 4.00%	R$1,778.65	R$2,144.33	R$365.68
	β' = 11.61%	R$5,162.54	R$7,427.78	R$2,265.24

Notes: This table shows the results of the cost-effectiveness analysis, comparing T2 and T3 treatments. The effectiveness is based on the estimates from the 2SLS specifications at Follow-Up 6 (see Table 5). Two tax rate scenarios are considered according to the revenue range, denoted by α and β. The results are calculated in two ways: first, in a more restricted way for the state of Bahia, and second, in a more comprehensive way for all levels of government ("general government") considering the total potential revenue of Simples Nacional (rates α' and β'). Details are provided in Annex B.

For firms with higher revenue (revenue subject to rates β and β'), T3 is more cost-effective than T2. The revenue potential is 20 percent higher for the state of Bahia (R$353.20 more per firm) and up to 44 percent higher for the general government (R$2,265.24 more per firm). In general, the assisted regularization intervention is more advantageous when targeting firms with higher turnover.

6. Conclusions and Policy Implications

This study evaluates the effectiveness of three different self-regularization interventions aimed at micro and small firms taxed under the simplified tax regime: (i) sending messages informing taxpayers about detected inconsistencies, (ii) providing a manual with information on the self-regularization process, and (iii) offering assisted or supervised regularization in which tax auditors assist taxpayers through the self-regularization process. The interventions were implemented by the TA of the Brazilian state of Bahia, leveraging the new *malha fiscal* platform which cross-checks information from different sources. The main objective of self-regularization interventions is to improve taxpayer compliance at lower costs to taxpayers and TAs.

The results indicate that self-regularization is an effective method for improving tax compliance. All three self-regularization interventions resulted in increasing declared revenue, reducing evasion, and reducing the percentage of declarations with inconsistencies detected by the TA. The interventions increased the tax base, thereby increasing the potential tax revenue for the state of Bahia and other levels of government, strengthening Brazilian fiscal federalism. We do not observe any change in

tax compliance in the declarations filed in the periods after the interventions. Given that self-regularization does not impose any fine or penalty for detected inconsistencies, the lack of change in tax compliance in future declarations is consistent with the opportunistic behavior of taxpayers waiting until they “get caught” by the TA, which is compatible with Allingham and Sandmo's (1972) model in a context of no penalty for tax evasion. For public policy decision-making, this result indicates that for self-regularization interventions to be effective, they should be implemented continuously and not as isolated stand-alone efforts.

With regard to the strength of different interventions, the results show that assisted regularization is the most effective, followed by providing a tax compliance manual, and, last, sending a message. The evaluation was affected by imperfect treatment compliance, with not all taxpayers reading the notification and some control group taxpayers receiving the message treatment. The preferred econometric specification based on 2SLS intends to account for this. From the public policy perspective, this is also an important lesson learned, showing that efforts should be made by TAs to improve the effectiveness of communication channels.

Assisted regularization had the largest effect in comparison to sending messages and providing a tax compliance manual. This can be explained by the higher intensity and strength of this intervention, which included interactions with tax auditors and the threat of taxpayer removal from the tax registrar if they did not self-regularize. However, the cost-effectiveness analysis shows that providing taxpayers with a manual is more advantageous for TAs than facilitating the assisted regularization: the tax revenue obtained from smaller firms does not compensate for the costs incurred in assisted regularization. This result highlights the need to consider interventions’ costs when making public policy decisions.

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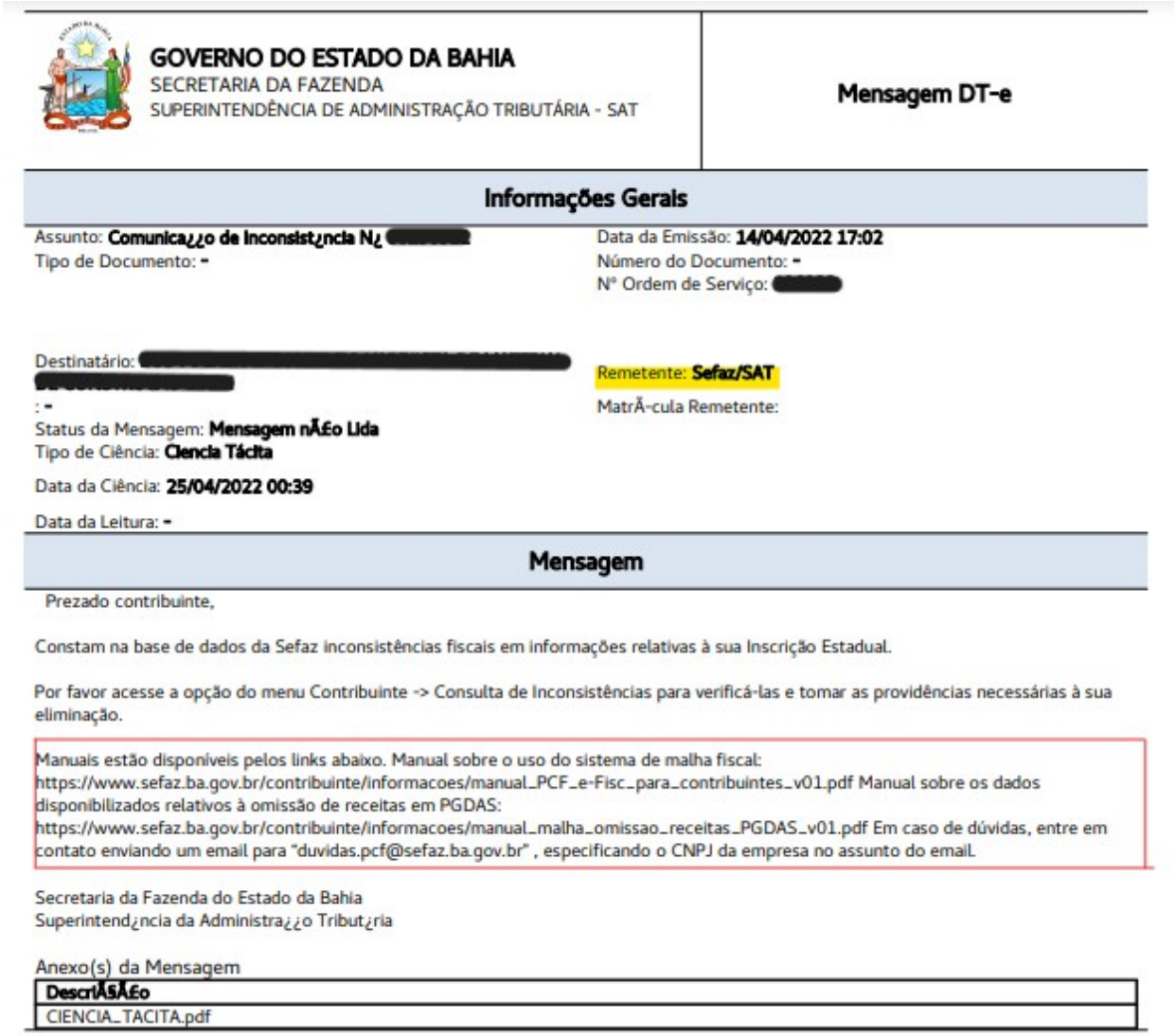
ANNEX A. Additional Figures and Tables

Figure A1. Example of a Message Sent to Treatment Groups T1 and T2



GOVERNO DO ESTADO DA BAHIA
SECRETARIA DA FAZENDA
SUPERINTENDÊNCIA DE ADMINISTRAÇÃO TRIBUTÁRIA - SAT

Mensagem DT-e

Informações Gerais

Assunto: **Comunica¿¿o de Inconsist¿ncia N¿** [redacted]
Tipo de Documento: **-**

Data da Emissão: **14/04/2022 17:02**
Número do Documento: **-**
N° Ordem de Serviço: [redacted]

Destinatário: [redacted]
: **-**
Status da Mensagem: **Mensagem nÃ£o Lida**
Tipo de Ciência: **Ciencia Tácita**

Remetente: **Sefaz/SAT**
MatrÃ-cula Remetente:

Data da Ciência: **25/04/2022 00:39**

Data da Leitura: **-**

Mensagem

Prezado contribuinte,

Constam na base de dados da Sefaz inconsistências fiscais em informações relativas à sua Inscrição Estadual.

Por favor acesse a opção do menu Contribuinte -> Consulta de Inconsistências para verificá-las e tomar as providências necessárias à sua eliminação.

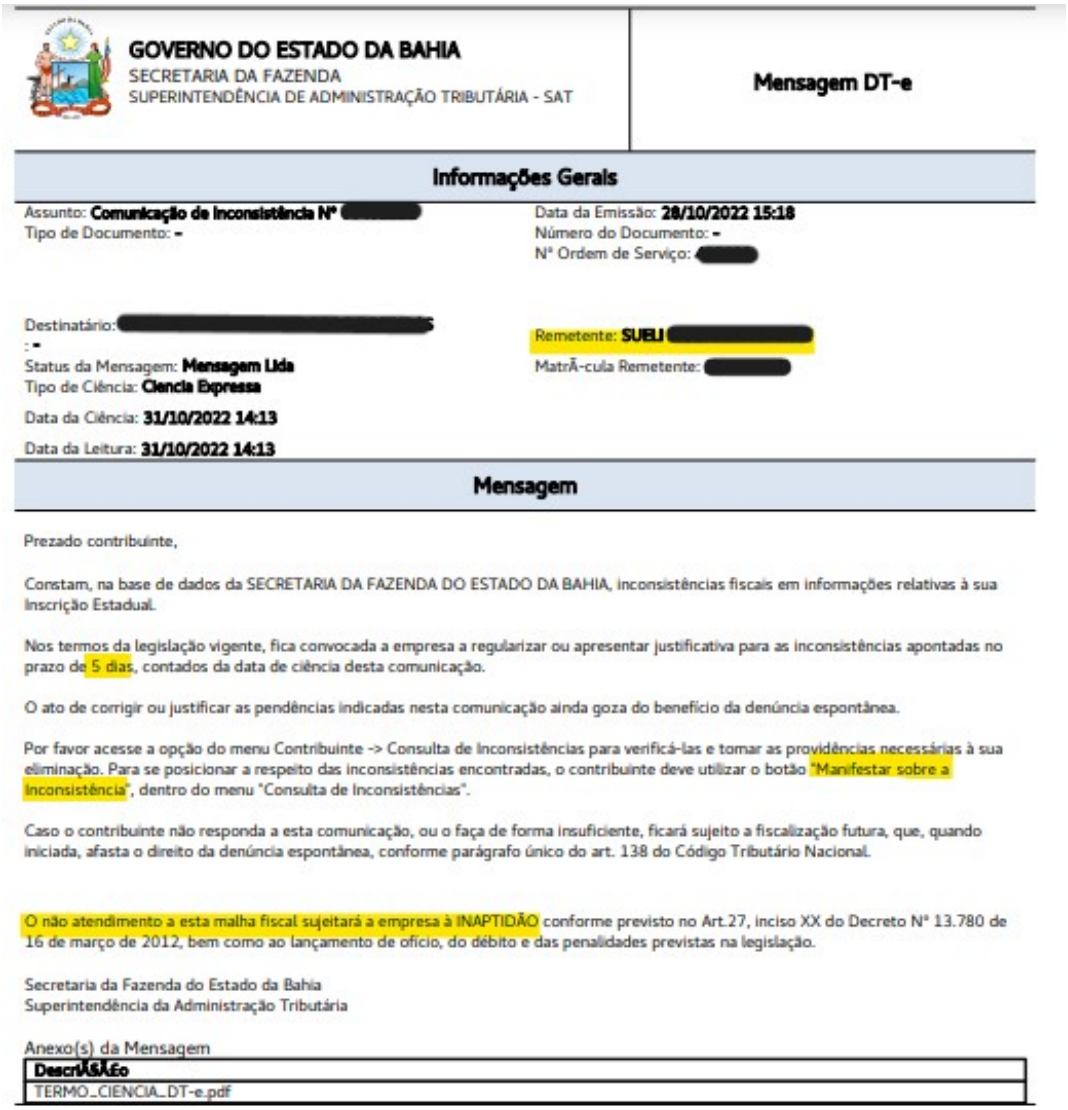
Manuais estão disponíveis pelos links abaixo. Manual sobre o uso do sistema de malha fiscal: https://www.sefaz.ba.gov.br/contribuinte/informacoes/manual_PCF_e-Fisc_para_contribuintes_v01.pdf Manual sobre os dados disponibilizados relativos à omissão de receitas em PGDAS: https://www.sefaz.ba.gov.br/contribuinte/informacoes/manual_malha_omissao_receitas_PGDAS_v01.pdf Em caso de dúvidas, entre em contato enviando um email para "duvidas.pcf@sefaz.ba.gov.br" , especificando o CNPJ da empresa no assunto do email.

Secretaria da Fazenda do Estado da Bahia
Superintend¿ncia da Administra¿¿o Tribut¿ria

Anexo(s) da Mensagem

DescrÃ§Ã£o
CIENCIA_TACITA.pdf

Figure A2. Example of a Communication Sent to Assisted Regularization Treatment Groups T3 and T4



GOVERNO DO ESTADO DA BAHIA
SECRETARIA DA FAZENDA
SUPERINTENDÊNCIA DE ADMINISTRAÇÃO TRIBUTÁRIA - SAT

Mensagem DT-e

Informações Gerais

Assunto: **Comunicação de Inconsistência Nº** [redacted]
Tipo de Documento: -
Data da Emissão: **28/10/2022 15:18**
Número do Documento: -
Nº Ordem de Serviço: [redacted]

Destinatário: [redacted]
: -
Status da Mensagem: **Mensagem Lida**
Tipo de Ciência: **Ciencia Expressa**
Data da Ciência: **31/10/2022 14:13**
Data da Leitura: **31/10/2022 14:13**

Remetente: **SUELI** [redacted]
MatrÃ-cula Remetente: [redacted]

Mensagem

Prezado contribuinte,

Constam, na base de dados da SECRETARIA DA FAZENDA DO ESTADO DA BAHIA, inconsistências fiscais em informações relativas à sua Inscrição Estadual.

Nos termos da legislação vigente, fica convocada a empresa a regularizar ou apresentar justificativa para as inconsistências apontadas no prazo de 5 dias, contados da data de ciência desta comunicação.

O ato de corrigir ou justificar as pendências indicadas nesta comunicação ainda goza do benefício da denúncia espontânea.

Por favor acesse a opção do menu Contribuinte -> Consulta de Inconsistências para verificá-las e tomar as providências necessárias à sua eliminação. Para se posicionar a respeito das inconsistências encontradas, o contribuinte deve utilizar o botão "Manifestar sobre a Inconsistência", dentro do menu "Consulta de Inconsistências".

Caso o contribuinte não responda a esta comunicação, ou o faça de forma insuficiente, ficará sujeito a fiscalização futura, que, quando iniciada, afasta o direito da denúncia espontânea, conforme parágrafo único do art. 138 do Código Tributário Nacional.

O não atendimento a esta malha fiscal sujeitará a empresa à INAPTIDÃO conforme previsto no Art.27, inciso XX do Decreto Nº 13.780 de 16 de março de 2012, bem como ao lançamento de ofício, do débito e das penalidades previstas na legislação.

Secretaria da Fazenda do Estado da Bahia
Superintendência da Administração Tributária

Anexo(s) da Mensagem

DescriÃ§Ã£o
TERMO_CIENCIA_DT-e.pdf

Table A1. Tax Rates for Simples Nacional in the Retail Sector

CPP	CSLL	ICMS	IRPJ	COFINS	PIS/Pasep	Total rate	12-month gross revenue (in R$)
2.75%	0.00%	1.25%	0.00%	0.00%	0.00%	4.00%	Up to 180,000.00
2.75%	0.00%	1.86%	0.00%	0.86%	0.00%	5.47%	From 180,000.01 to 360,000.00
2.75%	0.31%	2.33%	0.27%	0.95%	0.23%	6.84%	From 360.000,01 to 540.000,00
2.99%	0.35%	2.56%	0.35%	1.04%	0.25%	7.54%	From 540,000.01 to 720,000.00
3.02%	0.35%	2.58%	0.35%	1.05%	0.25%	7.60%	From 720,000.01 to 900,000.00
3.28%	0.38%	2.82%	0.38%	1.15%	0.27%	8.28%	From 900,000.01 to 1,080,000.00
3.30%	0.39%	2.84%	0.39%	1.16%	0.28%	8.36%	From 1,080,000.01 to 1,260,000.00
3.35%	0.39%	2.87%	0.39%	1.17%	0.28%	8.45%	From 1,260,000.01 to 1,440,000.00
3.57%	0.42%	3.07%	0.42%	1.25%	0.30%	9.03%	From 1,440,000.01 to 1,620,000.00
3.60%	0.43%	3.10%	0.43%	1.26%	0.30%	9.12%	From 1,620,000.01 to 1,800,000.00
3.94%	0.46%	3.38%	0.46%	1.38%	0.33%	9.95%	From 1,800,000.01 to 1,980,000.00
3.99%	0.46%	3.41%	0.46%	1.39%	0.33%	10.04%	From 1,980,000.01 to 2,160,000.00
4.01%	0.47%	3.45%	0.47%	1.40%	0.33%	10.13%	From 2,160,000.01 to 2,340,000.00
4.05%	0.47%	3.48%	0.47%	1.42%	0.34%	10.23%	From 2,340,000.01 to 2,520,000.00
4.08%	0.48%	3.51%	0.48%	1.43%	0.34%	10.32%	From 2,520,000.01 to 2,700,000.00
4.44%	0.52%	3.82%	0.52%	1.56%	0.37%	11.23%	From 2,700,000.01 to 2,880,000.00
4.49%	0.52%	3.85%	0.52%	1.57%	0.37%	11.32%	From 2,880,000.01 to 3,060,000.00
4.52%	0.53%	3.88%	0.53%	1.58%	0.38%	11.42%	From 3,060,000.01 to 3,240,000.00
4.56%	0.53%	3.91%	0.53%	1.60%	0.38%	11.51%	From 3,240,000.01 to 3,420,000.00
4.60%	0.54%	3.95%	0.54%	1.60%	0.38%	11.61%	From 3,420,000.01 to 3,600,000.00

Notes: Schedule valid until 2024. ISS (Municipal Tax on Services) and CPP (Social Security Contribution) do not apply to retail companies.

Table A2. Attrition Analysis

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
F1: May	0.00	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)
F2: June	0.01	0.00	0.00	0.01	0.00
		(0.00)	(0.00)	(0.01)	(0.01)
F3: July	0.01	0.00	0.00	0.00	0.00
		(0.01)	(0.01)	(0.01)	(0.01)
F4: August	0.02	0.00	-0.01	0.00	0.00
		(0.01)	(0.01)	(0.01)	(0.01)
F5: September	0.03	0.00	-0.01	-0.01	-0.01
		(0.01)	(0.01)	(0.01)	(0.01)
F6: October	0.03	0.00	-0.01	-0.01	-0.01
		(0.01)	(0.01)	(0.01)	(0.01)
Number of taxpayers	1,000	1,000	1,000	200	200

Notes: This table provides the results of attrition tests implemented to analyze the presence of systematic loss of observations within specific treatment groups across follow-ups. Column (1) shows the average loss of observations for the control group. Columns (2)–(5) show the parameter estimates from regressing the attrition indicator on the treatment assignment indicator. T1–T4 denote respective treatments. The analysis includes strata fixed effects. Follow-ups are denoted F1–F6 and include months. The standard errors are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

Table A3. Balance in Pre-Treatment Characteristics Control vs. Treatment Groups (Follow-Up 6 sample)

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Reported revenue Current values, in R$					
2020	318,844	-8,457	11,316	45,141	-20,663
		(21,897)	(22,013)	(43,271)	(36,443)
2021	409,461	-8,658	14,463	52,344	-42,731
		(27,327)	(27,244)	(5,660)	(44,084)
Tax evasion Current values, in R$					
2020	69,225	957	-256	-13,544*	-9,989
		(6,488)	(6,001)	(7,650)	(8,171)
2021	86,308	-1,385	3,246	-156	-1,839
		(10,273)	(10,057)	(15,560)	(16,934)
Calculated purchases Current values, in R$					
2020	244,566	-11,843	9,411	29,697	27,314
		(18,133)	(18,916)	(31,192)	(37,592)
2021	319,932	-20,669	14,787	46,115	24,995
		(22,818)	(24,205)	(46,519)	(44,088)
Number of periods with irregularities	13.12	0.11	0.12	0.23	0.47
		(0.26)	(0.26)	(0.46)	(0.46)
Municipality of Salvador	0.72	0.00	0.00	-0.01	0.01
		(0.02)	(0.02)	(0.04)	(0.03)
Size (share capital)	1,098,638	-984	-1,024	-1,027	100,998
		(1,032)	(1,030)	(1,031)	(101,872)
Age (registered years)	8.39	-0.26	-0.10	0.08	0.28
		(0.34)	(0.35)	(0.59)	(0.62)
Number of taxpayers	970	973	978	196	196

Notes: This table presents the statistics and estimated differences between the treatment and control means from the reduced-form regressions of pre-treatment characteristics on treatment assignment using the Follow-Up 6 sample. T1–T4 denote respective treatments. When the year is not specified, the values in columns (1)–(5) are for observations in 2020 and 2021. The values for revenue, evasion, and purchases are the sums of the monthly values over the year. Column (1) shows the control group means and columns (2)–(5) show the estimated differences in means. The standard errors are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

Table A4. 2SLS Estimates Using the "Message Sent" Indicator

	Average Control	T1 vs. Control	T2 vs. Control	T3 vs. Control	T4 vs. Control
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Change (correction) in reported revenue					
Current values, in R$					
F1: May	319.88	796.23***	994.74***	409.25	-
		(268.47)	(242.19)	(311.16)	
F2: June	456.45	1,211.03***	1,553.82***	2,510.83***	-
		(292.70)	(301.51)	(585.47)	
F3: July	485.66	1,860.72***	2,362.45***	4,129.17***	-
		(461.67)	(478.15)	(953.17)	
F4: August	973.86	1,345.28***	1,760.57***	6,425.78***	-489.73
		(495.42)	(507.61)	(1211.04)	(414.53)
F5: September	1,323.31	903.11*	1,274.46**	6,856.50***	1,626.32***
		(509.78)	(522.81)	(1247.56)	(618.12)
F6: October	1,576.72	620.79	1,574.46**	6,464.21***	4,145.95***
		(523.40)	(625.39)	(1,240.22)	(1,161.17)
Panel B:					
Change in tax evasion					
Current values, in R$					
F1: May	6,967.78	-891.36*	-910.72*	-717.49	-
		(482.70)	(470.92)	(755.87)	
F2: June	6,830.96	-1,170.95**	-1,337.54***	-2,657.39***	-
		(480.31)	(461.59)	(678.95)	
F3: July	6,801.68	-1,793.74**	-2,005.48***	-4,339.34***	-
		(753.24)	(724.82)	(1,086.54)	
F4: August	6,334.89	-1,262.55*	-1,474.69**	-6,665.95***	-650.96
		(752.71)	(722.61)	(1,035.09)	(1,237.60)
F5: September	5,944.64	-847.52	-946.78	-6,955.71***	-2,699.74**
		(746.79)	(714.97)	(1,008.56)	(1,239.66)
F6: October	6,286.16	-671.35	-948.25	-7,095.52***	-5,722.25***
		(783.83)	(766.89)	(1,030.18)	(1,058.91)
Panel C:					
Change in the probability of being caught by *malha fiscal*					
In percentage points					
F1: May	0.02	-0.03***	-0.03***	-0.03***	-
		(0.01)	(0.01)	(0.01)	
F2: June	0.02	-0.04***	-0.05***	-0.12***	-
		(0.01)	(0.01)	(0.02)	

F3: July	0.02	-0.07***	-0.07***	-0.20***	-
		(0.01)	(0.01)	(0.03)	
F4: August	-0.00	-0.05***	-0.06***	-0.39***	0.01
		(0.01)	(0.01)	(0.04)	(0.01)
F5: September	-0.01	-0.04***	-0.05***	-0.40***	-0.12***
		(0.01)	(0.01)	(0.04)	(0.03)
F6: October	-0.03	-0.04***	-0.06***	-0.41***	-0.34***
		(0.01)	(0.01)	(0.04)	(0.04)
Number of taxpayers	1,000	1,000	1,000	200	200
Observations	23,269	46,649	46,496	27,932	27,952

Notes: This table presents the statistics and estimated differences between the treatment and control groups for changes observed between the baseline and each follow-up from a 2SLS specification (equations 2 and 3) where the endogenous "message sent" variable is instrumented with the assignment to treatment indicator. T1–T4 denote respective treatments. Follow-ups are denoted F1–F6 and include months. Column (1) shows the control group means and columns (2)–(5) show the estimated coefficient β from equation (2). Reported revenue corresponds to the amount in taxpayers' declarations. Tax evasion is calculated as the difference between the revenue reported by the taxpayer and the revenue calculated by the TA based on third-party information. Estimates for T4 are reported starting in Follow-Up 4 when this group started receiving treatment. Standard errors clustered at the taxpayer level are in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

ANNEX B. Cost-Effectiveness Analysis

This section presents the cost-effectiveness analysis calculations for T2 and T3 per firm.

Table B1. Cost-Effectiveness Analysis: Comparison of T2 and T3 (detailed, in current Brazilian reais [R$])

		T2	T3	Difference T3 vs. T2 (2)–(1)
		(1)	(2)	(3)
Effectiveness	Monthly revenue correction	3,705.53	5,785.64	2,080.11
	Correction annual revenue	44,466.36	69,427.68	24,961.32
	Potential tax revenue Bahia (α = 1.25%)	555.83	867.85	312.02
	Potential tax revenue Bahia (β = 3.95%)	1,756.42	2,742.39	985.97
	Potential tax revenue general government (α' = 4.00%)	1,778.65	2,777.11	998.45
	Potential tax revenue general government (α' = 11.61%)	5,162.54	8,060.55	2,898.01
Cost	Estimated monthly remuneration of the tax auditor		15,819.35	
	No. of tax auditors per firm (1 auditor = 25 firms)	0	0.04	-
	Total	0.00	632.77	632.77
Cost-effectiveness	State of Bahia (α = 1.25%)	555.83	235.07	-320.76
	State of Bahia (β = 3.95%)	1,756.42	2,109.62	353.20
	General government (α' = 4.00%)	1,778.65	2,144.33	365.68
	General government (β' = 11.61%)	5,162.54	7,427.78	2,265.24

Notes: This table shows the detailed cost-effectiveness analysis, comparing T2 and T3. The effectiveness is based on the estimates from the 2SLS specifications at Follow-Up 6 (see Table 5). Two tax rate scenarios are considered according to the firms' revenue, denoted by α and β. The results are calculated in two ways: first, in a more restricted way for the state of Bahia, and second, in a more comprehensive way for all levels of government ("general government") considering the total potential revenue of Simples Nacional (rates α' and β').

The effectiveness was calculated from the 2SLS estimates for the change (correction) in the reported revenue of T2 and T3 at Follow-Up 6 (Table 5). The annualized value was transformed into potential tax revenue based on the rates for SN firms in the retail sector (see Table A1 in Annex A). Two tax revenue scenarios were considered. The first is based

on the lowest rate, designated as α, applied to firms with an annual revenue of up to R$180,000.00. The second scenario applied the highest rate, designated as β, corresponding to the firms with the highest revenue (from R$3,420,000.01 to R$3,600,000.00). The effectiveness is calculated in two ways. First, it is calculated for the state of Bahia (rates α and β). Second, it is calculated for all levels of government ("general government") considering the total SN rate (rates α' and β').

The analysis considers only the variable cost, without taking into account the fixed cost of developing and implementing the *malha fiscal* system. This is justified for several reasons. First, the *malha fiscal* system was used for the implementation of these two interventions, as well as for other needs of the TA. Furthermore, there is a significant gain in scale once the system is put into production, resulting in a very low fixed cost per notification sent or per firm. Finally, the fixed investment costs are diluted through the time of usage of the system. The assisted regularization treatment also included the time of tax auditors who assisted taxpayers through the self-regularization process. According to SEFAZ-BA, when implementing assisted regularization treatment, one tax auditor was assigned to 25 firms over the course of a month. Each tax auditor was compensated with a monthly remuneration of R$15,819.35.[28]

The cost-effectiveness ratios were computed by dividing the effectiveness per firm by the cost per firm and are reported in the last three rows of Table B1. The cost-effectiveness ratio is positive for both treatments. When considering solely the potential revenue for the state of Bahia, T2 is more advantageous when applied to firms in the lower revenue bracket (up to R$180,000), subject to the α tax rate. In this scenario, the TA would obtain a net revenue 58 percent lower had they chosen T3 (R$320.76 less per firm). However, when considering the total revenue, including all levels of government, even in the case of firms with lower revenue (rate α'), T3 has a net revenue potential of up to 21 percent more (R$365.68 more per firm), making it the most advantageous option. For firms with higher revenue (revenue subject to rates β and β'), T3 is more cost-effective than T2. The revenue potential is 20 percent higher for the state of Bahia (R$353.20 more per firm) and up to 44 percent higher for the general government (R$2,265.24 more per firm). In general, the assisted regularization intervention is more advantageous when targeting firms with higher turnover.

[28] The starting salary for a SEFAZ-BA tax auditor, as indicated in the Public Tender Opening Notice published in the Official Gazette of the state of Bahia on February 27, 2019, is used as a reference value.