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Abstract

Withholding of taxes by employers and by firms' trading partners is common around the world, but absent in public finance theory. We demonstrate the surprising power of withholding as a tax collection instrument, studying a scheme in Costa Rica where credit-card companies withhold tax on card sales. Doubling the withholding rate increases sales tax remittance among treated firms by 32 percent and aggregate revenue by 8 percent, although the statutory tax rate and third-party reporting requirements remain unchanged. We identify the mechanisms driving this effect and show that the current withholding rate is below the welfare-maximizing rate.

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1 Introduction

Governments commonly rely on withholding agents to collect taxes. Withholding of the personal income tax by employers is almost universal, and withholding is often applied to firms' transactions, to ensure compliance with corporate income and consumption taxes.[1] Large firms and financial institutions are common withholding agents. Figure 1 shows that the use of such withholding schemes is particularly prevalent in lower-income countries, and that lower-income countries apply withholding schemes more broadly and impose higher withholding rates. These facts suggest that withholding may be a desirable policy tool in a context with limited tax compliance. In standard public finance theory, however, tax compliance is modeled as a function of audits, penalties and third-party reported information about the tax base.[2] The fact that the third party may also withhold tax at source has been largely ignored.[3]

This paper studies the surprising power of withholding and its mechanisms. In our main application in Costa Rica, credit- and debit-card companies[4] report firms' card-machine sales, withhold a fraction of the transaction amount, and remit this to the tax authority as an advance on the firms' sales tax. Withholding applies to transactions that are also third-party reported to the tax authority and the withheld tax is fully creditable against a taxpayer's final tax liability. Standard models would hence suggest that withholding is irrelevant to tax compliance. However, our empirical evidence rejects these models. We exploit variation in firm-specific withholding rates in a difference-in-differences design to show that a doubling of the withholding rate increases sales tax remittance[5] among treated firms by 32 percent, although third-party reporting requirements and statutory tax rates do not change. The mechanisms are a default payment effect and a change in enforcement perceptions. This result rationalizes the use of with-

[1] In this case, the payer in a transaction withholds tax from the payee, sending the tax withheld to the tax authority as an advance tax remittance by the payee.

[2] Formal employment contracts (Kleven et al. 2011, Jensen 2022), modern accounting systems (Kleven et al. 2016), financial transactions (Gordon and Li 2009), electronic receipts (Naritomi 2019) and firm-to-firm transaction records (Pomeranz 2015) all generate third-party information, which allow the tax authority to verify a taxpayer's self-reported income and deter evasion.

[3] Slemrod (2008) and Slemrod and Boning (2018) discuss the importance of withholding qualitatively, without specifically modeling it.

[4] Henceforth referred to as credit-card companies for simplicity.

[5] We use the term "remittance" rather than "payment" to refer to transfers from taxpayers or other economic agents to the tax authority. The purpose of this term is to distinguish these transfers from transactions between economic agents and to avoid confusion between the transfer of money to the tax authority and bearing the burden of the tax (Slemrod 2008).

holding as a tax collection instrument, as we show in an Allingham and Sandmo (1972) style model.[6]

Evaluating the impact of withholding empirically and disentangling it from the impact of third-party reporting is challenging, as withholding and third-party reporting typically go hand in hand. To overcome this challenge we exploit a unique reform of the withholding-rate schedule applied by credit-card companies in Costa Rica. Withholding rates in Costa Rica are firm specific. The tax administration updates the rates each semester, using as inputs firms' sales tax declarations from two semesters prior. Before the reform, withholding rates were an increasing step function of firms' value-added rates. In August 2011, the government changed the schedule to be an increasing step function of firms' share of domestic sales. The reform was announced only a few weeks before entering into effect, so there was no scope for firms to manipulate withholding rates at the time, especially since rate calculations are based on firms' sales tax declarations from semester s-2. As a result of the reform, firms with a low value-added rate and a high share of domestic sales experienced an increase in their withholding rate. Firms in an intermediate range of value-added and the share of domestic sales were unaffected by the reform. These firms serve as the control group for a difference-in-differences estimation. The pre-reform trends in key outcome variables are identical in the treatment and control group, even in terms of seasonal fluctuations.[7]

Importantly, the reform allows us to isolate the impact of withholding from other determinants of compliance, as the statutory tax rate did not change and the information reporting environment was unaffected. Specifically, credit-card companies were required to report all card transactions both before and after the reform, and card machine usage hardly responded to the reform. Our analysis relies on the universe of income tax and sales tax records over a ten year period, matched with over 20 million third-party information and withholding reports.[8] In an innovation compared to most previous studies, we use

[6]Withholding in this context does not reduce transaction costs for the taxpayer, as withholding is incomplete and most taxpayers still have an outstanding tax liability to remit. Withholding reduces administrative costs for the tax authority, which may be a reason for the attractiveness of withholding schemes, but this cannot explain why withholding increases compliance, as we show in this paper.

[7]The setting is also advantageous because withholding agents remit the tax withheld monthly or even daily, and their pricing is highly standardized, meaning that the incidence of withholding is most likely on the retailers or their consumers rather than on the withholding agents.

[8]In appendix B, we provide event study and bunching evidence suggesting that third-party information reporting independently of withholding increases firms' tax compliance. Yet, in appendix C, we show that despite the presence of third-party information, compliance gaps remain widespread and sizable. This points to the need for an alternative (and stronger) compliance instrument: withholding.

not only reported tax liabilities but also actual tax payments to capture compliance outcomes.

We find that doubling the withholding rate leads to a 32 percent increase in total sales tax remittances from taxpayers subject to the rate change. This is due to a 14 percent increase in the share of firms that remit any sales tax and a 0.8 log point increase in remitted amounts on the intensive margin. In the aggregate, the withholding-rate reform increased sales tax revenue by 8 percent.[9] This is a large effect compared other tax compliance interventions. For instance, Naritomi (2019) finds that the successful e-receipts program in São Paulo, Brazil, increased aggregate tax revenue by only 3.5 percent.[10] Our estimates are robust to different ways of controlling for seasonality, different levels of clustering and considering longer or shorter pre- and post-reform periods. Our preferred specification relies on the sample of firms that use a credit card machine, but the results are very similar when including firms that did not use a card machine in the control group.

Using detailed information from all line items on the sales tax return, we can show that the treatment effect on sales tax remittance is driven by two mechanisms, which each explains roughly half of the total effect. First, a substantial share of the tax withheld — 27 percent before the reform and 38 percent after the reform — is not reclaimed by firms. We call this the default remittance effect. Second, the reform led to a 21 percent increase in the reported tax liability, an effect that emerges sharply at the time of the reform. This tax liability increase is fully driven by a reduction in input tax credits, suggesting it is likely a reduction in misreporting. We argue that this is because withholding increased firms' perceived likelihood of enforcement. Consistent with this, we show that the tax liability increase is larger among firms that are most likely to update their enforcement perceptions in response to the withholding rate reform: first time withholdees (i.e. firms for which the withholding rate increased from zero to greater than zero), firms that reclaim the tax that was withheld from them (and hence pay attention to withholding)

[9] While the withholding rate change affected firms' tax compliance, we find little evidence for an effect on real firm growth, as proxied by the wage bill and number of employees.

[10] Another way to gauge the size of the effect is to consider that tax withheld constitutes 15 percent of total tax payment for firms subject to withholding prior to the reform, and 30 percent thereafter. Put differently, for each CRC in tax withheld, more than two additional CRC in tax are recovered.

and firms that had previously under-reported their tax liability.[11]

We also replicate our results using other sources of variation in withholding rates in Costa Rica. We exploit the biannual updating of withholding rates in an event study and the introduction of withholding for the income tax in a difference-in-differences estimation. We find that an increase in withholding always leads to an increase in the reported tax liability.

To examine the optimal design of withholding, we extend a simple tax evasion model with third-party information reporting based on Allingham and Sandmo (1972). We allow the third party to both report a taxpayer's sale and withhold a share of the transaction amount as an advance tax remittance for the taxpayer. In this model, withholding is irrelevant to taxpayers' compliance decisions if the tax withheld can be fully reclaimed and if withholding does not affect taxpayers' perceptions of enforcement. When we relax these two assumptions, however, withholding can increase tax remittance through two channels: incomplete reclaiming of the tax withheld and a reduction in misreporting.[12] We then consider how a social planner would set the welfare-maximizing withholding rate. We show that this rate depends on the elasticity of the reported tax liability to the withholding rate and the marginal cost of evasion which withholding generates for the taxpayer. Under reasonable assumptions on this cost, our estimates imply that the current withholding rate in Costa Rica is below the optimal rate.

Our paper contributes to several strands of the literature. First, we contribute to a large body of work on tax compliance surveyed in Slemrod (2018) and Slemrod and Yitzhaki (2002).[13] We present withholding as an empirically important compliance mech-

[11] We also show that audit rates do not change during the period we study and that there is hardly any bunching of reported tax liabilities at the amount of tax withheld. Besides, firms with below-median profitability, which are more likely to be liquidity constrained, and bunchers do not exhibit a stronger response to withholding than other firms. This suggests that the increase in the reported tax liability is not a mechanical effect due to bunching or liquidity constraints.

[12] We also discuss how withholding would impact compliance if firms are liquidity constrained, but find no empirical evidence for such an effect.

[13] Previous studies have identified the key drivers of tax compliance as (i) audits and other enforcement mechanisms (Allingham and Sandmo 1972), (ii) third-party reporting and information trails more generally (Kleven et al. 2011, Kleven et al. 2016), and (iii) social motives, such as the desire to conform to social norms (Singhal and Luttmer 2014, Slemrod et al. 2022).

anism which has been almost absent from the literature until recently.[14] Withholding is not only less costly to implement than audits or other forms of enforcement, but it is also conceptually distinct from standard enforcement, as it abandons the idea of incentivizing taxpayers to correctly report their income, and instead establishes a default tax remittance, based on a proxy of the tax liability. As withholding agents are usually firms, our work also connects to Kopczuk and Slemrod (2006), who have emphasized the important role of firms in tax enforcement, and Slemrod (2008), who emphasized firms' role as withholding agents in particular. Related work by Garriga and Tortarolo (2022) studies the role of firms as tax enforcement agents in Argentina, but their policy variation combines third-party reporting and withholding. Our study is the first to estimate the impact of withholding on compliance and identify the mechanisms through which it works.

Our study is related to but distinct from Kopczuk et al. (2016) who show that shifting tax remittance responsibility from downstream retailers to upstream suppliers increases compliance and passthrough of the diesel tax. In their study, both the remittance responsibility and the statutory incidence of the tax shift upstream. This reform naturally increases compliance if the upstream agents are more compliant, but it is arguably a rare type of reform. In most cases, as in ours, withholding does not change the statutory incidence of a tax, but merely the way it is collected (remitted). In this case, shifting more remittance (withholding) responsibility to a more compliant agent does not necessarily increase overall compliance. Compliance increases only if the tax withheld is not fully reclaimed or if withholding changes the withholdee's reporting behavior. We argue that these mechanisms drive our results.[15]

Since withholding is always accompanied by third-party information reporting (but not vice-versa), our study also relates to the empirical literature on third-party reporting (Pomeranz 2015, Jensen 2022, Naritomi 2019). While these papers show that information trails increase compliance, it remains unclear to what extent compliance gaps remain, and

[14] A few policy reports (Samanamud 2013, OECD 2009) and legal studies (Soos 1990) anecdotally describe the relationship between withholding and tax compliance among small firms. More recently, Waseem (2022) argues that withholding is key to explaining the self-enforcement mechanisms of the VAT and Pessina (2020) shows that when the responsibility to remit VAT is shifted from sellers to buyers in Italy, firms are more likely to cease trading, which increases market concentration. Another literature has analyzed personal income tax withholding with a special focus on the United States, examining why individuals voluntarily over-withhold (Barr and Dokko 2008, Gandhi and Kuehlwein 2014, White et al. 1993, Highfill et al. 1998).

[15] Besides, compared to Kopczuk et al. (2016), our study relies on very finely grained and credibly exogenous variation and the nature of this variation and our data allow us to dissect the mechanisms of the response to withholding.

how large they are. There are also studies highlighting the limits of third-party reporting if firms can adjust less easily verifiable margins (Carrillo et al. 2017, Slemrod et al. 2017). We argue that asking third parties to not only report a transaction but to withhold tax on this transaction achieves much better compliance results. This findings is highly policy-relevant, as we show that even in a context where third-party information is routinely used for enforcement, there are still sizeable compliances gaps on all margins: on the extensive, intensive and payment margin.[16]

Third, our study relates to the literature on state capacity and development, and the optimal mix of tax instruments in a low-capacity setting (Besley and Persson 2013, Gordon and Li 2009, Keen 2008). Similar to the minimum tax studied in Best et al. (2015), withholding on firms can increase tax compliance but can also distort production efficiency. Both minimum taxes and withholding are instruments predominantly used in lower-income countries and low-compliance settings. We provide evidence that rationalizes the use of withholding in these contexts.[17]

The remainder of the paper is organized as follows. We start by presenting a simple conceptual framework in Section 2. Section 3 describes the context and data and Section 4 explains our empirical strategy. Section 5 evaluates the impact of withholding on compliance and its robustness and Section 6 examines the mechanisms of this result. Section 7 uses our empirical estimates to examine the optimal withholding rate. Section 8 provides evidence for the external validity of our results. Section 9 concludes.

2 Conceptual Framework

To guide our empirical analysis, we present a model of behavioral responses to withholding that allows us to examine how withholding affects compliance and to derive sufficient statistics for the optimal withholding rate. Our model is based on the canonical tax-

[16] In supplementary analysis in the appendix, we also reconcile previous findings on the effect of third-party information by presenting empirical evidence from a novel setting. We examine firms' responses not to intensive-margin increases in information reporting or to the use of preexisting reports (as in previous studies), but to extensive-margin changes in being reported, which is arguably where the largest compliance response should be expected. We find large increases in reported tax liability in response to information reporting, despite some offsetting adjustments on the cost margin.

[17] Lastly, by identifying the default mechanism as one of the two channels through which withholding raises compliance, our study complements the behavioral economics literature on defaults (Chetty et al. 2014, Thaler and Benartzi 2004, Madrian and Shea 2001). Our setting differs from other default studies in that the agents we study (firms) are likely rational, and that the cost that discourages agents from abandoning the default may be a monetary rather than a psychological cost.

evasion model by Allingham and Sandmo (1972), extended by Kleven et al. (2011) and Carrillo et al. (2017) to include third-party reporting for individuals and firms, respectively. We begin by describing the basic setup of the model, then introduce withholding, discuss the mechanisms through which withholding can impact compliance and finally consider the optimal design of withholding.

2.1 A Tax-Evasion Model with Third-Party Reporting

The basic setup of our model follows Carrillo et al. (2017). Firms have revenue $R = R_T + R_S$, where revenue can be either third-party-reported or self-reported, indexed by T and S, and firms declare $\hat{R}$. Firms have costs $C = C_T + C_S$ and choose to report $\hat{C}$. The government levies tax at rate τ on declared profits $\hat{\pi} = \hat{R} - \hat{C}$. The tax liability is $T = \tau\hat{\pi}$. With probability p, firms are audited, in which case any evasion is certain to be detected, and evaders pay a fine θ, which is proportional to the evaded liability. Firms maximize expected after-tax profit in the audited and non-audited states Y_A and Y_N.[18] To account for the tax authority's use of risk scores and third-party information to target audits, we assume that the audit probability is decreasing in the reported profit rate, $p = p((\hat{\pi} + \xi)/\hat{R})$ with $p' < 0$.[19] Misreporting against third-party information is automatically flagged and triggers the maximum audit probability: $p = \bar{p} = max(p)$ if $\hat{R} < R_T$.[20]

As previous research has shown that misperceptions about tax enforcement parameters are common (Erard and Feinstein 1994, Scholz and Pinney 1995), we allow firms' perceptions of the enforcement parameters p and R_T to diverge from the truth, without imposing any structure on how these perceptions are formed. Consider first a firm whose perceptions of the enforcement environment correspond to the truth, that is $\tilde{p} = p()$ and $\tilde{R}_T = R_T$. As $\xi \to 0$, the firm reports $\hat{R}^\star = R_T$ and sets $\hat{C}^* \gtrless C$ to satisfy the first-order condition. Now, consider a firm that misperceives the enforcement environment, so that $\tilde{p}() \gtrless p()$ and $\tilde{R}_T \gtrless R_T$. This is reasonable for many firms, as audits are rare and the audit function is not public knowledge. Third-party reporting mechanisms usually require

[18] Modeling firms in a middle-income country as risk-averse is reasonable, since more than half of the firms in our sample are unincorporated, and most firm owners are vulnerable to income volatility.

[19] The inclusion of ξ, a small positive number, ensures that firms declaring zero profits on a large revenue base incur a higher audit probability than firms declaring zero profits on a small revenue base, thus differentiating the two corner cases where $\hat{\pi} = 0$.

[20] As is standard in the literature, we ensure that the second-order condition on the firm's maximization problem is met and avoid non-concavities by imposing $p'' \geq 0$.

third parties to report transactions to the tax authority, but not directly to the taxpayer, so taxpayers may be unaware of the exact value of R_T. If this is the case, firms with $\tilde{R}_T < R_T$ underreport sales compared to third-party reports: $\hat{R}^\star \leq \tilde{R}_T < R_T$. Consistent with the existence of misperceptions, we show in appendix C that a significant share of firms misreports their sales compared to third-party reports, and reports costs lower than third-party reported costs. This happens despite the fact that third-party information is systematically used in tax enforcement such that firms should expect a discontinuously higher audit probability when misreporting.[21]

2.2 Modeling Withholding

We introduce withholding into the model by assuming that tax is withheld at a rate μ on third-party reported revenue R_T. The information reporting agent thus also acts as withholding agent. As revenue R_T is already reported to the tax authority by the third party, the introduction of withholding leaves the government's information set unchanged. For now we assume that the tax withheld can be fully reclaimed upon filing. This means that firms' net tax liability (tax to remit) is $P = T - \mu R_T$, where the tax withheld is deducted from the gross tax liability. We further assume that firms always pay their tax in full, meaning that the actual tax payment $\hat{P} = P$. There are no restrictions on the sign of P, $P \gtrless 0$, so that firms can request a refund if the reported tax liability is smaller than the tax withheld. In this model, firms' after-tax income in the audited and non-audited state of the world are identical to after-tax income in the model without withholding:

$$\bar{Y}_N = \pi - \mu R_T - [\tau\hat{\pi} - \mu R_T] = Y_N, \tag{1}$$

$$\bar{Y}_A = \pi - \mu R_T - [\tau\pi - \mu R_T] - \theta[(\tau\pi - \mu R_T) - (\tau\hat{\pi} - \mu R_T)] = Y_A. \tag{2}$$

Withholding should thus be irrelevant to firms' evasion decisions. This naive prediction, at odds with our empirical results, relies on assumptions which we relax in the next section.

[21] Note that the possibility that $p()$ is bounded below 1 is not enough to explain misreporting. If the audit probability discontinuously increases when firms report sales lower than third-party reported sales, it is always optimal for firms to match self-reported sales to third-party reported sales and manipulate costs to meet the first order condition.

2.3 Withholding Impact Mechanisms

This section examines firm behavior when relaxing some of the assumptions in the naive model of withholding to bring it closer to reality. In this case, withholding can impact compliance.

Default Mechanism. The naive model assumes that taxpayers subject to withholding can fully and costlessly reclaim the tax withheld. In reality, firms may incur administrative or monetary costs to credit the tax withheld against their liability. It has been shown that tax compliance costs can be substantial, especially for small firms, and an important determinant of firm behavior (Slemrod and Gillitzer 2014, Coolidge 2012). A simple way to model the compliance cost is to consider that firms incur a firm-specific fixed cost f_i, distributed according to a cumulative distribution function $H(f)$, to deduct the tax withheld μR_T from the gross tax liability T. This could represent the administrative or mental cost of tracking how much tax has been withheld during each transaction and then adding up those amounts when preparing the tax return. The presence of the fixed cost generates a cutoff $\bar{f} = \mu R_T$ such that firms with $f_i < \bar{f}$ reclaim the tax withheld, and firms with $f_i \geq \bar{f}$ do not reclaim. This yields the testable predictions that (i) reclaiming of the tax withheld is incomplete if reclaiming costs are sufficiently high, $H(\bar{f}) < 1$; and (ii) firms with larger amounts of withheld tax (either due to higher R_T or higher μ) are more likely to reclaim, $\partial H(\bar{f})/\partial R_T > 0$ and $\partial H(\bar{f})/\partial \mu > 0$.[22]

Enforcement-Perceptions Mechanism. Our baseline model implicitly assumes that taxpayer perceptions of enforcement, $\tilde{R}_T$ and $\tilde{p}()$, are not affected by withholding. Yet withholding agents must inform the taxpayer of the amount of tax withheld to enable the taxpayer to reclaim it. For instance, credit-card companies provide client firms with a monthly statement listing the volume of transactions processed, the commission due, and the tax withheld, if any.[23] Such a statement can prompt taxpayers to update their enforcement perceptions either because it provides new information or because it makes known information more salient (Chetty et al. 2009, Finkelstein 2009). Specifically, the statement conveys that an amount μR_T of tax was withheld and remitted to the tax

[22] A cap on reclaims or an increase in the audit probability for reclaimers would similarly generate incomplete reclaim, but these features are empirically not relevant, as we discuss below. These features also would not generate the pattern of reclaiming behavior that we observe, where firms with larger amounts of tax to reclaim are more likely to reclaim. Instead, a cap on claims and an audit probability increasing in reclaims would generate the opposite behavior.

[23] See Figure E.1 and section 3.2 for more details on reporting requirements.

authority, hence the value of R_T was communicated to the tax authority, and the tax authority employs credit-card companies for tax compliance purposes. Even though the true R_T and $p()$ do not change, withholding can thus lead taxpayers to update $\tilde{R}_T$ and $\tilde{p}()$, and increase reported sales $\hat{R}_T$ and tax liability $\hat{\pi}$ accordingly.

For example, for taxpayers that are initially unaware of third-party reporting, the introduction of withholding raises $\tilde{R}_T$ from 0 to R_T and moves reported profits from $\hat{\pi}^*(0)$ to $\hat{\pi}^*(R_T)$, where $\hat{\pi}^*(R_T) > \hat{\pi}^*(0)$ if $\tilde{p}' \neq 0$. As another example, taxpayers may have a perceived audit probability of $\tilde{p}$, which is an increasing function of the number of times they have witnessed tax enforcement in practice. When confronted with tax withholding, these taxpayers may revise $\tilde{p}$ upwards and hence increase $\hat{\pi}$.

Updating of $\tilde{R}_T$ and $\tilde{p}$ is more likely among the following grous of firms: firms that have previously misreported their taxable income compared to third-party reports R_T (and hence must misperceive $p()$ or R_T or both); firms that are subject to withholding for the first time (and hence experience tax remittance through a credit-card company for the first time); and firms that reclaim the tax remitted (and hence must have taken note of the information on the credit-card statement). We thus test the predictions that (i) an increase in the withholding rate prompts firms to increase their reported tax liability, and (ii) that this effect is larger among the aforementioned subsamples.

Alternative Mechanisms. In our empirical analysis, we consider and refute two potential alternative mechanisms. In a dynamic model with liquidity constraints, withholding could influence tax compliance behavior if taxpayers suffer unexpected shocks between the time of income receipt and the time of tax remittance, or if they myopically consume income before taxes are due. Such taxpayers earn taxable income, but find themselves without liquidity to remit tax at the end of the period. In this case, they would report $\hat{\pi} = 0 \leq \pi$.[24] The introduction of withholding could then increase compliance. It would allow taxpayers to report a positive tax liability, even if they have no liquidity to remit the tax at the end of the period, as (part of) the tax has already been withheld. In this case, the reported tax liability would equal the amount of tax withheld: $\hat{\pi} \cdot \tau = \mu R_T$, still

[24]Note, however, that the nature of shocks or myopia that would generate this result needs to be very specific, affecting only disposable but not taxable income. An example could be an owner-manager using business income to pay for a family emergency. A shock to taxable income would affect also true tax liabilities, and would thus not necessarily generate non-compliance. Also note that, for taxpayers who find themselves without liquidity to remit tax, and whose sales are partially covered by third-party reporting, non-payment or non-filing would not be optimal in our model, unless the taxpayers mis-perceive the enforcement parameters $p()$ and R_T.

ensuring $P = 0$. This mechanism thus predicts bunching of reported tax liabilities at the amount of tax withheld.[25] Another model of firm behavior which could generate such bunching is one in which firms interpret the amount of tax withheld as a signal about the appropriate tax liability to declare (e.g. rule-of-thumb reporting behavior or targeting as in Tourek (2022)). In either model, an increase in withholding would increase tax compliance, because it would mechanically move firms to report higher tax liabilities. We will thus examine the presence of bunching in reported tax liabilities, and any changes in bunching with the withholding rate.[26]

2.4 Optimal Withholding

We now consider how a policymaker would set the withholding rate to maximize welfare. Withholding involves a trade-off between collecting government revenue and maximizing firms' real (pre-tax) profits. Firms' production decisions can be distorted by withholding, for instance because withholding reduces firm liquidity. To remain as general as possible, we do not model specific channels through which withholding affects firm productivity. We consider a firm producing revenue R at cost $c(R, \mu)$. We thus let withholding affect firms' productivity by increasing production costs. The firm evades part of its net revenue, e, at a cost $\gamma(e, \mu)$. The dependence of the evasion cost on μ captures in the most general form the idea that withholding increases the cost of evasion. For simplicity, and to focus on the revenue-efficiency trade-off, we assume that the tax withheld is fully reclaimed by the firm, so withholding enters the firm decision only via the cost functions.The firm's objective function is

$$\max_{R,e} R - c(R, \mu) - \tau[R - c(R, \mu) - e] - \gamma(e, \mu). \tag{3}$$

Note that this formulation is equivalent with the model presented above.[27] We assume that c is strictly increasing, strictly convex and differentiable with respect to R and μ.

[25] In a more complicated model where only part of firms' taxable income is lost between the receipt of income and tax remittance, the distribution of (reported tax liability-tax withheld)/(reported tax liability) would exhibit excess mass just above 0, and an increase in the withholding rate would lead to an increase in bunching at 0.

[26] We also test whether firms with low profit margins, for whom liquidity constraints are more likely to bind, exhibit a larger response to the withholding rate.

[27] In particular, if we let γ depend on the proportional fine θ and the perceived audit probability $\tilde{p}$, we have $\gamma(e, \mu, \tilde{p}, \theta) = \tilde{p}\tau[(\pi - \hat{\pi})(1 + \theta)] = \tilde{p} * \tau * e(1 + \theta)$. In that case, $E(Y) = (1 - \tilde{p})Y_N + \tilde{p}Y_A = \pi - \tau(\pi - e) - \gamma(e, \mu, \tilde{p}, \theta)$.

We assume that γ is strictly increasing, strictly convex and differentiable with respect to to e and μ. The firm's first order conditions are the following:

$$[R] \quad 1 - c_R(R, \mu) = 0 \implies R^*(\mu) \tag{4}$$

$$[e] \quad \tau - \gamma_e(e, \mu) = 0 \implies e^*(\tau, \mu) \tag{5}$$

The government provides a public good g which generates benefit $v(g)$ for firms, which is strictly increasing and concave. The government maximises welfare of firms subject to its budget constraint $\tau(\pi - e) = \tau[R - c(R, \mu) - e] \geq g$:[28]

$$\max_{\mu,\tau} W(\tau, \mu) = R - c(R, \mu) - \tau[R - c(R, \mu) - e] - \gamma(e, \mu) + v(\tau(\pi - e)) \tag{6}$$

Taking the derivatives of the welfare function with respect to the policy instruments yields the following envelope conditions:

$$W_\tau = -\hat{\pi} + v'(\tau\hat{\pi}) * [\hat{\pi} + \tau\hat{\pi}_\tau] = 0 \tag{7}$$

$$W_\mu = -\gamma_\mu + v'(\tau\hat{\pi}) * \tau\hat{\pi}_\mu = 0 \tag{8}$$

where $\hat{\pi} = R^* - c(R^*, \mu) - e^*(\tau, \mu)$. We rearrange the envelope condition for μ to obtain

$$\varepsilon_{\hat{\pi},\mu} = \frac{\gamma_\mu \mu}{\tau\hat{\pi}v'} \equiv \frac{\gamma_\mu(e^*, \mu)\mu}{\tau\hat{\pi}v'(\tau\hat{\pi})}, \tag{9}$$

where $\varepsilon_{\hat{\pi},\mu}$ is the elasticity of the reported tax liability $\hat{\pi}$ with respect to the withholding rate μ and γ_μ is the partial derivative of the evasion cost function with respect to μ.

The optimal withholding rate is increasing in the marginal value of public goods and in the elasticity of the reported tax liability to the withholding rate, and decreasing in the marginal cost of evasion generated by withholding, scaled by the reported tax liability. The elasticity of the reported tax liability captures the net effect of withholding on tax liability, balancing the positive reporting effect and the negative real effect. The marginal cost of evasion captures the fact that withholding generates a welfare loss by making evasion more costly. While the marginal cost of evasion is difficult to estimate, the

[28] Note that the substitution is possible under the assumption that $v(\cdot)$ is strictly increasing. Therefore, the government's budget constraint will always hold with equality.

elasticity of the reported tax liability to the withholding rate is an estimable parameter in our setting.

3 Context and Data

We test the predictions of our conceptual framework and estimate the parameters to assess the optimal withholding rate using policy variation and administrative tax records from Costa Rica. This section describes the relevant taxes, the compliance mechanisms used to enforce them, and the data we use.

3.1 Relevant Taxes

Our main analysis leverages variation in Costa Rica's monthly sales tax, which constituted 37 percent of total tax revenue in 2010. The sales tax is effectively a VAT with an invoice-credit system, i.e. deductability of tax paid on inputs. The tax base includes most goods and some retail services (e.g. hotels and tailors), but it excludes professional services (e.g. lawyers and doctors). Only firms remitting tax on their sales can deduct tax paid on their inputs. The sales tax rate was constant at 13 percent for the entire period of our study, with reduced rates of 10 percent and 5 percent levied on wood and residential electricity, respectively.

In a secondary analysis, we also leverage the introduction of withholding in Costa Rica's business income tax system. Business income taxes contributed 26 percent of tax revenue in 2010. Table B.1 shows the income tax schedules. Unincorporated businesses face a kinked income tax schedule with marginal tax rates of 0, 10, 15, 20, and 25 percent on profits. Corporations face a notched tax schedule whereby the average tax rate depends on gross revenue while the tax base is profits. The average tax rates are 10, 20, and 30 percent. Income tax declarations are filed annually by December 15, with three quarterly advance remittances due in March, June, and September.[29]

Retailers in certain sectors and below certain size thresholds[30] can opt into a simplified

[29]Fiscal year t in Costa Rica starts on October 1 in year $t-1$ and ends on September 30 in year t. Taxpayers can request to remit taxes according to a different fiscal schedule, which we account for in our analysis. Each quarterly advance remittance is a quarter of either the previous year's tax liability or of the average liability over the last three years, whichever is higher.

[30]These include having annual purchases of less than 150 base salaries, owning fixed assets of less than 350 base salaries, and employing fewer than six workers. The base salary is a national accounting unit equivalent to CRC 446,200 (US$764) in calendar year 2019.

regime that unifies the sales tax and the income tax. This regime levies taxes on inputs at sector-specific rates that vary from 3 percent to 9.8 percent. Firms file and remit tax quarterly and are not subject to tax withholding by credit-card companies. We use the revenue trend in this regime as a counterfactual when studying the aggregate revenue impact of withholding.

3.2 Third-party Reporting and Withholding

The natural experiment our study exploits occurs in the credit-card reporting and withholding system. Card companies report all sales processed through card machines to the tax authority and withhold taxes at a firm-specific rate which varies from 0 percent to 6 percent. The withheld tax is creditable against the firm's sales tax liability. Withholding agents remit the withheld tax to the tax authority the day after the transaction takes place and thus receive almost no liquidity benefit. Compliance with withholding obligations is high, as discussed in section 4.1.

Table 1 shows the withholding-rate schedule. Prior to August 2011, the withholding rate was increasing in the reported value-added rate. Value added is defined as tax-liable sales net of tax-liable purchases and imports, where tax-liable refers to the sales tax. In August 2011, in an effort to better align withholding rates with sales tax liability, the authorities changed the rate-determination methodology, while also consolidating the withholding-rate schedule to three rates of 0, 3, and 6 percent. As exports are exempt from the sales tax, the rates are now increasing in the share of domestic sales in total sales, with notches at 0 percent and 50 percent.

Importantly, firms were not able to manipulate the withholding rates assigned to them at the time of the reform. This is because withholding rates for semester t are always based on domestic sales reported in firms' tax declarations in semester $t-2$.[31] Each semester, the tax authority calculates the firm-specific withholding rates and communicates them to the withholding agents. Only in special circumstances (e.g. consecutive annual losses) are firms able to request a reduction in their withholding rate before the end of the semester. In this case, the realized withholding rate may differ from the rate predicted by value added or share of domestic sales reported in semester $t-2$.

Withholding agents are required to provide firms with a receipt confirming the amount

[31] The two semesters extend from January to June and from July to December.

of tax withheld, as illustrated in Appendix Figure E.1. This receipt lists the volume of transactions processed, the commission charged, and the tax withheld. Taxpayers should thus know whether or not they are subject to withholding, and a change in the withholding rate from 0 percent to any positive rate should be very salient.

Taxpayers can deduct (henceforth "reclaim") the amount of tax withheld from their gross tax liability by simply filling in one additional box on their tax return. Taxpayers only need to keep track of the amount of tax withheld. If the taxpayer has reported zero tax liability for three consecutive months, and therefore has no liability from which to deduct withheld taxes, the taxpayer can submit a "refund request" form. Such a request requires detailed information on the withholding agent, including the amount of tax withheld and the timing of withholding, and may take serveral months to be processed. While taxpayers reclaiming the tax withheld are not subject to higher audit rates than other taxpayers, taxpayers requesting a refund are often subjected to a desk audit. Refund requests are, however, very rare, as the amount of tax withheld is smaller than the tax liability for most taxpayers in our context. We will show below that the difficulty of obtaining refunds is not the key driver of our results.

For completeness, we should mention that there are two other categories of third party reporting agents in Costa Rica's tax system. First, state institutions report all purchases from the private sector and withhold 2 percent of the transaction amount, which is remitted to the tax authority and creditable against the taxpayer's income tax liability. Second, firms report firm-to-firm sales if the annual transaction value reaches 2.5 million Costa Rican colones (CRC), equivalent to US$4,365.[32] The payment of rent, commissions, professional-service fees, or interests must be reported if annual transactions with a single transaction partner reach CRC 50,000 (US$87). These reports are purely for information purposes and are not linked to tax withholding. Table E.1 provides an overview of the third-party reporting and withholding declarations. The tax authority uses the third party and withholding reports, as well as customs declarations on imports and exports, to automatically cross-check taxpayers' self-reported tax declarations. Enforcement actions are informed by these cross-check, though the exact algorithm is not public knowledge and changes over time. Non-compliant taxpayers face monetary sanctions, temporary

[32] As of October 5, 2017, US$1 was equal to CRC 573.

firm closure and in exceptional cases even prison sentences.[33]

3.3 Data and Summary Statistics

Our main analysis uses the universe of monthly sales tax declarations and credit card withholding reports for 2008-2015. These data feature all line items, including VAT on different revenue categories, VAT on different cost categories, deductions, gross and net liability, amount of tax withheld, reclaim of tax withheld and final tax to pay, in addition to firm characteristics such as sector and firm type (incorporated vs unincorporated). Importantly, we merge the tax returns with the corresponding tax remittance (payment) receipts to observe the actual payments made, which is still rarely done in this literature.

Table 2 presents summary statistics of the samples used in the analysis. The data contains roughly 67,700 sales tax filers in 2010 (panel 1). The average firm has a turnover of 260 million colones and a profit rate of 10 percent. Slightly over half of all firms are incorporated. A quarter of sales tax filers use a credit card machine and a fifth are subject to withholding. While there are over 14,000 withholdees in 2010, there are less than 150 withholding agents.

Our main analysis relies on the subsample of sales taxpayers that already used a credit card machine in the beginning of 2010 and that file regularly during 2010-2013 (panel 2). The restriction to regular filers means that this sample captures predominantly larger firms. The fact that we focus on firms using a credit card machine means that we capture a larger share of retailers that have lower profit rates. Indeed the average profit rate in this sample is about half the profit rate in the full sample. In an extended analysis sample, we also include irregular filers, defined as firms that file at least once per semester during 2010-2013 (panel 3). This sample is of interest because irregular filers might be

[33]Relatively minor non-compliance such as non-filing, non-payment, non-filing of third-party reports, or non-emission of receipts is subject to monetary sanctions of up to three base salaries (one base salary was CRC 446,200, i.e. USD 764, in calendar year 2019). For repeated non-filing or non-payment, the tax authority can close a business for five days. Misreporting is sanctioned with a 25 percent or 75 percent penalty on the unreported tax liability, with the higher sanction applying in cases where misreporting with the intention to evade taxes can be proven and unintentional errors ruled out. The sanction for misreporting also applies to incorrect reclaims of tax withheld and to refund requests. Taxpayers who evade tax of an amount higher than 200 base salaries (USD 152,800) can be imprisoned for up to ten years. Prison sentences are applied in rare cases of extraordinary levels of fraud, and the judicial proceedings can take many years: https://www.nacion.com/sucesos/judiciales/empresario-ira-15-anos-a-prision-por-fraude/4TVYNLZZ2BDMDKDDTZKU57EQBU/story/. As of September 2016, 24 judicial proceedings were ongoing. On the other hand, the number of firm closures is usually in the hundreds each year (Brockmeyer et al. 2019)

disproportionately more affected by withholding. Irregular filers are slightly smaller than regular filers but have a similar profit rate and are similarly likely to be corporations. Finally, we also consider a sample in which firms that did not use a card machine in the beginning of 2010 are included in the analysis (panel 4). Firms in this sample are smaller than firms in our main analysis sample, but larger than the average sales tax filer. This makes sense, as we are still restricting the sample to firms that file at least once per semester in 2010-2013.

Columns 6-10 in Table 2 display summary statistics for the treatment groups in our analyses (see Section 4 for details on how treatment is defined). We find that the treatment groups are very similar to the control groups in terms of their turnover, profit rate and the share of incorporated firms. An exception is the extended analysis in which we include firms without a card machine in the control group (panel 4). Here, treated firms have on average 40 percent higher turnover than control firms and are slightly less profitable. The fact that our results are robust to the different samples suggests that differences between treatment and control group firms are not driving our results.

In our secondary analyses, we use data from the income tax for 2006-2016, including again all line items on the tax return. These data contain information for 154,00 corporations and 227,000 unincorporated businesses in 2011 (panel 5). As this sample includes a much larger share of service sector firms and small unincorporated firms, the average turnover (77 million colones) is much smaller and the profit rate (33 percent) higher than among the sales tax filers. Only 7 percent of income tax filers used a card machine in 2011.

When analyzing the causal effect of the introduction of withholding for the income tax, we restrict the analysis to firms that filed income tax every year during 2011-2016 (panel 6). In 2011, firms in this sample are similar in size and profit rate to the typical income tax filer. Treated firms, i.e. those that used a card machine prior to 2015 and hence were affected by the introduction of withholding in 2015, are only slightly larger and less profitable than the average income tax filer (columns 6-10). Given the later timing of this reform and the balancing restrictions imposed on the samples of analysis, there is little overlap in the treatment groups for the 2011 sales tax reform and the 2015 introduction of income tax withholding: only 38 firms are in the treatment group for both reforms.

In the appendix, we conduct an anatomy of compliance by merging the sales tax and income tax records will all the different third-party reports mentioned in Table E.1, as well as with tax remittance records and registration and deregistration reports. Appendix B uses heterogeneity in bunching at kinks and notches and event studies of firm behavior around the first time they are subject to third-party reporting to show that third-party reporting is associated with increased compliance. Appendix C shows that, despite the tax authority's systematic use of third-party information in enforcement, compliance gaps remain widespread. About 50 percent of firms fail to file their taxes, another 13-16 percent under-report their sales, 35-50 percent under-utilize their deductible costs, and 15-25 percent remit outstanding tax liabilities with several months of delay.[34] The persistence of large compliance gaps despite third-party reporting is consistent with taxpayers misperceiving tax enforcement parameters R_T and $p()$. This suggests that there is need for another mechanism to enhance compliance. We hence turn to study the effect of withholding.

4 Empirical Strategy

We now describe how we use the August 2011 reform of the sales tax withholding-rate schedule to estimate the compliance impact of withholding. We first provide descriptive evidence on the policy change and then present our estimation strategy.

4.1 Policy Change

As discussed in section 3.2, the government revised the withholding-rate schedule for the sales tax in August 2011. Panel A in Figure 2 shows that the reform roughly doubled the average withholding rate applied to sales tax payers. Before the reform, 40 percent of firms using a credit/debit card machine faced a withholding rate of 0 percent, and only 22 percent faced the maximum rate of 6 percent. Since the reform, over 60 percent of firms using a card machine have faced a withholding rate of 6 percent. The graph also displays small jumps every semester, when the withholding rates are revised by the tax authority and the new rates are communicated to the withholding agents. This suggests

[34] Perfect enforcement could increase income tax revenue by over 30 percent. Yet, the observed effect of desk audits is orders of magnitude smaller than would be necessary to achieve full compliance.

that withholding agents (card companies) tend to comply with the government-assigned withholding rates.

To better understand the relationship between the assigned and realized withholding rates, we predict each firm's withholding rate based on its past tax returns and the withholding-rate schedule (Table 1). As panel B in Figure 2 shows, the predicted rate tracks the realized rate very closely among firms for which we can observe both rates. The realized withholding rate is slightly higher, though only prior to the reform. This is consistent with the fact that firms can request a lower withholding rate from the tax authority if, for instance, they experience losses for several consecutive months.[35]

Panels C and D investigate whether the reform reduced firms' propensity to file their sales tax declarations or to use their credit-card machines. The effect of withholding on filing propensity is theoretially ambiguous. Panel C shows that the number of sales tax filers increases steadily and smoothly around the reform. This is true both in the full sample, and in the retail sector, which has the highest share of treated firms (over a third). Figure F.1 confirms this zero-effect on tax filing, using a difference-in-differences analysis on an unbalanced sample.

Panel D in Figure 2 shows that also the number of credit card reports and the share of sales tax filers with a credit-card machine displays no discontinuity at the time of the reform. Similarly, there is little change in card machine usage. As panels E and F show, among firms whose transactions are reported by at least one credit-card company, neither the share of card sales in total sales nor the average of the firm-specific share of card sales changes drastically with the reform. While both series display a small drop at the time of the reform, this drop is statistically significant only for the average share of card sales, suggesting it is driven by firms with a relatively small volume of total sales. Moreover, the size of the drop is economically very small even in this sample, accounting for one percentage point of an average share of 50 percent.[36]

This suggests that most firms lack the market power to refuse card transactions to avoid the withholding-rate increase or reduce its impact. We can thus regard the third-

[35]There is only a weak behavioral response to the withholding-rate notches in reported value added and the share of domestic sales, suggesting that few firms manipulate the withholding rate by misreporting the relevant line items on their sales tax declaration.

[36]This is consistent with the regression results presented below. While the PPML and OLS estimations do not detect a significant effect on the volume of card transactions, the estimation with an inverse hyperbolic sine transformation, which put more weight on small observations, finds a small negative effect.

party reporting environment as unaffected by the reform and use the reform to isolate the effect of withholding.[37]

4.2 Difference-in-Differences Estimation

To estimate the impact of the withholding-rate increase on total tax remittances, we start by conducting a binary difference-in-differences estimation around the time of the withholding rate increase. To obtain an estimate of the treatment effect on the treated rather than an intention-to-treat effect, we work with a sample of firms that accepted card payments prior to the withholding rate increase.[38] Firms with an increase in the *predicted* withholding rate are considered treated.[39] The treatment assignment is based on the predicted rather than the realized increase in the withholding rate, as the latter may be affected by a firm-specific request or a connection to the tax authority that allowed the firm to obtain a lower withholding rate.[40] Statutory withholding rates for semester s are determined based on firms' sales tax declarations from semester $s-2$, so the predicted rate change depends on a firm's value added and share of domestic sales in total sales in the second semester of 2010, well before July 2011 when the reform decree was drafted. Consequently, firms could not have gamed the system to avoid an increase in the predicted withholding rate. Table 2 shows that treated and control firms are very similar in terms of their size (turnover) and profit rate in our main samples of analysis.

We estimate the effect of the rate increase using the specification

$$y_{it} = \alpha_i + \gamma_t + \beta \cdot Treat_i \cdot Post_t + \delta X_{it} + \epsilon_{it}, \tag{10}$$

where y_{it} is the outcome reported by firm i in month t; α_i and γ_t are firm and month fixed effects; $Treat_i$ and $Post_t$ are dummies indicating the treatment group and the

[37] Any reduction in credit-card usage would cause a downward bias in the difference-in-differences estimates presented below. If the small number of firms that reduced their card usage after the withholding-rate reform were the firms with the largest potential evasion rents, our estimates would constitute a lower bound on the true compliance impact of withholding.

[38] We show below that the results are similar when including firms that did not accept card payments in the control group.

[39] We exclude firms that experienced a reduction in their withholding rate, as the small size of this sample does not allow us to separately estimate the impact of a rate reduction, which is not necessarily symmetric to the impact of a rate increase. We instead estimate the effect of a rate reduction in an event study, shown in Figure H.1.

[40] Collusion between the withholding agent and the firm is unlikely, given the small number of withholding agents and the intense monitoring to which they are subject.

post-reform period; X_{it} is a vector of pre-treatment firm characteristics interacted with month fixed effects; and ϵ_{it} is the error term.[41] We also estimate the monthly event study version of Equation 10, to confirm that the pre-reform trend in the treatment group is not statistically distinguishable from the control group.

For the treatment status to be defined, firms need to file at least one tax declaration in the second semester of 2010. The least restrictive panel we can use is thus a semesterly-balanced panel, in which firms file at least once per semester during the period we study. In practice, most filers file regularly, so that the semesterly-balanced panel is similar to a fully balanced panel, our preferred choice.[42]

As several outcome variables take a value of zero for a large share of observations, we use the PPML estimator as our preferred specification, a choice we explain in Appendix A. In the PPML estimation, the point estimate on the treatment dummy has the interpretation of a semi-elasticity. We use this specification to obtain the treatment effect on both the realized withholding rate and on tax remittance, which allows us to back out the elasticity of tax remittance to the withholding rate. We use this method rather than an IV strategy (instrumenting the realized withholding rate with the reform) to back out the elasticity, as the PPML does not currently allow for an IV estimation. We discuss below the robustness of our results to numerous alternative specifications.

5 The Impact of Withholding

We now present the main results on the tax-remittance response to the withholding-rate increase and examine its robustness.

5.1 Tax Remittance Response to Withholding

To visualize the identifying assumption and treatment effect on total tax remittance, Figure 3, panel A, plots total tax remittance for the treatment and control groups over time, scaled by the pre-reform mean, together with the DiD estimate from Equation 10. Total tax remittance is the sum of the tax withheld and the taxpayer's remittance. We

[41] The vector X_i contains sector dummies and dummies for the decile of card machine usage (volume of transactions) at the beginning of the period of analysis.

[42] As filing rates are not affected by the reform (cf previous section) using a semesterly-balanced panel is not a strong restriction. The results are robust to using a longer or shorter semesterly-balanced panel, or balancing the panel only pre-reform and allowing firms to exit at any time after the reform (Table 4).

observe that the treatment and control groups exhibit parallel pre-reform trends, including the same seasonal fluctuations, with peaks during the December shopping season. At the time of the reform, tax remittances in the treatment group increase sharply by 32 percent and remain at this elevated level for the next 16 months. Panel B of Figure 3 plots the event-study version of Panel A to confirm that the differences between the treatment and control group are statistically insignificant in the pre-reform period, and highly significant during the post-reform period. While tax remitted increased by 32 percent after the reform, the withholding rate increased by almost 100 percent, implying an elasticity of tax remitted to the withholding rate of 0.36. Thus, for a 10 percent increase in the withholding rate, tax payments of affected firms increase by 3.6 percent.

In addition to the revenue effect from tax filers, the withholding-rate increase mechanically increased tax remittance by non-filers. Prior to the reform, non-filers represent about 15 percent of firms for which taxes are withheld and account for 5-7 percent of the amount of withheld taxes. The amount of tax withheld from non-filers doubled at the time of the reform, while the filing propensity did not change, as discussed above.[43]

In aggregate, the withholding-rate reform increased sales tax revenue by 8.1 percent. Panel C in Figure 3 illustrates this result by using a simple regression discontinuity in time on demeaned semester-wise revenue data. Importantly, the revenue data is from official government statistics and net of any tax refunds granted to taxpayers. We also show in panel D that revenue from the simplified tax regime, which is paid quarterly and not subject to withholding, evolves completely smoothly at the time of the withholding-rate reform, allaying concerns that the increase in sales tax revenue may be driven by fluctuations in the business cycle.[44]

5.2 Robustness

Table 3 reports the treatment effect on total tax remittance and other tax return line items for various specifications. We report the treatment effect (semi-elasticity) for the fully

[43]The reform also advanced part of the tax remittance among delayed remitters, but this has little impact on the total treatment effect, even under the assumption of large discount rates. Delayed remitters comprise 5 percent of taxpayers, they have small liabilities on average, and most remit within a few months of the deadline.

[44]To investigate potential real effects of withholding, we use data on the wage bill and number of employees, and a similar difference-in-differences estimation as in our main analysis of sales tax withholding. We do not find a significant effect of withholding on these proxies of real firm size (results available upon request).

balanced and the semesterly-balanced panel. For each panel, we report three different specifications, trimming the data at the 99.9th, 99th, and 95th percentile, respectively, of the distribution of total sales. We trim rather than winsorize the data to preserve internal consistency of a firm's tax return, for the decomposition of the treatment effect. Our preferred specification, used in the previous section and in Figure 3, is to trim at the 99th percentile, as it achieves the highest internal consistency between variables.

The treatment effect on total sales tax remittance is highly significant and large in all specifications. The point estimate is larger in the more trimmed samples, showing that withholding has a larger effect on smaller firms. The effect is also slightly larger in the semesterly balanced sample, suggesting that irregular filers (though few in number) are relatively more responsive than regular filers. Table F.1 summarizes the elasticity estimates for the different levels of trimming the data in the balanced panel. We find that the proportional effect on the tax withheld (row 3) is slightly smaller than the effect on the withholding rate, and the corresponding elasticity hence slightly smaller. This is consistent with a small behavioral response by firms reducing the base to which withholding is applied, as discussed above.

Our estimates are robust to different ways of controlling for time trends, different balancing restrictions and different treatment definitions. In Table 4, we show that our main results hardly change when we use only firm and time fixed effects or when we augment our preferred specification with treatment-group-specific Christmas fixed effects to account for the larger share of retailers among the treated firms; when we use a shorter or longer panel, or a panel which is balanced only before the reform; when clustering standard errors at the sector level; and when adding firms without a card machine to the control group.

Appendix Tables F.2 to F.4 show that the estimates from our preferred PPML specification are quantitatively very similar to OLS estimates, and also similar to estimates from data transformed with the inverse hyperbolic sine transformation or from collapsed data (Bertrand et al. 2004), though the latter two specifications suggest much larger point estimates (due to how these specifications process the presence of zeros).

The effect on total tax remittance is driven by the combination of an 14 percent increase in the share of firms that remitted any sales tax (either by direct remittance or via withholding), and a 0.8 log-point increase in the remittance amount among firms

that already remitted regularly before the reform. A similar combination of intensive and extensive margin reporting changes holds for other tax return items. This is evidenced in an OLS estimation with a binary dependent variable (Tables F.5 and F.6) and an IHS estimation on the sample of firms with mostly non-zero outcomes pre-reform (Tables F.7 and F.8).

Table F.9 shows that the treatment effect is not overturned by refund requests, increases in compensation requests on the income tax declaration (possibly due to net credits from sales tax withholding), or a reduction in income tax remittance. The main treatment effect is statistically indistinguishable when the outcome is defined as total sales tax remittances net of any refund requests and income tax compensation.[45] When the outcome is the sum of total income and sales tax remittances minus refunds, the treatment effect is slightly smaller than when considering sales tax remittance only as the outcome (Table F.9, column 2). Given that annual sales tax remittances among these firms are on average twice as high as income tax remittances, this is consistent with the demonstrated increase in sales tax remittances and even with a slight increase in income tax remittances. Indeed, to the extent that taxpayers are internally consistent (reporting the same tax base on their income and sales tax declarations), an increase in reported sales tax liability should spill over to the income tax.

6 Mechanisms

The detailed tax-return data allow us to precisely decompose the treatment effect into changes in the underlying components of final tax liability, as shown in Table 3. The order of variables in this table follows the logical order on the tax return. The decomposition suggests that the treatment effect occurs through two main mechanisms, each of which explains about half of the total effect. The first is the incomplete reclaiming of withheld taxes, which we call the default remittance mechanism. The second is the increase in reported liabilities, which we argue is driven by a change in firms' perceptions of enforcement. We discuss each in turn.

[45] The number of the refund requests increased slightly at the time of the reform, but we observe less than 150 refund requests by sales tax filers per month, for 6000 treated firms in our balanced panel. This is because the amount of tax withheld is smaller than the gross tax liability for most firms, so a refund is rarely necessary.

6.1 Default Remittance Mechanism

The withholding rate increase led to a substantial increase in the amount of tax withheld, but only part of this tax withheld was reclaimed by taxpayers and credited against their liability. The amount of tax withheld reclaimed increased by less, and from a lower base, than the total amount of tax withheld (Table 3).

Our conceptual framework predicts that withholding increases tax remittances if some taxpayers do not reclaim the withheld tax, and it shows how a fixed cost of reclaiming would shape reclaiming behavior. Panels A1 and A2 of Figure 4 show that reclaiming behavior is indeed consistent with this framework. First, panel A1 shows that reclaiming is incomplete: fewer than 50 percent of all firms with withheld taxes and fewer than 60 percent of those with a non-zero gross liability reclaim any amount of withheld tax in a given month prior to the reform. Second, panel A1 also shows that the withholding-rate increase led to an increase in taxpayers' likelihood of making any reclaim. The share of reclaimers eventually surpasses the pre-reform level by approximately 10 percentage points (albeit never approaching full reclaim).[46] Third, the comparison of panels A1 and A2 shows that firms with larger amounts of withheld tax are more likely to reclaim. Indeed, the share of withheld tax reclaimed is much higher than the share of reclaimers, consistent with the fact that reclaims are more likely among firms with larger amounts of tax withheld. This is the case both before and after the reform.[47] These three empirical facts support our argument that a fixed cost prevents some firms from reclaiming their withheld taxes, thereby establishing a compliance default.

6.2 Enforcement Perceptions Mechanism

Second, the withholding rate change was followed by a 21 percent increase in the reported gross tax liability. Figure 4, panel C, shows that this increase, just as the tax remittance response, occurs sharply at reform time after otherwise parallel trends in the treatment

[46] Graphs with a longer post-reform window show that the reclaiming rate eventually approaches a steady level at below 60 percent. At the time of the reform, the reclaiming rate temporarily fell because the reform increased the number of taxpayers subject to withholding, many of whom were initially unfamiliar with the reclaiming procedure. As these firms gradually begin reclaiming withheld taxes, the share of reclaiming firms rose.

[47] Panel A2 also suggests that while the reform pushes more small firms to reclaim the tax withheld, it also pushes some firms to the point where their amount of withheld tax exceeds their declared gross liability, constraining their ability to reclaim. As a result, the overall share of withheld taxes reclaimed decreases.

and control groups. The tax liability increase is fully driven by a reduction in input tax credits. The increases in the reported tax liability and in the reclaiming of withheld taxes roughly offset each other, so that the final tax to be remitted by the taxpayer and the taxpayer remittance hardly changes (it decreases slightly only among the largest firms).[48]

Table 5, columns 1-6, studies the heterogeneity of the increase in reported gross tax liability to substantiate our claim that it is driven by a change in enforcement perceptions. As discussed in section 2, firms which had previously misreported their tax liability, firms which are subject to withholding for the first time, and those that reclaim their reported tax liability are more likely to update their perceived enforcement probability with the withholding rate reform. These firms should thus exhibit larger increases in their reported tax liability. This is indeed the pattern we observe. The interactions between the treatment indicator and the stated characteristics are all highly statistically significant, and remain so when we use them all at once and additionally control for an interaction with firm size. Firms which are neither misreporters, nor first-time withholdees nor reclaimers do not exhibit any increase in their reported tax liablity.[49] This heterogeneity in the treatment effect is consistent with an increase in the perceived probability of enforcement.

6.3 Alternative Mechanisms

We now refute potential alternative mechanisms. First, the withholding reform does not seem to coincide with or lead to an increase in enforcement probabilities. Panel C1 in Figure 4 shows that audit rates are constant over time.[50]

Second, the reader may be concerned that taxpayers match their reported tax liabilities to the amount of tax withheld (bunching), in which case an increase in withholding would mechanically generate an increase in reported tax liabilities. Tourek (2022) shows

[48]For the largest firms (column 1 in Table 3), the gross tax liability changes less and the increase in the reclaim of tax withheld is substantial, so the final tax to remit by the taxpayer decreases slightly. For smaller firms (column 3), the liability response is much larger. This means that, despite the increase in reclaims for tax withheld, the tax to remit by the taxpayer increases.

[49]Table G.2 shows the response is larger for larger withholding rate changes (4-5 percentage points, as opposed to 1-3 percentage points), particularly among previous withholdees. Among first-time withholdees, even small changes in the withholding rate seem salient enough to generate a large change in reported liabilities.

[50]There is no evidence that the withholding reform was accompanied by a public statement on enforcement activities, or that enforcement activities other than audits changed discontinuously with the reform (such a change would also have to be targeted only at firms subject to withholding to generate our results).

evidence for a similar behavior small firms in Rwanda, that match their tax liabilities to previous year's liabilities. As discussed in section 2, bunching behavior in the context of withholding could arise if taxpayers are liquidity constrained and declare a liability equal to the amount of tax withheld to avoid having to remit any tax, or if taxpayers consider the tax withheld as a signal for an "appropriate" tax liability to declare. Panel C2 in Figure 4 plots the distribution of the difference between the reported tax liability and the amount of tax withheld. It shows that only a small fraction of firms exhibit bunching of reported liabilities, and the vast majority of firms report liabilities much larger than the amount of tax withheld.[51] Importantly, although the withholding reform shifts the distribution left-wards, the degree of bunching does not increase disproportionately.

Columns 6, 7 and 9 of Table 5 show that firms with below-median profitability, which are more likely to be liquidity constrained, or bunchers do not exhibit a stronger response to the withholding rate increase than other firms.[52] This evidence runs counter the idea that liquidity constraints mediate the effect of withholding, or that withholding increases tax compliance mechanically. Instead, the evidence is consistent with our interpretation of the reported tax liability change as a conscious behavioral response by firms.

We conclude that two mechanisms drive the impact of withholding on compliance: a default mechanism, whereby some firms fail to reclaim withheld taxes, which mechanically translates into higher tax remittances; and a reporting mechanism, whereby the withholding-rate increase alters firms' perceptions of the enforcement environment, increasing the reported tax liability.

7 Optimal Withholding

We now return to our model which shows that the optimal tax withholding rate is determined by equation 9:

$$\varepsilon_{\hat{\pi},\mu} = \frac{\gamma_{\mu}(e^*, \mu)\mu}{\tau\hat{\pi}v'(\tau\hat{\pi})},$$

where $\varepsilon_{\hat{\pi},\mu}$ is the elasticity of the reported tax liability $\hat{\pi}$ with respect to the with-

[51] The fact that tax filing and remittance is monthly for the sales tax, and at a minimum quarterly (for the income tax) also limits the potential impact of shocks and myopia among liquidity-constrained firms. It also means that the damage which withholding can do to firms' liquidity is limited, as withholding advances the timing of tax remittance only marginally.

[52] We do not use seasonality or variability of income as a marker of liquidity constraints, as the frequency at which we observe outcomes (monthly) is the same at which firms have to remit tax.

holding rate μ and γ_μ is the partial derivative of the evasion cost function with respect to μ.

We can use this condition to examine whether the current tax withholding rate in Costa Rica is below the welfare-maximizing rate. Using our estimate of $\varepsilon_{\hat{\pi},\mu} = 0.24$ $(= 0.21/0.87)$, the fact that $\tau = 0.13$, and assuming $v'(\tau\hat{\pi}) = 1.2$ as in Keen and Slemrod (2017), we obtain

$$0.03744 = \mu\frac{\gamma_\mu}{\hat{\pi}} \tag{11}$$

Hence, unless the marginal cost of evasion as a share of the reported tax base is greater than 62 percent (0.0374/0.06), the current maximum withholding rate of 6 percent is below the welfare maximizing rate. The marginal cost of evasion is likely much smaller, suggesting that the withholding rate should be increased. A more optimistic assumption on the marginal value of public goods would imply further increases in the optimal withholding rate.

8 External Validity

As with any policy evaluation that relies on a specific source of variation in a specific context, concerns about the external validity of our study may arise. This section provides causally identified evidence on the impact of withholding from multiple reforms. We find that other quasi-experimental withholding rate increases have a similar impact on compliance as our main reform. This alleviates concerns that the impact of the August 2011 reform was exceptional due to fortunate timing or a particular targeting.

8.1 Event Study of Semesterly Withholding-Rate Updates

As discussed in Section 3.2, withholding rates in Costa Rica are firm specific and updated in January and July each year, with the rates calculated based on firms' reported value-added and share of domestic sales two semesters prior. This means that each January and July, firms within a specific range of value-added (or share of domestic sales) growth rate in year t-1 experience an increase in their withholding rate from zero to a non-zero rate, i.e. become subject to withholding for the first time. The fact that firms become subject to withholding at this particular time is driven by changes in their value-added rate or

share of domestic sales a year earlier, combined with the rigid semesterly schedule at which withholding rates are updated. There is thus no reason to believe that the withholding rate change would be correlated with changes in the firm production or performance in the specific month at which the withholding rate change enters into effect.

We conduct an event study of firm behavior around the July updating of withholding rates. We discard changes in January, when a seasonal increase in sales could confound the treatment effect, focus on the self-employed, and drop the year 2011, due to the large withholding rate reform. The treatment group contains firms that used a card machine prior to July in the relevant year and experience an increase in the withholding rate from zero to a positive rate in July. These firms were subject to third-party reporting by card companies both before and after the withholding rate change. The control group contains firms that experienced no change in the withholding rate nor in the third-party reporting regime between June and July.[53]

We estimate

$$y_{i_y m} = \gamma_m + \alpha_{i_y} + \beta \cdot I\{m \geq 6, i \in E\} + u_{i_y m}. \tag{12}$$

The unit of observation in this estimation is a firm i in event year y in month of year m. We estimate the firm's reported taxable income as a function of event-time dummies γ_m, firm-year fixed effects α_{i_y},[54] and the post-event and treatment group dummy $I\{m \geq 6, i \in E\}$. Panel A1 in Figure 5 shows the normalized treatment and control group trends before and after the event. Consistent with our identifying assumption that the withholding rate change is not associated with underlying changes in firm fundamentals shortly before the event, the reported tax liability in the event and control groups evolves in parallel between March and June. Upon treatment in July, the event group diverges and increases its reported tax liability by 12 percent.[55],[56]

[53] This is includes both firms that did not use a card machine before July of the relevant year, and firms that used a card machine before July but experienced no change in their withholding rate. We exclude firms that used a card machine for the first time in July.

[54] This is because control group firms can appear for multiple years.

[55] These results are robust to winsorizing the outcome at the 99th or 95th percentile, considering only events before or only after the withholding rate reform in 2011, and reducing or increasing the considered pre and post-event period, which conditions the size of the sample as we focus on a sample that is balanced around the event time.

[56] Figure H.1 displays event studies for a reduction in the withholding rate, showing that a (larger) reduction in the rate leads to a (larger) reduction in reported tax liability.

8.2 Introduction of Withholding for the Corporate Income Tax

Another source of quasi-experimental variation in withholding in Costa Rica comes from the introduction of withholding for the corporate income tax in 2015. Starting with the first month of fiscal year 2015, card companies were required to withhold 2 percent of card sales as an advance tax remittance for the income tax.[57] Similar to the 2011 reform to sales tax withholding, the introduction of withholding for the income tax did not affect the government's information set as all card transactions were already reported nor did it affect the statutory tax rates. Firms using a card machine prior to 2015 were affected by the reform, whereas firms that did not use a card machine prior to the reform are unaffected and hence serve as a control group. We conduct a difference-in-differences estimation of firm behavior around the time of the reform in a balanced panel of firms that we can observe between 2011 and 2016. We divide the treatment group into firms that had misreported in one of the previous years (i.e. had reported sales lower than third-party reported sales at least once), and firms that had not misreported (labeled "compliers"). The estimation follows equation 10 (with the t referring to years). The outcome of interest in this estimation is the reported tax liability for the income tax.

Panel A2 of Figure 5 shows that treatment and control firms are on parallel trends between 2011 and 2014, and that the treatment group diverges after the introduction of income tax withholding. This divergence is statically significant among both compliers and misreporters, but quantitatively larger among misreporters, who exhibit a 25 percent increase in their reported tax liability after the reform. The larger response among misreporters is consistent with the idea that a change in enforcement perceptions drives the change in compliance behavior.

8.3 Enforcement Environment

In addition to concerns about the particular reform we study, one may be concerned that the Costa Rican context exhibits features which would lend withholding an outsized impact. For instance, in a context where audit rates are low, third-party information reporting may have little bite, as taxpayers would assume that audits based on cross-checks between third-party reports and self-reports are unlikely. A similar result may hold true if audits are not based on risk assessment or cross-checks, regardless of the

[57] This is in addition to pre-existing withholding on card sales for the purpose of sales tax compliance.

audit rate. However, as Figure 5, panel B shows, audit rates in Costa Rica are in line with the average for countries at a similar level of per capita income. Section II.C. in Brockmeyer et al. (2019) shows that the Costa Rican tax authority conducts a variety of enforcement interventions, from phone calls to taxpayers with discrepancies between self-reports and third-party reports to comprehensive audits, most of which are targeted using cross-checks and risk criteria.

These results support the external validity of our study, not only in terms of its main finding – that withholding increases tax compliance – but also in terms of a key mechanism to which we ascribe the positive impact of tax withholding – the fact that withholding leads to an increase in reported tax liabilities.

9 Conclusion

This paper has studied the compliance impact of tax withholding, exploiting quasi-exogenous variation in withholding on firms' sales in Costa Rica. We show that doubling the withholding rate applied by credit-card companies increases sales tax remittances by 32 percent among treated firms and by 8 percent overall, although the government's information set and the statutory tax rates remain constant. The treatment effect is driven by the incomplete reclaiming of withheld taxes and by an increase in the reported tax liability. We interpret our results on the impact channels of withholding as evidence that withholding is a distinct compliance mechanism, which, unlike traditional enforcement and third-party reporting mechanisms, does not attempt to elicit taxpayers' true income, but instead establishes a default tax remittance at source. The revenue-raising property of withholding explains why withholding schemes for firms are a key feature of tax systems in lower-income countries and in low-compliance sectors.

Under most reasonable assumptions on the cost of evasion, our empirical estimates imply that the maximum withholding rate in Costa Rica is currently below the welfare-maximizing one. In our model, the elasticity of the tax liability to the withholding rate is key in determining the optimal withholding rate, as this elasticity captures the combination of the positive effect of withholding on compliance and the potential negative effect of withholding on firm production and output. However, our model is agnostic about the specific mechanism through which withholding distort firms' decisions.

Fruitful avenues for future research include modeling and empirically examining the channels through which withholding can distort production, e.g. by shifting administrative costs from the tax authority to the withholding agent and the taxpayer, by transferring liquidity from the taxpayer to the government, and by increasing effective tax rates, particularly for small and liquidity-constrained firms. Analyzing the spillover effects of withholding on firms along the supply chain and on competitor firms in the same sector or location is also worthwhile. This would allow decomposing the aggregate revenue impact of withholding into the direct effect on treated firms and the potential indirect effects.

Finally, investigating the choice of withholding agents would be relevant. In addition to state institutions and credit-card companies, governments may consider using other financial institutions and large firms as withholding agents. In doing so, they face a trade-off between improving compliance and increasing administrative costs for both the government and the withholding agents. These costs are likely to be smallest for firms that are already subject to increased government monitoring and have sophisticated accounting departments. It would also be interesting to study under which conditions governments should provide monetary or non-monetary incentives to withholding agents.

Tables

Table 1: Reform of The Withholding Rate Schedule

	Withholding Rate						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Before 08/2011: Value-Added Rate $\leq$	5	20	30	40	55	75	∞
Since 08/2011: Share of Domestic Sales $\leq$	0	-	-	50	-	-	100

Notes: This table shows the withholding rate which credit-card companies apply to the card sales sales of firms using a credit/debt card machine. The tax withheld is considered a quasi advance payment of the sales tax. Prior to August 2011, the average withholding rate was determined by a notched schedule on the withholdee's value-added rate, with notches at value-added rates of 5, 20, 30, 40, 55 and 75 percent, and resulting withholding rates of 0, 1, 2, 3, 4, 5 and 6 percent. Since August 2011, the schedule has been consolidated to three withholding rates of 0, 3 and 6 percent. The rates are determined by a notched schedule on the share of domestic (i.e. non-export) sales, with a notch at 50 percent. A firm's value-added rate and share of domestic sales are calculated based on its sales tax declarations in semester $t-2$, as an average across months in the semester. This table is discussed in Section 3.2.

Table 2: Summary Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All Firms (2010)					Treatment Group (2010)				
	Turnover	Profit Rate	% Corporation	% w/ Card Machine	% s.t. Withholding	Turnover	Profit Rate	% Corporation	% w/ Card Machine	% s.t. Withholding
Panel 1: All Sales Tax Filers										
Mean	261.6	10.4	55.8	26.7	20.8	.	.	.	.	.
SD	1231.4	91.8	49.7	44.3	40.6	.	.	.	.	.
P50	19.4	3.2	.	.	.	.	.	.	.	.
N	67734	56646	59566	67734	67734	.	.	.	.	.
Panel 2: Main Analysis Sample: Sales Tax Filers Using Card Machine, Regular Filers										
Mean	689.7	4.6	68.3	100	82.1	651.9	4.5	63.7	100	77.6
SD	1930.8	18.2	46.5	0	38.3	1805.6	15.5	48.1	0	41.7
P50	144.6	2.2	.	.	.	144.3	2.2	.	.	.
N	7131	7088	7129	7131	7131	5315	5283	5313	5315	5315
Panel 3: Extended Analysis Sample A: Including Irregular Filers										
Mean	597.6	4.6	67.5	100	81.9	575.2	4.5	63	100	77.3
SD	1762.3	17.2	46.9	0	38.5	1666.4	15	48.3	0	41.9
P50	129.3	2.2	.	.	.	130.8	2.1	.	.	.
N	9163	9095	9152	9163	9163	6852	6798	6842	6852	6852
Panel 4: Extended Analysis Sample B: Including Firms Withhout Card Machine										
Mean	436.5	8.8	59	33.7	27	604.3	4.8	61.9	94.7	72.1
SD	1631.5	63.4	49.2	47.3	44.4	1729.6	16.3	48.6	22.3	44.8
P50	46	3.1	.	.	.	128.9	2.2	.	.	.
N	27452	25194	27411	27452	27452	6239	6185	6236	6239	6239
Panel 5: All Income Tax Filers (2011)										
Mean	77.5	32.9	40.5	7.2	0	.	.	.	.	.
SD	607.9	33.5	49.1	25.9	0	.	.	.	.	.
P50	4	20	.	.	.	.	.	.	.	.
N	380789	266674	348959	390543	390543	.	.	.	.	.
Panel 6: Secondary Analysis Sample: Regular Income Tax Filers Around Withholding Introduction (2011)										
Mean	73.4	30.2	36.7	5.6	5.6	76.3	23.7	33.9	100	100
SD	427	31.2	48.2	22.9	22.9	314.9	24.3	47.4	0	0
P50	8	18.2	.	.	.	15.9	16.8	.	.	.
N	104592	84316	104104	104592	104592	5814	5423	5809	5814	5814

Notes: The variables are from the 2010 income tax declaration (2011 for panels 5 and 6). We use the income tax declarations rather than the sales tax declarations as the former measures the profit rate and almost all sales tax filers also file income tax but not vice-versa. Turnover is in 2015 constant CRC millions, profit rate in percent. Turnover and the profit rate were winsorized at the 99.99th percentile. The samples are defined as follows: (1) all sales tax filers; (2) sales tax filers in the main analysis sample, i.e. firms that had a card machine at the beginning of 2010 and file regularly during 2010-2013; (3) firms that had a card machine at the beginning of 2010 and file at least once per semester during 2010-2013; (4) firms that file at least once per semester during 2010-2013; (5) all income tax filers in 2011; (6) analysis sample for the study of income tax withholding: firms that filed every year during 2011-2016. This table is discussed in Section 3.3.

Table 3: The Impact of Withholding

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Reported	0.0420*	-0.0236	-0.00670	0.0184	-0.00254	0.00645
	(0.0247)	(0.0172)	(0.0159)	(0.0233)	(0.0153)	(0.0135)
Sales Tax Collected	0.0402	-0.00451	-0.00438	0.0202	0.0156	-0.000917
	(0.0278)	(0.0178)	(0.0162)	(0.0268)	(0.0152)	(0.0152)
Input Tax Credits	-0.0197	-0.112***	-0.107***	-0.0443	-0.0883***	-0.101***
	(0.0374)	(0.0255)	(0.0187)	(0.0378)	(0.0215)	(0.0178)
- Import Credits	-0.0282	-0.0480	-0.0859**	-0.0658	-0.0379	-0.0916**
	(0.0618)	(0.0463)	(0.0414)	(0.0656)	(0.0428)	(0.0446)
- Local Purchase Credits	0.00164	-0.133***	-0.0884***	-0.0102	-0.110***	-0.0847***
	(0.0387)	(0.0342)	(0.0235)	(0.0386)	(0.0318)	(0.0199)
Gross Tax Liability	0.153***	0.211***	0.291***	0.147***	0.251***	0.294***
	(0.0337)	(0.0294)	(0.0275)	(0.0319)	(0.0247)	(0.0257)
Withholding Base	0.0305	-0.0213	0.00274	0.0269	0.0153	0.00924
	(0.0281)	(0.0274)	(0.0184)	(0.0263)	(0.0160)	(0.0164)
Withheld Tax	0.721***	0.723***	0.828***	0.762***	0.807***	0.786***
	(0.0760)	(0.0672)	(0.0379)	(0.0673)	(0.0353)	(0.0318)
Withheld Tax Reclaims	0.637***	0.664***	0.786***	0.664***	0.735***	0.758***
	(0.0738)	(0.0628)	(0.0408)	(0.0708)	(0.0368)	(0.0349)
Compensation Requests	0.622***	0.582***	0.208	0.528***	0.536***	0.305**
	(0.221)	(0.221)	(0.175)	(0.195)	(0.195)	(0.136)
Final Tax To Remit	-0.0912**	-0.00791	0.113***	-0.0855*	0.0257	0.0878***
	(0.0440)	(0.0411)	(0.0347)	(0.0442)	(0.0361)	(0.0309)
Taxpayer Sales Tax Remittance	-0.0719*	0.0203	0.119***	-0.0698*	0.0537*	0.0903***
	(0.0421)	(0.0358)	(0.0312)	(0.0419)	(0.0314)	(0.0277)
Total Sales Tax Remittance	0.270***	0.316***	0.428***	0.272***	0.369***	0.418***
	(0.0315)	(0.0321)	(0.0247)	(0.0317)	(0.0237)	(0.0220)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	332,100	325,764	303,300

Notes: This table displays DiD estimates of the impact of the (predicted) withholding-rate increase, as per equation 10. Each cell represents the point estimate (semi-elasticity) on the treatment dummy, indicating firms with a predicted rate increase at reform time. The rows reflect different outcome variables corresponding to the main line items on the sales tax return. Taxpayer remittance is the remittance made by the taxpayer at the end of each month. Total remittance is the sum of taxpayer remittance and any tax withheld. The estimates are based on the Poisson Pseudo Maximum Likelihood Estimator (PPML, see Appendix A). All estimations allow for firm fixed effects and for month fixed effects interacted with firm characteristics (sector, deciles of card usage at the beginning of the period), and standard errors are clustered at the firm level. Columns 1-3 and 4-6 correspond to estimations on a fully balanced panel (firms filing every month during 2010-2012), and on a semesterly balanced panel (firms filing at least once per semester during 2010-2012), respectively. To reduce the effect of outliers while maintaining the internal consistency of the tax declaration, we trim rather than topcode outliers, at the 99.9th, 99th or 95th percentile in the distribution of reported sales (as indicated in the column headings). This table is discussed in Sections 5.2 and 6.

Table 4: Robustness of Withholding Impact

	(1) Baseline: Three-year Panel Fully Balanced	(2) One-Year Panel Fully Balanced	(3) Five-Year Panel Semesterly Balanced	(4) Three-Year Panel Fully Balanced Pre-Reform	(5) Baseline With Larger Control Group
Basline: Firm FE + Month FE					
+ CharacteristicsXMonth FE	0.316	0.318	0.340	0.322	0.376
	(0.0321)***	(0.0346)***	(0.0311)***	(0.0306)***	(0.0246)***
	[0.0495]***	[0.0626]***	[0.0502]***	[0.0449]***	[0.0593]***
Firm FE + Month FE					
Only	0.324	0.399	0.332	0.320	0.304
	(0.0264)***	(0.0284)***	(0.0245)***	(0.0249)***	(0.0213)***
	[0.0481]***	[0.0753]***	[0.0356]***	[0.0383]***	[0.0414]***
Firm FE + Month FE					
+ Treatment-Group-Specific					
Christmas Fixed Effects	0.311	0.387	0.321	0.308	0.286
	(0.0259)***	(0.0283)***	(0.0243)***	(0.0245)***	(0.0209)***
	[0.0481]***	[0.0753]***	[0.0356]***	[0.0383]***	[0.0414]***
Baseline					
Dropping Months					
Dec and Jan	0.301	0.330	0.325	0.311	0.366
	(0.0318)***	(0.0325)***	(0.0323)***	(0.0302)***	(0.0258)***
	[0.0495]***	[0.0626]***	[0.0502]***	[0.0449]***	[0.0593]***
Month FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	210,540	103,690	313,752	246,647	786,960

Notes: This table presents PPML DiD estimates of the effect of the withholding-rate change on total tax remittance. The benchmark estimates displayed in column 1 row 1 use our preferred specification from the main DiD results Table 3. The columns vary the length and balancing of the panel used for estimation, and the size of the control group. Column 5 uses both firms that experienced no rate change and firms that did not use a credit card machine at the time of the reform as control group. The rows vary in terms of how time effects are controlled for. In all estimations in this table, the data is trimmed at the 99th percentile of total sales.

Table 5: Heterogeneity of Withholding Impact

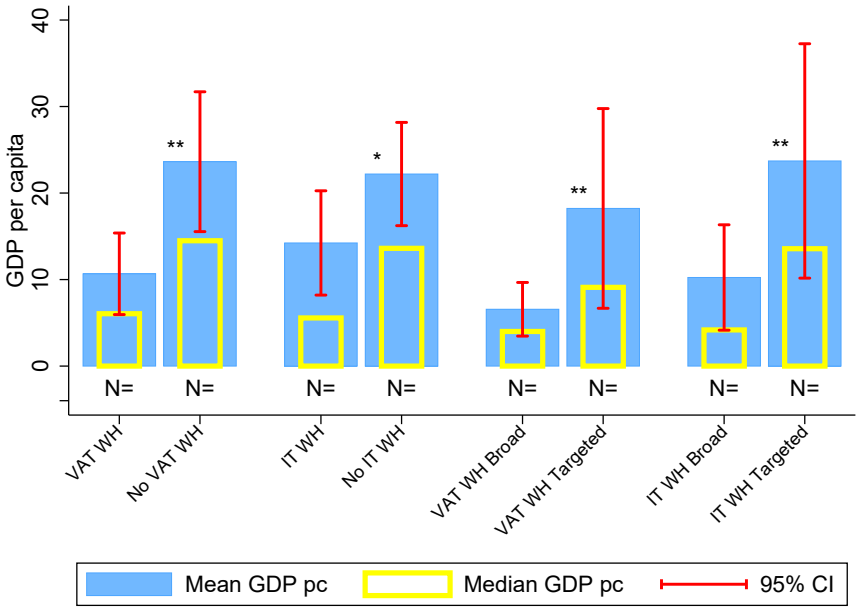
	Outcome: Reported Gross Tax Liability								
	Evidence for Enforcement Perception Mechanism						No Evidence for Liquidity Mechanism		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treated (Withholding Rate Increase)	0.211***	0.185***	0.158***	0.176***	0.123	-0.0319	0.196***	0.205***	-0.0328
	(0.0294)	(0.0306)	(0.0314)	(0.0287)	(0.0763)	(0.0769)	(0.0345)	(0.0312)	(0.0882)
Treated X Below Median Turnover		0.292***				0.248***			0.257***
		(0.0407)				(0.0512)			(0.0518)
Treated X Mispreporter			0.184***			0.148**			0.161***
			(0.0531)			(0.0580)			(0.0555)
Treated X First-Time Withholdee				0.681***		0.671***			0.644***
				(0.211)		(0.218)			(0.218)
Treated X Reclaimer					0.0933	0.154**			0.154**
					(0.0755)	(0.0701)			(0.0721)
Treated X Below Median Profitability							0.0292		0.0288
							(0.0381)		(0.0354)
Treated X Buncher								0.0214	-0.0619
								(0.0479)	(0.0482)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXMonth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	245,848	245,848	245,848	245,848	245,848	245,848	240,033	245,848	240,033

Notes: This table displays PPML DiD estimates of the impact of the withholding-rate increase on firms' reported gross tax liability, as per equation 10. The specification is identical to the one used in Table 3, column 2. In addition to the treatment dummy, columns 2-9 control for interactions between the treatment dummy and various firm characteristics. Misreporters are firms that declared sales less than third-party reports at least once prior to 2011. First-time withholdees are firms for whom the treatment (withholding-rate increase) was an increase from zero to a non-zero rate. We drop firms that experience the maximum withholding-rate increase of six percentage points, to ensure that the average rate increase among first-time withholdees is not larger than the average rate increase among other treated firms. Reclaimers are firms that reclaim (part of) the tax withheld on their tax return. Bunchers are firms that report a gross tax liability within a 5 percent margin of the amount of tax withheld. Table G.1 shows the same analysis when including also firms which do not use a card machine in the control group to maximize power. This table is discussed in Section 6.

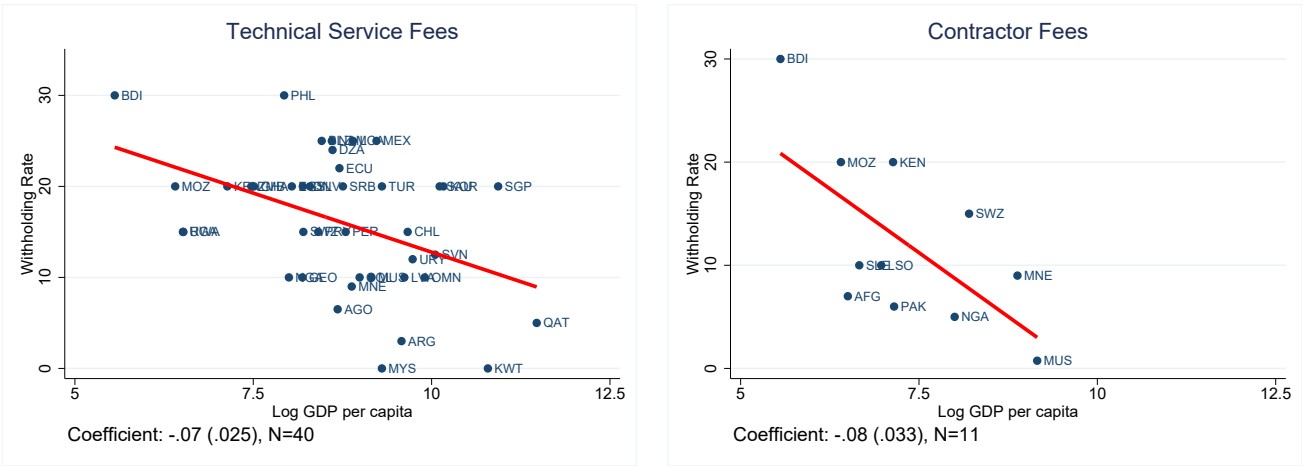
Figures

Figure 1: Withholding Systems and Development

A: Withholding Bases

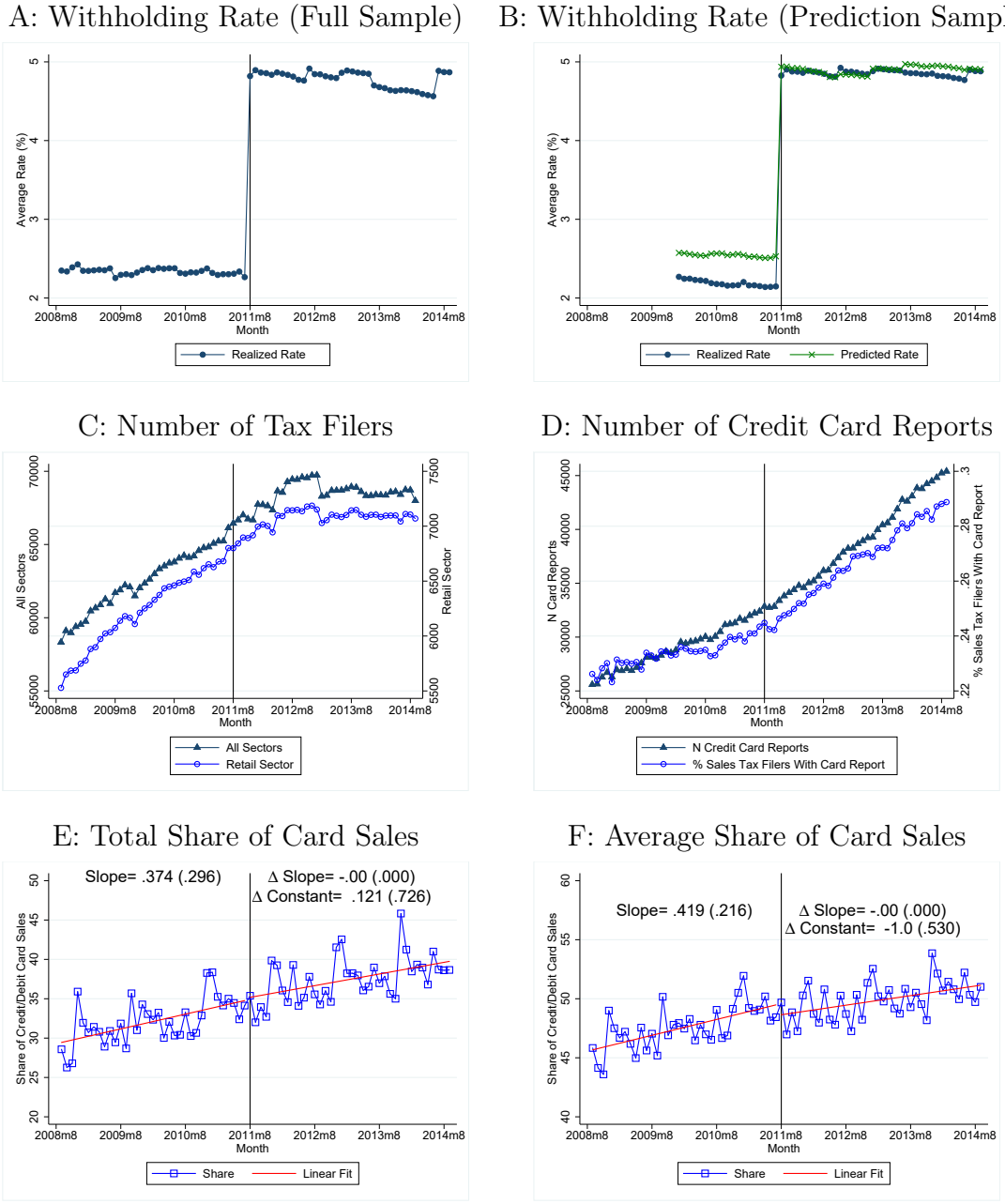


B: Withholding Rates



Notes: This figure shows that tax withholding on firms is widespread, and that the use of withholding, the breadth of withholding bases and the level of withholding rates are all negatively correlated with GDP per capita. Panel A displays the mean/median GDP per capita (in thousands of 2013 USD, WDI) for different subsamples of countries. The number below each bar displays the sample size. The stars reflect the significance levels of the mean difference between two adjacent bars: countries that use and do not use withholding on the VAT/sales tax; countries that use and do not use withholding on income taxes for firms; countries that use a broad withholding regime (that applies across sectors), and those that use a targeted withholding regime, applicable only to certain sectors (e.g. construction, fishing). The analysis is based on a sample of 118 countries for which data was available from the PKF International Worldwide Tax Guide 2015, recent EY International Tax Alerts, PWC Tax Summaries, or the secondary sources referenced in the introduction. Panel B displays the correlation between log GDP per capita and the withholding rate, for withholding on technical services fees and on contractor fees, collected from the PKF International Worldwide Tax Guide 2015. This figure is discussed in Section 1.

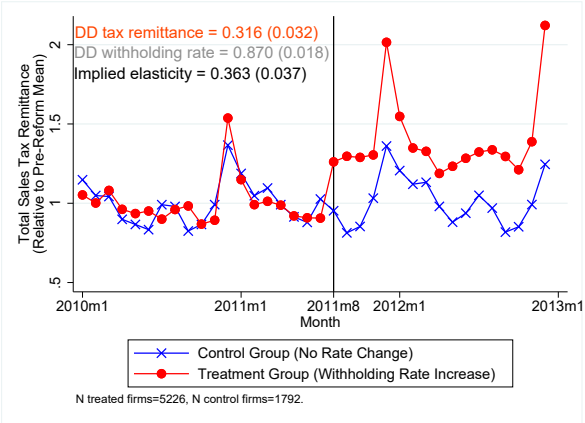
Figure 2: The Withholding Rate Reform



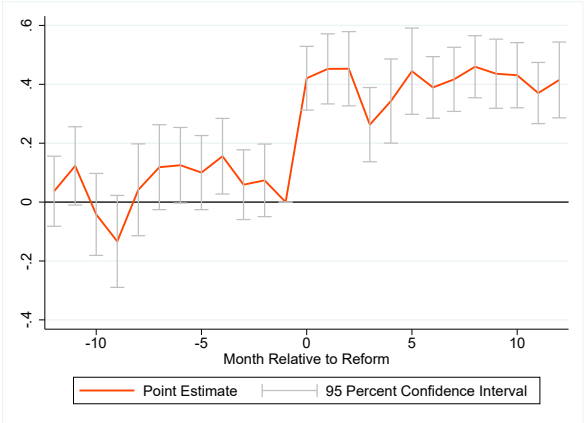
Notes: This figure displays the first stage of the withholding-rate reform and analyzes the reform's effect on sales tax filing and credit/debit card use. Panel A shows the average realized withholding rate among all firms subject to withholding. Panel B shows the average realized and predicted withholding rate among firms for whom we can predict the withholding rate based on previous semester's tax returns and the withholding-rate schedule in Table 1. Panel C shows the number of sales tax declarations for all firms, and for the retail sector which has the highest rate of card machine usage and is thus most susceptible to be treated by the reform. The number of sales tax declarations corrects for revisions and duplicates. Panel D shows the number of firms using a credit/debit card machine (as per the third-party reports received by the government), and the share of sales tax filers that use a credit/debit card machine. Panel E shows the share of card sales in total sales among firms with a credit/debit-card machine, and panel E shows the average over the firm-specific shares of card sales among firms with a credit/debit-card machine. The black solid line in all panels marks 08/2011, when the increase in the withholding rate for the sales tax entered into effect. Panel E and F show a linear fit that allows for a different trend and constant after the reform. The text displays the pre-reform slope of the linear fit, and the change in slope and constant after the reform, along with standard errors in parentheses. This figure is discussed in Section 4.1.

Figure 3: The Impact of Withholding

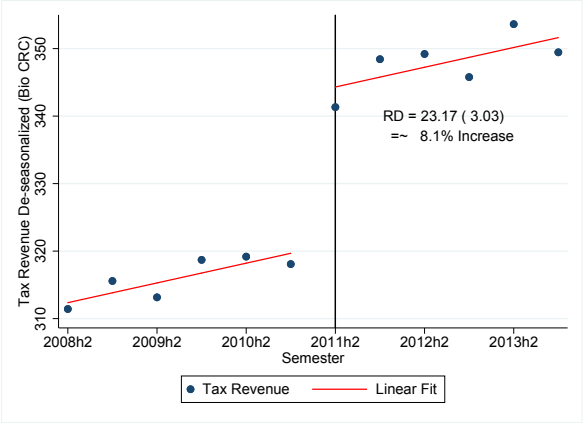
A: Impact on Sales Tax Remittance



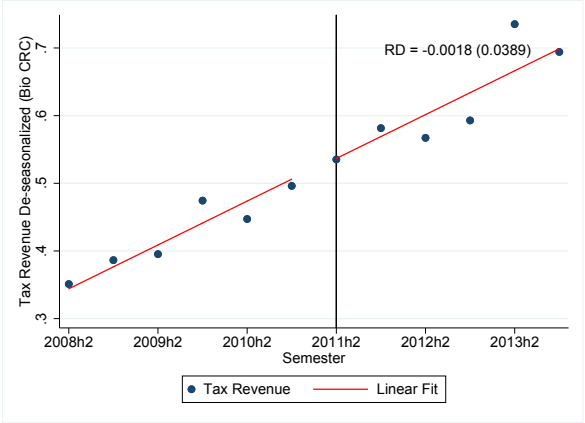
B: Event Study Graph



C: Impact on Aggregate Sales Tax Revenue



D: Counterfactual, Simplified Regime Tax Revenue

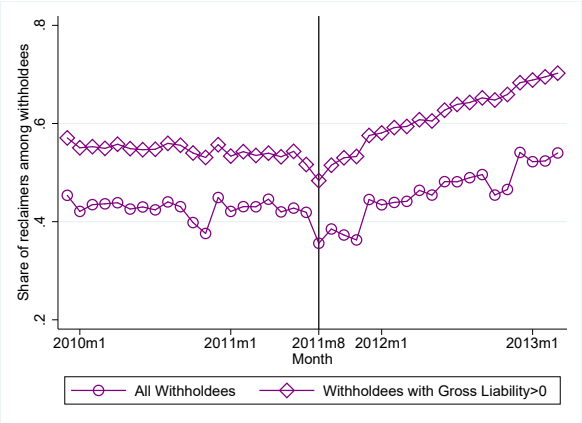


Notes: Panel A shows the evolution of total sales tax remittance in the DiD treatment and control group, as well as the DiD estimate from Equation 10. The black solid line marks 08/2011, when the increase in withholding rates entered into effect. The data is trimmed at the 99th percentile of total sales, and scaled by the pre-reform average. Panel B shows the event-study version of the Panel A, using the same controls variables and fixed effects as in Equation 10. The bottom panels show the reform's impact on aggregate sales tax revenue (panel c), and on aggregate revenue from the quarterly simplified regime tax, as a counterfactual (panel D). The sales tax data is based on official revenue statistics from the Ministry of Finance, net of the sum of refunds made by the tax authority to taxpayers who were subject to withholding in excess of their liability, and the simplified regime data is based on firm-level tax declarations. For panel B, semesters are defined to fit exactly around the time of the reform, so the first semester of each year includes February to July, and the second semester includes August to December, and January of the following year. The results are robust to running the analysis on monthly or quarterly data, using shorter or longer time series, and adding controls for the months of December and January (in the monthly data). This figure is discussed in Section 5.1.

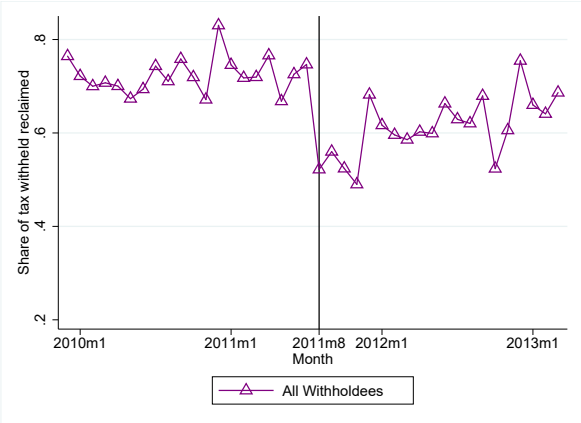
Figure 4: Mechanisms of Withholding Impact

A: Default Mechanism - Incomplete Reclaim of Withheld Tax

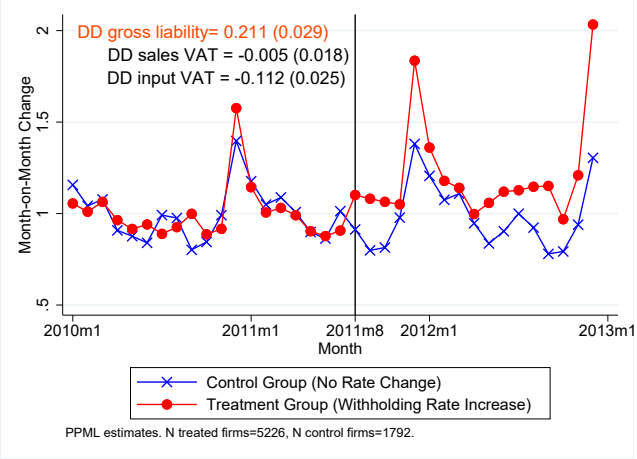
A1: Share of Reclaimers



A2: Share of Withheld Tax Reclaimed

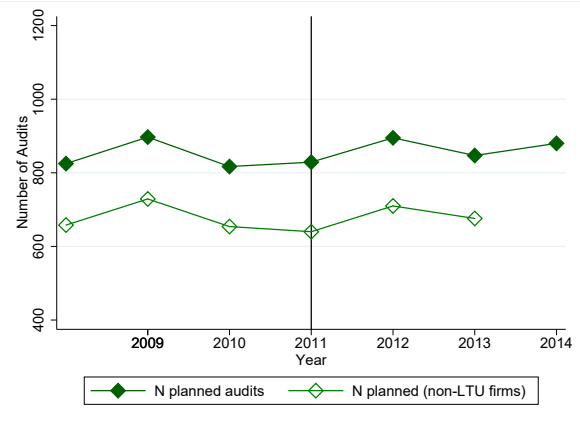


B: Enforcement-Perceptions Mechanism - Increase in Reported Tax Liability

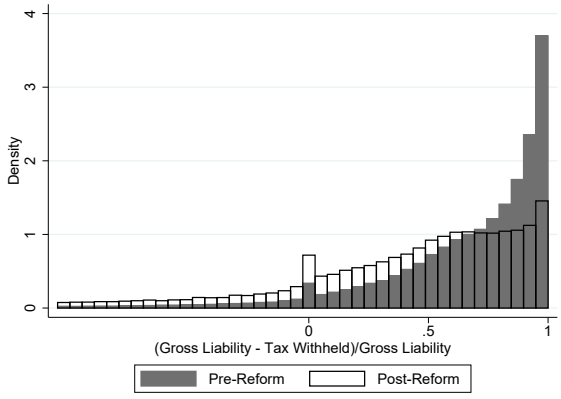


C: Ruling Out Alternative Explanations

C1: No Change in Audit Rates



C2: Little Bunching in Gross Tax Liability

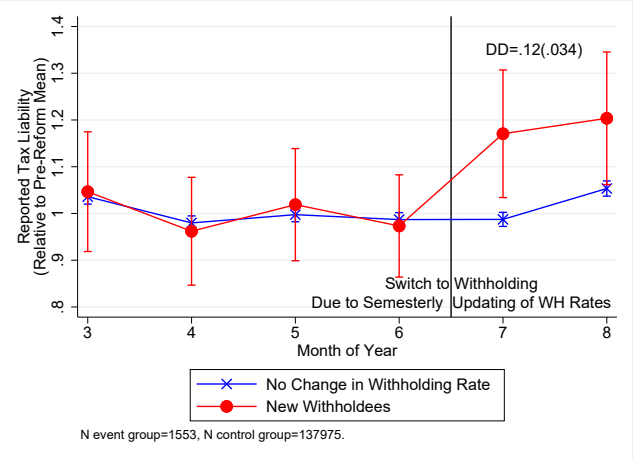


Notes: This figure illustrates the mechanisms for the withholding-rate impact. In all panels, the black solid line marks 08/2011, when the increase in withholding rates entered into effect. Panels A and B display, for all firms subject to withholding in a given month, the share of firms making a reclaim, and the average share of withheld tax reclaimed respectively. Panel B shows results of the difference-in-differences estimation of Equation 10, on gross liability. The Panel is constructed as Panel A in Figure 3. Panel C1 shows the evolution over time of the number of planned audits for all taxpayers and for taxpayers who are part of the large taxpayer unit, as per the annual work programs of the audit department. Panel C2 shows the distribution of the deviation of reported gross liability from the amount of tax withheld, before and after the reform, for the balanced panel underlying all difference-in-differences estimation. This figure is discussed in Section 6.

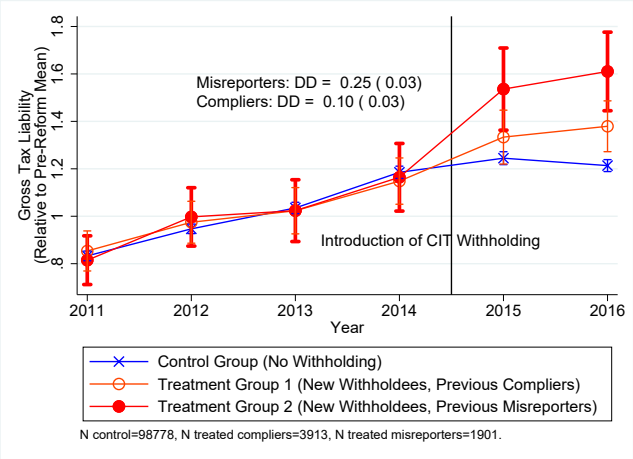
Figure 5: External Validity

A: Impact of Other Withholding Schemes in Costa Rica

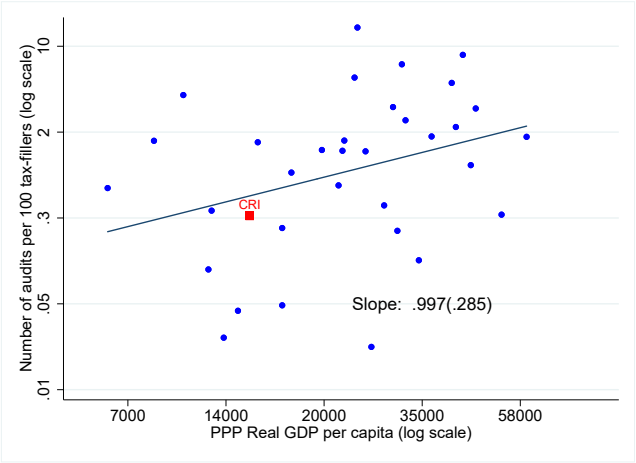
A1: Event Study of Sales Tax Withholding



A2: Introduction of Income Tax Withholding



B: Audit Rates Across Countries



Notes: Panel A1 displays an event study of the application of sales tax withholding to the self-employed, where the event group experiences an increase in the withholding rate from zero to positive in July, due to the biannual updating of withholding rates. Both groups are subject to credit card reporting prior to the reform. The outcome is the reported tax liability. Panel A2 displays a difference-in-differences study of the introduction of credit-card withholding for the income tax, where the treated group are firms which had a credit-card machine prior to 2015. Mis-reporters are firms which reported sales lower than third-party reported sales prior to 2015. The outcome variable is the reported tax liability. Panel B plots the number of comprehensive audits completed per 100 expected CIT filers, using data.rafit.org. The construction of all graphs is described in more detail in Appendix H. This figure is discussed in Section 8.

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APPENDIX FOR ONLINE PUBLICATION

For

TAXATION, INFORMATION AND WITHHOLDING:

EVIDENCE FROM COSTA RICA*

Anne Brockmeyer (IFS, UCL, World Bank and CEPR)

& Marco Hernandez (World Bank)

November 23, 2022

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Appendix

A Choice of Estimation Method

This appendix explains our choice of estimation method. We first review the disadvantages of the standard log-linear model in our context, and then discuss several alternatives.

A.1 Disadvantages of the Log-Linear Model

A generic version of the models we would like to estimate in this paper is

$$y_{it} = \alpha_i + \gamma_t + \beta \cdot Treat_i \cdot Post_t + \epsilon_{it}, \tag{1}$$

where y is a firm-level outcome, e.g. tax remittance, the treatment $Treat$ is a policy change expected to affect the outcoume, and which is relevant only to a subset of firms, i indexes firms and t indexes time periods. It is standard practice to assume that this is a log-linearized version of an exponential relationship, and run an OLS estimation with a log-transformed outcome on the left-hand-side. This generates a point estimate of β which can be interpreted as a semi-elasticity, i.e. the proportional change in y in response to the treatment, and which is scale-invariant. If the distribution of the original outcome variable is right-skewed, the log-transformation reduces heteroscedasticity in the data and leads to a distribution that resembles the normal distribution more closely, moving towards more consistency in estimated standard errors. For outcome variables which feature zeros or negative values, the inverse hyperbolic sine (IHS) transformation ($(ln(y + sqrt(y^2 + 1))$ has been proposed as a log-like transformation that achieves benefits similar to those of the log transformation (Johnson 1949, Burbidge et al. 1988).[1]

In our case, however, the distribution of our main outcome variables y (e.g. profits, tax liability, tax remittance) is not only highly skewed, but also features an unusually large share of zeros ($>$ 5 percent of observations for some variables, over 30 percent for others). This means that no log-like transformation yields an approximately normally distributed outcome. Both the log and the IHS transform the non-zero part of the distribution, but leave the mass point at zero unchanged. In this case, an OLS estimation with the transformed outcome yields

[1] Compared to the log transformation $ln(y + \epsilon)$, which requires specifying ϵ - usually 1 - and which does not deal with negative values, the IHS transformation is considered less arbitrary. However, this view ignores the fact that the IHS transformation also has a parameter, referred to as θ by Johnson (1949) and as α by Ravallion (2017). The standard assumption is $\theta = 1$, in which case the transformation simplifies to $(ln(y + sqrt(y^2 + 1))$ (as above), but there is no clear theoretical justification for this assumption. Thus, neither the log nor the IHS transformation is non-arbitrary.

coefficients which are biased, scale-variant and not interpretable as a percentage change.

Santos Silva and Tenreyro (2006a) discuss the intuition behind this challenge more generally in the framework of the standard constant elasticity model $y_i = exp(\beta x_i)$. The stochastic version of the model is $y_i = exp(x_i\beta) + \epsilon_i$, with $\epsilon_i = y_i - E(y_i|x)$. In the log-linearized version of this model, the error is typically not independent of the regressor x_i because of Jensen's inequality, i.e. $E(ln(y)) \neq ln(E(y))$. Only under very specific functional forms would the errors in the log-linearized model be independent of the regressor, so that unbiased coefficient estimates can be obtained.

As we show in Table A.1, the results from estimations on data transformed using $ln(y+1)$ or the IHS are very similar. Both are qualitatively consistent with but quantitatively inconsistent with non-parametric evidence and estimation results using more appropriate estimators, which we discuss in the following sections.[2]

Table A.1: Different Estimation Methods

	Log(x+1)	IHS	Log	Linear			PPML
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Collapsed Data	Point Estimate (Absolute Effect)	Pre-Reform Mean Among Treated	Proportional Effect	
Treatment	1.069***	1.158***	0.811***	205.7***	451.7***	0.455***	0.316***
	(0.0406)	(0.0448)	(0.0259)	(43.68)	(14.16)	(0.0966)	(0.0321)
post			0.0541***				
			(0.0192)				
Month FE	Yes	Yes	No	Yes	n/a	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	n/a	Yes	Yes
CharacteristsXMonth	Yes	Yes	No	Yes	n/a	Yes	Yes
Observations	252,648	252,648	13,166	252,648	133,342	282,924	252,000

Notes: This table displays the results from estimating equation 1, using different estimation methods/transformations to the outcome variable as indicated by the column title. The outcome variable is total sales tax remittance, and the treatment indicates whether the firm was subject to the increase in the tax withholding rate in August 2011. The data is a monthly balanced panel of firms filing sales tax during 2010-2012. The data is trimmed at the 99th percentile of total sales. The results in columns 2, 6 and 7 correspond to those in Tables F.3, F.2 and 3, column 2, respectively.

[2]Relatedly, Bellemare and Wichman (2019) show that coefficient estimates from regressions involving IHS transformations can differ substantially from a semi-elasticity, and are sensitive to whether the IHS transformation is applied to the dependent or the independent variable or both.

A.2 Alternative 1: Log-Linar Estimation on Collapsed Data

As discussed by Bertrand et al. (2004) and used in Naritomi (2019), one option of dealing with the presence of zeros in a difference-in-differences estimation is to collapse (i.e. average) the data for the pre-reform and post-reform period at the firm-level, and estimate a simple log-linear difference-in-differences model on the collapsed data. The collapsing ensures that only observations which have a zero outcome for an entire period are dropped from the sample. The procedure also leads to more accurate standard error estimates in serially-correlated data, which is why Bertrand et al. (2004) initially suggested this method. When using this method, the identifying assumption should of course still be verified non-parametrically.

The downsides of working with collapsed data in our context are twofold. First, it does not allow for flexibly controlling for time trends and treatment-group-specific seasonality. As a precaution, we thus use only 12 month before and after the reform, and take out observations in December, as differential changes in December spikes between treatment and control group could disproportionately drive the treatment effect estimates. Second, the strategy faces the same challenges as the standard log-linear model if many observations have zero-outcomes for an entire period (either pre-reform or post-reform). In our context, we still have a significant share of zero observations even after collapsing (see the number of observations in Table F.8 compared to Table 3).[3] This means that the estimates still apply only to a subsample of firms.

This method is thus not our preferred specification, but yields results that are qualitatively similar but still much larger than those from our preferred specification, discussed below.

Instead of aiming to estimate a treatment effect for the full sample, including zero and non-zero observations, we also estimate separately the "extensive" margin effects (reporting a non-zero outcome) and the intensive margin effect. The former is estimates as OLS on a dummy outcome variable, and the latter is estimated as as log-linear model on the observations that consistently (or mostly) report non-zero outcomes pre-reform. This exercise allows us to show that our effect is driven by both extensive and intensive margin responses, but the analysis remains incomplete, as it ignores the share of firms which register both zero and non-zero outcomes before the reform. In addition, the sample on which intensive margin effect can be estimated changes from outcome to outcome. This means that a method which can deal with both zero and non-zero outcomes still preferred.

[3] This is particularly true for the amount of tax withheld, reclaims of tax withheld and taxpayer tax remittance.

A.3 Alternative 2: Linear Estimation

As a second alternative to the log-linear model, we run the estimation as a simple linear model without transforming the outcome variable. If the model is correctly specified, this yields an unbiased estimate of the absolute rather than the proportional effect of the treatment. This absolute effect estimate is useful for our decomposition exercise, in which we decompose the treatment effect on total tax remittance into changes in the components of the tax remittance (gross tax liability, deductions, tax withheld etc). Relying on an absolute effect estimate makes the decomposition simple and transparent. However, we are interested in the proportional effect as well, which we can obtain by scaling the coefficient of interest by the treatment-group mean in the last pre-reform month/year (or, alternatively, the treatment group mean over the entire pre-reform period, which is valid in the absence of time trends). We use the delta rule to obtain standard errors on these transformed point estimates (using boostrap yields very similar results). To ensure our results are not driven by influential outliers, we test robustness to winsorizing the outcome variable at different levels (the 99.9th, 99th and 95th percentile).

The key shortcoming of this strategy is that, if the true model is not linear, the linear estimation yields biased estimates of β. Another disadvantage is that results from an augmented difference-in-difference model with interaction terms (e.g. to estimate differential effects for different subsampls of firms) are difficult to interprete, as subsamples may differ in both absolute and relative effects.

A.4 Alternative 3: PPML Estimation

Given the shortcomings of the linear model, our main and preferred strategy uses the Poisson Pseudo Maximum Likelihood estimator (PPML) suggested by Santos Silva and Tenreyro (2006a). This estimator is based on the constant elasticity model $y_i = exp(\beta x_i) + \epsilon_i$ and the appealing assumption that $V(y_i|x) \propto E(y_i|x) = exp(x_i\beta)$. The estimator maximizes the log-likelihood $\sum_{i=1}^{n}[y_i x_i \beta - exp(x_i b)]$, with first-order condition $\sum_{i=1}^{n}[y_i - exp(x_i\beta)]\, x_i = 0$. The PPML is a consistent estimator for β if the conditional mean is correctly specified, i.e. $E(y_i|x) = exp(x_i\beta)$. Importantly, consistency does not require that the data follow a Poisson distribution (or that the data contain only integers) nor that the variance is correctly speci-

fied.[4],[5]

This estimator coincides with the standard Poisson maximum-likelihood estimator (MLE), which is derived from the assumption of the Poisson distribution where $V(y_i|x) = E(y_i|x)$ - a phenomenon referred to as equidispersion, as opposed to overdispersion where $V(y_i|x) > E(y_i|x)$).[6] The estimator proposed by Santos Silva and Tenreyro (2006a) is a "pseudo" MLE because, unlike standard MLE estimators, it does not require complete specification of the joint density distribution (Gourieroux et al. 1984). The conditional mean is assumed to be correctly specified, while the conditional variance is allowed to be misspecified. Efficiency, however, is achieved only with correct specification of both the conditional mean and conditional variance. If the data is overdispersed, so that the second moment assumption is incorrect, the PPML-estimated standard errors are downward biased (a finding which Ryan et al. (2018) illustrate more generally for Poisson estimators). We thus follow Santos Silva and Tenreyro (2006a)'s recommendation to use robust standard errors (essentially an extension of White (1980) robust standard errors for OLS).[7]

The PPML was devised for consistent estimation of constant elasticity models in multiplicative form, with a focus on the gravity model and characteristics of trade data, namely non-negativity, heteroscedasticity, and the occurence of zeros. The PPML is surprisingly suitable for work with tax data as well, as these data share many features with trade data. Both types of data usually feature a highly skewed distribution, a large share of zeros (country pairs with no trade, and firms with zero tax liability) and non-negativity. Besides, estimation in both trade and public finance usually requires controlling for multi-dimensional fixed effects, which the PPML estimator (and accompanying Stata package) was developed to do. While the PPML is still most popular among trade economists, its application has been extended to topics as diverse as international taxation (Azémar and Dharmapala 2019), R&D investment (Azoulay et al. 2018), drug addiction (Alpert et al. 2018, Powell et al. 2018) and migration (Parsons and Vézina 2018).

The advantages of the PPML over the above-discussed alternatives can be summarized as

[4]Instead of the PPML, one could use the non-linear least squares estimator $\hat{\beta} = argmin \sum_{i=1}^{n}[y_i - exp(x_i b)]^2$, with first order condition $\sum_{i=1}^{n}[y_i - exp(x_i\hat{\beta})]exp(x_i\hat{\beta})x_i = 0$. However, this estimator is inefficient as it gives more weight to large observations which are also the more noisy ones.

[5]In two follow-up papers, Santos Silva and Tenreyro (2011) show that the PPML behaves well even if the share of zeroes in the data is very large and Santos Silva et al. (2014) develop a method to choose between competing models for non-negative data with many zeros.

[6]The model assumed for the PPML, $y_i = exp(x_i\beta)$, is the log-linear version of the poisson regression model.

[7]Alternatively, valid inference can be done with standard errors based on the negative binomial distribution of type 1 or type 2 (if the assumption that the variance is a multiple of the mean or a quadratic function of the mean, respectively, is reasonable), or by bootstrapping (Cameron and Trivedi (1998), chapter 3). Also see Winkelmann (2003) on count data econometrics.

follows:

- All data points, including zeros, are considered in the estimation[8] without the need to make ad hoc transformations such as taking $ln(y+1)$ or the IHS assuming $\theta = 1$. All observations are weighted equally.

- Estimates for β are consistent despite heteroscedasticity, and robust to different patterns of heteroscedasticity, if the conditional mean is correctly specified.

- The estimates are semi-elasticities, so no transformation or scaling is needed for interpretation. This ensures that results from subsample regressions and coefficients on different interactions with the treatment indicator can easily be compared.

For our main estimation of the policy treatment effect on tax remittance, Table A.1 (columns 6 and 7) shows that the PPML estimation and the linear estimation yield very similar results.[9]

A.5 Comparison of Alternatives

All estimation strategies yield biased estimates of β if the conditional mean is misspecified. The linear model has the additional drawback that it requires an ad hoc derivation of the semi-elasticity, the log-linear model on collapsed data cannot take into account the remaining zero-observations, and the PPML estimator with robust standard errors has the additional drawback that it is inefficient. If it is theoretically unclear whether the true relationship between the outcome and the treatment is linear or log-linear, and either of those assumptions is unlikely to hold exactly, it convenes to emphasize results for analyses for which the various estimation strategies yield qualitiatively identical and quatitatively very similar results. Given that the linear model gives more weight to large observations, whereas the PPML treats all observations equally, the emphasized results would also be the ones that are relatively more stable across the sample. The PPML as our preferred method yields the quantiatively smallest and hence most conservative estimates.

[8] The exception are observations in panel data that register a zero outcome for each period, which are dropped by the PPML estimator with fixed effects.

[9] Instead of the poisson estimation, one could consider a negative binomial (NB) estimator, a generalization of the poisson estimator suitable for over-dispersed data. The NB estimator can provide more efficiency if an assumption on the conditional variance (as either a multiple or a quadratic function of the mean) can be correctly specified. However, the efficiency gains come at the cost of a higher risk of inconsistency of $\hat{\beta}$, as consistency requires correct specification of the full density. We therefore do not use the NB estimator in this paper. To the best of our knowledge, there is no Stata package available to implement the negative binomial estimation with high-dimensional fixed effects.

B The Impact of Information Reporting

This section presents estimates of the impact of third-party information on self-reported taxable income. We begin by analyzing the heterogeneity of bunching–a proxy for misreporting–across subsamples of firms with different degrees of third-party information coverage. We then conduct an event study of firms' responses to the first third-party report. Table B.2 presents summary statistics on the different samples of analysis.

B.1 Heterogeneity in Bunching

Table B.1 shows the income tax schedule in Costa Rica, which features kinks for the self-employed individuals and notches for corporations. Numerous studies have used bunching at kinks or notches in the tax schedule to estimate tax base responses to the tax rate. Bunching is usually shown to be driven by tax evasion or avoidance rather than a real response (e.g. Bachas and Soto 2019, Almunia and Lopez-Rodriguez 2018, Seim 2017). In Costa Rica, we observe large and sharp bunching at the first kink for self-employed individuals and at the first notch for corporations. Bunching moves every single year with the location of the kink, as shown in Figure B.1 for self-employed individuals.[10] This speedy adjustment supports the interpretation of bunching as a reporting response rather than a real production change.[11] We thus use bunching as a proxy for misreporting.

To examine the heterogeneity of bunching with the coverage of third-party information, we pool the data for 2006 to 2015 and display the distribution as a percentage difference from the year-specific threshold location in 1 percent bins. To estimate the size of bunching, we fit a flexible polynomial to the observed distribution, excluding a range around the thresholds, as is standard in the bunching literature (Chetty et al. 2011, Kleven and Waseem 2013). Given the asymmetric nature of bunching, we estimate bunching to the left of the kink and the missing mass to the right of the kink. As the missing mass does not seem to be the same size as the excess mass, at least for self-employed filers, we apply the estimation strategy suggested by Best and Kleven (2018) rather than the convergence method.[12]

[10] We focus on the first threshold as it is the most salient one, and also the largest in terms of the tax rate change for the self-employed.

[11] Strikingly, the excess mass is always concentrated to the left of the kink, and in some years the distribution exhibits a missing mass to the right of the kink. Such asymmetric bunching at kinks is at odds with the prediction of standard utility theory and might instead reflect reference-point dependence (Kleven 2016). While caution should be exercised when using bunching to estimate the elasticity of taxable income, this does not prevent us from interpreting bunching as a measure of misreporting that generates a revenue loss for the government.

[12] We choose the lower bound of the excluded range as the point where bunching starts and the upper bound as the point where the derivative of the observed distribution shifts from positive to negative. The convergence method would require the missing mass and the excess mass to be of the same size and assumes that there are no extensive-margin responses, which is unlikely in our context due to the large share of non-filers.

Figure B.2 displays the observed distribution (dotted blue line), the estimated counterfactual (solid red line), and excess-mass estimates for different sub-samples of the self-employed individuals (row A) and corporations (row B). Among both firm types, the largest excess mass is found in the sample of firms not subject to third-party reporting (panels A1 and B1). The subsample of firms subject to third-party reporting (panels A2 and B2) still exhibits a large excess mass around both the kink and the notch, but in both cases the excess-mass estimate is significantly smaller than the estimate for firms not subject to third-party reporting. The excess mass drops from 4.5 to 2.08 for self-employed individuals and from 4.49 to 3.17 for corporations, and those changes are statistically significant at the 1 percent level.[13] The fact that bunching is smaller but still highly significant, among firms subject to third-party reporting is consistent with the fact that the information trail is incomplete, and that firms could still bunch through legal tax avoidance.

Third-party reporting by state institutions and credit-card companies, which also act as withholding agents, is associated with a further reduction in misreporting (panels A3 to B4). For self-employed filers, the excess mass among firms subject to state reporting is similar to the excess mass among firms subject only to third-party reporting by other firms, but the excess mass drops to 0.52 for firms subject to reporting by credit-card companies. For corporations, the excess mass drops to 1.44 and 1.35, respectively, for firms subject to reporting by state institutions and credit-card companies. Once again, these changes are highly statistically significant. While the heterogeneity of bunching across subsamples captures a correlation rather than a causal relationship, it is consistent with a compliance impact of third-party information reporting and an even stronger impact of withholding.[14]

[13]Note that the change in the missing-mass estimate is driven by a change in the counterfactual density that scales the excess mass, rather than by a change in the absolute size of the excess mass. The missing mass drops for corporations, but increases for self-employed individuals. In fact, the missing mass for the latter is clearly visible only in panels A2 to B3. This suggests that some self-employed individuals in subsample may erroneously perceive the threshold to be a kink not covered by third-party reporting.

[14]Our results are also consistent with estimates from the United States, where the Internal Revenue Service reports tax evasion rates of 63 percent, 7 percent and 1 percent, respectively, on income covered by little third-party reporting, income covered by substantial third-party reporting, and income subject to withholding (IRS 2016).

Table B.1: Income Tax Schedule

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Panel A: Self-Employed										
Kink 1	1,858	2,074	2,252	2,599	2,747	2,890	3,042	3,171	3,339	3,522
Kink 2	2,775	3,097	3,362	3,880	4,102	4,316	4,543	4,735	4,986	5,259
Kink 3	4,629	5,167	5,609	6,473	6,843	7,199	7,577	7,898	8,317	8,773
Kink 4	9,276	10,354	11,241	12,972	13,713	14,427	15,185	15,827	16,667	17,581
Panel B: Corporations										
Notch 1	27,811	31,043	33,701	38,891	41,112	43,253	45,525	47,451	49,969	52,710
Notch 2	55,943	62,444	67,791	78,231	82,698	87,004	91,573	95,447	100,513	106,026

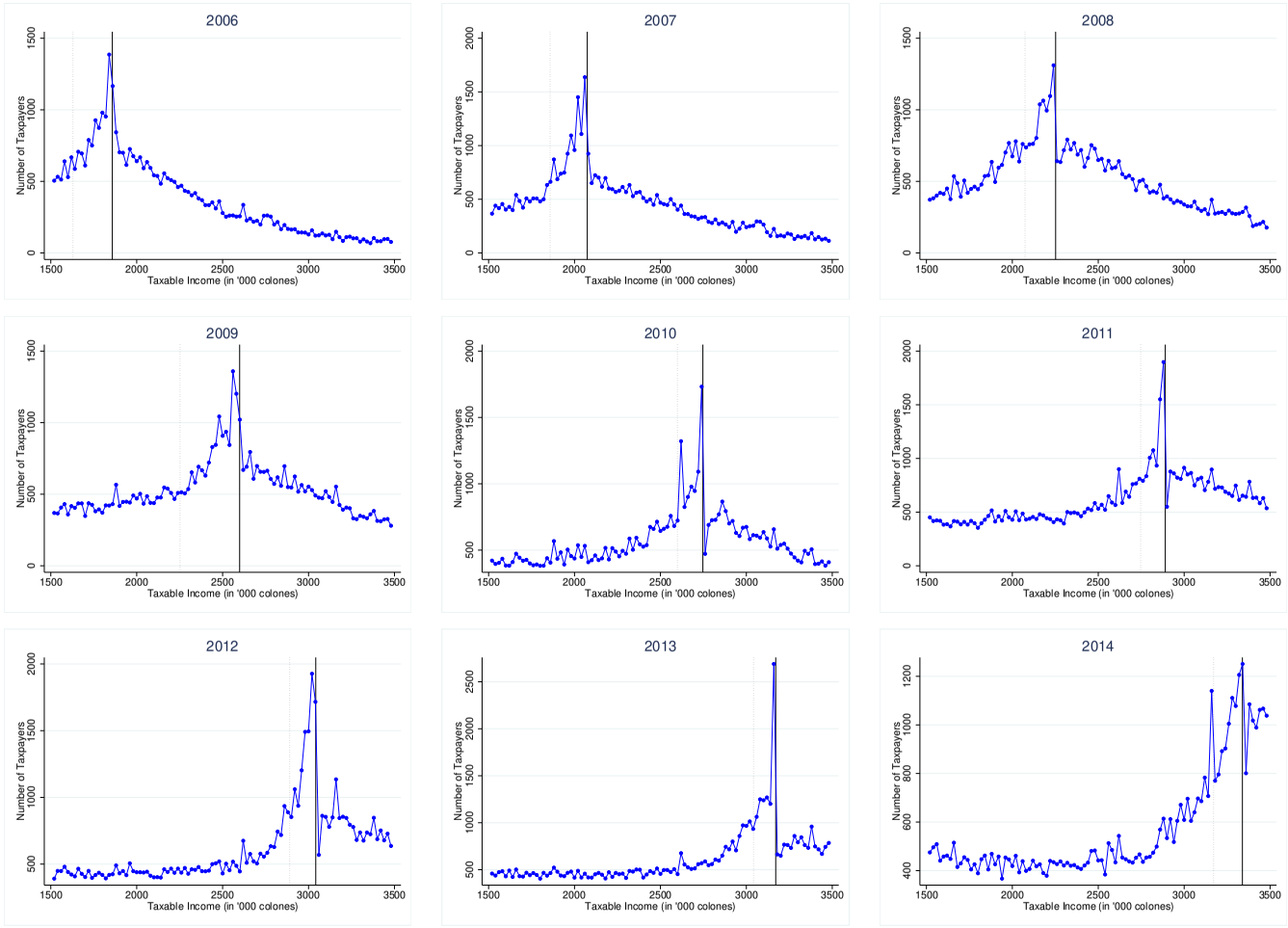
Notes: This table shows the income tax schedule for the years 2006 to 2015. Amounts are in thousands of CRC (1USD=573CRC). Panel A shows the location of the kinks on taxable income that separate the five tax brackets for the self-employed. The tax is applied to taxable income at marginal rates of 0, 10, 15, 20 and 25 percent respectively for the first to fifth tax bracket. Panel B shows the location of the notches on revenue that separate the three tax brackets for corporations. The tax is applied to taxable income at average rates of 10, 20 and 30 percent respectively for the first to third tax bracket. For more information on the tax base, tax schedule and the filing procedure, see http://www.hacienda.go.cr/contenido/12994-regimen-tradicional.

Table B.2: Summary Statistics for Different Samples

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2010				2013			
	Turnover	Profit Rate	Years in Data	% Corporation	Turnover	Profit Rate	Years in Data	% Corporation
Panel 1: All Income Tax Filers								
Mean	83	28.1	1.9	41.5	75.7	34.4	3.1	35.1
P50	4.3	14.4	1	.	4.2	22.6	2	.
P90	77.8	75.7	4	.	72	90.8	7	.
N	355354	251745	355354	311800	402964	291053	402964	397610
Panel 2: Income Tax Filers in Bunching Sample								
Mean	24	39.2	1.8	21.5	21.1	41.7	2.9	18.9
P50	11.3	31.3	1	.	9.7	36.2	2	.
P90	55.9	76	4	.	51.4	82.6	7	.
N	90798	90479	90798	90798	115406	115405	115406	115406
Panel 3: Income Tax Filers in Event Study								
Mean	122.1	27.2	1.8	37.5	121.9	29.9	1.8	37.5
P50	8.9	13.5	1	.	8.6	17.5	1	.
P90	131.6	75	4	.	130.5	75	4	.
N	218952	189670	218952	218097	218952	180187	218952	218097
Panel 4: All Sales Tax Filers								
Mean	261.6	10.4	1.9	55.8	240.8	12.6	3	50.4
P50	19.4	3.2	1	.	18.7	4.5	1	.
P90	341.1	33.5	4	.	317.9	36.6	7	.
N	67734	56646	67734	59566	75018	63402	75018	74927
Panel 5: Regular Sales Tax Filers								
Mean	460.3	8.7	1.4	59.4	344.7	10.7	2.3	55.7
P50	49.2	3.1	1	.	41.3	4.3	1	.
P90	731.6	24.7	3	.	520.4	28.9	6	.
N	27710	25353	27710	27541	38451	35494	38451	38435
Panel 6: Irregular Sales Tax Filers								
Mean	124.1	11.9	2.2	52.7	131.6	15.1	3.7	44.9
P50	9.7	3.4	1	.	7.3	4.9	3	.
P90	162.6	41.5	5	.	135	48	8	.
N	40024	31293	40024	32025	36567	27908	36567	36492

Notes: The variables are from the 2010 (2013) income tax declaration. Turnover is in 2015 constant CRC millions, profit rate in percent. The samples are defined as follows: (1) all income tax filers; (2) income tax filers in the bunching sample, i.e. corporations (self-employed) with revenue (profits) within [-50 percent,+50 percent] around the first notch (kink) in the tax schedule; (3) income tax filers that experienced at least one of the events analyzed in the event study during 2009-2012 (4) all sales tax filers; (5) regular sales tax filers, filing each month within a 36 months window around July of the relevant year, [July of t-1, June of t+2] i.e. the equivalent of the sample used in the withholding DiD; (6) similar to (5), but retaining only firms that file at least once but not each month within the 36-months window.

Figure B.1: Bunching at the First Income Tax Kink for Self-Employed Individuals

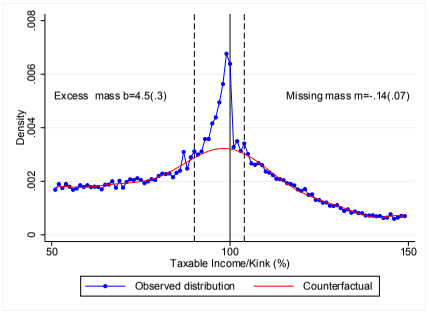


Notes: This figures show the frequency distribution of taxable income of the self-employed (personas fisicas con actividad lucrativa) around the first kink in the income tax schedule, for the years 2006-2014. The data is aggregated in bins of CRC 20,000. The black solid line marks the kink in year t (as per the figure title), the black dashed line marks the kink in year $t-1$.

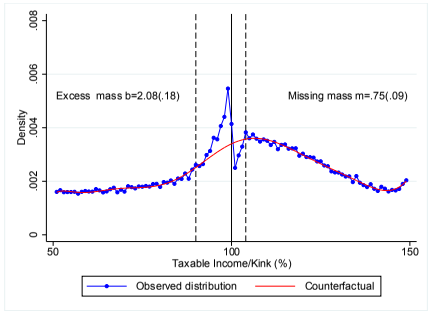
Figure B.2: Bunching, Information Reporting and Withholding

A: Self-Employed

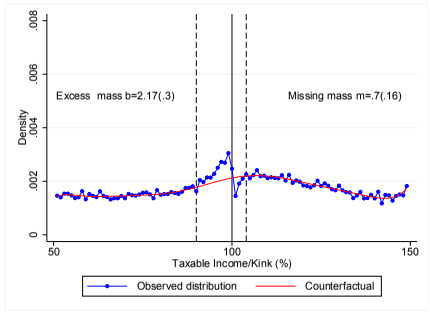
A1: No Information Reporting



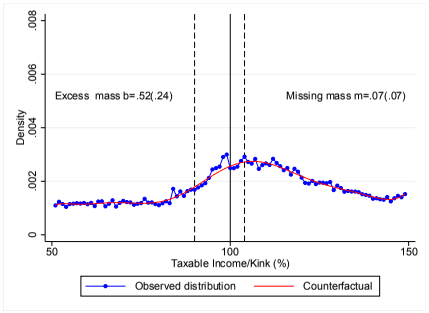
A2: Reporting by Firms



A3: Reporting by State

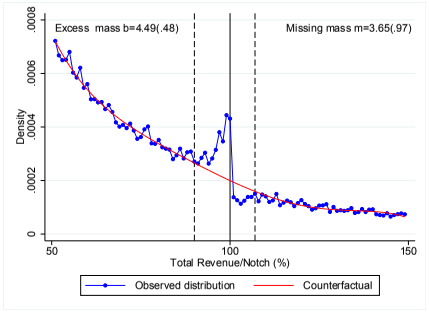


A4: Reporting by Credit/Debit Card

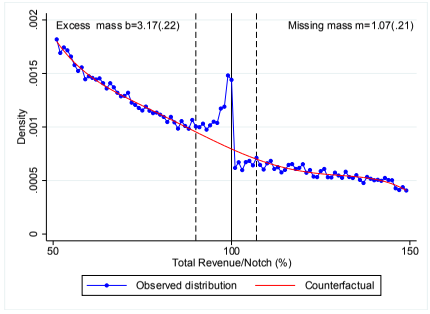


B: Corporations

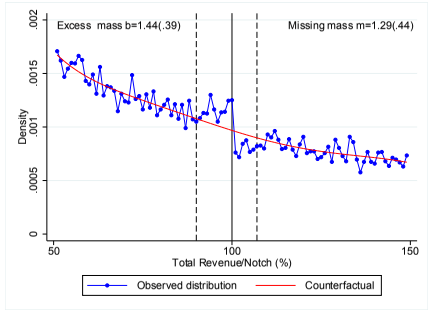
B1: No Information Reporting



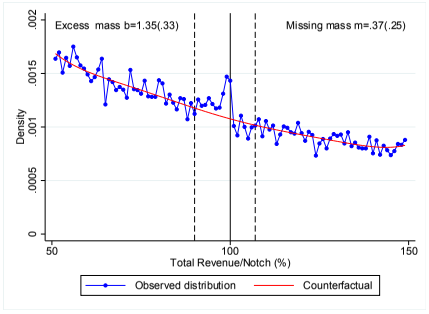
B2: Reporting by Firms



B3: Reporting by State



B4: Reporting by Credit/Debit Card



Notes: This figure shows the density distribution of taxable income for the self-employed around the first kink in the income tax schedule (top row, A), and the density distribution of total revenue for corporations around the first notch in the corporation tax schedule (bottom row, B). The data is pooled for years 2006-2015, represented as percentage distance from the kink, and aggregated in taxable income bins of 1 percent. The panels show the distribution for different subsamples, as per the panel titles that indicate whether and by what type of information reporting firms in the subsample are covered.. The blue dotted line marks the empirical distribution, the red solid line marks the counterfactual, fitted as a flexible polynomial to the observed distribution outside the excluded range. We use an tenth-degree polynomial for self-employed and a sixth-degree polynomial for corporations. The excluded range above the threshold covers four and seven bins respectively in the two groups of firms. The excess mass b and missing mass m are estimated as the difference between the observed and estimated density, weighted by the height of the counterfactual density. The standard errors are bootstrapped.

B.2 Event Study

To move towards estimating a causal effect of information reporting, we exploit within-firm variation across time in the coverage of information reporting. Each year, over a thousand Costa Rican firms become subject to third-party reporting for the first time. Our conceptual framework predicts that, among firms which correctly perceive the enforcement parameters, third-party reporting of sales R_T imposes a lower bound on reported taxable sales $\hat{R}$, and an increase in R_T weakly increases reported sales and profits.

We thus conduct an event study of firm behavior around the time of its first third-party report, distinguishing reports by the different informing agents, which may be other firms, state institutions, or credit-card companies. As we seek to identify a reporting rather than a real response to the information reports, we are mindful of two identification challenges. First, the receipt of a first information report may coincide with a real growth acceleration the firm is experiencing. Second, the event leading to the first information report may itsself cause a growth acceleration. This is most relevant for the receipt of a first information report by a state institution and card company, which are generated by the award of a public procurement contract and the adoption of a credit card machine respectively.[15] We argue below that our estimates capture a reporting rather than a real response, because of the sharpness and large size of the response, the fact that almost the entire response is realized immediately in the event period after otherwise parallel trends between event-group firms and control-group firms, and the absence of a trend-break in the wage bill, a real outcome unlikely to be misreported.

Our main specification considers the event group E of firms that become subject to third-party reporting for the first time at event time $k = 0$ and a control group C of firms that have not become subject to third-party reporting by $k = 0$. As a precaution, but without substantively modifying the estimates, we follow Hilger (2016) and Naritomi (2019) in re-weighting the control group to match the treatment group. We estimate each firms' propensity score of being reported by a third party for the first time in $k = 0$, and then re-weight the control group by quintile bins of the propensity score to match the propensity-score distribution of the event group, following DiNardo et al. (1996).[16] We consider a balanced sample of firms we can observe for at least four periods before and three periods after the event. This means that

[15] Incomplete compliance by firms with third-party reporting obligations is not a concern for our analysis, which seeks to identify the impact of actual (observed) third-party reports rather than that of reporting obligations, as the former is the policy-relevant effect.

[16] The weight is thus constant within a firm over time. The propensity score is estimated separately for each of the four different third-party reports, using firm-type and tax-administration dummies and the two lags of a third-order polynomial of total income and taxable income. See Yagan (2015) for a detailed description of the re-weighting procedure.

we use events in event periods $p = \{2010, 2011, 2012, 2013\}$(for the income tax) and between February 2009 and August 2014 (for the sales tax).

Table B.3 illustrates why estimates from a balanced panel are most meaningful. The definition of the event requires that a firm is economically active, which is correlated with filing a tax declaration. A substantial fraction of firms only start filing at or after the event, and a few firms file prior to the event but not afterwards. Moving from a balanced to an unbalanced panel thus increases the sample size but adds little useful variation. Moving from a panel in which a firm appears at least once before and after the event to a fully balanced panel around the event has little effect on the number of observations. We thus focus on the balanced panel in our main results. The appendix shows robustness of our results to numerous other specifications.[17]

Our main results are shown in Figure B.3. Each panel displays the trend in reported taxable income for the event group (orange dots) and the control group (blue crosses), scaled by the pre-event average, along with the difference-in-differences coefficient obtained from estimating

$$y_{i_p k} = \gamma_k + \alpha_{i_p} + \beta \cdot I\{k \geq 0, g = E\} + u_{i_p k}. \tag{2}$$

The unit of observation in this estimation is a firm i in event period p at event time k. We estimate the firm's reported taxable income as a function of event-time dummies γ_k, firm-event-period fixed effects α_{i_p}, and the post-event and treatment group dummy $I\{k \geq 0, i \in E\}$.[18] A challenge for all estimations in this paper is that our preferred outcome variables (tax base, tax liability or tax remittance) take the value zero for a large fraction of observations, which means that estimates from a log or inverse hyperbolic sine transformation are difficult to interpret. To obtain an estimate that is equivalent to a percentage effect, we use the Poisson Pseudo Maximum Likelihood (PPML) estimator pioneered by Santos Silva and Tenreyro (2006b) throughout the paper. Appendix A discusses this choice and the properties of this estimator.[19]

[17] First, we show that the results hardly change when dropping the propensity score reweighting (Figure B.4), when considering shorter pre- and post-event periods which means considering a larger number of events over more event periods (Figure B.5), and when considering a semi-balanced panel (in which case there is also no propensity score reweighting, Figure B.6). To further explore the robustness of the results to unbalanced or semi-balanced samples, Table B.4 reports the difference-in-difference estimates from all event studies, for five different samples, adopting the preferred specification presented in this section, but without propensity score reweighting. Table B.5 does the same for the specifications with shorter pre- and post-periods (as in Figure B.5). These tables show that the effects are robust to all sample definitions, and that our preferred estimates from the balanced sample are in fact on the lower end.

[18] A firm could, for example, be in the control group for events happening in 2010 and 2011, but in the treatment group for events in 2012. Each firm-year observation for this firm would appear in the event dataset three times, for event years 2010, 2011, and 2012. Firm-event-period fixed effects and clustering of standard errors at the firm level account for the potentially repeated appearance of firm-year/firm-month observations.

[19] Our estimates are qualitatively robust to running an OLS estimation on log or IHS-transformed data, and are quantitatively very similar when running an OLS estimation on untransformed data, and scaling the coefficient by the pre-event mean to obtain a proportional effect (see Figure B.7).

For most firms, the first transaction partner that reports to the tax authority is a supplier providing a report about the firm's purchase. As panels A1 and B1 in Figure B.3 show, this first third-party report is associated with a 20 percent increase in reported taxable income for self-employed individuals and a 40 percent increase for corporations. This large effect emerges precisely at event time, after otherwise similar trends in the event and control groups. Almost the entire treatment effect materializes in the event period, after which the event and control group return to parallel trends. This is perfectly consistent with a reporting response but difficult to reconcile with a real growth effect, which would emerge less suddenly and prove more persistent.

Over time, firms gradually become subject to more third-party reports, including reports from their clients. This event, which happens on average one year after the first supplier report, is considered in panels A2 and B2. The first client report is still associated with an increase in reported taxable income but the deviation is now less sharp. This is likely because firms receiving the first client report have already become more compliant when receiving the first supplier report, so that the new report does not provide much additional information. A sharp deviation at event time emerges again when firms receive the first report by a state institutions, or by a card company, which raises reported taxable income by 20-23 percent (panels A3-B4). Although most firms that become subject to reporting by a state institution or a credit-card company are already subject to reporting by other firms, these new reports expand the coverage of third-party reporting to transactions that were previously not reported, and should therefore have an additional effect on the self-reported tax base.[20]

In all figures, the event and control group follow almost identical trends in the pre-event period, and then diverge precisely at event time $k = 0$[21], until the difference between the two groups stabilizes at approximately $k = 1$. It is particularly striking that the sharp deviation at event time can be observed even in the sales tax data with monthly frequency (panels A4 and B4). In further robustness tests (available upon request), we find that the of pattern results – a sharp deviation at event time and a large increase in the reported tax base/liability in the event group – is still present after controlling for the wage bill or the number of employees. Neither of these two proxies of firm size changes discontinuously at event time. We thus conclude that

[20]Figure B.7 shows that, consistent with the fact that firms under-report both sales and costs, the taxable-income response to all events is driven by a similarly-sized percent increase in reported sales and reported costs. The increase in reported taxable income is also associated with an increase in the reported profit rate. For reporting by credit-card companies (last two panels), we use the reported tax liability (rather than reported taxable income) as the main outcome, and use sales tax collected and input tax credits deducted (rather than sales and costs) for the decomposition, as sales and costs are not available on monthly sales tax declarations.

[21]The only exception to this pattern are corporations receiving a first client report from other firms (fourth panel), whose trend diverges from the control group at $k = -1$ rather than $k = 0$.

the size and timing of the effect is hard to reconcile with a pure growth effect, and must be largely driven by a compliance response to information reporting.

Table B.3: Timing of Events (First Third-Party Report) and First Tax Filing

	(1)	(2)	(3)
	First Report Supplier	First Report Client	First Report State
Share started filing in event year	.39	.17	.18
Share filing before and after event	.39	.48	.7
Share filing before event only	.05	.11	.04
Share filing after event only	.18	.24	.08

Notes: This table examines firms' filing behavior around the timing of the main events considered in the event studies if Figure B.3. The sample includes firms experiencing the event (first third-party report) in 2010-2013 and filing at least once during 2006-2016.

Table B.4: Event Study of Third-Party Reporting: No Propensity-Score Reweighting, Long Panel

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Self-Employed				Corporations			
	Event of First Third-Party Report By							
	Supplier	Client	State	Card	Supplier	Client	State	Card
1: Balanced Sample								
DD	.203	.094	.216	.199	.344	.188	.207	.221
SE	.009	.005	.009	.016	.035	.022	.024	.023
N event group	8810	27460	4408	5215	5827	9447	3003	5160
N control group	21565	37347	116919	529890	20145	22083	83476	532355
2: Unbalanced Sample, Missings Dropped								
DD	.242	.108	.254	.267	.433	.275	.276	.315
SE	.007	.004	.008	.014	.027	.018	.02	.022
N event group	31220	63268	9329	7803	14827	20601	5842	7586
N control group	58199	95896	260701	640616	61155	61691	172274	625759
3: Semi-Balanced Sample: Missings Replaced by Zero								
DD	.356	.102	.26	.257	.374	.208	.232	.255
SE	.01	.005	.009	.016	.033	.02	.023	.023
N event group	20027	52944	7394	6170	8835	13568	4031	5971
N control group	47196	75070	225234	645234	33332	34325	115436	632621
4: Semi-Balanced Sample: Missings Replaced by Zero for Max Three Consecutive Years								
DD	.321	.088	.262	.218	.368	.203	.229	.231
SE	.01	.005	.009	.015	.033	.02	.023	.022
N event group	17688	48763	7119	5809	8439	13087	3983	5713
N control group	40572	65204	208362	598623	30949	32095	112181	598254
5: Unbalanced Sample of Firms Filing at Least Twice Pre-Event, Missings Dropped								
DD	.272	.119	.288	.278	.441	.283	.295	.317
SE	.008	.005	.008	.015	.028	.018	.021	.022
N event group	22330	61727	8109	7360	13657	20641	5521	7248
N control group	57078	96000	249835	654899	62739	64639	174975	637775

Notes: This table displays difference-in-differences estimates from event study specification 2, standard errors and the number of observations in the event and control groups. All parameters of the specification are as in the main results in Figure B.3, except that the control group is not propensity-score-reweighted. Table B.5 provides identical results for a shorter period (three pre-event years/months and two post-event years/months). We conduct the estimation for five different panels, as indicated by the sub-table titles: 1) the fully balanced panel; 2) the unbalanced sample in which missing observations are dropped; 3) and 4) two different semi-balanced panels described in more detail below; and 5) an unbalanced sample of firms that file at least twice prior to the event, and in which we again drop missing observations. The semi-balanced panel in sub-table 3 is constructed in the following way: we sort the data by firm-year/month, replace by zero any missing outcome variables that are followed and preceeded by non-missings for the same firm, drop the remaining missing observations, and retain those firms that are now in the data in all four periods before and three periods after the event. In panel 4, we impose the additional restriction that we do not replace missings by zeros for a spell of missing periods longer than three years/months.

Table B.5: Event Study of Third-Party Reporting: No Propensity-Score Reweighting, Short Panel

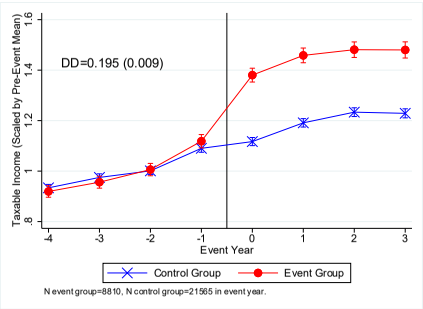
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Self-Employed				Corporations			
	Event of First Third-Party Report By							
	Supplier	Client	State	Card	Supplier	Client	State	Card
1: Balanced Sample								
DD	.213	.089	.215	.21	.38	.147	.173	.242
SE	.006	.004	.007	.016	.025	.014	.018	.024
N event group	18357	54367	7949	5896	12289	21917	5934	5827
N control group	44386	77324	226661	560378	45154	48513	161300	557042
2: Unbalanced Sample, Missings Dropped								
DD	.25	.098	.252	.26	.416	.194	.211	.304
SE	.005	.003	.006	.015	.021	.013	.016	.024
N event group	47484	93608	13819	7803	22455	34261	8750	7586
N control group	87483	142926	391715	641035	87719	89166	249437	625301
3: Semi-Balanced Sample: Missings Replaced by Zero								
DD	.431	.101	.282	.266	.438	.179	.213	.273
SE	.007	.004	.008	.016	.024	.014	.017	.024
N event group	40484	93290	12956	6785	17723	28933	7569	6592
N control group	91442	142259	403373	669883	68102	69234	212445	649849
4: Semi-Balanced Sample: Missings Replaced by Zero for Max Three Consecutive Years								
DD	.407	.096	.279	.234	.421	.176	.213	.252
SE	.007	.004	.008	.016	.024	.014	.017	.024
N event group	38046	89200	12685	6535	17279	28433	7528	6402
N control group	80642	126382	379588	624113	64643	65755	207256	617188
5: Unbalanced Sample of Firms Filing at Least Twice Pre-Event, Missings Dropped								
DD	.276	.114	.279	.273	.417	.203	.228	.303
SE	.006	.004	.007	.015	.022	.014	.017	.024
N event group	32647	89419	11719	7305	20432	33991	8260	7185
N control group	83507	139486	366676	648472	88755	91016	251341	631205

Notes: This table is identical to Table B.4, but considers a shorter period (three pre-event years/months and two post-event years/months).

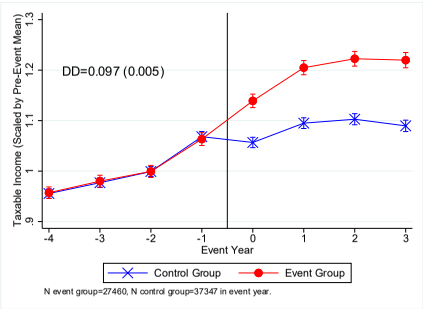
Figure B.3: Event study of First Information Report

A: Self-Employed

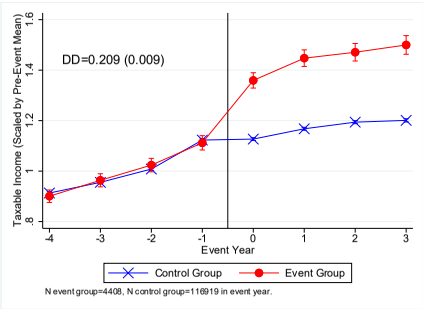
A1: Report by Supplier



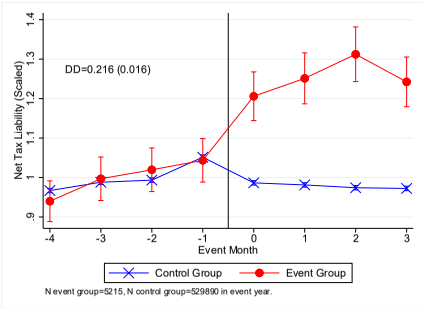
A2: Report by Client



A3: Report by State

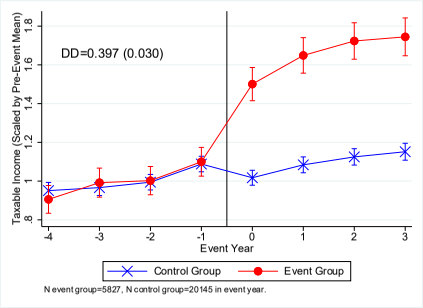


A4: Report by Credit/Debit Card

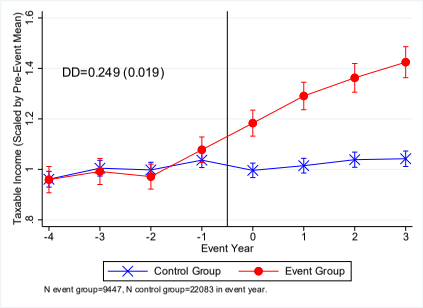


B: Corporations

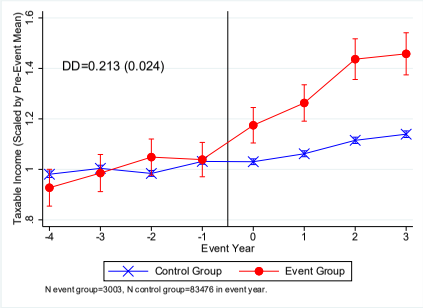
B1: Report by Supplier



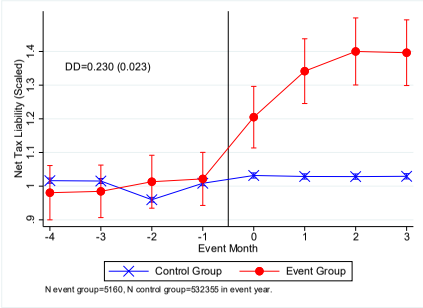
B2: Report by Client



B3: Report by State



B4: Report by Credit/Debit Card

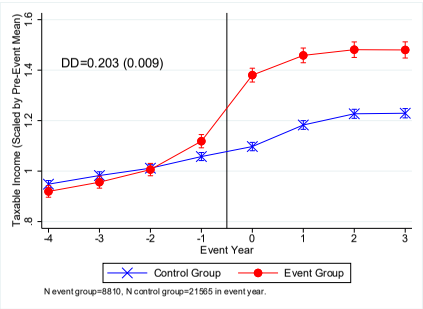


Notes: This figure displays event studies of firms' behavior after being reported for the first time by different reporting agents. Each panel displays the reported taxable income (tax liability, in panels A4 and B4) around the year (month) of the event, scaled by the pre-event mean, for an event group (orange doted line) and an event control group (blue crossed line). The black solid line marks event time 0, when firms in the event group are reported to the tax authority for the first time by the reporting agent indicated in the panel title. The data is top-coded at the 98th percentile by event-group-month. The control group is re-weighted by its propensity score of experiencing the event (cf. section B.2 and footnote 16 for details). Each group consists of a balanced panel of firms that can be observed for the period displayed (four years/months before and three years/months after the event). Panels A1-A3 and B1-B3 consider events happening in 2010-2013. Panels A4 and B4 consider events happening in 02/2009-08/2014. The text displays the difference-in-differences coefficient from estimating equation 2. Standard errors are clustered at the firm-level. Figures B.4, B.5, B.6 and B.7, and Tables B.5 and B.4 show robustness of the results to alternative specifications.

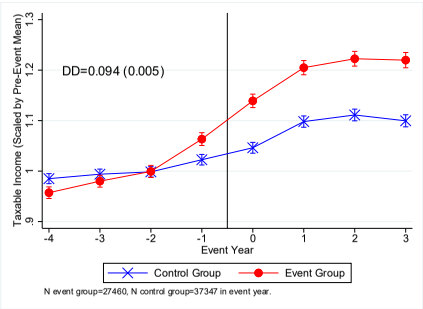
Figure B.4: Event Study Robustness I: No Propensity Score Reweighting

A: Self-Employed

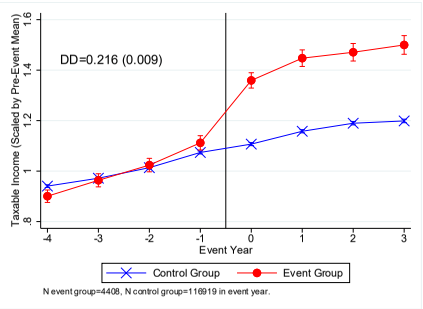
A1: Report by Supplier



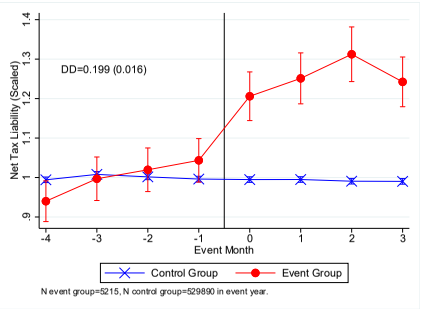
A2: Report by Client



A3: Report by State

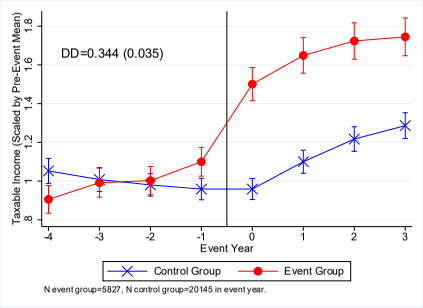


A4: Report by Credit/Debit Card

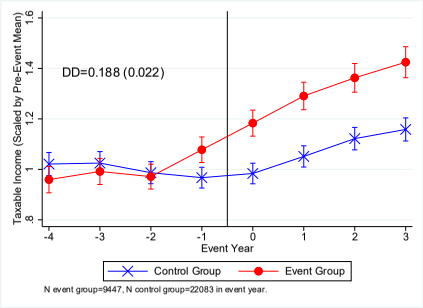


B: Corporations

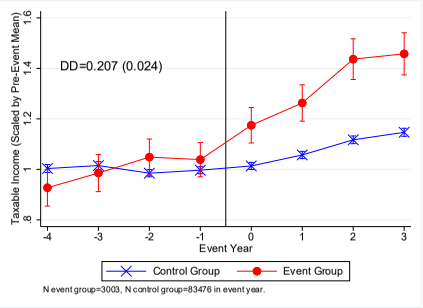
B1: Report by Supplier



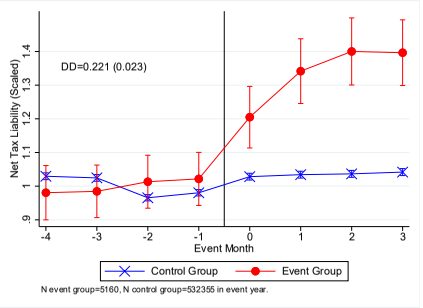
B2: Report by Client



B3: Report by State



B4: Report by Credit/Debit Card

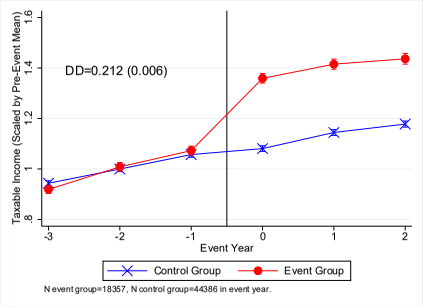


Notes: This figure is identical to Figure B.3, except that the control group is not reweighted by its propensity to experience the event.

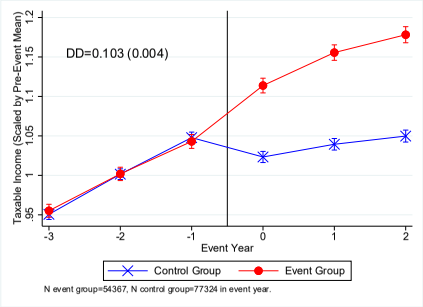
Figure B.5: Event Study Robustness II: Shorter Pre- and Post-Event Periods, Hence More Events Considered

A: Self-Employed

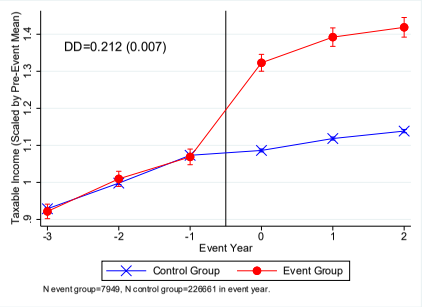
A1: Report by Supplier



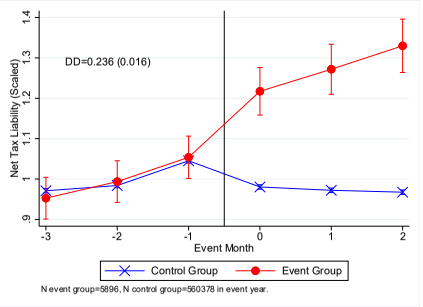
A2: Report by Client



A3: Report by State

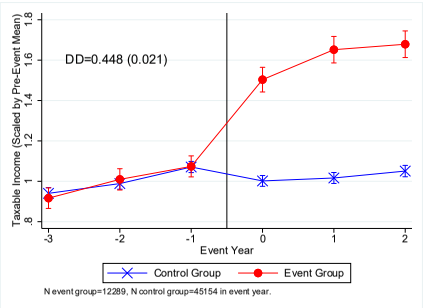


A4: Report by Credit/Debit Card

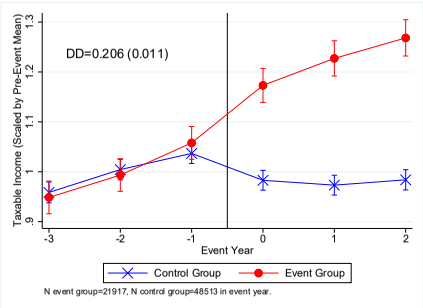


B: Corporations

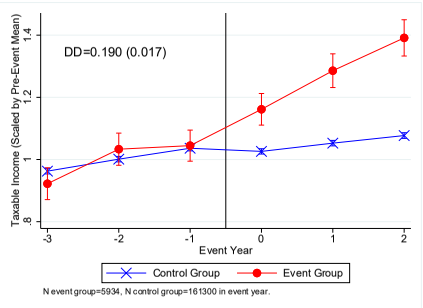
B1: Report by Supplier



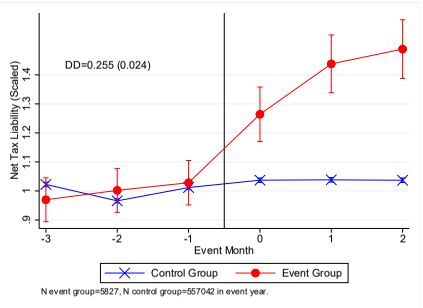
B2: Report by Client



B3: Report by State



B4: Report by Credit/Debit Card

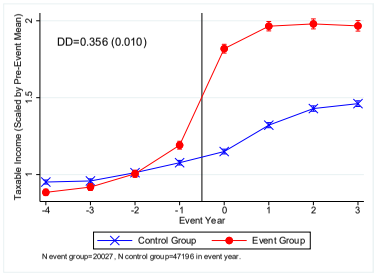


Notes: This figure is identical to Figure B.3, except that it focuses on a shorter period around the event (three years/months before the event and two years/months after), and thus considers a larger number of events and firms.

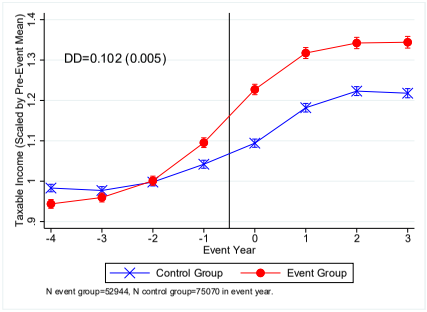
Figure B.6: Event Study Robustness III: Semi-Balanced Panel

A: Self-Employed

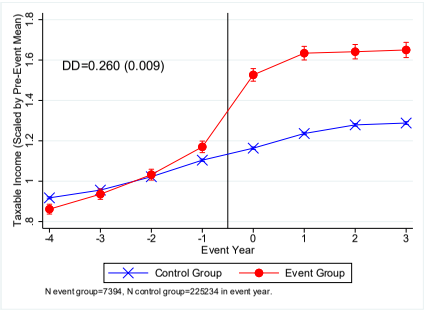
A1: Report by Supplier



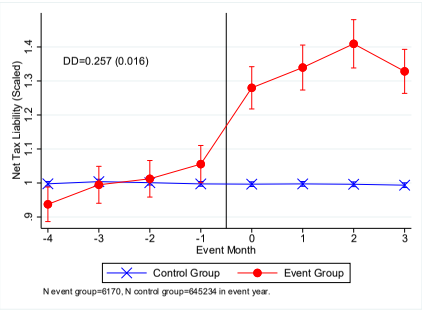
A2: Report by Client



A3: Report by State

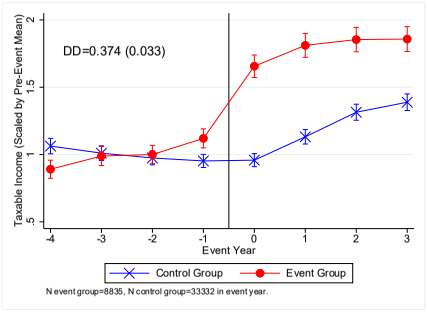


A4: Report by Credit/Debit Card

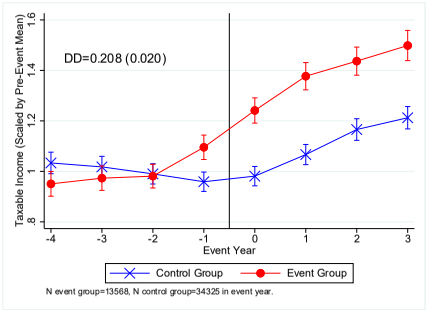


B: Corporations

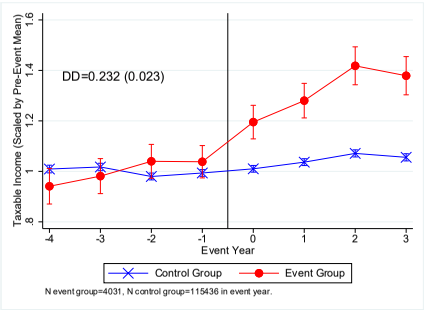
B1: Report by Supplier



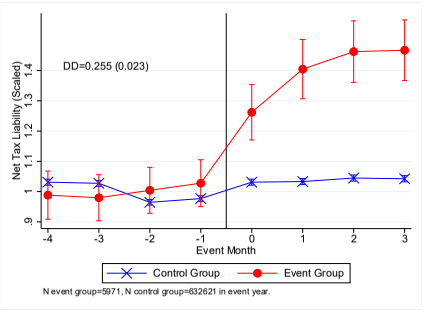
B2: Report by Client



B3: Report by State



B4: Report by Credit/Debit Card

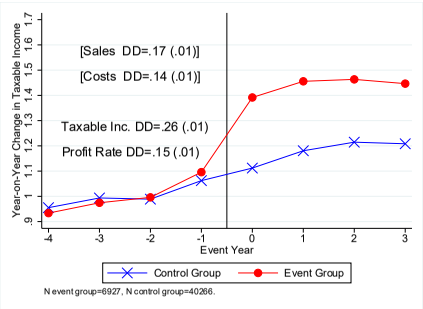


Notes: This figure is identical to Figure B.3, except that it considers a semi-balanced panel of firms (as in sub-table 3 of Tables B.4 and B.4). To construct this semi-balanced panel, we sort the data by firm-year, replace by zero any missing outcome variables that are followed and preceeded by non-missings for the same firm, drop the remaining missing observations, and retain those firms that appear in the data in all four periods before and three periods after the event. In these figures, the control group is not reweighted by its propensity to experience the event.

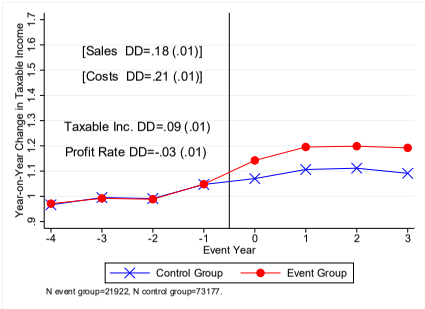
Figure B.7: Event Study Robustness IV: OLS Estimation, Multiple Outcome Variables

A: Self-Employed

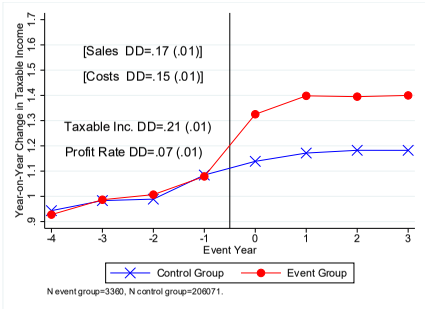
A1: Report by Supplier



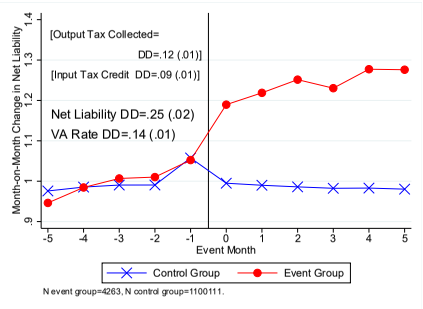
A2: Report by Client



A3: Report by State

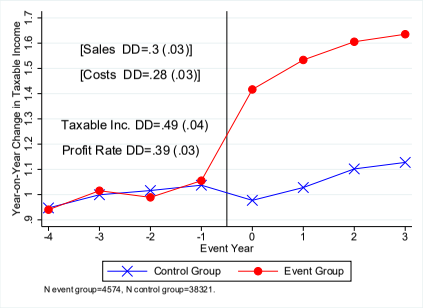


A4: Report by Credit/Debit Card

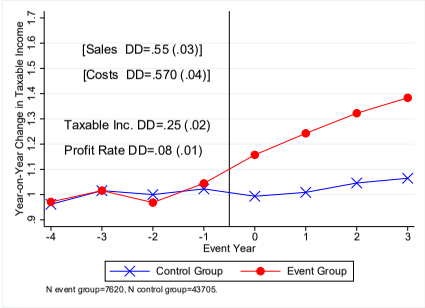


B: Corporations

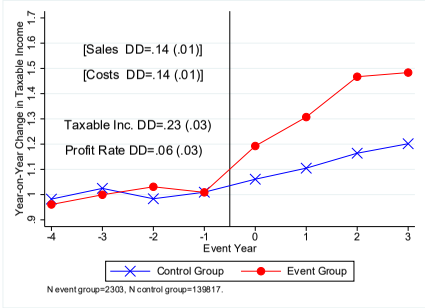
B1: Report by Supplier



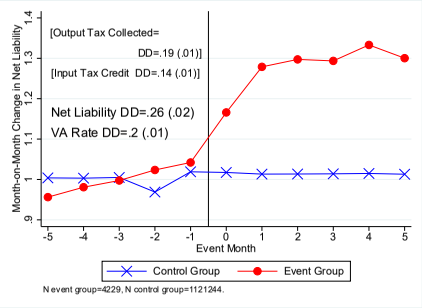
B2: Report by Client



B3: Report by State



B4: Report by Credit/Debit Card



Notes: This figure is similar to B.3, except that the data is top-coded at the 95th percentile for each event-group-year/month, and the estimation is OLS. The figures display DiD estimates of equation 2 for different outcome variables, as noted in the figures. VA stands for value added.

C The Anatomy of Compliance

Having shown that third-party reporting substantially increases reported tax liability, we now study whether it moves taxpayers close to full compliance. Our conceptual framework suggests that this should be the case if taxpayers correctly perceive the enforcement parameters R_T and $p()$, but not if taxpayers misperceive those parameters. Following Fisman and Wei (2004), we examine compliance by comparing two data reports on the same tax base. We consider successively the extensive, intensive and remittance margin of compliance.

C.1 The Extensive Margin

To examine compliance on the extensive margin, we construct the set of tax-liable firms based on all tax declarations, third-party reports, and registration reports, and compare it to self-reported income tax and sales tax declarations. The algorithm to identify tax-liable firms is described in detail in the appendix.[22] Table C.1 reports the share of non-filers for different taxes and subsamples. The overall share of non-filers for the income tax is substantial in all years and rose from 38 percent of tax-liable firms in 2010 to 55 percent in 2013 (panel A, column 1). Non-filing for the sales tax seems less prevalent at about 20 percent of tax-liable firms, which is consistent with the self-enforcing nature of Costa Rica's VAT-like sales tax. However, identifying non-filers is more difficult for sales tax than for income tax, as third-party reports provide no information on which firms are liable for sales tax. The majority of the sales tax non-filers that we identify are registered firms that file only intermittently. By contrast, the majority of income tax non-filers are identified through third-party reports (column 2). This suggests that although third-party information helps identify taxable activities, it does not necessarily induce reported firms to comply with their tax-filing obligations.

An analysis of filing behavior across firm types shows that non-filing rates are generally lower for registered firms (panel B, column 1). Among registered firms, non-filing rates are lower for corporations than for self-employed individuals (columns 2 and 4).[23] The coverage of third-party reporting is also correlated with tax filing among registered firms, as theory would predict (columns 3 and 5), and this correlation is stronger for corporations. Non-filing rates

[22] Note that our algorithm is more conservative than the tax authority's own algorithm, which considers firms to be tax-liable if they have filed in the past three years and have not deregistered since. Appendix Table C.2 reports estimates using a more lenient algorithm, which goes back three years for income tax and 12 months for sales tax. The estimates are marginally higher for the income tax and about one-third higher for the sales tax. The three-year window reflects the tax authority's practice of deregistering a firm *de oficio* if it has not filed a tax declaration for three years.

[23] Note that column 1 in panel B is not the average of columns 2 and 4, as column 1 also includes firms for which the firm-type indicator, which identifies self-employed individuals and corporations, is missing.

are significantly lower among firms reported by state institutions or credit-card companies than among firms reported only by their suppliers or clients (panel C). This suggests that reporting mechanisms have a stronger compliance impact when accompanied by withholding.

To proxy the loss of tax revenue due to non-filing, we estimate that the share of undeclared sales represents 16-23 percent of declared sales and that the estimated share of unreported income tax liabilities represents 7-10 percent of reported liabilities (panel A, columns 4-5). The estimates rely on non-filers' third-party-reported sales or their most recent available tax return. It is assumed that the distribution of profit rates by firm size is similar for non-filers and filers and that the tax schedule is applied according to Costa Rican law (see the notes to Table C.1 for details).

As our data does not capture firms that are fully informal and do not transact with any third-party reporting agents, our estimates provide a weak lower bound for extensive-margin compliance gaps. However, they should still capture the policy-relevant subsample of extensive-margin non-compliers. Indeed, while several studies find that formalizing fully informal firms is difficult and costly (de Mel et al. 2013, Bruhn and McKenzie 2014), Brockmeyer et al. (2019) show that low-cost deterrence messages can significantly increase filing rates among firms known to the tax authority, especially those covered by third-party reporting.

Table C.1: Non-Filing

Panel A: Non-filing among all tax-liable firms

	(1)	(2)	(3)	(4)	(5)
	% Non-filers	Of which registered non-filers	Non-filers' TPR sales as % of declared TPR sales	Undeclared sales as % of declared sales	Unreported liability as % of declared liability
Income Tax 2010	0.384	0.185	0.155	0.211	0.071
Income Tax 2011	0.485	0.125	0.195	0.230	0.069
Income Tax 2012	0.528	0.116	0.115	0.168	0.071
Income Tax 2013	0.556	0.121	0.114	0.181	0.099
Sales Tax 2011	0.196	0.894	.	.	.
Sales Tax 2012	0.185	0.884	.	.	.
Sales Tax 2013	0.198	0.891	.	.	.

Panel B: Non-filing among registered firms

	All	Self-Employed	Self-Employed with TPR	Corporations	Corporations with TPR
Income Tax 2010	0.104	0.095	0.082	0.081	0.045
Income Tax 2011	0.105	0.090	0.078	0.061	0.033
Income Tax 2012	0.115	0.080	0.070	0.065	0.028
Income Tax 2013	0.131	0.128	0.094	0.137	0.043
Sales Tax 2011	0.180	0.263	0.122	0.094	0.060
Sales Tax 2012	0.168	0.247	0.103	0.085	0.045
Sales Tax 2013	0.181	0.269	0.079	0.085	0.034

Panel C: Non-filing among firms covered by information reporting

	All	Reported by firms	Reported by state	Reported by card companies	
Income Tax 2010	0.574	0.579	0.235	0.293	.
Income Tax 2011	0.653	0.659	0.202	0.297	.
Income Tax 2012	0.673	0.679	0.186	0.308	.
Income Tax 2013	0.677	0.682	0.177	0.319	.

Notes: These panels show the share of non-filers (tax liable firms that do not file) for the income tax (rows 1-4) and the sales tax (rows 5-7). The algorithm used to construct the share of non-filers is explained in the appendix. Panel A shows the share of non-filers among all tax liable firms (column 1), the share of non-filers that are registered (2), non-filers' third-party reported sales as share of filers' reported sales (3), non-filers' estimated sales as share of declared sales (4), and non-filers' estimated tax liability as share of declared liability (5). TPR stands for third-party reports, and TPR sales is the sum of all third-party reports except cost reports. A non-filing firm's estimated sales in period t is max(third-party reported sales in t ; self-reported sales in the most recent prior reporting period). A non-filer's tax liability is estimated using its estimated sales, applying the average profit rate of filers in the corresponding decile of the sales distribution of filers, and then applying the tax schedule. Panel B reports the share of non-filers among all registered firms (1), and among subsamples of registered firms as indicated by the column headings (2-5). Panel C reports the share of non-filers among all firms covered by information reporting (1), and among subsamples of firms reported by different informing agents, as indicated by the column headings (2-4).

Table C.2: Robustness of Non-Filing Estimates

Panel A: Non-filing among all tax-liable firms

	(1) % Non-filers	(2) Of which registered non-filers	(3) Non-filers' TPI sales as % of declared TPI sales	(4) Undeclared sales as % of declared sales	(5) Unreported liability as % of declared liability
Income Tax 2010	0.420	0.335	0.154	0.225	0.081
Income Tax 2011	0.509	0.239	0.195	0.246	0.077
Income Tax 2012	0.547	0.218	0.114	0.189	0.076
Income Tax 2013	0.586	0.266	0.112	0.203	0.104
Sales Tax 2011	0.335	0.960	.	.	.
Sales Tax 2012	0.325	0.955	.	.	.
Sales Tax 2013	0.372	0.962	.	.	.

Panel B: Non-filing among registered firms

	All	Self-Employed	Self-Employed with TPI	Corporations	Corporations with TPI
Income Tax 2010	0.195	0.158	0.131	0.155	0.073
Income Tax 2011	0.198	0.161	0.134	0.143	0.071
Income Tax 2012	0.209	0.153	0.126	0.128	0.051
Income Tax 2013	0.273	0.215	0.158	0.216	0.067
Sales Tax 2011	0.326	0.439	0.155	0.192	0.073
Sales Tax 2012	0.315	0.423	0.126	0.185	0.054
Sales Tax 2013	0.363	0.478	0.101	0.185	0.040

Panel C: Non-filing among firms covered by information reporting

	All	Reported by firms	Reported by state	Reported by card companies	
Income Tax 2010	0.573	0.578	0.235	0.293	.
Income Tax 2011	0.652	0.658	0.202	0.297	.
Income Tax 2012	0.672	0.678	0.186	0.308	.
Income Tax 2013	0.676	0.681	0.177	0.320	.

Notes: The construction of this table is identical to Table C.1, except that it uses a less conservative algorithm to calculate the share of non-filers, as explained in Appendix D.

C.2 The Intensive Margin

To examine compliance on the intensive margin, we compare taxpayers' self-reports and third-party reports, for sales and costs respectively. We construct a taxpayer's third-party reported sales as the sum of sales reported by other firms (the taxpayer's clients), state institutions, and credit-card companies, as well as sales recorded in export data from the customs service. A taxpayer's third-party-reported costs (purchases) are the sum of sales reported by the taxpayer's suppliers as well as purchases recorded in import data. Firms reporting an amount at least 0.25 percent smaller that the relevant comparison amount are defined as "under-reporters," while firms reporting an amount at least 0.25 percent larger than the relevant comparison amount are defined as "over-reporters."

Table C.3 shows estimated under-reporting for tax year 2012, distinguishing sales reports and cost reports and self-employed individuals from corporations. Panel A focuses on income tax under-reporting, panel B on estimating under-reported income tax liability, and panel C on the internal consistency between the income tax and sales tax.[24]

While 16 percent of self-employed individuals and 13 percent of corporations under-report sales compared to third-party reports, the share of firms under-reporting their costs is even higher, at 51 percent for self-employed individuals and 35 percent for corporations (row 1). This indicates that firms not only under-report sales, they also under-report the scale, which is consistent with the findings of Carrillo et al. (2017). The presence of an exempt tax bracket in the self-employed tax schedule explains the larger share of cost under-reporters among self-employed individuals. While under-reporters leave 41-46 percent of their third-party-reported sales and 36-40 percent of their third-party-reported costs unreported (row 5), these amounts represent about 20 percent of total third-party reports (row 6). The share of unreported sales in total third-party-reported sales is slightly larger than the share of sales under-reporters, at least among corporations, suggesting that under-reporters are not disproportionately likely to be small firms (rows 1 vs 6, column 2). The share of under-reported costs in total third-party-reported costs is significantly smaller than the share of cost under-reporters (rows 1 vs 6, columns 3 and 4). This suggests that although cost under-utilization is widespread, it is modest in scale.

With a few assumptions, we estimate that if all third-party-reported sales were declared, reported tax liability would increase by 19 percent for corporations and by 48 percent for self-

[24]Estimating under-reporting for sales tax is more challenging, due to its narrow base and the fact that third-party reports do not distinguish between sales that are liable for sales tax and those that are not.

employed individuals (row 9).[25] The especially large increase among self-employed individuals is driven by their high initial reported profit rates, given the exempt tax bracket. However, self-employed individuals report tax liabilities that are, on average, much smaller than those reported by corporations. If all third-party reported sales were declared and taxed, overall income tax revenue from firms would increase by about 22 percent.

Combining estimates from the extensive and intensive margin indicates that fully enforcing compliance with third-party reports could boost income tax revenue by up to 30 percent. However, enforcement is costly, and the limited impact of desk audits (phone calls to misreporting taxpayers requesting that they file an amended tax declaration) suggests that it is unlikely to substantially increase compliance rates. Figure C.1 displays the results of desk audits for the income tax (panel A) and the sales tax (panel B). Comparing a firm's initial tax return to the post-audit amended return, the figure plots the change in reported costs against the change in reported revenue (the change in reported input tax credit against the change in sales tax collected in panel B). The figures focus on the small share of desk-audited firms that actually amend their declarations in response to the desk audit: 19 percent of firms for income tax and 16 percent for sales tax. Firms that amend their declarations clearly offset increases in reported revenue by increasing reported costs. Such changes offset each other by almost 100 percent for income tax and by about two-thirds for sales tax. On average, firms that file an amended declaration more than double their reported tax liability, as their initial reported liability is extremely low, but the number of such firms and their aggregate liability are so small that amended declarations increase total revenue by less than 0.5 percent.[26]

[25] We assume that under-reporters declare all third-party-reported sales, apply the initially reported profit rate to their initially unreported sales, and then apply the tax schedule. This means we allow under-reporters to offset additional reported sales with additional reported costs in proportion to their initial declared profit rate. This assumption is supported by evidence from Carrillo et al. (2017) and Slemrod et al. (2017), and it is consistent with firms' response to desk audits discussed below.

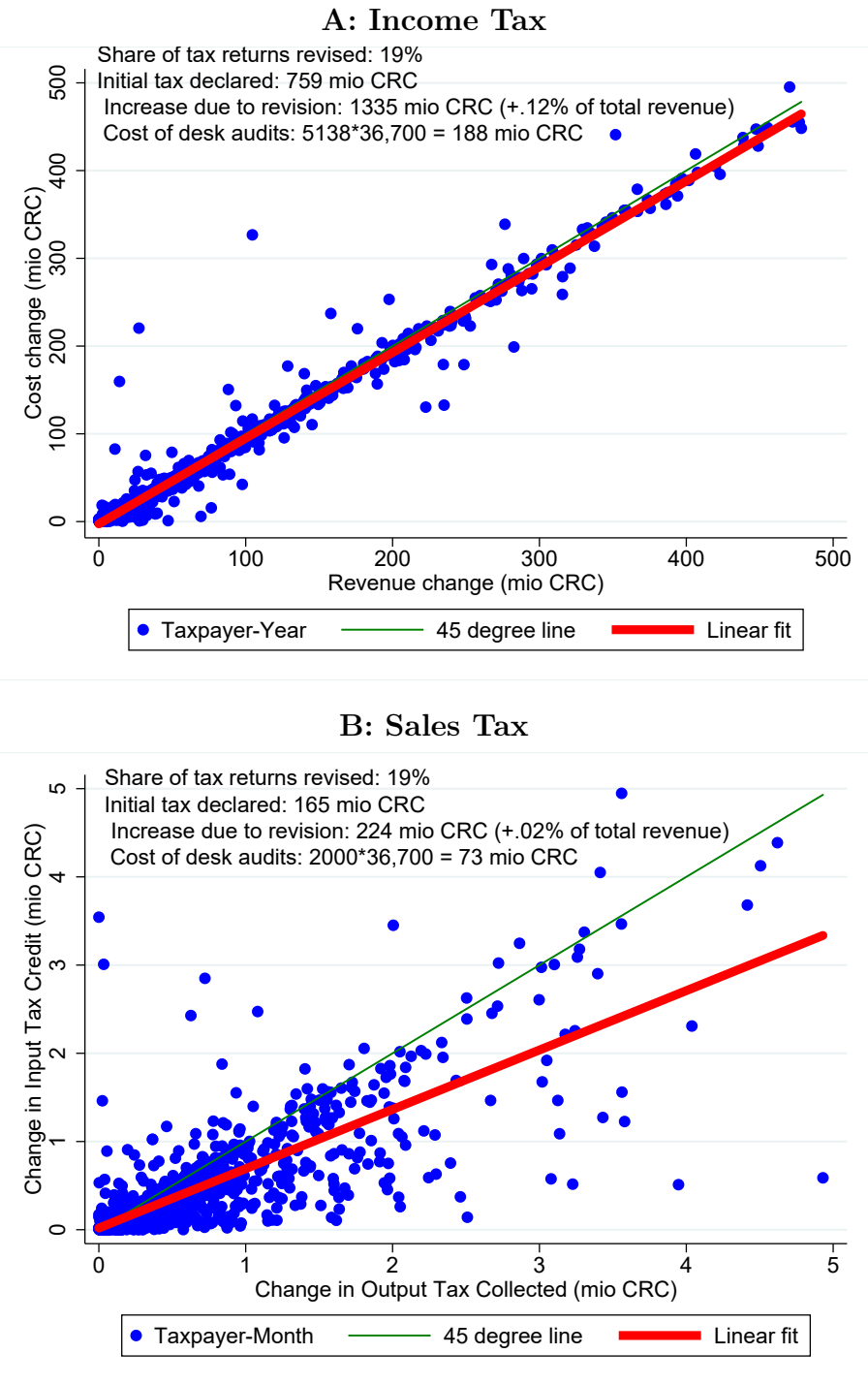
[26] Whether it is optimal for the tax authority to invest in desk audits rather than full audits or follow-up communications with non-filers or late payers depends on the relative revenue elasticities of these different enforcement methods. See, e.g., Keen and Slemrod (2017).

Table C.3: Misreporting

	(1)	(2)	(3)	(4)
	Sales Reports		Cost Reports	
	Self-Employed	Corporations	Self-Employed	Corporations
Panel A: Underreporting for Income Tax				
1) % Underreporters	16.1	13.2	51.4	35.6
2) Unreported Amount (bio CRC)	283	4540.9	448.6	3572.7
3) Underreporters' TPR	680.2	9679.7	1244.4	8865.6
4) Total TPR	2088.8	19489.9	1902.7	16140.3
5) Unreported Amount(% UR TPR)	41.6	46.9	36.1	40.3
6) Unreported Amount(% TPR)	13.6	23.3	23.6	22.1
Panel B: Underreported Liability				
7) Unreported Tax	17.2	61.4		
8) Reported Tax	35.7	318.8		
9) Unreported Tax (% Reported Tax)	48.4	19.3		
Panel C: Internal Consistency, Income Tax vs Sales Tax				
10) % Underreporters IT vs ST	7.8	8.4	12.5	6
11) % Overreporters IT vs ST	56.9	60.3	84.8	93.5

Notes: This table displays estimates of compliance gaps between third-party reports and self-reports. Third-party reported sales for the income tax is the sum of sales reported by clients, state institutions and credit-card companies, and exports. Third-party reported costs for the income tax is the sum of costs reported by suppliers, and imports. Third-party reported sales for the sales tax is the sum of sales reported by credit-card card companies. All figures in this table are either in percent (as indicated), or in billions of constant 2015 CRC. Under-reporters (over-reporters) are firms reporting an amount at least 0.25 percent smaller (larger) than the relevant comparison amount. Rows 1-6 examine under-reporting of third-party reported sales/costs. They show the share of under-reporters among firms subject to third-party reporting for the income tax (1), the amount unreported (as compared to third-party reports) (2), the total third-party reports for under-reporters (3), the total third-party reports for the full sample (4), and the unreported amount as a share of the underreporters third-party reports (5), and as a share of total third-party reports (6). Rows 7-9 convert unreported sales into tax liabilities. They show an estimate of the unreported tax liability (7), the reported tax liability (8), and the unreported tax as a share of the reported tax (9). The estimation of the unreported (gross) tax liability assumes that the profit rate on unreported sales is the same as the profit rate on reported sales, and applies the tax schedule as displayed in Table B.1. Rows 10 and 11 analyze internal consistency in filing, comparing income tax reports to sales tax reports. All calculations are based on 2012 data, and we drop 2,200 firms that file following a non-standard fiscal year. Results are similar in the full sample and in other years.

Figure C.1: Impact of Desk Audits on Misreporting



Notes: This figure shows the revenue and cost adjustments made by firms after they are informed that a desk audit uncovered a discrepancy between self-reported and third-party reported sales. The desk audits are for income tax returns for 2013 and 2014, and for sales tax returns for 2013. The figures focus on firms submitting a revised tax return, and display the change in revenue and costs (output tax collected and input tax credit deducted in panel B), comparing the initial return with the revised return. The text displays the share of audited firms that submit a revised return, the initial tax declared by revisers, the increase in declared tax due to the revision, and the cost of the desk audit intervention. The cost is calculated by multiplying the number of cases by the daily wage of a tax officer, as tax officers are asked to handle one case per day.

C.3 The Tax Remittance Margin

Finally, to examine taxpayers' compliance with the obligation to remit their net tax liability, we match income and sales tax returns with remittance records (payment receipts). Importantly, Costa Rican remittance records display the remittance date, the tax period, and the taxpayer to which each remittance corresponds, allowing us to exactly match remittances with liabilities. To our knowledge, this is the first attempt to estimate remittance compliance for the income and sales tax and to test the previously implicit assumption that declared tax liabilities automatically translate into tax remittances.[27] The relevant liability is the taxpayer's final tax liability and is to be remitted per the final (amended) tax declaration, after deductions, advance remittances, and withheld taxes have been subtracted. We compare this liability to each taxpayer's final tax remittance, excluding remittances made by withholding agents and advance remittances made by the taxpayer.[28] We then take the share of remittance over liability for each taxpayer, and average this share across all taxpayers in each fiscal period.

The results are displayed in Figure C.2, where panel A corresponds to the income tax and panel B correspond to the sales tax, and the thick blue and thin red lines correspond to corporations and self-employed individuals, respectively. In both panels, the average remittance share is below 100 percent in all fiscal periods and decreases in more recent periods, dropping to 85 percent for the sales tax and 70 percent for the income tax in the most recent period considered (solid lines). This patterns is clear despite the fact that we consider remittances made until April 2015, the remittance deadline for fiscal year 2014. There are two potential explanations for this downward sloping profile of the average remittance rate: delayed remittance and diminished compliance. If taxpayers remit tax only after a substantial delay, then more recent periods will mechanically display lower remittance rates than earlier periods, for which a longer data series is available. It is also possible that a rising number of firms is failing to remit tax entirely, and these two explanations are not mutually exclusive.

To distinguish these two explanations, we add two more remittance profiles, considering only remittances made until April 2013 and April 2011, respectively (dashed and dotted lines). These remittance profiles are similarly downward sloping and shifted to the left, suggesting that remittance delays do indeed play a role in the observed decline in average remittance rate. For

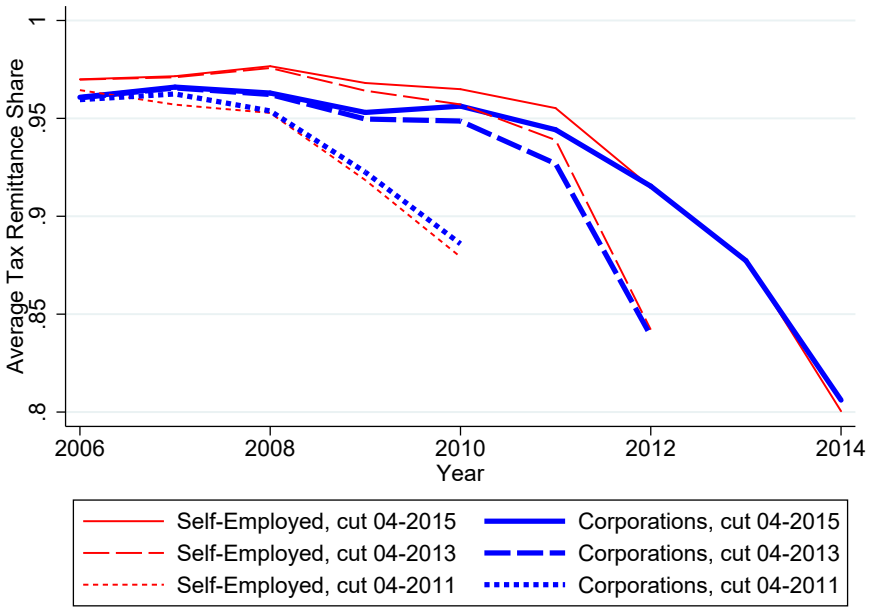
[27] The estimates of property tax compliance in Peru by Del Carpio (2014) are conceptually different from our estimates, as property taxes are assessed by the government and thus have no misreporting margin.

[28] Note that we use the net liability derived from the firm's tax return, and take into account only the amount of advance tax remittances and withheld taxes that the taxpayer chose to reclaim on the tax declaration. Including remittances that are enforced retroactively by the tax authority through administrative or judicial procedures does not significantly affect the results.

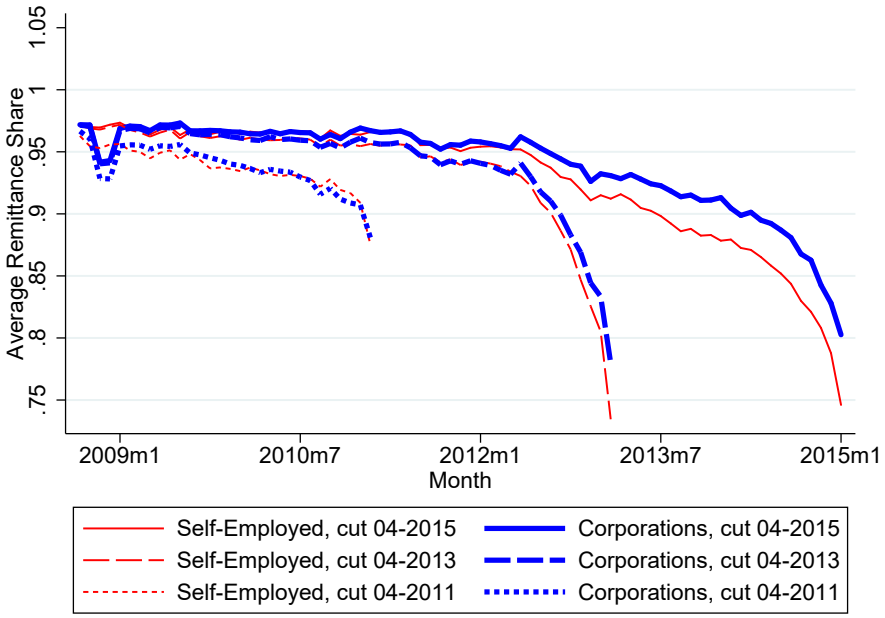
instance, while the income tax remittance share for 2010 is about 88 percent when measured in April 2011, it is above 95 percent when measured in April 2015–indicating that a small share of taxpayers remit their tax after a substantial delay. This finding is consistent with anecdotal evidence that cash-constrained firms remit tax when they have adequate liquidity rather than when the remittance is due, as fines and interest fees for late remittance are small. Meanwhile, remittance compliance is relatively high, especially in the aggregate. As firms that do not remit tax or remit after a significant delay are disproportionately small, the aggregate remittance rate (i.e., the sum of remittances divided by the sum of final liabilities) approaches 100 percent shortly after the remittance deadline and remains stable over time.

Figure C.2: Remittance of Tax Liabilities

A: Income Tax, Average Share of Net Liability Remitted



B: Sales Tax, Average Share of Net Liability Remitted



Notes: This figure shows the average tax remittance share, defined as the remittance made by the taxpayer for a specific tax period, divided by the tax liability to be remitted for that period. The average is an unweighted average across all taxpayers with a positive final liability. The tax liability is net of any deduction made for tax withheld, and the remittance data does not include tax withheld. The income tax data includes all declarations filed and remittances made by June 2015. The sales tax data includes all declarations filed and remittances made by October 2015. The thin red lines correspond to the self-employed and the thick blue lines corresponds to corporations. We show the series for three different cuts in the remittance data, taking into account all remittances made before the cut date.

D Algorithm to Estimate Non-Filing

D.1 Income Tax

This section describes the procedure by which the pool of income tax-liable taxpayers is constructed for each year between 2010 and 2013. This pool forms the sample for Tables C.1 and C.2. The following algorithm is used to identify tax-liable firms:

- **Income tax filing**: Firms that declare income tax in current fiscal year t and are not found to have deregistered or switched to a simplified (non-tax-liable) regime by year t are included in the pool of income tax-liable taxpayers. Additionally, firms that filed in the previous year $t-1$ and did not deregister or switch regimes in the interim are included to capture taxpayers who were previously identified as income tax-liable and then do not file in subsequent years. This condition is applied to generate the sample used in Table C.1; for the sample used in Table C.2, the rule is extended to include firms that declared income tax in any year between $t-1$ and $t-3$ for years 2011 and later and between $t-1$ and $t-4$ for years prior to 2011, which are the historical rules officially applied by the tax authority for determining income tax liability, though in practice this condition may not have been systematically applied.

- **Registration**: Firms that are found to have registered with the tax authority in any of the previous three years prior to the current fiscal year t but did not file income tax returns in the current fiscal year are included. This step identifies firms that are officially registered as tax-liable but which did not file for the years during which these firms were registered, which step 1 does not capture as it relies only on the records of filings.

- **Subsequent deregistration**: In addition to identifying firms that are registered but do not file for income tax in prior years in step 2, firms that deregister in years following the current fiscal year t but are not found to have registered in year t or the previous three years are classified as having been income tax-liable despite not appearing on the official registration roster.

- **Declaring sales tax in current fiscal year**: Firms that declare sales tax in any of the months of the current fiscal year t - which spans from October of year $t-1$ to September of year t - are included in the pool of income tax-liable taxpayers. This rule corresponds to the tax authority's official regulation that firms liable for sales tax are also deemed liable for remitting income tax (though the reverse is not true).

- **Informative declarations**: Records of transactions between firms or between firm and the government provide information on the sales and costs of individual firms that can be used to identify income tax-liable taxpayers. Firms that report or are reported as having tax-liable sales in the current fiscal through the third-party reporting mechanisms described above are included in the pool of income tax-liable firms.

D.2 Sales Tax

This section describes the procedure by which the pool of sales tax-liable taxpayers are constructed for each month of fiscal years 2011 to 2013. This pool forms the sample for Tables C.1 and C.2, which reports the average of the monthly values for each measure in corresponding fiscal year. The following algorithm, which is similar to the method used to identify income tax-liable firms, is used to identify sales tax-liable firms:

- **Income tax filing**: Firms that declare sales tax in month m of the current fiscal year t and are not found to have deregistered or switched to a simplified (non-tax-liable) regime by month m in year t are included in the pool of sales tax-liable taxpayers. Additionally, firms that filed in the previous four months - $m-4$ to $m-1$ - and did not deregister or switch regimes in the interim are included to capture taxpayers who were previously identified as sales tax-liable and then do not file in subsequent months. This could include firms that either declare sales tax in previous months within the same fiscal year or in months falling within the previous fiscal year $t-1$, depending on the month. This condition is applied to generate the sample used in Table C.1; for the sample used in Table C.2, the rule is extended to include firms that declared sales tax in months between $m-12$ and $m-1$.

- **Registration**: Firms that are found to have registered with the tax authority in any of the previous thirty six months (three years) prior to the current month m of fiscal year t but did not declare sales tax in month m are included. This step identifies firms that are officially registered as tax-liable but which did not file for the years during which these firms were registered, which step 1 does not capture as it relies only on the records of filings.

- **Subsequent deregistration**: In addition to identifying firms that are registered but do not file for income tax in prior years in step 2, firms that deregister in months following the current month m but are not found to have registered within the previous thirty

six months are classified as having been income tax-liable despite not appearing on the official registration roster.

- **Informative declarations**: Firms that are reported as having been subject to withholding by credit-card companies are considered tax-liable for the sales tax.

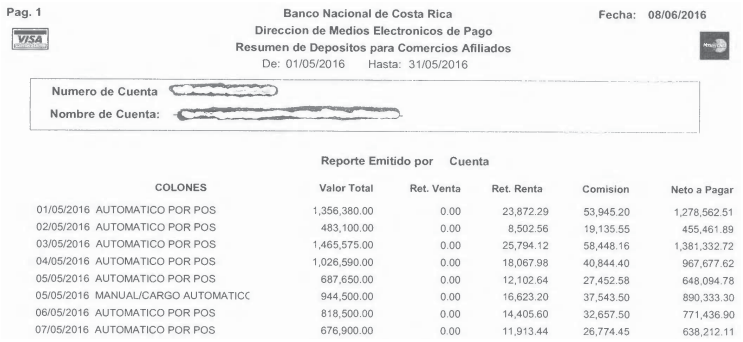
E Data Appendix

Table E.1: Informative Declarations to the Tax Authority

(1) Form	(2) Purpose	(3) Record Type	(4) Coverage of Corporations	(5) Coverage of Self-Employed	(6) % Matched With Income Tax Records
D151	Reporting of firm-firm transactions	Sales	46.4	38.9	36.8
	N=17,251,681 (53.4% sales)	Purchases	49.2	53.9	65.1
D150	Reporting of and withholding on	Sales to state institutions	8.4	5.0	78.2
	sales to specific clients	Sales to specific firms	0.22	0.08	40.2
	for purpose of income tax compliance				
	N=864,695 (98.7% state purchase)				
D153	Reporting of and withholding on	Sales	11.5 [29.4]	5.8 [20.7]	67.8 [48.7]
	credit/debit-card sales for sales tax				
	for purpose of sales tax compliance				
	N=3,928,545				

Notes: This table provides information about the nature and coverage of third-party informative declarations used by the tax authority in Costa Rica, for 2006-2015. Columns 4 and 5 display the share of income tax filers covered by the different third-party declarations, distinguishing corporations and the self-employed. Column 6 displays the share of informative declarations which are matched with an income tax declaration. In the last row, the shares in brackets refer to the match rate with the monthly sales tax declarations for 2008-2014. The shares are calculated on the pooled data for all years/months. All declarations identify the reporter and taxpayer by their administration-internal anonymous tax ID, and provide information on the transaction amount, and (where applicable) the amount of the tax withheld. Amounts are accrued. Since January 2012, all declarations must be prepared using the DECLAR@7 software. All declarations are annual, except D153, which is monthly. D151 requires reporting of transactions >2.5 million CRC annually with a transaction partner, and transactions of >50,000 CRC annually for rent, commissions, professional services or interests. For D150, the withholding rate is 2 percent and 3 percent respectively for state and private purchases. For D153, the withholding rate is firm specific, following the schedule in Table 1. For more information on the filing of informative declarations, see http://www.hacienda.go.cr/contenido/12997-declaraciones-informativas.
This table is mentioned in Section 3.2.

Figure E.1: Card-Machine Statement



Pag. 1

Banco Nacional de Costa Rica
Direccion de Medios Electronicos de Pago
Resumen de Depositos para Comercios Afiliados
De: 01/05/2016 Hasta: 31/05/2016

Fecha: 08/06/2016

Numero de Cuenta [redacted]
Nombre de Cuenta: [redacted]

Reporte Emitido por Cuenta

COLONES	Valor Total	Ret. Venta	Ret. Renta	Comision	Neto a Pagar
01/05/2016 AUTOMATICO POR POS	1,356,380.00	0.00	23,872.29	53,945.20	1,278,562.51
02/05/2016 AUTOMATICO POR POS	483,100.00	0.00	8,502.56	19,135.55	455,461.89
03/05/2016 AUTOMATICO POR POS	1,465,575.00	0.00	25,794.12	58,448.16	1,381,332.72
04/05/2016 AUTOMATICO POR POS	1,026,590.00	0.00	18,067.98	40,844.40	967,677.62
05/05/2016 AUTOMATICO POR POS	687,650.00	0.00	12,102.64	27,452.58	648,094.78
05/05/2016 MANUAL/CARGO AUTOMATICC	944,500.00	0.00	16,623.20	37,543.50	890,333.30
06/05/2016 AUTOMATICO POR POS	818,500.00	0.00	14,405.60	32,657.50	771,436.90
07/05/2016 AUTOMATICO POR POS	676,900.00	0.00	11,913.44	26,774.45	638,212.11

Notes: This figure shows an example of the credit-card marchine statement, that card processing companies provide to their affiliated businesses (clients) on a daily or monthly basis. The statement lists transaction amounts, withholding for the income tax and the sales tax remitted to the tax authority and commissions to the card processing company.

F The Impact of Withholding – Robustness

Table F.1: The Impact of Withholding: Elasticity Estimates

	Pre-Reform Mean Among Treated			Treatment Effect			Implied Elasticity of Sales Tax Remittance		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile	(7) Trimmed 99.9th pctile	(8) Trimmed 99th pctile	(9) Trimmed 95th pctile
Total Sales Tax Remittance	713.2	451.7	265.5	0.270***	0.316***	0.428***	.	.	.
	(47.07)	(14.16)	(5.451)	(0.0315)	(0.0321)	(0.0247)	(.)	(.)	(.)
Withholding Rate	1.486	1.485	1.476	0.869***	0.870***	0.882***	0.310***	0.363***	0.485***
	(0.00929)	(0.00940)	(0.00978)	(0.0175)	(0.0177)	(0.0185)	(0.0363)	(0.0369)	(0.0280)
Withheld Tax	140.4	87.92	58.49	0.721***	0.723***	0.828***	0.374***	0.437***	0.516***
	(8.770)	(4.452)	(1.949)	(0.0760)	(0.0672)	(0.0379)	(0.0437)	(0.0444)	(0.0298)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	257,796	252,648	235,944	257,796	252,648	235,944

This table displays mean outcomes in the treatment group (columns 1-3), DiD estimates of the impact of the (predicted) withholding-rate increase as per equation 10 (columns 4-6), and the associated elasticities (columns 7-9). The treatment effect in columns 4-6 is a semi-elasticity/proportional effect. The elasticity estimate is derived using the DiD estimate for total sales tax remittance and for the withholding rate (or for the withheld tax). Standard errors are derived using the delta rule. The DiD estimates are based on the Poisson Pseudo Maximum Likelihood Estimator (PPML, see Appendix A). They allow for firm fixed effects, month fixed effects and firm characteristics (sector, deciles of card usage at the beginning of the period) interacted with month fixed effects. Standard errors are clustered at the firm level. The estimations are for a fully balanced panel (firms filing every month during 2010-2012). We show robustness to weaker balancing restrictions in Table 3. To reduce the effect of outliers while maintaining the internal consistency of the tax declaration, we trim rather than topcode outliers, at the 99.9th, 99th or 95th percentile in the distribution of reported sales (as indicated in the column headings). This table is discussed in Section F.

Table F.2: The Impact of Withholding: OLS Estimation

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Filed Sales Tax				-0.00199	-0.00183	-0.00193
				(0.00225)	(0.00229)	(0.00243)
Card-Company Reportee	0.00310	0.00300	0.00220	0.00206	0.00234	0.00184
	(0.00506)	(0.00513)	(0.00544)	(0.00451)	(0.00458)	(0.00486)
Total Sales Reported	0.0566	-0.0133	0.000767	0.0339	0.0158	0.0146
	(0.0383)	(0.0200)	(0.0154)	(0.0314)	(0.0157)	(0.0126)
Sales Tax Collected	0.0603	-0.000929	0.00134	0.0324	0.0292	0.00714
	(0.0481)	(0.0235)	(0.0190)	(0.0403)	(0.0180)	(0.0173)
Input Tax Credits	0.0278	-0.0806***	-0.0872***	-0.00387	-0.0562***	-0.0798***
	(0.0473)	(0.0230)	(0.0141)	(0.0395)	(0.0173)	(0.0129)
- Import Credits	-0.0195	-0.0922	-0.156**	-0.0820	-0.0548	-0.161**
	(0.0963)	(0.0710)	(0.0637)	(0.0852)	(0.0571)	(0.0641)
- Local Purchase Credits	0.0546	-0.0758***	-0.0756***	0.0349	-0.0568***	-0.0686***
	(0.0486)	(0.0213)	(0.0141)	(0.0384)	(0.0185)	(0.0123)
Gross Tax Liability	0.156	0.348***	0.513***	0.148	0.437***	0.491***
	(0.147)	(0.0821)	(0.0708)	(0.137)	(0.0657)	(0.0645)
Withholding Base	0.127**	-0.00981	0.0199	0.110**	0.0558*	0.0354
	(0.0642)	(0.0569)	(0.0330)	(0.0553)	(0.0304)	(0.0261)
Withheld Tax	1.776***	1.467***	1.962***	1.730***	1.843***	1.892***
	(0.405)	(0.346)	(0.151)	(0.371)	(0.156)	(0.125)
Withheld Tax Reclaims	1.215***	1.023***	1.523***	1.114***	1.325***	1.532***
	(0.386)	(0.325)	(0.194)	(0.353)	(0.185)	(0.167)
Compensation Requests	1.231***	1.201***	0.502*	1.214***	1.147***	0.629**
	(0.356)	(0.383)	(0.277)	(0.334)	(0.368)	(0.261)
Final Tax To Remit	0.0205	0.251**	0.401***	0.0631	0.292***	0.321***
	(0.165)	(0.114)	(0.125)	(0.156)	(0.104)	(0.112)
Taxpayer Sales Tax Remittance	0.0752	0.211**	0.354***	0.0883	0.270***	0.270***
	(0.160)	(0.0855)	(0.0736)	(0.151)	(0.0740)	(0.0627)
Total Sales Tax Remittance	0.410***	0.455***	0.708***	0.405***	0.588***	0.666***
	(0.137)	(0.0967)	(0.0698)	(0.129)	(0.0681)	(0.0606)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	332,100	325,764	303,300

Notes: This table is similar to the main DiD results Table 3, except that these estimates here are based on an OLS estimation with untransformed outcome variables. The point estimates (absolute effects) are then scaled by the pre-reform mean to obtain a relative effect, which we display in this table. The standard errors are derived using the delta rule.

Table F.3: The Impact of Withholding: IHS Estimation

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Reported	0.0846**	0.0822**	0.0932**	0.0704*	0.0759*	0.0825*
	(0.0393)	(0.0400)	(0.0422)	(0.0417)	(0.0422)	(0.0444)
Sales Tax Collected	0.0468	0.0453	0.0503	0.0324	0.0365	0.0404
	(0.0326)	(0.0331)	(0.0351)	(0.0332)	(0.0336)	(0.0355)
Input Tax Credits	-0.0950***	-0.0958***	-0.0952***	-0.0824**	-0.0779**	-0.0760**
	(0.0333)	(0.0337)	(0.0355)	(0.0327)	(0.0331)	(0.0347)
- Import Credits	-0.00474	-0.0116	-0.0163	-0.0191	-0.0242	-0.0228
	(0.0226)	(0.0224)	(0.0230)	(0.0198)	(0.0196)	(0.0201)
- Local Purchase Credits	-0.116***	-0.115***	-0.111***	-0.0942***	-0.0873***	-0.0874**
	(0.0350)	(0.0353)	(0.0368)	(0.0335)	(0.0337)	(0.0350)
Gross Tax Liability	0.585***	0.591***	0.611***	0.531***	0.545***	0.546***
	(0.0422)	(0.0425)	(0.0436)	(0.0385)	(0.0386)	(0.0400)
Withholding Base	0.0456	0.0406	0.0305	0.0421	0.0424	0.0371
	(0.0426)	(0.0431)	(0.0454)	(0.0380)	(0.0385)	(0.0403)
Withheld Tax	1.592***	1.586***	1.594***	1.593***	1.592***	1.578***
	(0.0536)	(0.0537)	(0.0541)	(0.0462)	(0.0463)	(0.0466)
Withheld Tax Reclaims	0.744***	0.740***	0.747***	0.704***	0.709***	0.700***
	(0.0485)	(0.0488)	(0.0495)	(0.0423)	(0.0425)	(0.0434)
Compensation Requests	0.0832***	0.0830***	0.0578**	0.0798***	0.0790***	0.0636***
	(0.0225)	(0.0229)	(0.0230)	(0.0189)	(0.0192)	(0.0192)
Final Tax To Remit	0.0516	0.0737	0.126**	0.0277	0.0517	0.0760*
	(0.0504)	(0.0502)	(0.0506)	(0.0439)	(0.0437)	(0.0443)
Taxpayer Sales Tax Remittance	0.0987**	0.119**	0.161***	0.0669	0.0920**	0.107**
	(0.0496)	(0.0495)	(0.0500)	(0.0437)	(0.0435)	(0.0442)
Total Sales Tax Remittance	1.160***	1.158***	1.165***	1.169***	1.173***	1.160***
	(0.0447)	(0.0448)	(0.0462)	(0.0395)	(0.0395)	(0.0407)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	332,100	325,764	303,300

Notes: This table is similar to to the main DiD results Table 3, except that the estimates here are based on an OLS estimation, with outcome variables transformed by the inverse hyperbolic sine (IHS) transformation.

Table F.4: The Impact of Withholding: OLS Estimation on Collapsed Data

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Reported	0.00910	0.00558	0.0104	0.0135	0.0120	0.0157
	(0.0119)	(0.0120)	(0.0120)	(0.0114)	(0.0115)	(0.0115)
Sales Tax Collected	0.00732	0.00595	0.00550	0.0120	0.0112	0.0117
	(0.0121)	(0.0122)	(0.0130)	(0.0117)	(0.0118)	(0.0126)
Input Tax Credits	-0.0639***	-0.0649***	-0.0655***	-0.0669***	-0.0680***	-0.0699***
	(0.0156)	(0.0159)	(0.0168)	(0.0145)	(0.0147)	(0.0154)
- Import Credits	-0.0828	-0.0931	-0.146**	-0.139***	-0.153***	-0.209***
	(0.0541)	(0.0572)	(0.0655)	(0.0504)	(0.0531)	(0.0609)
- Local Purchase Credits	-0.0590***	-0.0629***	-0.0591***	-0.0610***	-0.0634***	-0.0635***
	(0.0187)	(0.0188)	(0.0195)	(0.0170)	(0.0171)	(0.0175)
Gross Tax Liability	0.429***	0.432***	0.443***	0.410***	0.414***	0.420***
	(0.0209)	(0.0212)	(0.0220)	(0.0188)	(0.0190)	(0.0197)
Withholding Base	-0.00237	-0.00499	-0.00779	-0.0000743	-0.00124	-0.000623
	(0.0158)	(0.0160)	(0.0168)	(0.0138)	(0.0139)	(0.0140)
Withheld Tax	1.321***	1.319***	1.328***	1.307***	1.304***	1.309***
	(0.0306)	(0.0307)	(0.0315)	(0.0270)	(0.0271)	(0.0277)
Withheld Tax Reclaims	1.065***	1.065***	1.072***	1.027***	1.025***	1.027***
	(0.0334)	(0.0339)	(0.0353)	(0.0302)	(0.0307)	(0.0320)
Compensation Requests	0.589***	0.583***	0.484***	0.515***	0.491***	0.439***
	(0.165)	(0.166)	(0.169)	(0.148)	(0.149)	(0.154)
Final Tax To Remit	0.125***	0.129***	0.136***	0.120***	0.124***	0.128***
	(0.0257)	(0.0260)	(0.0272)	(0.0230)	(0.0232)	(0.0242)
Taxpayer Sales Tax Remittance	0.114***	0.118***	0.129***	0.104***	0.108***	0.117***
	(0.0276)	(0.0279)	(0.0287)	(0.0245)	(0.0247)	(0.0256)
Total Sales Tax Remittance	0.805***	0.811***	0.829***	0.815***	0.822***	0.836***
	(0.0257)	(0.0259)	(0.0264)	(0.0227)	(0.0228)	(0.0235)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,322	14,036	13,108	18,450	18,098	16,850

Notes: This table is similar to to the main DiD results Table 3, except that the estimates are from an OLS estimation using outcome data that is collapsed at the taxpayer level for the pre-reform and post-reform period, and then log-linearized. The procedure is based on the suggestion by Bertrand et al. (2004), as implemented in Naritomi (2019).

Table F.5: The Impact of Withholding: Binary Outcomes (1/2)

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Reported	0.00791**	0.00800**	0.00923**	0.00537	0.00594	0.00684
	(0.00397)	(0.00404)	(0.00428)	(0.00429)	(0.00434)	(0.00461)
Sales Tax Collected	0.00219	0.00217	0.00327	-0.000297	0.000345	0.00135
	(0.00432)	(0.00440)	(0.00468)	(0.00450)	(0.00456)	(0.00484)
Input Tax Credits	0.00204	0.00225	0.00342	0.00345	0.00419	0.00554
	(0.00482)	(0.00490)	(0.00521)	(0.00487)	(0.00494)	(0.00524)
- Import Credits	0.000833	0.000403	0.000149	-0.00128	-0.00168	-0.00139
	(0.00303)	(0.00304)	(0.00318)	(0.00267)	(0.00268)	(0.00280)
- Local Purchase Credits	-0.00259	-0.00186	-0.000510	-0.000103	0.00109	0.00227
	(0.00523)	(0.00530)	(0.00559)	(0.00514)	(0.00520)	(0.00548)
Gross Tax Liability	0.0510***	0.0518***	0.0546***	0.0468***	0.0485***	0.0496***
	(0.00636)	(0.00644)	(0.00671)	(0.00590)	(0.00596)	(0.00624)
Withholding Base	0.00301	0.00292	0.00214	0.00201	0.00228	0.00179
	(0.00492)	(0.00499)	(0.00529)	(0.00440)	(0.00446)	(0.00473)
Withheld Tax	0.207***	0.209***	0.216***	0.214***	0.216***	0.219***
	(0.00962)	(0.00972)	(0.00987)	(0.00831)	(0.00837)	(0.00850)
Withheld Tax Reclaims	0.102***	0.103***	0.107***	0.0977***	0.0998***	0.101***
	(0.00846)	(0.00856)	(0.00876)	(0.00742)	(0.00751)	(0.00771)
Compensation Requests	0.0117***	0.0118***	0.00900**	0.0125***	0.0125***	0.0109***
	(0.00408)	(0.00415)	(0.00429)	(0.00342)	(0.00348)	(0.00359)
Final Tax To Remit	-0.00610	-0.00404	0.00175	-0.00972	-0.00735	-0.00420
	(0.00789)	(0.00797)	(0.00824)	(0.00703)	(0.00709)	(0.00735)
Taxpayer Sales Tax Remittance	-0.00330	-0.00146	0.00289	-0.00682	-0.00449	-0.00258
	(0.00774)	(0.00781)	(0.00808)	(0.00696)	(0.00702)	(0.00729)
Total Sales Tax Remittance	0.111***	0.112***	0.113***	0.120***	0.121***	0.121***
	(0.00683)	(0.00688)	(0.00716)	(0.00605)	(0.00609)	(0.00631)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	332,100	325,764	303,300

Notes: This table is similar to the main DiD results Table 3, except that the outcome is a binary variable capturing whether the underlying outcome is positive or not and we run an OLS rather than a PPML estimation. Table F.6 displays pre-reform means of the outcomes and absolute effect size estimates for the balanced sample.

Table F.6: The Impact of Withholding: Binary Outcomes (2/2)

	Pre-Reform Mean Among Treated			Treatment Effect			Proportional Effect		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile	(7) Trimmed 99.9th pctile	(8) Trimmed 99th pctile	(9) Trimmed 95th pctile
Total Sales Reported	0.984	0.984	0.983	0.00791**	0.00800**	0.00923**	0.00803	0.00813	0.00939
	(0.00161)	(0.00163)	(0.00169)	(0.00397)	(0.00404)	(0.00428)			
Sales Tax Collected	0.979	0.978	0.977	0.00219	0.00217	0.00327	0.00224	0.00222	0.00334
	(0.00161)	(0.00163)	(0.00169)	(0.00432)	(0.00440)	(0.00468)			
Input Tax Credits	0.969	0.969	0.967	0.00204	0.00225	0.00342	0.00211	0.00232	0.00353
	(0.00160)	(0.00162)	(0.00168)	(0.00482)	(0.00490)	(0.00521)			
- Import Credits	0.109	0.0987	0.0747	0.000833	0.000403	0.000149	0.00765	0.00408	0.00200
	(0.00104)	(0.00101)	(0.000934)	(0.00303)	(0.00304)	(0.00318)			
- Local Purchase Credits	0.953	0.953	0.952	-0.00259	-0.00186	-0.000510	-0.00272	-0.00196	-0.000536
	(0.00161)	(0.00163)	(0.00169)	(0.00523)	(0.00530)	(0.00559)			
Gross Tax Liability	0.682	0.682	0.683	0.0510***	0.0518***	0.0546***	0.0748	0.0759	0.0800
	(0.00196)	(0.00198)	(0.00205)	(0.00636)	(0.00644)	(0.00671)			
Withholding Base	0.973	0.973	0.973	0.00301	0.00292	0.00214	0.00310	0.00300	0.00220
	(0.00163)	(0.00164)	(0.00170)	(0.00492)	(0.00499)	(0.00529)			
Withheld Tax	0.625	0.623	0.617	0.207***	0.209***	0.216***	0.332	0.335	0.350
	(0.00199)	(0.00201)	(0.00209)	(0.00962)	(0.00972)	(0.00987)			
Withheld Tax Reclaims	0.271	0.268	0.257	0.102***	0.103***	0.107***	0.377	0.383	0.416
	(0.00180)	(0.00181)	(0.00186)	(0.00846)	(0.00856)	(0.00876)			
Compensation Requests	0.0318	0.0322	0.0320	0.0117***	0.0118***	0.00900**	0.367	0.365	0.281
	(0.000578)	(0.000588)	(0.000609)	(0.00408)	(0.00415)	(0.00429)			
Final Tax To Remit	0.632	0.633	0.635	-0.00610	-0.00404	0.00175	-0.00965	-0.00639	0.00275
	(0.00194)	(0.00196)	(0.00203)	(0.00789)	(0.00797)	(0.00824)			
Taxpayer Sales Tax Remittance	0.620	0.621	0.623	-0.00330	-0.00146	0.00289	-0.00531	-0.00236	0.00464
	(0.00194)	(0.00196)	(0.00203)	(0.00774)	(0.00781)	(0.00808)			
Total Sales Tax Remittance	0.804	0.803	0.802	0.111***	0.112***	0.113***	0.138	0.139	0.141
	(0.00188)	(0.00190)	(0.00197)	(0.00683)	(0.00688)	(0.00716)			
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	257,796	252,648	235,944	257,796	252,648	235,944

Notes: This table is similar to Table F.5, but it focuses on the balanced panel, and presents more detailed results, displaying the pre-reform means in the treatment group (columns 1-3), the point estimates from an OLS estimation with binary outcome variables (columns 4-6), and the proportional effect, i.e. the point estimates scaled by the pre-reform mean in the treatment group (columns 7-9).

Table F.7: The Impact of Withholding: IHS Estimation on Sample With Non-Zero Outcomes Pre-reform (1/2)

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Reported	0.0836**	0.0811**	0.0873**	0.0334	0.0381	0.0349
	(0.0379)	(0.0386)	(0.0410)	(0.0380)	(0.0384)	(0.0405)
Sales Tax Collected	0.0653**	0.0641**	0.0687**	0.0244	0.0275	0.0275
	(0.0309)	(0.0315)	(0.0334)	(0.0302)	(0.0305)	(0.0323)
Input Tax Credits	-0.0563*	-0.0565*	-0.0560	-0.0729**	-0.0684**	-0.0711**
	(0.0317)	(0.0322)	(0.0342)	(0.0308)	(0.0311)	(0.0327)
- Import Credits	-0.0467	-0.0587	-0.118	-0.0778	-0.113	-0.146
	(0.107)	(0.116)	(0.159)	(0.109)	(0.120)	(0.164)
- Local Purchase Credits	-0.0547*	-0.0529	-0.0497	-0.0692**	-0.0631**	-0.0701**
	(0.0330)	(0.0334)	(0.0350)	(0.0315)	(0.0318)	(0.0329)
Gross Tax Liability	0.426***	0.438***	0.459***	0.362***	0.376***	0.391***
	(0.0416)	(0.0418)	(0.0432)	(0.0383)	(0.0383)	(0.0398)
Withholding Base	0.0310	0.0243	0.0255	0.0281	0.0283	0.0311
	(0.0419)	(0.0423)	(0.0450)	(0.0375)	(0.0379)	(0.0399)
Withheld Tax	0.916***	0.906***	0.938***	0.899***	0.891***	0.905***
	(0.0493)	(0.0495)	(0.0486)	(0.0424)	(0.0426)	(0.0420)
Withheld Tax Reclaims	0.699***	0.706***	0.714***	0.645***	0.647***	0.626***
	(0.0617)	(0.0619)	(0.0619)	(0.0576)	(0.0579)	(0.0587)
Compensation Requests	0.688	0.688	0.684	-0.000953	-0.000953	0.101
	(0.584)	(0.584)	(0.587)	(0.646)	(0.646)	(0.681)
Final Tax To Remit	-0.117**	-0.0818	-0.0251	-0.155***	-0.121**	-0.0878*
	(0.0553)	(0.0548)	(0.0553)	(0.0494)	(0.0490)	(0.0492)
Taxpayer Sales Tax Remittance	-0.0845	-0.0506	-0.00285	-0.124**	-0.0916*	-0.0635
	(0.0573)	(0.0568)	(0.0575)	(0.0515)	(0.0512)	(0.0517)
Total Sales Tax Remittance	0.779***	0.782***	0.811***	0.758***	0.764***	0.778***
	(0.0376)	(0.0380)	(0.0393)	(0.0338)	(0.0341)	(0.0353)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	332,100	325,764	303,300

Notes: This table is similar to Table F.3, except that it retains for each outcome variable only firms for which at least 14 of the (at most) 19 pre-reform obervations for this variable were positive. We transform the outcomes using the inverse hyperbolic sine transformation, and conduct an OLS estimation. Given the sample restriction, the estimation sample is different for each outcome variable. Table F.8 shows the number of observations for each outcome and specification in the balanced panel.

Table F.8: The Impact of Withholding: IHS Estimation on Sample With Non-Zero Outcomes Pre-reform (2/2)

	Treatment Effect			N		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Reported	0.0836**	0.0811**	0.0873**	280368	274716	255816
	(0.0379)	(0.0386)	(0.0410)			
Sales Tax Collected	0.0653**	0.0641**	0.0687**	275184	269568	251100
	(0.0309)	(0.0315)	(0.0334)			
Input Tax Credits	-0.0563*	-0.0565*	-0.0560	260820	255312	236988
	(0.0317)	(0.0322)	(0.0342)			
- Import Credits	-0.0467	-0.0587	-0.118	24480	21024	13500
	(0.107)	(0.116)	(0.159)			
- Local Purchase Credits	-0.0547*	-0.0529	-0.0497	255204	250056	232380
	(0.0330)	(0.0334)	(0.0350)			
Gross Tax Liability	0.426***	0.438***	0.459***	190620	186948	174492
	(0.0416)	(0.0418)	(0.0432)			
Withholding Base	0.0310	0.0243	0.0255	278136	272592	254232
	(0.0419)	(0.0423)	(0.0450)			
Withheld Tax	0.916***	0.906***	0.938***	159624	156060	143460
	(0.0493)	(0.0495)	(0.0486)			
Withheld Tax Reclaims	0.699***	0.706***	0.714***	93060	90468	81684
	(0.0617)	(0.0619)	(0.0619)			
Compensation Requests	0.688	0.688	0.684	2232	2232	2196
	(0.584)	(0.584)	(0.587)			
Final Tax To Remit	-0.117**	-0.0818	-0.0251	167256	164268	153396
	(0.0553)	(0.0548)	(0.0553)			
Taxpayer Sales Tax Remittance	-0.0845	-0.0506	-0.00285	163548	160488	149904
	(0.0573)	(0.0568)	(0.0575)			
Total Sales Tax Remittance	0.779***	0.782***	0.811***	225756	220932	205992
	(0.0376)	(0.0380)	(0.0393)			
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table is similar to Table F.7, but it focuses on the balanced panel, and presents both the point estimates (columns 1-3, same as columns 1-3 in Table F.7) as well as the number of observations underlying each estimation (columns 4-6).

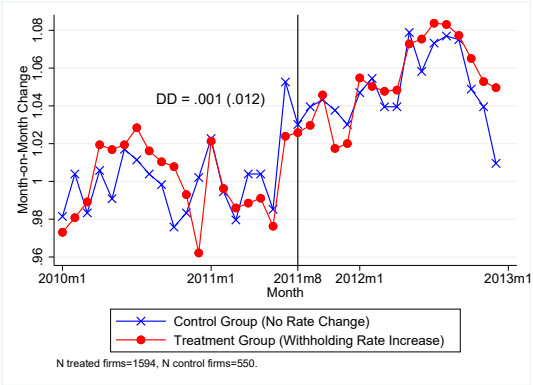
Table F.9: The Impact of Withholding: Robustness When Considering Refunds and Potential Reduction in Income Tax Remittance

	Fully-Balanced Panel			Semesterly-Balanced Panel		
	(1) Trimmed 99.9th pctile	(2) Trimmed 99th pctile	(3) Trimmed 95th pctile	(4) Trimmed 99.9th pctile	(5) Trimmed 99th pctile	(6) Trimmed 95th pctile
Total Sales Tax Remittance	0.410***	0.455***	0.708***	0.405***	0.588***	0.666***
	(0.137)	(0.0967)	(0.0698)	(0.129)	(0.0681)	(0.0606)
Total Sales Tax Remittance - Refund	0.410***	0.457***	0.711***	0.402***	0.591***	0.668***
	(0.138)	(0.0984)	(0.0705)	(0.130)	(0.0692)	(0.0613)
Total Sales Tax Remittance - Refund - IT Compensation	0.385***	0.435***	0.712***	0.376***	0.582***	0.674***
	(0.143)	(0.104)	(0.0747)	(0.135)	(0.0730)	(0.0649)
Sales Tax + Income Tax - Refund	0.310**	0.307***	0.582***	0.379***	0.431***	0.544***
	(0.140)	(0.0900)	(0.0662)	(0.128)	(0.0673)	(0.0547)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXmonth FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257,796	252,648	235,944	332,100	325,764	303,300

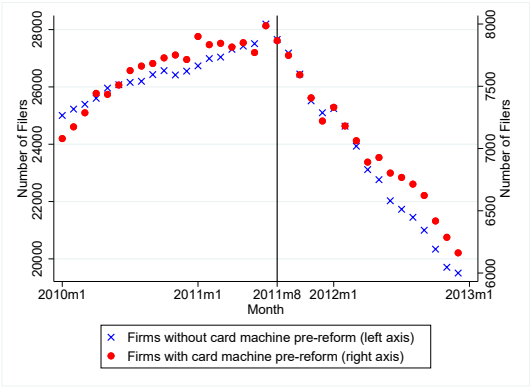
Notes: This table is similar to Table F.2, but considers a different set of outcome variables. The first row reproduces as benchmark the effect of the tax withholding-rate increase on total sales tax remittance from Table F.2. The following rows present the same estimate after accounting for refunds, income tax compensation and potential reductions in income tax remittance. Taxpayers who cannot fully deduct the tax withheld for the sales tax on their sales tax declaration, due to low tax liability, can either request a refund, or deduct the tax withheld on their income tax declaration. The latter process is referred to as compensation. Regarding the estimates on sales tax + income tax - refund, it is useful to note that total sales tax remittances are on average twice as high as income tax remittances. The estimates are consistent with no effect or even a slight increase in income tax compliance. We use OLS estimations rather than PPML for this exercise, as some of the outcome variables can take negative values, which is not allowed under PPML. We display the proportional effects, as in Table F.2.

Figure F.1: No Filing Response to Withholding

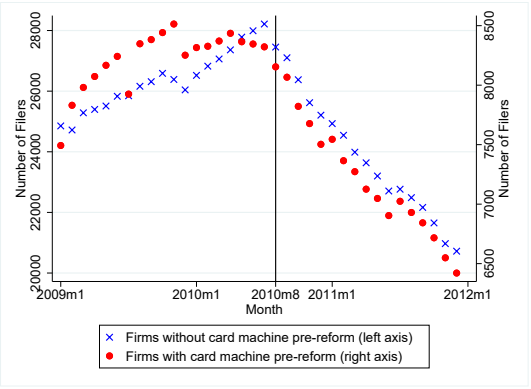
A: DiD-Estimation on Irregular Filer Panel



B: At-least-once Filers Around Reform



C: At-least-once Filers Around Placebo Reform



Notes: This figure illustrates the absence of a filing response to the August 2011 withholding-rate increase. Panel A concerns firms that file at least once per semester in the three years around the withholding reform. This means we can determine treatment status at the firm level. We drop all firms that file regularly, and estimate equation 10 on the remaining panel of irregular filers, which we balanced so that each firm appears every month. The outcome in the DiD estimation is a dummy that indicates if the firm filed a sales tax declaration in a particular month. We relax the balancing restriction in Panel B, which concerns firms that filed at least once before the reform, regardless of whether they continue to file after the reform or not. In this group, we plot the number of filers with and without a card machine prior to the reform, considering that having a card machine is a proxy for treatment status. To establishe a counterfactual, Panel C repeats this exercise, but moves the reform (and requirement that firms in the sample file at least once pre-reform) to a placebo reform date of August 2010.

G The Impact of Withholding – Mechanisms

Table G.1: Heterogeneity of Withholding Impact: Extended Control Group

	Outcome: Reported Gross Tax Liability								
	Evidence for Enforcement Perception Mechanism						No Evidence for Liquidity Mechanism		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treated (Withholding Rate Increase)	0.274***	0.250***	0.231***	0.236***	0.158**	0.0269	0.250***	0.262***	0.0107
	(0.0259)	(0.0271)	(0.0280)	(0.0247)	(0.0617)	(0.0619)	(0.0321)	(0.0277)	(0.0707)
Treated X Below Median Turnover		0.258***				0.221***			0.226***
		(0.0386)				(0.0473)			(0.0493)
Treated X Mispreporter			0.166***			0.142**			0.150***
			(0.0531)			(0.0576)			(0.0549)
Treated X First-Time Withholdee				0.572***		0.564***			0.515**
				(0.189)		(0.196)			(0.202)
Treated X Reclaimer					0.129**	0.168***			0.170***
					(0.0628)	(0.0575)			(0.0587)
Treated X Below Median Profitability							0.0349		0.0412
							(0.0375)		(0.0357)
Treated X Buncher								0.0514	-0.0394
								(0.0492)	(0.0499)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CharacteristicsXMonth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	773,514	773,514	773,514	773,514	773,514	773,514	765,892	773,514	765,892

Notes: This table is identical to Table 5 but includes in the control group firms which did not use a card machine, to maximize statistical power.

Table G.2: Impact of Withholding-Rate Increase: Heterogeneity by Rate Change Size

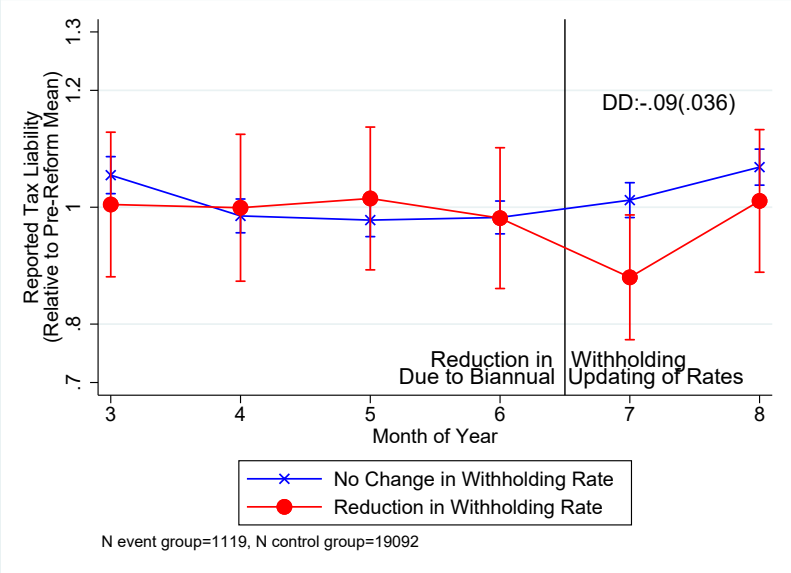
	Outcome: Reported Gross Tax Liability
	(1)
Treated X First-Time Withholdee X Big Rate Change	0.860***
	(0.242)
Treated X First-Time Withholdee X Small Rate Change	0.881***
	(0.161)
Treated X Previous Withholdee X Big Rate Change	0.274***
	(0.0363)
Treated X Previous Withholdee X Small Rate Change	0.137***
	(0.0308)
Month FE	Yes
Firm FE	Yes
CharacteristicsXMonth FE	Yes
Observations	226,372

Notes: This table is identical to Table 5, but presents the coefficient estimates on interactions between the treatment dummy (withholding-rate increase) interacted with dummies to indicate first-time withholdees and previous withholdees, and big (5-6 ppt) and small (1-3 ppt) changes in the withholding rate. We drop firms which experienced a 6 ppt change in the withholding rate, as this can be the case only among first-time withholdees. The estimates are based on a PPML estimation with firm and month fixed effects and a sector-specific linear time trend.

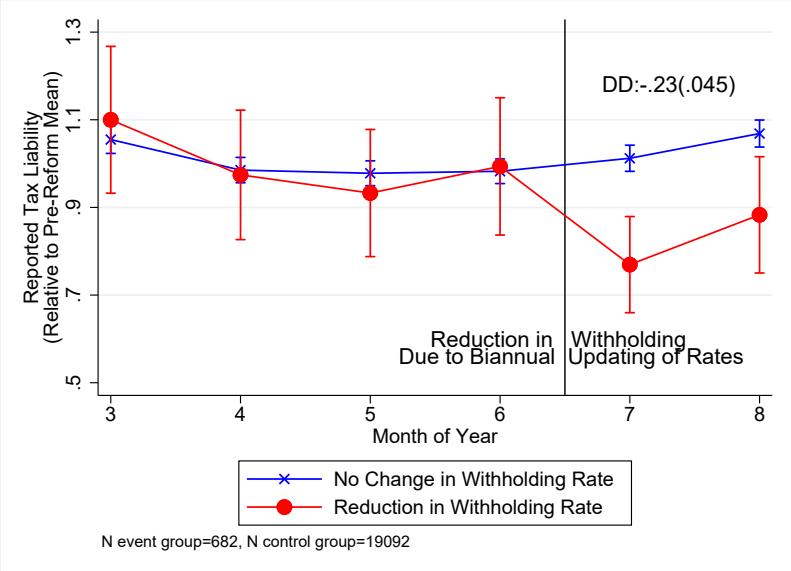
H Event Study of Withholding-Rate Reduction

Figure H.1: Event Study of Withholding-Rate Reduction

A: Small Withholding-Rate Reduction (1-2 points)



B: Large Withholding-Rate Reduction (3-4 points)



Notes: This figure is constructed as Figure 5, Panel A, except that the event groups here contain firms that experienced a decrease in their withholding rate in July, due to the biannual updating of withholding rates. The control group contains firms that experienced no change in the withholding rate.

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