Three Essays in Public Finance in Developing Countries

by

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DEDICATION

An achievement such as the completion of a doctorate degree is seldom the result of an individual effort. Throughout the years, I have been privileged to receive the support of many wonderful people. However, this journey would not have been possible without the ever-present support and guidance of my parents, as well as the understanding and encouragement of my wife. I dedicate this achievement to them. A special mention goes to Regina de Riojas and the members of Asociación Becaria Guatemalteca, an institution that believed in my early potential and gave me the opportunity to develop it. Thank you for your selfless, tireless, and inspiring work in favor of Guatemala's youth.

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ABSTRACT

The three chapters presented in this dissertation focus on fiscal issues affecting developing countries. Low tax revenue collection, weak enforcement capabilities, high levels of tax evasion, inefficient tax system design, and reactive handling of contingent liabilities –such as natural disasters–, are characteristics commonly observed in countries across the developing world. In the analyses presented here, I study some of these issues and seek to contribute to their understanding through new empirical evidence.

Chapter 1: Minimum taxes are attractive to governments because under such regimes evasion incentives are expected to be lower than under profit taxation. Until recently, this type of policies was considered suboptimal from a social welfare perspective. The present analysis focuses on the Guatemalan corporate income tax regime faced by firms registered in *Regimen Optativo*. The empirical evidence shown in this chapter suggests strong firm responses to the minimum tax and to its exemption rule, most of which seem in accordance with evasion behavior. Upper-bounds for average reported profits are estimated to be as low as 42% of actual firms' profits, implying an evasion rate of 58% in the absence of the minimum tax scheme. These results are consistent with the view that minimum taxes can be an effective mechanism to lower tax evasion in environments with limited enforcement capabilities.

Chapter 2: This chapter analyses the fiscal impact of extreme weather events. While the literature analyzing the economic incidence of natural disasters has mainly focused on their macroeconomic consequences, the fiscal dimension of this problem remains relatively neglected. Due to their

adverse effect on the economy, extreme weather events tend to reduce government revenues and increase public expenditure, creating a negative pressure on the budget balance. According to the results shown in this chapter, the occurrence of at least one extreme weather event is associated with an increase in the budget deficit between 0.4% and 0.9% of GDP. This impact comes primarily from an immediate reduction in government revenues, as a percentage of GDP, with some evidence pointing out to a lagged effect on public expenditure two years after the event. The analysis also shows that the fiscal effect is larger for low-income and lower-middle income countries but is not significant for high-income and upper-middle income countries.

Chapter 3: This chapter explores the consequences of having two co-existing corporate income tax regimes within a domestic tax system. This scenario is interesting because, in such environments, a simple theoretical model predicts an optimal strategy involving tax arbitrage through income shifting across regimes. The empirical exercise focuses on the case of Guatemala, where firms choose between a regime that taxes profits –*Regimen Optativo*–, and a regime that taxes turnover –*Regimen General*–. Following a difference-in-difference approach, where treatment and control groups are defined by whether firms belong to a tax arbitrage network or not, the results show differential behavior between the two groups. Firms that do not belong to a tax arbitrage network faced a decrease of around one percentage point more than the treatment group in the probability of registering in *Regimen General* after the reform. Despite their consistency with the theoretical predictions, it is acknowledged that these results should only be interpreted as indirect evidence of profit shifting and the existence of tax arbitrage networks in Guatemala.

CHAPTER 1

Firms' (mis)reporting under a minimum tax: Evidence from Guatemalan corporate tax returns

1.1. Introduction

It is well documented that, despite similar statutory tax rates, developing countries have relatively low tax revenues in comparison to the developed world. For instance, in 2010 the average tax-to-GDP ratio in low income countries was 13.0%, in contrast with the OECD mean of 35.4%. The difference is particularly striking when comparing income tax collection, which represented 12.9% of GDP in OECD countries, while only reaching 3.5% in low income countries (IMF, 2011). Such a reality points at significant limitations in the ability of developing countries to collect taxes, and several studies have discussed different dimensions of this problem, including informality and tax evasion (e.g. Gordon and Li, 2009; IDB, 2013; Beasly and Persson, 2014).

This paper studies firm behavior under a minimum tax scheme in the context of a developing country. Minimum taxes are a form of taxation that calculates the amount a taxpayer owes using alternative bases (e.g. profits, turnover), levying the largest liability of the two. These schemes are attractive to governments in advanced and developing economies because under such regimes evasion incentives are expected to be lower than under profit taxation, hence increasing tax collection.[1] Until recently, this type of policies was considered suboptimal from a social welfare perspective, due to their distortionary nature. However, new research has shed some light into this issue (Best et al., 2015).

The specific focus of this paper is the Guatemalan corporate income tax regime faced by firms registered in *Regimen Optativo*. This regime features a minimum tax scheme in which firms pay the largest tax liability between a tax on profits and a tax on turnover. As shown in the paper, the kink in the tax liability function created by this policy induces bunching behavior among firms, which allows for the identification of evasion responses (Saez, 2010; Chetty et al., 2011). Moreover, *Regimen Optativo* also features an exemption rule, based on the firm's cost structure, as well as no loss carryforward. The former trait causes a *firm-specific* upward notch in the tax liability function, while the latter generates an additional kink, similar to the one provoked by the minimum tax.[2] The differentiated misreporting incentives that arise as a result of these kinks and notch provide helpful variation, which is exploited in the paper to identify behavior consistent with evasion strategies.

The present study contributes to the growing literature focusing on firms' behavior in developing countries in three ways. First, it focuses on the analysis of exemption rules and their impact within the framework of a minimum tax scheme. To the best of the author's knowledge, a systematic approach to this issue has not been attempted in any previous studies. Using previously unexplored Guatemalan administrative data, the empirical analysis demonstrates that firms react

[1] Some examples include Bolivia, Cambodia, Cameroon, Chad, Colombia, Dominican Republic, El Salvador, Gabon, Guatemala, Honduras, Hungary, India, Ivory Coast, Liechtenstein, Madagascar, Mauritius, Nicaragua, Nigeria, Pakistan, Panama, Republic of the Congo, Senegal, Slovakia, South Korea, Tanzania, and the United States. (see Price-Waterhouse-Coopers, 2014).

[2] In this context, a kink occurs when there is a discontinuous change in the tax rate, but not in the tax liability. Instead, a notch represents a discontinuous change in the level of the tax liability.

strongly to the incentives created by this type of notch, strategically misreporting specific cost categories to become exemption-eligible. Second, this paper provides new empirical evidence in support of the use of minimum taxes as a tool to increase tax revenue. Estimates obtained from bunching analysis suggest that the minimum tax induces firms to reduce misreporting, as a proportion of *reported* profits, by as much as 137%. Third, the paper exploits the no loss carryforward rule of *Regimen Optativo* to derive a method that allows the estimation of upper bounds for the ratio of reported-to-actual profits. According to these calculations, firms report, on average, no more than 42% of their true profits in the absence of the minimum tax scheme. This number implies that evasion arising from profit misreporting would be at least 58% of actual profits if this scheme was not in place. The large estimated rate of evasion is consistent with other estimates found in the literature for developing countries.[3]

The rest of the paper is structured as follows. Section 2 introduces the theoretical model used throughout the analysis. Section 3 provides a description of the Guatemalan income tax and the dataset. Section 4 discusses the methodology which guides the empirical analysis, with results presented in Section 5. Finally, the conclusions of the paper are summarized in Section 6.

1.2. Theoretical Model

This section develops the theoretical framework needed to understand a minimum tax scheme, as well as the implications of introducing an exemption rule into this setup. It starts by separately describing optimal firm behavior under a pure profit tax and a turnover tax. Then, building on

[3] For instance, Bachas and Soto (2017) estimate that evasion could be as large as 70% of actual firm profits in the case of Costa Rica. Similarly, Pecho et al. (2012) present estimates of income tax non-compliance in Latin America ranging between 34.5% and 72%.

those cases, it presents a model where firms face a minimum tax. Finally, the model is expanded to account for the introduction of an exemption rule.

1.2.1. Profit maximization under a pure profits tax

The basic model used in this paper is an extension of the canonical income tax model (Allingham and Sandmo, 1972) in which firms maximize profits, taking into account a tax liability function, as well as the expected benefits and costs of evasion. The tax liability faced by firms, $T(y, \hat{c})$, depends on output y and reported cost $\hat{c}$.[4, 5] As is common in the literature, the model assumes that firms face total costs $c(y)$ that are a convex function of output; private costs of evasion $h(\hat{c} - c(y))$ that are a convex function of misreported cost; and, as is the case in the developing world, imperfect enforcement.[6] Hence, the firm's problem is,

$$\max_{y,\, \hat{c}}\ y - c(y) - T(y, \hat{c}) - h\big(\hat{c} - c(y)\big). \tag{1}$$

For the case of a pure profits tax with a marginal rate τ_π, the tax liability function becomes $T(y, \hat{c}) = \tau_\pi(y - \hat{c})$. The key feature of such a scheme is that firms can fully deduct costs from their turnover, in order to determine their taxable income. The firm's first order conditions for an interior solution are,

$$c'(y)\big[1 - h'\big(\hat{c} - c(y)\big)\big] = 1 - \tau_\pi \tag{2}$$

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[4] The terms output and turnover are used interchangeably in this study. This follows from a normalization of the price level, which simplifies the exposition of the problem.
[5] For simplicity, firms can only misreport cost in this framework. However, the model can be extended to account for turnover misreporting without changing the basic results presented in this section. See the appendix to this chapter for a model with such a representation.
[6] The choice of the private costs of evasion as a convex function of misreported cost, $h(\hat{c} - c(y))$, mirrors the typical penalty structure observed in many tax systems around the world. Moreover, it also replicates the penalty structure of the Guatemalan tax system, which will be the subject of analysis in the empirical section.

$$h'(\hat{c} - c(y)) = \tau_\pi. \quad (3)$$

Optimal evasion is governed by equation (3), which indicates that firms will engage in tax evasion by misreporting costs, up to the point where the marginal cost of doing so equals the tax rate.[7] Furthermore, in this simplified model, combining equations (2) and (3) yields,

$$c'(y) = 1. \quad (4)$$

This condition implies that a pure profits tax is non-distortionary, since the determination of the optimal output level is independent of the tax rate.[8] Therefore, under this scheme, if the government decides to increase the tax rate, firms will react by adjusting their level of cost misreporting, $\hat{c} - c(y)$, without altering their output decision. In other words, any observed behavioral response would map directly to a change in the firm's evasion pattern, as there is no real (i.e. output) response in this framework.

1.2.2. Profit maximization under a turnover tax

An alternative approach to profits taxation often observed in developing countries is turnover taxation. The main difference with the pure profits tax setting is that this type of taxation does not allow for costs deduction. In this context, the tax liability function takes the form $T(y, \hat{c}) = \tau_y y$, where τ_y represents the tax rate on turnover. The first order conditions for an interior solution to this problem are,

[7] The dependence of the level of misreporting on the tax rate relies on the specification of $h(\hat{c} - c(y))$, as discussed in the literature (Yitzhaki, 1974; Cremer and Gahvari, 1994; Slemrod and Yitzhaki, 2002). The result in equation (3) is consistent with a setting in which the probability of detection is an increasing function of the evaded amount. It is also consistent with a scenario in which there are variable costs of evasion on top of the expected penalty incurred if caught by the tax authority.

[8] The characterization of a profit tax as non-distortionary is used for tractability. However, this is not in agreement with the empirical evidence. See Auerbach et al. (2008) for an example of this literature.

$$c'(y)\left[1-h'\big(\hat{c}-c(y)\big)\right]=1-\tau_y \tag{5}$$

$$h'\big(\hat{c}-c(y)\big)=0, \tag{6}$$

which together imply,

$$c'(y)=1-\tau_y. \tag{7}$$

Contrary to the pure profits tax, a turnover tax has a distortionary effect, as equation (7) relates the optimal output level to the tax rate. As a consequence, a firm under this tax regime will produce less output than under a profit tax. Moreover, the firm will not engage in tax evasion via cost misreporting, as the marginal benefit of this action would be zero.[9]

1.2.3. Profit maximization under a minimum tax

The previous two cases serve as the foundation for the analysis of firm behavior under a minimum tax scheme (MTS). These types of schemes find their rationale in the fact that firms have no incentives to misreport costs whenever they face a turnover tax, hence, reducing evasion.[10]

A typical minimum income tax liability function has the form,[11]

$$T(y,\hat{c})=\max\{\tau_\pi(y-\hat{c}),\tau_y y\}. \tag{8}$$

[9] In this model, the possibility of turnover misreporting is ignored for simplicity. See the appendix to this chapter for a model that incorporates this margin of evasion. The main results are unchanged, as turnover misreporting also decreases with respect to its level under a profit tax, as long as the tax rate on turnover is lower than the tax rate on profits.

[10] The cost of reducing evasion using a minimum tax comes from the distortion to production incentives. Nonetheless, Best et al. (2015) show that minimum taxes can be more socially efficient than profit taxes in environments with low enforcement.

[11] Examples of this type of tax liability function are provided by Best et al. (2015) for the case of Pakistan, and Mosberger (2016) for the case of Hungary. In the empirical section, the Guatemalan corporate tax regime will be added to this list, but there are many other similar schemes around the world.

Equation (8) indicates that a firm faces the largest tax liability between a profit tax and a turnover tax. For a given combination of output and reported cost, $(y, \hat{c})$, the two liabilities are equal when,

$$\tau_\pi(y - \hat{c}) = \tau_y y \qquad \Leftrightarrow \qquad \hat{p} \equiv \frac{(y-\hat{c})}{y} = \frac{\tau_y}{\tau_\pi}. \tag{9}$$

Here, $\hat{p}$ is known as the reported (pre-tax) profit margin. The value τ_y/τ_π –referred to as the MTS *payment* threshold, from this point onwards– defines which tax liability is higher. Firms reporting a profit margin lower than the MTS payment threshold face a turnover tax, while those reporting a larger profit margin are required to pay a tax on profits. This means that the incentives for a profit-maximizing firm change depending on whether it locates to the left or the right of the MTS payment threshold. Figure 1.1 provides a graphical representation of how a minimum tax scheme works.

In order to have a better understanding of how firm behavior is affected by a minimum tax, let us suppose that we start in a scenario with a pure profit tax. Under this regime, a firm with a reported profit margin below the MTS threshold would locate on the profit tax liability function (dashed line), as shown by point A in Figure 1.2.[12] At that point, there is no tax distortion to output and evasion is positive, in line with equations (3) and (4). If the tax regime suddenly changed to a minimum tax scheme, the firm would face a higher tax liability. Before accounting for any response, the firm would find itself at point B in the figure. However, given the new tax incentives, the firm will respond by decreasing output and reducing evasion, in accordance with equations (6) and (7). As a result, the firm's reported profit margin will increase, and the firm will locate at

[12] Throughout this paper, the term "tax liability function" may also be used (imprecisely, admittedly) to refer to the function $T(y, \hat{c})/y$. This is mainly done so when describing the tax liability function as a proportion of turnover in the different figures presented in the study.

point C.[13] In aggregate, firms' responses will create bunching in the density distribution at the MTS threshold, as illustrated in Panel (b) of Figure 1.2.

Contrary to the case shown in Figure 1.2, firms with an initial reported profit margin above the MTS payment threshold will not show any behavioral response. This is because their incentives remain unchanged after the introduction of the minimum tax scheme. Thus, under the new regime, the overall tax revenue gains from lower evasion, as well as the efficiency costs from distorting production, are all coming from firms with an initial reported profit margin below the MTS payment threshold.

1.2.4. Implications of adding an exemption rule to the MTS

An implicit assumption of the minimum tax framework developed above is that all firms are required to pay the minimum tax, provided that their profit margin lies below the MTS payment threshold. However, in practice, it is not uncommon to find schemes that exempt a group of firms from facing the minimum tax. As it is shown below, accounting for exemption rules is important because of their effect on tax incentives. When an exemption rule is available, firms take into consideration their eligibility prospects at the time of making output and evasion decisions.

The previous model can be expanded to account for the effects of an exemption rule. Let θ be a binary parameter that defines whether a firm is exempt or not, with $\theta = 1$ if the firm is eligible for a minimum tax exemption, and $\theta = 0$ if the firm is non-exempt. The tax liability function under this scheme is,

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[13] The reported profit margin can be written as $\hat{p} = \frac{y-c(y)}{y} - \frac{\hat{c}-c(y)}{y}$. The first term corresponds to the firm's "true" profit margin and is decreasing in output under the assumption of decreasing returns to scale. The second term captures the evasion component and is increasing in misreported cost. Thus, if a firm reduces both its output and misreported cost, its reported profit margin will increase.

$$T(y, \hat{c}) = \theta\tau_\pi(y - \hat{c}) + (1 - \theta)\max\{\tau_\pi(y - \hat{c}), \tau_y y\}. \tag{10}$$

Equation (10) is equivalent to equation (8) whenever a firm is non-exempt, and it reverts into a pure profits tax if a firm is exempt.

In order to fully appreciate the implications of the new setup on the tax liability function, it is convenient to consider different specifications of this exemption rule. The next subsections will analyze two broad categories of exemption rules, which create a notch in the tax liability function.

1.2.4.1. Exemption rules that create an upward notch in the tax liability function

Suppose, for simplicity, that the government defines the exemption rule according to the following condition,

$$\theta \equiv \begin{cases} 0, & \frac{y-\hat{c}}{y} > \varphi \\ 1, & \frac{y-\hat{c}}{y} \leq \varphi. \end{cases} \tag{11}$$

This definition indicates that firms are exempt if their profit margin is less or equal to an exogenous value φ –the MTS *exemption* threshold–, but are non-exempt otherwise.[14]

It is useful to point out that equation (11) provides a condition that is similar in nature to equation (9), insofar it relates the MTS exemption threshold to the profit margin.[15] However, both conditions differ in a fundamental manner. One way to think about the separate roles of the MTS exemption and payment thresholds is to view the former as a parameter defining the *intention to*

[14] The specification of this exemption rule is based on a simplified version of the Guatemalan case, which is analyzed in the empirical section.

[15] The use of the profit margin in equation (11) to define the exemption rule is deliberate. In practice, these rules may not be stated in terms of the profit margin. However, the basic results of this section remain the same, as long as there is a mapping between the statistic that defines the exemption rule and the profit margin.

treat, and the latter as the *actual treatment* determinant. For instance, a firm with a reported profit margin above the MTS exemption threshold will be non-exempt, but it will only pay the minimum tax if its profit margin is below the MTS payment threshold. On the other hand, a firm with a reported profit margin below the MTS exemption threshold is, by definition, exempt, which means it is not subject to pay the minimum tax, independently of whether its profit margin lies above or below the MTS payment threshold.

Figure 1.3 illustrates the consequences of such an exemption rule on the shape of the tax liability function. There are two cases to consider, each depending on how the MTS exemption threshold relates to the MTS payment threshold. Panel (a) shows that when $\varphi \geq \frac{\tau_y}{\tau_\pi}$ the tax liability function reverts to that of a pure profits tax. This occurs because all firms that would be subject to pay the minimum tax are exempt from doing so, rendering the MTS payment threshold irrelevant.[16] The second case arises when $\varphi < \frac{\tau_y}{\tau_\pi}$ and is depicted in panel (b). In this situation, there is an upward notch in the tax liability function exactly at the MTS exemption threshold. Firms with a profit margin below φ avoid the minimum tax, but those with a higher profit margin must pay it if they also lie to the left of the MTS payment threshold.

Clearly, in both cases the existence of an exemption rule has important implications on the impact of a minimum tax scheme on firm behavior. For instance, a firm facing the tax liability function in panel (a) will not have incentives to bunch at the MTS payment threshold. However, if it faces the tax liability function in panel (b), the firm will evaluate its best alternative –that which maximizes after-tax profits– between two options. The first one is to respond to the kink at

[16] In this highly stylized framework, this case seems trivial, as no government would create an exemption rule that effectively dismantles their minimum tax scheme. However, in practice, the MTS exemption threshold can be firm-specific, when considered in terms of the profit margin. The Guatemalan minimum tax scheme analyzed in the empirical section provides an example where this is the case.

the MTS payment threshold, in which case the firm will follow the path from points A to C, increasing its reported profit margin. A firm choosing this path will bunch at the MTS payment threshold in the same fashion as in Figure 1.2. The second alternative is to respond to the notch at the MTS exemption threshold. If it chooses to do so, the firm will adjust its output and evasion choices so that its reported profit margin drops to point C', where the firm is now exempt from paying the minimum tax. In this latter case, firms will bunch to the left of the MTS exemption threshold.[17]

1.2.4.2. Exemption rules that create a downward notch in the tax liability function

Now, let us consider an alternative case, where the government inverts the exempt and non-exempt groups by defining the rule as follows,

$$\theta = \begin{cases} 0, & \frac{y-\hat{c}}{y} < \varphi \\ 1, & \frac{y-\hat{c}}{y} \geq \varphi. \end{cases} \tag{12}$$

Contrary to (11), in this setting firms are exempt from the minimum tax scheme if their profit margin is greater or equal to the MTS exemption threshold, φ, but remain non-exempt otherwise.[18] The implications of this simple change in the eligibility rule are presented in Figure 1.4.

As in the case of the previous subsection, there are two cases to consider. Panel (a) shows that when $\varphi \geq \frac{\tau_y}{\tau_\pi}$ the MTS tax liability function remains unaffected by the exemption rule. This is because all the exempt firms are to the right of the MTS payment threshold, meaning that they

[17] For cases where the MTS exemption threshold is firm-specific in terms of the reported profit-margin, as in the empirical section, this bunching will not be evident in the corresponding density distribution. This occurs because every firm faces the notch at a different value of the profit margin.

[18] This specification is based on a simplified version of the Hungarian case, which is analyzed by Mosberger (2016).

did not have to pay the minimum tax even in the absence of the exemption rule.[19] Panel (b) presents the case when $\varphi < \frac{\tau_y}{\tau_\pi}$. In this scenario, there is a downward notch in the tax liability function exactly at the MTS exemption threshold. Firms with a reported profit margin below φ are non-exempt and face the minimum tax, but those with a higher profit margin are exempt. While firms in panel (a) have incentives to bunch at the MTS payment threshold, moving from points A to C, those in panel (b) face incentives to bunch at the MTS exemption threshold, repositioning from points A to C'.

1.3. Context and Data

1.3.1. Guatemalan income tax and minimum tax scheme

As mentioned earlier in this study, one of the reasons why the analysis of taxpayer behavior is important for developing countries is their persistently low tax revenues. Guatemala represents an example of this reality. With a tax-to-GDP ratio averaging 11% in recent years –of which income tax is only about 2% of GDP–, the difficulties surrounding tax collection are a central aspect of the country's fiscal policy. Evasion levels are believed to be high, given the legal and financial limitations of the tax authority, with some estimates placing the rates of noncompliance for income tax and VAT around 40% and 35%, respectively (ICEFI, 2015).

Guatemala's corporate income tax law allows taxpayers to choose between two schemes, *Regimen General* and *Regimen Optativo*, with the former being a tax on turnover and the latter a tax on profits with a minimum tax (i.e. a minimum tax scheme of the type shown in section 2).

[19] As was the case of panel (a) in Figure 1.3, this seems trivial, as no government would be expected to implement an exemption rule that has no relevance. Nevertheless, this can occur inadvertently for some firms if the MTS exemption threshold is firm-specific, when expressed in terms of the profit margin. The Hungarian exemption rule to their minimum tax scheme provides an example of such a setup.

According to data from *Superintendencia de Administración Tributaria* (SAT), Guatemala's tax authority, approximately 60% of corporate income tax is collected from *Regimen Optativo* (Franco, 2011).

In this paper, the analysis is restricted to firms filing under *Regimen Optativo*. In this regime, firms must pay a tax on profits, with a marginal rate of 31%, if their reported profit margin is at least 3% of reported turnover. Firms reporting a profit margin below this threshold, pay a minimum tax equivalent to 0.93% of their turnover.[20] Additionally, there is an exemption rule based on a firm's reported *gross margin*, a measure that subtracts the direct cost of goods sold (COGS) from turnover but does not consider the costs of services sold.[21] Firms with a gross margin larger than 4% of turnover are non-exempt, while firms with a lower gross margin are eligible to claim the exemption. In order to fully obtain the exemption, qualified firms must also submit a series of legal and accounting documents at least two months before the filing deadline for annual income tax returns.[22]

Finally, it is important to remark that Guatemala's corporate income tax regimes do not allow loss-carryforward. Table 1.1 summarizes the main features of corporate income taxation under *Regimen Optativo*.

1.3.2. Data

[20] The tax rate on profits and the minimum tax changed after 2012, following a tax reform. The data used in this analysis is unaffected by these adjustments, as it does not cover the post-reform period.

[21] The gross margin is regarded as a measure of how a firm's *production costs* relate to its turnover. The cost of goods sold (COGS) refers to the direct costs attributable to the production of the goods sold by a company. This amount includes the cost of the materials used in creating the good along with the direct labor costs used to produce the good. It excludes indirect expenses such as distribution costs and sales force costs.

[22] Among the required documentation, firms must submit an affidavit and externally-audited financial statements.

The data used in this paper comes from a novel panel database of Guatemalan tax administrative records. This dataset contains the universe of corporate income tax returns filed annually under *Regimen Optativo* for the years 2006 to 2012. Since the units of analysis in this paper are all firms filing in this regime, individual taxpayers are not considered in the sample.

Consistency checks were carried out to ensure basic reliability of the data, which resulted in some observations being dropped. Firms reporting revenues from exports are not considered due to the impossibility to distinguish which of them are eligible for income tax exemption under Guatemalan tax law.[23] The total number of observation points remaining after filtering is 133,122, which corresponds to an average of about 19,000 firms per year. Table 1.2 provides summary statistics for the final sample under analysis.

1.4. Empirical Strategy

Based on the theoretical framework developed earlier in this paper, this section adapts the model to the case of the Guatemalan corporate income tax scheme. It starts by describing the scheme's tax liability function and exemption rule in a form comparable to those shown in Section 2. Then, it analyzes the expected behavioral responses of firms in this setting, yielding a set of testable predictions from the model. Finally, it describes the bunching methodology used to estimate firms' responses from the empirical data.

1.4.1. Tax liability function and exemption rule under Regimen Optativo

In terms of the model described in Section 2, the main features of the Guatemalan minimum tax scheme can be incorporated into a tax liability function with the following form,

[23] Exporting firms were, on average, approximately 2,000 per year, for a total of 13,529 observations.

$$T(y, \hat{c}_{COGS}, \hat{c}_o) = \theta \max\{\tau_\pi(y - \hat{c}_{COGS} - \hat{c}_o), 0\} + (1-\theta)\max\{\tau_\pi(y - \hat{c}_{COGS} - \hat{c}_o), \tau_y y\} \quad (13)$$

where,

$$\theta \equiv \begin{cases} 0, & \frac{y-\hat{c}_{COGS}}{y} > 4\% \\ 1, & \frac{y-\hat{c}_{COGS}}{y} \leq 4\%. \end{cases} \quad (14)$$

Here, the variable $\hat{c}_{COGS}$ incorporates the firm's reported cost of goods sold (COGS), while the variable $\hat{c}_o \equiv \hat{c} - \hat{c}_{COGS}$, referred to as "other" costs, is defined as the difference between total reported costs and reported COGS. Notice that, in the first term of equation (13), the inability of exempt firms to carry forward net operating losses creates, in practice, a kink in the tax liability function at $\hat{p} = 0$.[24] The second term of the tax function in equation (13) describes the tax liability faced by non-exempt firms. As in the theoretical framework, this term generates a kink at the MTS payment threshold, which in this context occurs at $\hat{p} = \tau_y/\tau_\pi = 0.93\%/31\% = 3\%$.

A feature of the exemption rule in equation (14) is that it is expressed in terms of the reported gross margin, $\hat{g} \equiv \frac{y-\hat{c}_{COGS}}{y}$. However, in order to reconcile this rule with the theoretical framework, equation (14) needs to be considered in terms of the profit margin, which is the statistic that matters to determine the tax base. This transformation yields,

$$\theta = \begin{cases} 0, & \frac{y-\hat{c}_{COGS}-\hat{c}_o}{y} > 4\% - \frac{\hat{c}_o}{y} \\ 1, & \frac{y-\hat{c}_{COGS}-\hat{c}_o}{y} \leq 4\% - \frac{\hat{c}_o}{y}. \end{cases} \quad (15)$$

[24] The figures presented in Section 2 incorporated this feature; however, for simplicity, the equations representing the theoretical tax liability functions did not.

The key difference between equation (15) and equation (11) –its theoretical equivalent– is that, in this case, the MTS exemption threshold is *firm-specific*, as $\varphi(y, \hat{c}_o) = 4\% - \frac{\hat{c}_o}{y}$. Therefore, firms for which $\varphi(y, \hat{c}_o) \geq 3\%$ will face a tax liability function as in panel (a) of Figure 1.3. Instead, for firms with $\varphi(y, \hat{c}_o) < 3\%$, a tax liability function of the type depicted in panel (b) of the same figure will apply.

To facilitate the understanding of how a firm-specific MTS exemption threshold affects the tax function, it is helpful to see these features graphically. Figure 1.5 shows the implications of this exemption rule on the Guatemalan minimum tax scheme. Panel (a) depicts the tax liability function faced by firms, ignoring the effects of the exemption rule. The figure is equivalent to Figure 1.1, with a MTS payment threshold at 3%. On the other hand, panel (b) incorporates the relationship between the firm's reported profit margin and its reported "other" costs, $\hat{c}_o$, as implied by the exemption rule in equation (15). As it can be seen, the resulting tax function is somewhat complex. In terms of their cost structure, firms can be allocated into one of three groups.[25] Firms with $\frac{\hat{c}_o}{y} \leq 1\%$ face a pure profits tax with a kink at $\hat{p} = 0$, created by the no loss carryforward rule. Those with $1\% < \frac{\hat{c}_o}{y} \leq 4\%$ face a kink at the MTS payment threshold, a notch at the firm-specific MTS exemption threshold, $\varphi(y, \hat{c}_o)$, and a second kink at $\hat{p} = 0$, which basically reproduce the tax liability function of panel (b) in Figure 1.3. Finally, firms with $\frac{\hat{c}_o}{y} > 4\%$ only face a kink at the MTS payment threshold and a notch at $\varphi(y, \hat{c}_o)$, with the latter located at negative values of the firm's reported profit margin. The substantial heterogeneity generated by this complex structure will be useful to corroborate the empirical results shown in later sections.

[25] These groups are separated by the white lines in panel (b) of Figure 1.5.

1.4.2. Firm behavior and testable predictions

Under *Regimen Optativo*, the basic firm's problem can be written as,

$$\max_{y,\,\hat{c}_{COGS},\,\hat{c}_o} \; y - c_{COGS}(y) - c_o(y) - T(y, \hat{c}_{COGS}, \hat{c}_o) - h\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big). \quad (16)$$

In this setting, firms choose output, reported COGS and reported other costs to maximize their after-tax profits. The cost of evasion function, $h\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big)$, considers misreporting of both types of cost.[26] Allowing the total cost function to be expressed as $c(y) = c_{COGS}(y) + c_o(y)$, yields optimal responses in line with those of the theoretical model.[27]

Overall, three groups of testable implications can be considered. The first group relates to firms' expected bunching at the kinks of the tax liability function. The second group results from the repercussions of the notch created by the exemption rule. A third group arises from the differentiated incentives to misreport faced by firms selling physical goods versus those selling services. All these sets of implications are discussed below.

1.4.2.1. Bunching at the kinks of the tax liability function

As shown in Figure 1.2, kinks in the tax liability function can lead to bunching when firms behave optimally. In the Guatemalan setting, there is two differentiated kink-induced responses expected from firms. On the one hand, non-exempt firms face a kink at the MTS payment threshold (i.e.

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[26] As in the theoretical framework, this specification ignores turnover misreporting. The model can be expanded to include this type of misreporting without altering its general conclusions.

[27] This total cost specification assumes that a given firm can only produce a level of output, y, with a unique combination of COGS and other costs. While this assumption about the firm's technology may be too restrictive in the long run, it seems plausible in the short run. For the full derivation of the model's optimality conditions in this setup, see the appendix to this chapter.

$\hat{p} = 3\%$). On the other, exempt firms face the kink at $\hat{p} = 0$. Therefore, the two predictions arising from the existence of kinks in the tax liability function are the following:

Prediction 1 - Non-exempt firms will have incentives to bunch at $\boldsymbol{\hat{p} = 3\%}$. As explained in the theoretical framework, non-exempt firms whose reported profit margin under a profit tax lies below 3% will respond to a minimum tax by decreasing both output and cost misreporting.[28] This, in turn, increases the reported profit margin, causing bunching at the MTS payment threshold.

Prediction 2 - Exempt firms will have incentives to bunch at $\boldsymbol{\hat{p} = 0\%}$. Contrary to the non-exempt group, exempt firms face a kink at $\hat{p} = 0\%$. This is a consequence of the impossibility to engage in loss carryforward. Interestingly, from an analytical point of view this is equivalent to a minimum tax with a tax rate, $\tau_y = 0\%$, which implies that there is no real distortion as firms' optimal output choice is guided by the condition $c'(y) = 1 - \tau_y = 1$. In other words, any observed bunching by exempt firms at the specified threshold cannot be caused by an output response; instead, it would be generated by the evasion response, thus providing direct evidence of firms' cost misreporting behavior.[29]

1.4.2.2. Bunching at the MTS exemption threshold

Figure 1.5 illustrates how the exemption rule of *Regimen Optativo* generates a firm-specific notch in the tax liability function. This notch creates incentives for firms to misreport their gross margin, with the aim of becoming exemption-eligible and avoiding the minimum tax scheme. However,

[28] Conditional on being non-exempt, a firm's reported COGS and other costs are equivalent for tax purposes. Hence, there is no differentiated response in either, and a firm facing the minimum tax will reduce its cost misreporting in both margins.

[29] In a model that allows turnover misreporting, the difference in interpretation is that the evasion response is composed of both turnover and cost misreporting. However, the no-real-response argument remains unaffected.

not all firms face the same misreporting incentives, as discussed earlier. Besides their cost structure, firms' incentives are also affected by their reported profit margin.[30] For instance, a firm with a reported profit margin larger than 3% has no incentives to misreport $\hat{g}$, since their tax liability is the same whether it is exempt or non-exempt. However, if its reported profit margin is lower than 3%, there are two scenarios in which it will have incentives to misreport its gross margin. The first case is when the firm's other costs are such that $4\% \geq \frac{\hat{c}_o}{y} > 1\%$ and their reported profit is positive; this corresponds to the middle quadrant in panel (b) of Figure 1.5. The second case occurs if the firm reports losses and its cost structure is such that $\frac{\hat{c}_o}{y} > 4\%$; a notch is also visible in the respective quadrant in panel (b) of Figure 1.5. Table 1.3 summarizes firms' incentives to misreport the gross margin according to their profitability and cost structure.

The heterogeneity of incentives to misreport the gross margin provides a valuable source of testable implications of the model. The predictions derived from this framework are:

Prediction 3 - Firms with incentives to misreport their gross margin will bunch at $\hat{g} = 4\%$. As discussed above, firms located in quadrants where there is a notch will have incentives to misreport their gross margin. These firms will tend to bunch below $\hat{g} = 4\%$ in order to avoid payment of the minimum tax.

Prediction 4 - Firms with no incentives to misreport their gross margin, will not bunch at this threshold at $\hat{g} = 4\%$. In contrast to the previous group, firms located in quadrants where there is no notch face no incentives to misreport their gross margin. Hence, this group serves as a placebo test, as firms should not bunch at $\hat{g} = 4\%$.

[30] Profit margin groups are separated by the yellow lines in panel (b) of Figure 1.5.

1.4.2.3. Differentiated behavior of merchandise and services firms

An additional implication of the minimum tax exemption rule is that firms selling physical goods –referred to as *merchandise* firms from here onwards– are more likely to engage in misreporting of the gross margin, in comparison to firms selling services. This is because, in the Guatemalan context, the gross margin only takes into consideration the direct costs of producing physical goods, but it does not include the costs of producing services.[31] Thus, it is expected that, on average, merchandise firms will have a lower gross margin than services firms. This means that, for a given profit margin, merchandise firms are expected to be closer to the MTS exemption threshold than services firms. This leads to the following prediction:

> **Prediction 5 - Merchandise firms will show stronger bunching at $\hat{g} = 4\%$ than services firms.** For any given profit margin, merchandise firms will have, on average, a smaller gross margin. Hence, for merchandise firms with an initial gross margin above 4%, the additional COGS misreporting needed to cross the MTS exemption threshold is smaller than that required by services firms. Given the resulting difference in the marginal and total cost of misreporting, merchandise firms are expected to have a stronger response to the notch created by the MTS exemption, in comparison to services firms.

Since it is expected that firms engage in cost misreporting, Prediction 5 cannot be tested directly. This is because the actual values of COGS and other costs are not observable. Therefore, the analysis uses an instrument to separate firms into those likely to have a high ratio of COGS (i.e. lower gross margin before misreporting) and those expected to have a low one. The

[31] For a more detailed explanation, see the description of the gross margin provided in earlier sections.

instrument used exploits the availability of detailed information on the sources of turnover, with firms categorized as either merchandise or services, as follows:

- *Merchandise firms* - Firms reporting sales of physical goods equivalent to more than 80% of total turnover are considered in this category.[32] Given their business focus, a large proportion of total costs coming from either production or inventory costs would be expected. Hence, it is likely that these group of firms will run a high COGS ratio before misreporting occurs.
- *Services firms* - Firms reporting sales coming from services provision amounting to more than 80% of turnover are selected in this category. Due to the nature of their activities, a small proportion of physical goods production or inventory costs would be expected. As a result, these firms are assumed to have a low COGS ratio before any misreporting takes place.

1.4.3. Methodology for the estimation of bunching responses

The existence of kinks and notches allows for the use of bunching techniques to identify firms' responses (Saez, 2010; Chetty et al., 2011; Kleven and Waseem, 2013). In the specific case of a minimum tax scheme, Best et al. (2015) show that firms' responses can be decomposed into an output and an evasion component. This paper uses their method to obtain estimates of those margins of response.

Let us express the reported profit margin as,

[32] This percentage is arbitrary. However, robustness checks were carried out for both types of firms, with values ranging from 51% to 90%. No significant changes in the results were observed.

$$\hat{p} = \frac{y-c(y)}{y} - \frac{(\hat{c}-c(y))}{y}, \tag{17}$$

where the first term in the right-hand side encapsulates the firm's true profit margin, while the second term captures cost misreporting.[33] When $\Delta\hat{p}$ is small the above decomposition can be used to totally differentiate $\hat{p}$ and obtain,

$$\begin{aligned}
\Delta\hat{p} &= \frac{\partial\hat{p}}{\partial y}dy + \frac{\partial\hat{p}}{\partial(\hat{c}-c)}d(\hat{c}-c) \\
&= \left(\frac{\hat{c}}{y} - c'(y)\right)\frac{dy}{y} - \frac{d(\hat{c}-c)}{y} \\
&= ((1-\hat{p})-1)\frac{dy}{y} - \frac{d(\hat{c}-c)}{y} \\
&\approx \frac{{\tau_y}^2}{\tau_\pi}\varepsilon_y - \frac{d(\hat{c}-c)}{y}
\end{aligned}$$

The third row in the previous expression follows from the definition of the reported profit margin and the firm's optimality condition for output. The fourth row approximation arises from realizing that

$\hat{p} \cong \frac{\tau_y}{\tau_\pi}$ in the vicinity of the MTS payment threshold, as well as from the definition of the elasticity of output with respect to the net-of-tax rate,

$$\varepsilon_y \equiv \frac{dy/y}{d(1-\tau)/(1-\tau)}$$

where the fact that $\frac{d(1-\tau)}{(1-\tau)} = -\tau_y$ when crossing the kink is also used.[34]

[33] As this decomposition will be used to obtain response estimates for non-exempt firms, there is no need to distinguish between COGS and other costs.
[34] The basic idea is that, to the right of the MTS payment threshold, the *effective* tax rate on output is zero because costs are fully deductible (i.e. there is no output distortion); however, to the left of the threshold, output is taxed at a rate τ_y. See Best et al. (2015) for further details.

The usefulness of the approximation above is that it allows us to separate the output and evasion responses. The first term in the right-hand side captures the real response as a proportion of the elasticity of output. The decomposition shows that this term will be relatively insensitive to the output elasticity, as $\frac{{\tau_y}^2}{\tau_\pi}$ will be a very small value.[35] The second term absorbs the evasion response, as a proportion of turnover. This latter term can be converted to a ratio of reported profits as follows,

$$\frac{d(\hat{c}-c)}{y} = \left(\frac{y-\hat{c}}{y}\right)\frac{d(\hat{c}-c)}{y-\hat{c}} \approx \left(\frac{\tau_y}{\tau_\pi}\right)\frac{d(\hat{c}-c)}{y-\hat{c}}$$

In order to obtain empirical estimates using the previous decomposition, an estimate of the change in the reported profit margin is required. This estimate can be calculated from the excess mass observed at the bunching point. Following Saez (2010), when the bunching response, B, is local we can approximate the change in the reported profit margin as,

$$B \approx \Delta\hat{p}\, f_0\left(\frac{\tau_y}{\tau_\pi}\right) \iff \Delta\hat{p} \approx \frac{B}{f_0\left(\frac{\tau_y}{\tau_\pi}\right)}$$

where $f_0\left(\frac{\tau_y}{\tau_\pi}\right)$ is the density of the profit margin around the MTS payment threshold in the absence of the minimum tax kink.

The key aspect for this calculation to provide a good estimate of the bunching response is the choice of counterfactual density distribution. The standard approach in the literature is to fit a polynomial using data from the empirical density distribution, leaving out the area visibly affected by the bunching response. However, in the setting of this paper applying that procedure directly

[35] In the case of the Guatemalan tax system, this value is equal to 0.000279.

would likely lead to a biased estimate of the bunching response. This is because in the absence of a minimum tax, firms would be expected to bunch at $\hat{p} = 0\%$, due to the no loss carryforward rule. Since, under a minimum tax, non-exempt firms are not expected to bunch at that threshold, using the empirical density distribution of this group to estimate the counterfactual distribution would not be appropriate. Instead, the approach followed here is to obtain the counterfactual distribution from the empirical density distribution of exempt firms, as this group represents the environment that would be faced by non-exempt firms in the absence of the minimum tax.

1.5. Empirical Results

This section shows the empirical evidence obtained using Guatemalan tax administrative data. First, evidence of bunching at the MTS payment threshold is analyzed. Second, evidence of gross margin misreporting is presented. Finally, estimates of evasion obtained from the bunching responses are provided.

1.5.1. Evidence of bunching at the kinks

Prediction 1 states that non-exempt firms will have a tendency to bunch at the MTS payment threshold, while Prediction 2 indicates that exempt firms will have bunching incentives at $\hat{p} = 0\%$. The empirical evidence shown in Figure 1.6 strongly supports these theoretical predictions. Panel (a) presents the density distribution of the reported profit margin for exempt and non-exempt firms. As seen in the figure, for the case of non-exempt firms there is clear evidence of bunching at $\hat{p} = 3\%$. In contrast, exempt firms show large bunching at $\hat{p} = 0\%$, although there is also a smaller amount of bunching at the MTS threshold.

A possible explanation for the unexpected bunching of exempt firms at the MTS payment threshold is that there are fixed costs of obtaining the exemption.[36] In other words, a firm may be exemption-eligible, but may decide not to claim this benefit if the costs of doing so exceed the tax gains received by the firm. As explained earlier in the paper, firms claiming the MTS exemption face costs associated with submitting a series of legal and accounting documents well in advance of the filing deadline. A firm that has not complied with these requirements is liable to pay the minimum tax, which means it faces the same incentives as non-exempt firms. Unfortunately, the dataset does not include information on whether a given firm presented this documentation or not.

However, one way to indirectly test this hypothesis is to analyze firms' behavior by turnover groups. If the costs of obtaining the exemption are fixed, firms with higher turnover should be less affected by them, as they represent a smaller proportion of their turnover. Panel (b) of Figure 1.6 provides some empirical support for this hypothesis. Exempt firms with a reported turnover below 8 million quetzales –*low turnover* firms– show sizeable bunching at the MTS payment threshold.[37] In contrast, exempt firms with a reported turnover above 8 million quetzales –*high turnover* firms– appear to behave differentially, as they bunch significantly at $\hat{p} = 0\%$, while having a negligible concentration at the MTS threshold. As a comparison, non-exempt firms do not seem to alter their behavior, independently of their level of turnover.

Further evidence in support of the fixed-cost hypothesis is provided in panels (c) and (d) of Figure 1.6. In the first of these panels, the density distribution of the reported profit margin is shown for firms, according to their cost structure. As indicated in Figure 1.5 and Table 1.3, firms

[36] The literature on crime displacement has highlighted the importance of fixed costs when enforcement is selective. For instance, Yang (2008a) analyzes the role of fixed costs of switching to alternative duty-avoidance methods in the context of customs reform in the Philippines, finding evidence consistent with their existence.
[37] The exchange rate for the Guatemalan quetzal was roughly Q8 per US$1 for the period of analysis.

face different misreporting incentives depending on their ratio of other costs to turnover. Firms with $\frac{\hat{c}_o}{y} \leq 1\%$ essentially face a pure profit tax and, hence, should not show any bunching at the MTS payment threshold in the absence of fixed costs. However, the empirical density shows bunching at this threshold. As in the case of panels (a) and (b), the density distributions presented in panel (d) illustrate that this bunching diminishes significantly for firms with a higher level of turnover. Interestingly, firms with $1\% < \frac{\hat{c}_o}{y} \leq 4\%$ behave in a similar fashion as the previous group, suggesting that misreporting incentives are strong for this group. Instead, firms with $\frac{\hat{c}_o}{y} > 4\%$ do not show any differentiated behavior, a pattern consistent with the fixed-costs hypothesis.

1.5.2. Evidence of gross margin misreporting

As explained earlier in this paper, the income tax scheme under *Regimen Optativo* creates incentives for some firms to bunch below the gross margin exemption threshold, with the intention of avoiding the minimum tax. Figure 1.7 shows evidence that firms behave according to what is predicted by the theoretical model. Panel (a) displays the density distributions for firms with incentives to misreport the gross margin and those without these incentives.[38] As expected from Predictions 3 and 4, the first group shows significant bunching at the MTS exemption threshold, while the latter group does not. The two points of observed bunching for the group without incentives to misreport correspond to the kinks in the tax liability function, but not to the notch.[39]

Panel (b) of Figure 1.7 also provides strong evidence in favor of the theoretical predictions. First, it can be seen that firms reporting losses show large bunching at the MTS exemption

[38] See Table 1.3 for the definition of which firms have incentives to misreport their gross margin and which do not.
[39] The reported profit margin can be expressed as $\hat{p} = \hat{g} - \frac{\hat{c}_o}{y}$. Hence, for firms with a small value of $\frac{\hat{c}_o}{y}$, we get that $\hat{p} \approx \hat{g}$. This means that the observed bunching at $\hat{p} = 0\%$ and $\hat{p} = 3\%$ in Figure 1.6 will be partially visible around $\hat{g} = 0\%$ and $\hat{g} = 3\%$, as seen for firms without incentives to misreport in panel (a) of Figure 1.7.

threshold. This is important because these firms do not face a local kink in their tax liability function, indicating that their bunching behavior at that point can only be reconciled with gross margin misreporting. Moreover, firms reporting a non-negative profit margin below 3% also bunch significantly at the MTS exemption threshold. Once again, this is consistent with the theory, as this group faces strong incentives to misreport their gross margin. Finally, firms with a reported profit margin above 3% provide a placebo test, as they should not bunch at the MTS exemption threshold. This is because they do not face the minimum tax, given that their reported profit margin is above the MTS payment threshold. Indeed, the figure shows that there is no observed bunching in this group.

Additionally, panels (c) and (d) in Figure 1.7 offer graphical evidence of gross margin misreporting for merchandise and services firms. Two features are significant in these graphs. On the one hand, firms with misreporting incentives bunch at the MTS exemption threshold, while those without these incentives do not bunch. This pattern, consistent with Predictions 3 and 4, occurs independently of whether the firms are merchandise or services firms. On the other hand, the intensity of the bunching at the critical threshold is weaker for services firms, a feature consistent with Prediction 5. In all, this pattern is suggestive of services firms facing, on average, higher costs of gross margin misreporting than merchandise firms.

1.5.3. Bunching responses estimates

The previous results provided evidence of firms' bunching responses and their consistency with the theoretical framework. This subsection builds on that behavior in order to calculate estimates of the bunching response, applying the methodology detailed in Section 4. The analysis focuses on firms with a reported profit margin between 0% and 4%, for two reasons. First, in this range there is a common support between exemption-eligible and non-exempt firms, allowing for meaningful comparisons of the two groups. Second, restricting the analysis to firms not reporting losses facilitates a better fit of the counterfactual distributions, which in turn results in better estimates of the bunching response at the minimum tax kink.

Figure 1.8 displays the empirical density distribution of the profit margin for exemption-eligible firms. It also presents the estimated counterfactual density for this group. Using these two distributions, the estimated excess bunching, b, caused by the fixed-costs of claiming the exemption is calculated at 5.66.[40] Table 1.4 provides details of this estimation. For instance, the implied average profit margin response at the MTS payment threshold consistent with this level of bunching is 0.57 percentage points. If this response was only driven by a real adjustment (i.e. no evasion response), the estimated output elasticity would be 20.28, a value well above the typical range found in the literature.[41] Instead, imposing more reasonable output elasticity values —from 0 to 10— yields estimated evasion responses ranging from 9.56% to 18.36% of reported profits.

A more dramatic picture is given by non-exempt firms. Figure 1.9 illustrates the empirical density distribution for this group and compares it to the estimated counterfactual distribution of exemption-eligible firms. As argued earlier in this study, the latter distribution is the appropriate counterfactual for non-exempt firms, due to the existence of the no loss carryforward rule. For this reason, in this context, the estimation procedure refrains from using the typical polynomial regression, which would fit data from non-exempt firms.[42] In its place, the bunching response is

[40] As in Best et al. (2015), the value of the excess bunching presented here is scaled by the average counterfactual density around the kink. Formally, $b = \hat{B}/E(\hat{d}_j | j \in [p_L, p_U])$, where $\hat{d}_j$ represents the estimated counterfactual density at j, and $[p_L, p_U]$ defines the excluded range.

[41] See, for example, Gruber and Rauh (2007), Devereux et al. (2014), and Patel et al (2017).

[42] For comparison purposes, the estimation results derived from fitting a flexible polynomial to the density distribution of non-exempt firms are shown in Table A.1 in the appendix to this chapter.

calculated by comparing the empirical density of non-exempt firms and the counterfactual distribution estimated with data from exemption-eligible firms.

Given the above procedure, the estimate of b is much larger than in the preceding case, at 41.28. The implied average profit margin response is 4.13 percentage points, more than seven times larger than the equivalent response for exemption-eligible firms. In itself, the difference in estimated values for the profit margin response provides an interesting comparison of the impact that the minimum tax scheme has on firms' reporting. This difference is even more striking when contrasting estimates of the real and evasion responses. Assuming no evasion, the estimated output elasticity for this group is a massive 147.96, a value that can be safely disregarded as unrealistic. When imposing reasonable output elasticities, the evasion response still shows disproportionate values, ranging from 128.30% to 137.60% of reported profits.

The key to reconciling such large values with meaningful estimates of evasion is to note that this response, in terms of *reported* profits, can be linked to the firm's response in terms of *actual* profits via,

$$\frac{d(\hat{c}-c)}{y-c} = \left(\frac{y-\hat{c}}{y-c}\right)\frac{d(\hat{c}-c)}{y-\hat{c}}.$$

The ratio of reported-to-actual profits, $(y-\hat{c})/(y-c)$, is unobserved. However, in a tax system with no loss carryforward, it is possible to estimate an upper-bound for this ratio. Since reported profits can be expressed as, $(y-\hat{c}) = (y-c) - (\hat{c}-c)$, then the ratio of reported-to-actual profits can be written as,

$$\left(\frac{y-\hat{c}}{y-c}\right) = 1 - \left(\frac{\hat{c}-c}{y-\hat{c}}\right)\left(\frac{y-\hat{c}}{y-c}\right).$$

Solving for the variable of interest yields,

$$\left(\frac{y-\hat{c}}{y-c}\right)=\frac{1}{1+\left(\frac{\hat{c}-c}{y-\hat{c}}\right)}.$$

While the ratio of reported costs to reported profits is also unobserved, in the absence of loss carryforward the model predicts that the absolute value of the evasion response cannot be larger than total misreporting. This is because there is no benefit of reporting losses if they cannot be carried forward to the next fiscal year. Using this fact, we can obtain an upper-bound for the ratio of reported-to-actual profits as follows,

$$\left(\frac{y-\hat{c}}{y-c}\right)\leq\frac{1}{1+\left|\frac{d(\hat{c}-c)}{y-\hat{c}}\right|}.$$

The above formula is very useful, as it allows us to obtain an estimate of the minimum level of evasion (as a proportion of actual profits), directly from the estimated evasion response. In the context of a minimum tax scheme, this estimate should be interpreted as the ratio of reported-to-actual profits that would be observed in the absence of the minimum tax.

Table 1.4 summarizes the estimates of the evasion response and the ratio of reported-to-actual profits for the Guatemalan case. As it can be seen, the data suggests that evasion is a big concern, with estimates of the average ratio of reported-to-actual profits ranging between 0.42 to 0.91. Such magnitudes are indicative of an environment where tax enforcement is weak, creating strong incentives for firms' misreporting.

While the implied levels of evasion derived from these estimates seem high when compared with expected levels of evasion in developed economies, these numbers are not entirely surprising for developing countries. For instance, Bachas and Soto (2017) estimate that evasion could be as large as 70% of actual firm profits in the case of Costa Rica. Similarly, Pecho et al. (2012) present estimates for income tax non-compliance in several Latin American countries during the period 2000-2010; their estimates range from 34.5% in Colombia to 72% in Guatemala.

1.6. Conclusions

This paper studies firm responses under a minimum tax in the context of a developing country. The study of such behavior is important for societies in the developing world for two reasons. First, many of these countries collect lower tax revenues than advanced economies, despite similar statutory rates. Second, in environments with weak enforcement, governments are inclined to use production-inefficient taxation, such as minimum tax schemes, in order to increase revenues. Recent work by Best et al (2015), suggests that these policies can improve social welfare through their effect on the government's revenue efficiency.

Besides the behavioral consequences of the kink created by minimum taxes in the tax liability function, the present study also analyses the implications of exemption rules in this framework. As shown in the paper, the revenue effectiveness of minimum tax schemes is negatively affected by the existence of exemption rules allowing firms to avoid the minimum tax. Depending on their specification, these exemption rules can create *firm-specific* upward or downward notches in the tax liability function faced by firms. The resulting incentives on firms' reporting behavior run contrary to the government's objective of increasing tax collection.

The empirical evidence from Guatemalan corporate income tax returns provides strong support to the paper's theoretical predictions. As expected, firms facing the upward notch created by *Regimen Optativo*'s exemption rule respond by significantly bunching below the exemption threshold. Interestingly, this behavior is also salient in firms reporting negative profits, despite the fact that it implies an overstatement of their losses. Additionally, the analysis finds differentiated responses for merchandise and services firms, with the former group showing stronger bunching behavior. This is consistent with the fact that, on average, merchandise firms face lower marginal costs of crossing the exemption threshold than services firms.

The empirical results also suggest that the Guatemalan minimum tax scheme contributes considerably to the reduction of tax evasion among firms that cannot avoid this scheme. Non-exempt firms bunch significantly at the minimum tax kink, a behavior consistent with a reduction in firms' misreporting. Estimates of the evasion response in this group suggest a reduction in misreporting of as much as 137% of *reported* profits. Using this estimate, the paper exploits the no loss carryforward rule of *Regimen Optativo* to calculate an upper bound for the ratio of reported-to-actual profits. According to these computations, firms report, on average, no more than 42% of their true profits in the absence of the minimum tax scheme. This number implies that evasion arising from profit misreporting would be at least 58% of actual profits if this scheme was not in place. Hence, the results provide empirical support to the view that minimum taxes can be an effective mechanism to lower tax evasion in environments with limited enforcement capabilities.

1.7. References

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1.8. Figures and Tables

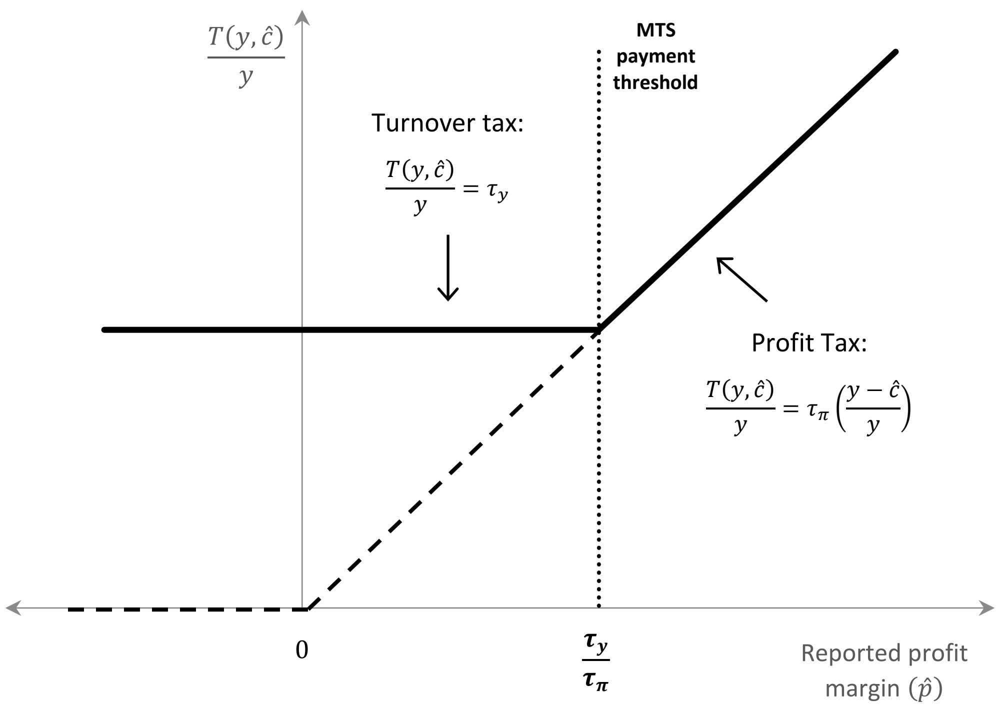


Figure 1.1 – Income tax liability function under a minimum tax scheme. The figure illustrates the implications of introducing a minimum tax on the income tax liability function, expressed as a proportion of turnover, y. The dashed line shows what the tax liability would have been under a pure profits tax (assuming no loss carryforward); the solid line corresponds to the tax liability under the minimum tax scheme. Firms with a reported profit margin, $\hat{p} \equiv \frac{y-\hat{c}}{y}$, above the threshold $\frac{\tau_y}{\tau_\pi}$ face a tax rate τ_π on reported profits. Instead, firms with a reported profit margin below the threshold pay a tax rate τ_y on turnover. As a result, the conditions that characterize firm behavior change depending on which side of the threshold the firm is located.

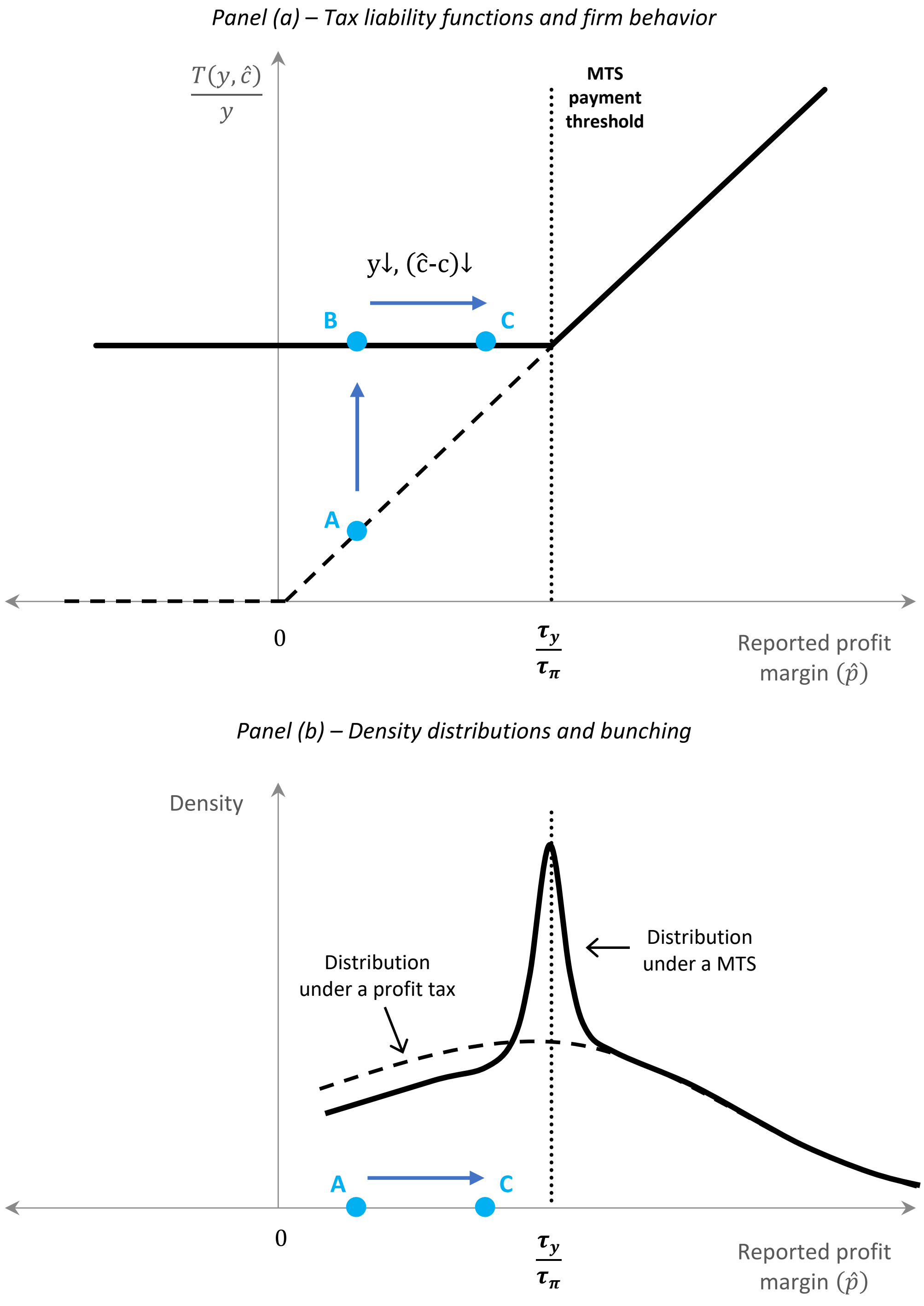


Figure 1.2 – Firm behavior and bunching when switching from a profit tax to a minimum tax scheme. Point A depicts a firm facing a profit tax, with an initial reported profit margin below the MTS payment threshold. When a minimum tax scheme is introduced, the firm suddenly finds itself at point B, where the initial reported profit margin does not reflect the firm's optimal choices any longer. Under the new tax incentives, the firm responds by reducing both its output and misreported cost. The firm's new optimal choice is illustrated by point C, where the reported profit margin moves closer to the MTS payment threshold, causing bunching in the density distribution.

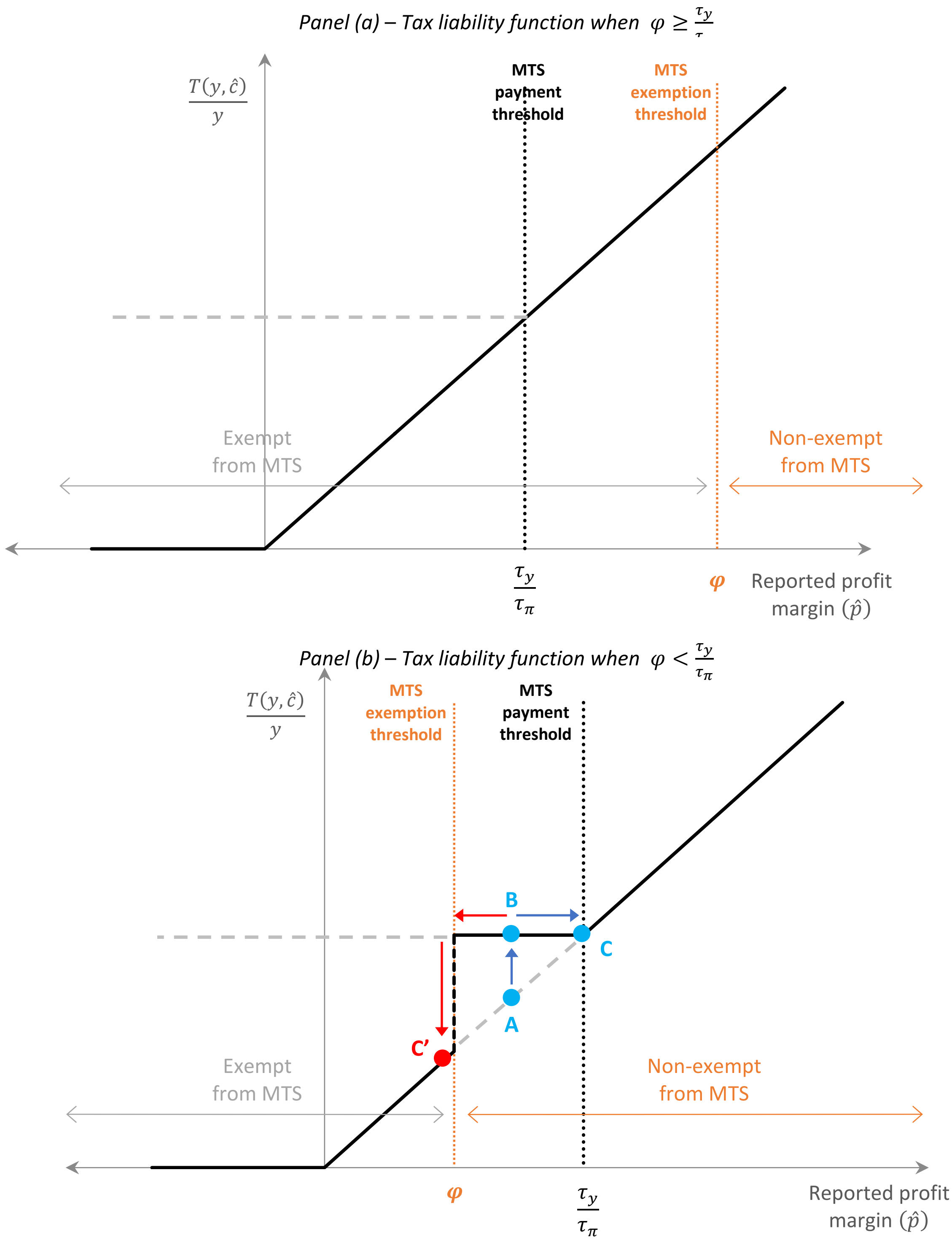


Figure 1.3 – Implications of exemption rules that create an upward notch. In the above graphs, firms' exemption from a minimum tax scheme is dictated by the parameter φ. To the left of φ firms are exempt and, hence, the tax function corresponds to that of a pure profit tax. Instead, to the right of φ firms are non-exempt, resulting in a tax function akin to that of Figure 1. Panel (a) illustrates the case where φ effectively eliminates the MTS, while panel (b) shows the case where it creates an upward notch at the MTS exemption threshold. In contrast to the environment in Figure 2, a firm in panel (b) can now choose to move from points A to C, or from points A to C'.

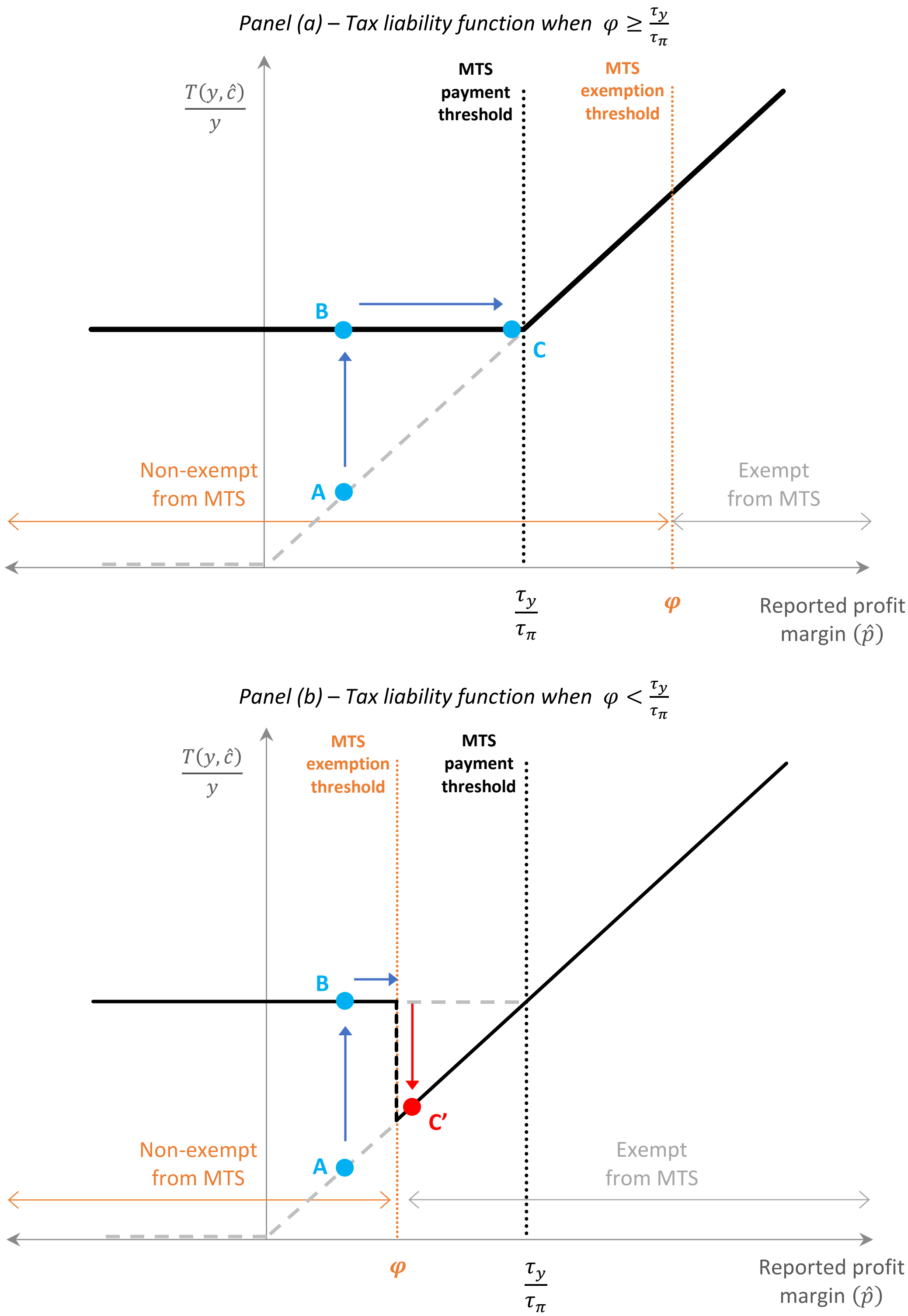
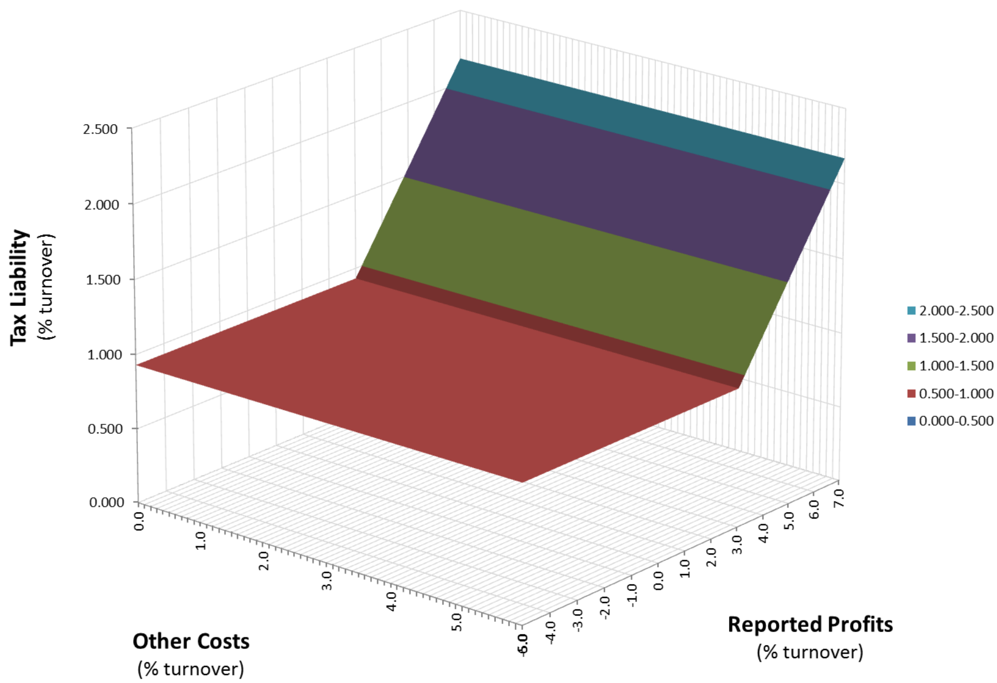


Figure 1.4 – Implications of exemption rules that create a downward notch. Firms' exemption from the minimum tax scheme is defined by the parameter φ. Firms with a reported profit margin below φ are non-exempt and, thus, face a tax function identical to that of Figure 1. Instead, firms to the right of φ are exempt, facing a tax function that corresponds to a pure profit tax. Panel (a) illustrates the case where φ has no impact on the MTS tax liability function; firms in this setting behave as in Figure 2, moving from points A to C. Panel (b) shows the case where a downward notch is created; firms respond to the new tax incentives by moving from points A to C'.

Panel (a) – Minimum Tax Scheme for non-exempt firms under Regimen Optativo



Panel (b) – Minimum Tax Scheme and Exemption Rule under Regimen Optativo

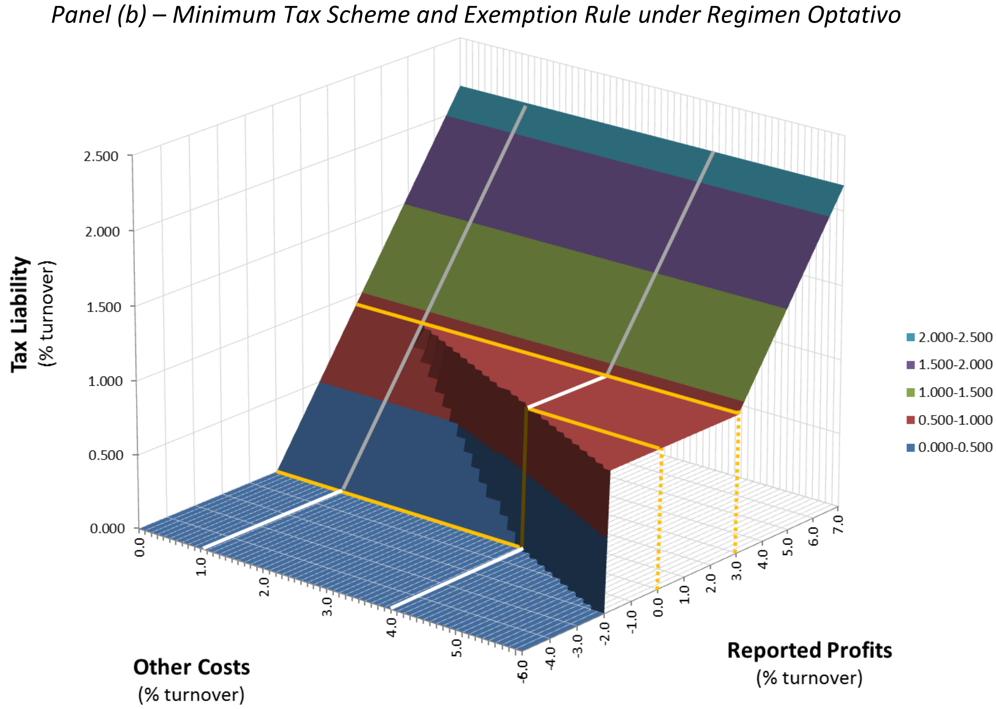
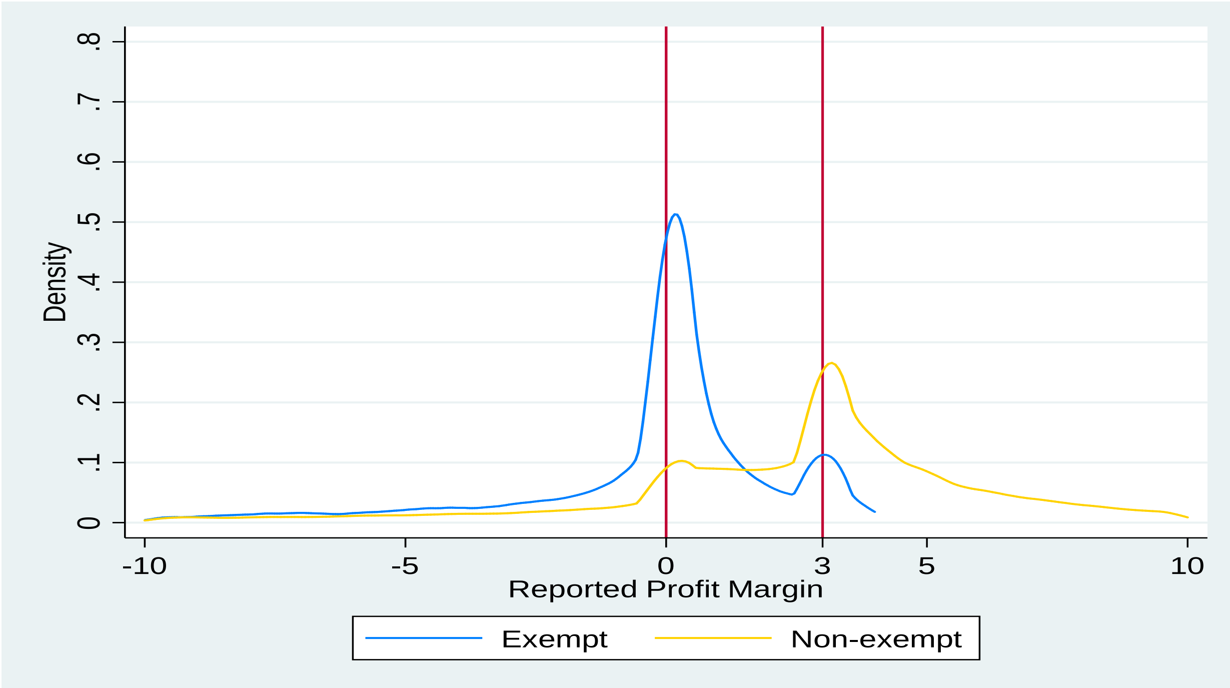


Figure 1.5 – Implications of the exemption rule for the Guatemalan minimum tax scheme. Panel (a) displays the minimum tax scheme, ignoring the implications of the exemption rule. Non-exempt firms face a kink in the tax function at $\hat{p} = 3\%$. When accounting for the exemption rule, the tax function also features a notch whose location varies depending on the firm-specific MTS exemption threshold. Panel (b) shows that this location is related to the firm's reported "other" costs (i.e. the difference between the firm's total costs and COGS).

Panel (a) – By exemption-eligibility



Panel (b) – By exemption-eligibility and turnover

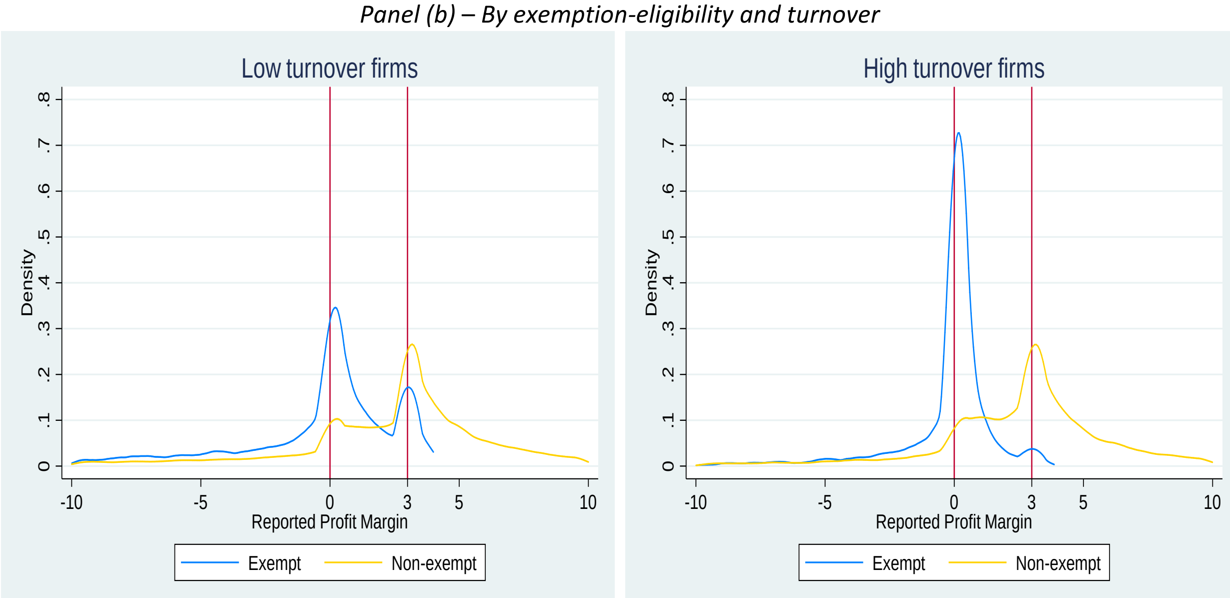
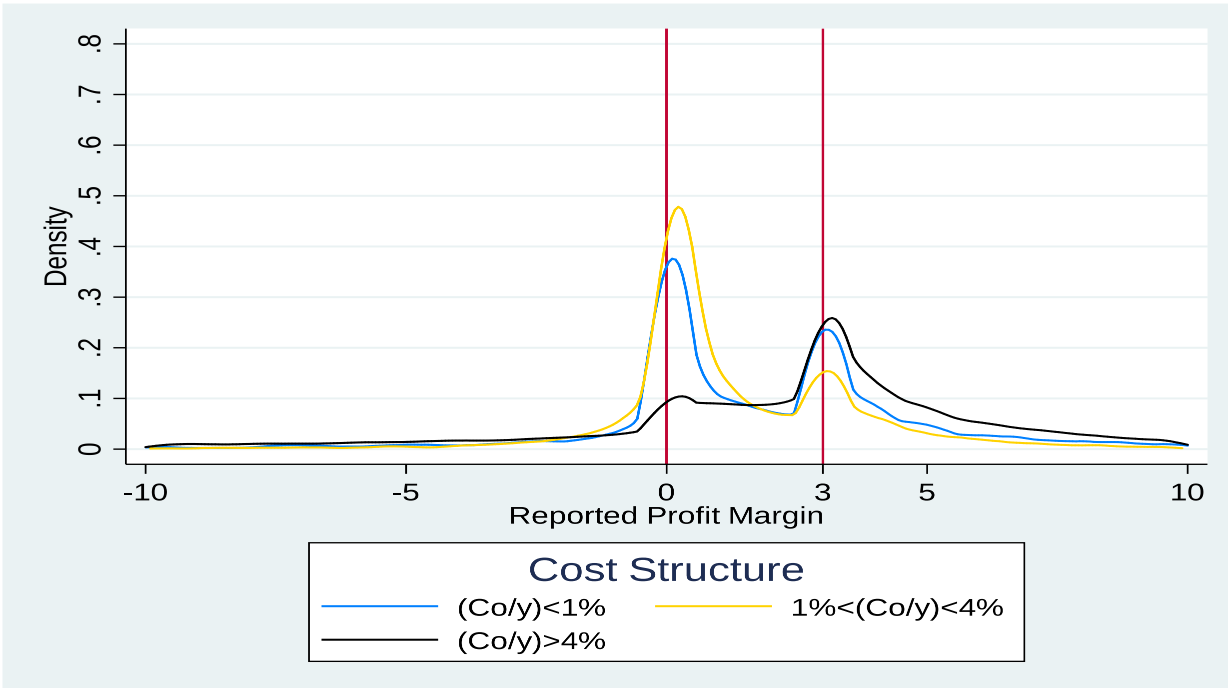


Figure 1.6 – Kernel density distributions of reported profit margin. – *Panels (a) and (b)* – Panel (a) shows the kernel density distribution of reported profit margin for exempt and non-exempt firms. As expected, exempt firms bunch at $\hat{p} = 0\%$, while non-exempt firms do so at $\hat{p} = 3\%$. Panel (b) displays the corresponding distributions for low-turnover and high-turnover firms. Low-turnover firms are those reporting less than Q8 million turnover annually – about US$1 million–, and high-turnover firms include those reporting more than this amount. The evidence is consistent with the existence of fix costs for claiming the exemption, as the behavior of high turnover exempt firms is substantially different than that of low turnover exempt firms. The bin size used in the kernel densities is 0.25.

Panel (c) – By cost structure



Panel (d) – By cost structure and turnover

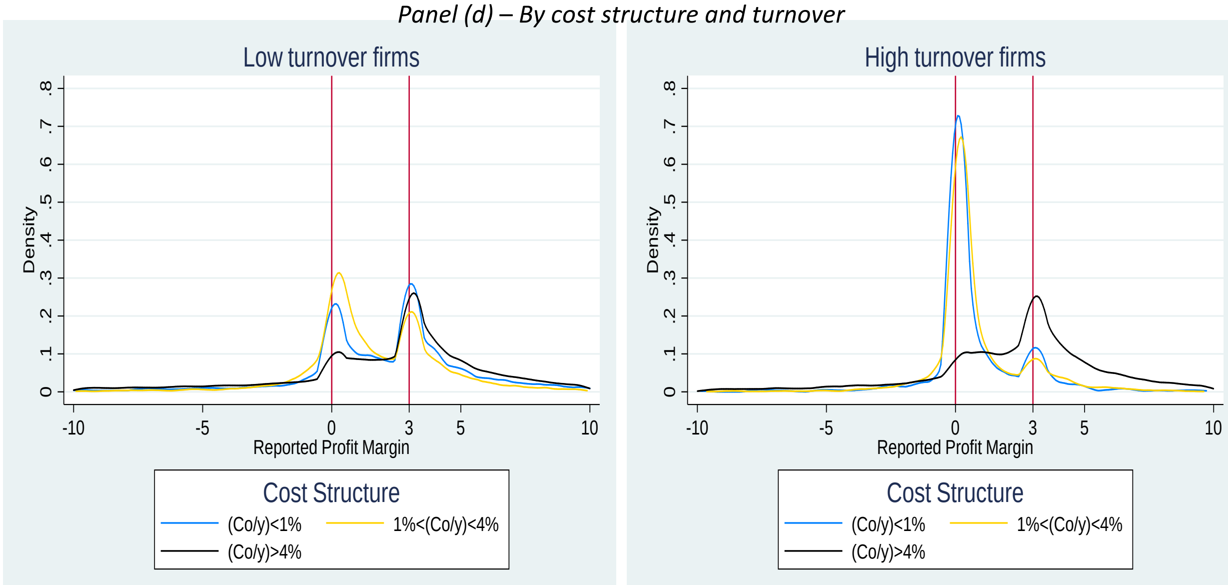
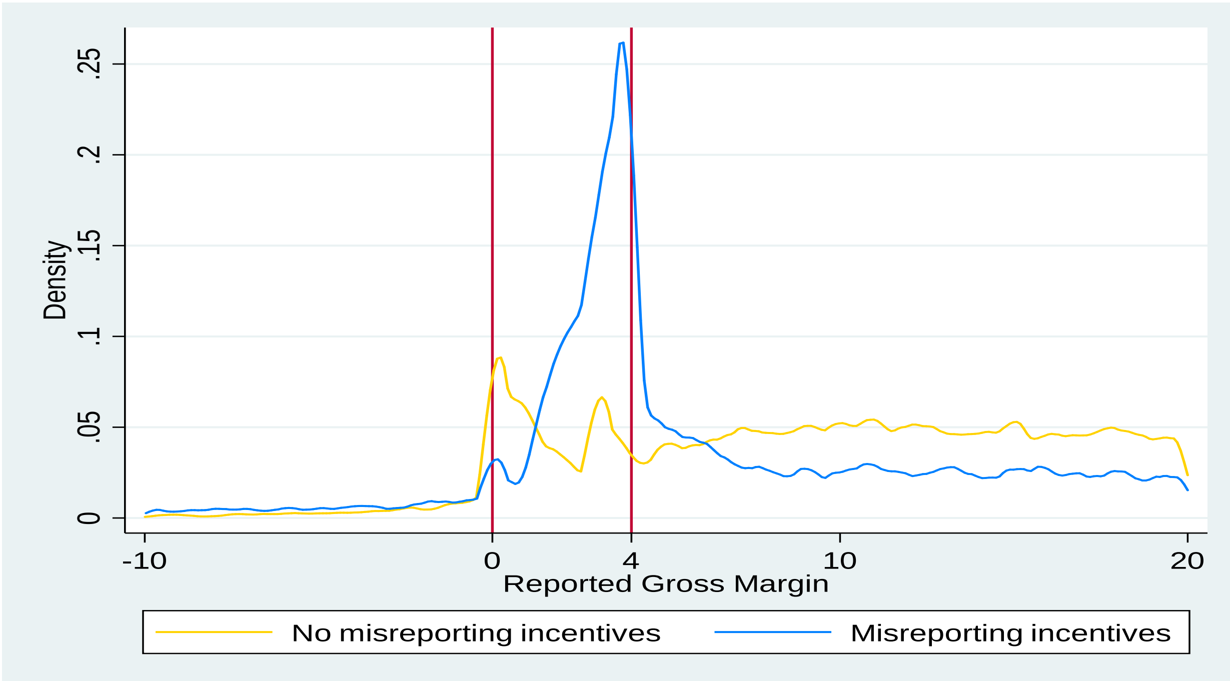


Figure 1.6 – Kernel density distributions of reported profit margin. – *Panels (c) and (d)* – Panel (c) presents the kernel density distribution of reported profit margin for firms according to their cost structure. As expected, firms with $\frac{\hat{c}_o}{y} > 4\%$ bunch at the MTS payment threshold, while firms with lower other costs ratio have a stronger tendency to bunch at $\hat{p} = 0\%$. Panel (d) shows the respective distributions for low-turnover and high-turnover firms. As in panel (b), the graphic evidence is consistent with the existence of fixed costs of claiming the exemption. The bin size used in the kernel densities is 0.25.

Panel (a) – By misreporting incentives



Panel (b) – By profitability

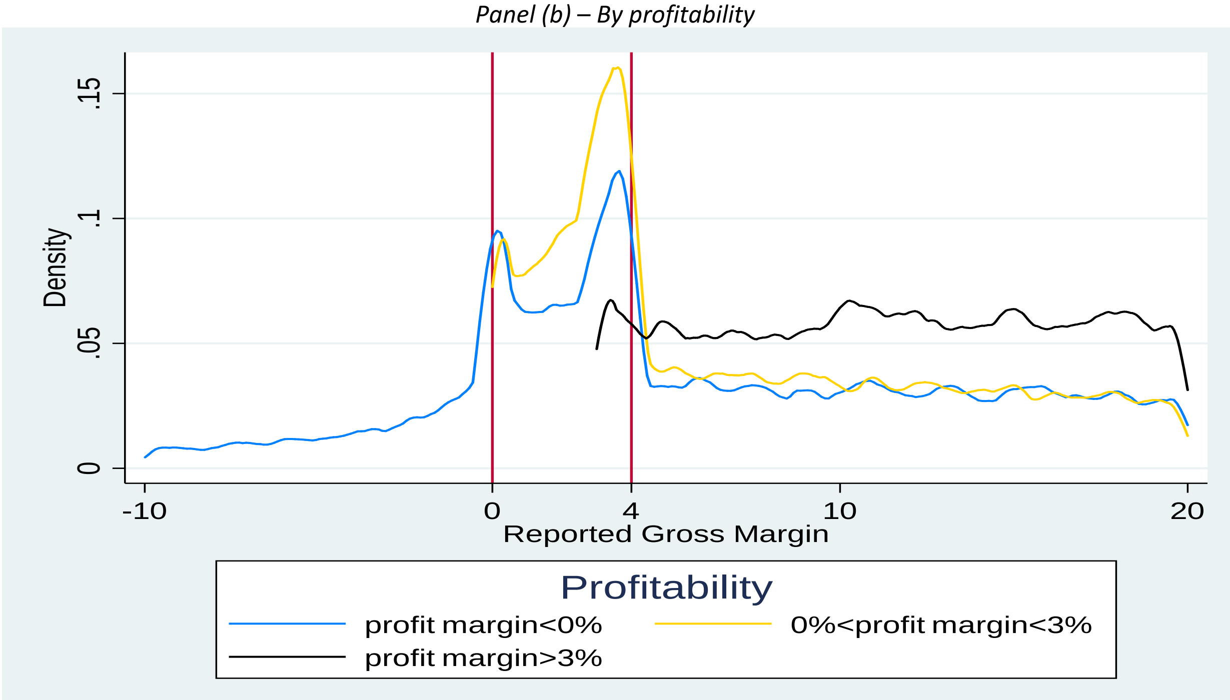
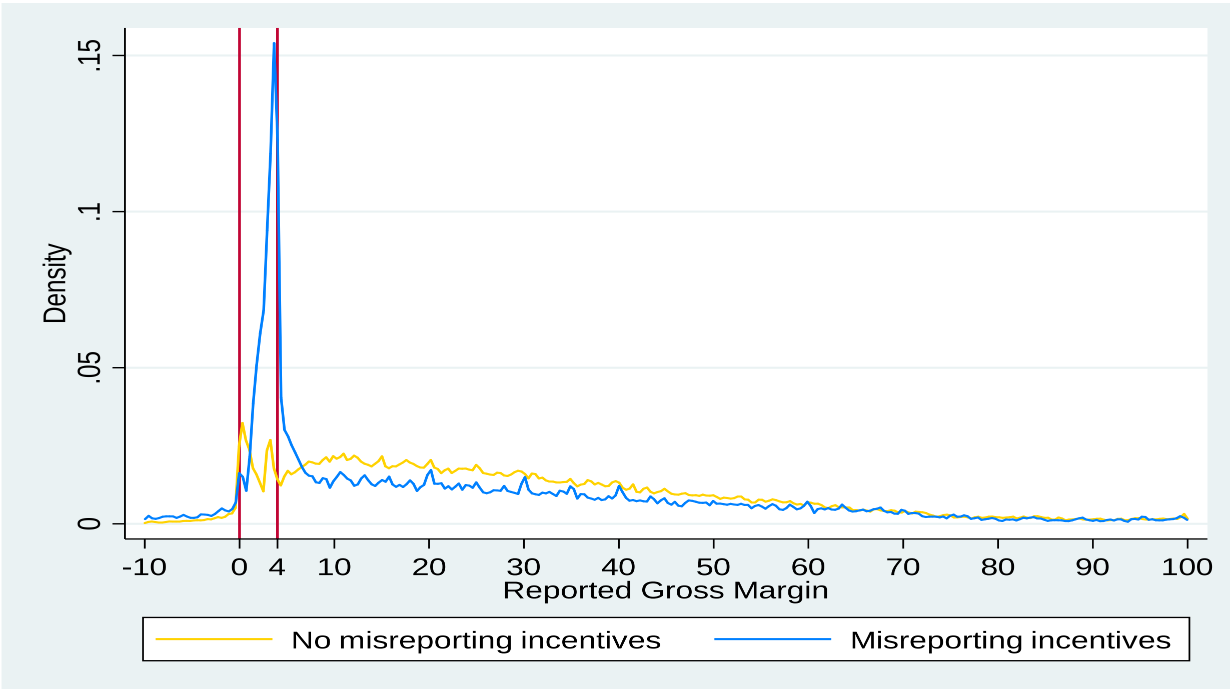


Figure 1.7 – Kernel density distributions of reported gross margin. – *Panels (a) and (b)* – Panel (a) shows the density distribution of the reported gross margin for firms with and without misreporting incentives. For those with misreporting incentives, bunching occurs at the MTS exemption threshold. In contrast, firms with no misreporting incentives, do not show bunching at the same threshold. Panel (b) presents the density distribution for firms with different profit margin ranges. Firms with a reported profit margin below 3% show significant bunching, but those with a larger profit margin do not. This behavior is consistent with differentiated misreporting incentives.

Panel (c) – Merchandise firms, by misreporting incentives



Panel (d) – Services firms, by misreporting incentives

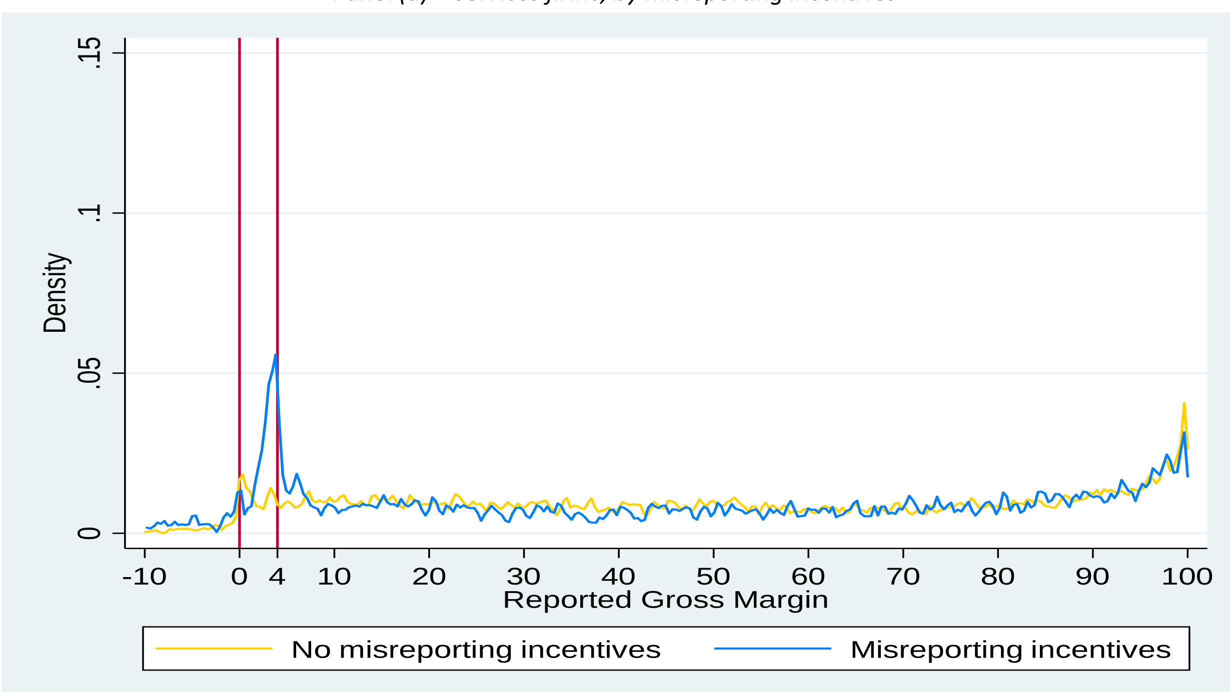


Figure 1.7 – Kernel density distributions of reported gross margin. – *Panels (c) and (d)* – Panel (c) illustrates the density distribution of the reported gross margin for merchandise firms with and without misreporting incentives. As expected, significant bunching occurs at the MTS exemption threshold for the group with misreporting incentives only. Panel (d) displays a similar pattern for services firms. Moreover, it shows that the intensity of the bunching is weaker for services firms in comparison to merchandise firms, as predicted by the theory. The bin size used in the graphs is 0.2.

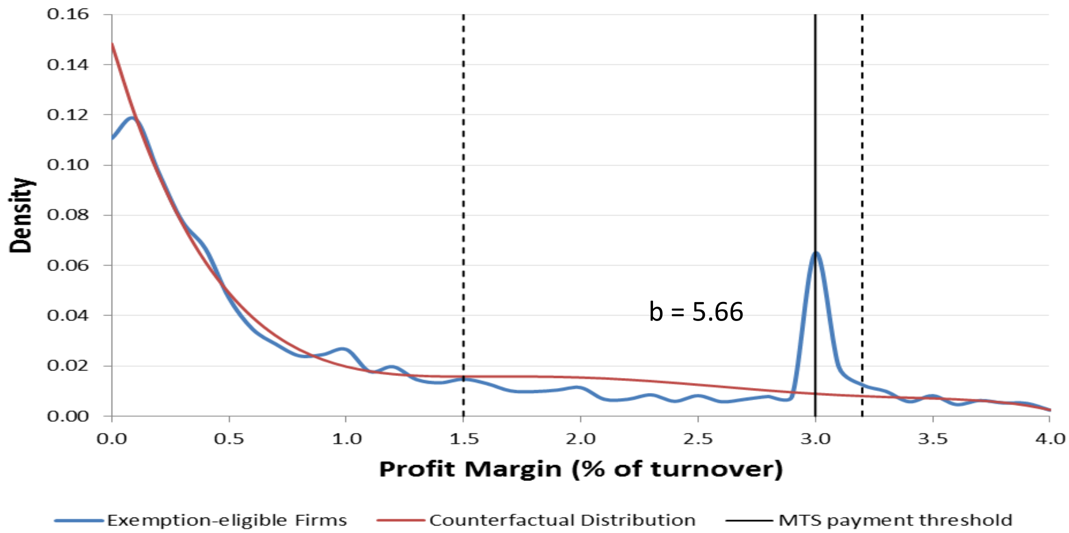


Figure 1.8 – Bunching Estimation for Exemption-eligible Firms at the MTS payment threshold. The figure illustrates the empirical density of the profit margin (in % of turnover) and the estimated counterfactual density for exemption-eligible firms. The counterfactual density is estimated from the empirical density, using a fifth-order polynomial, excluding data around the threshold where bunching is visible, and imposing that the excess area created by this bunching be equal to the missing area in the affected region to the left of the threshold. The excluded area is delimited by the two dashed vertical lines. A bin size of 0.1 is used to plot the graph. Since firms in this group are eligible to claim the minimum tax payment exemption, the bunching at the MTS threshold arises from the existence of fixed costs and other frictions that prevent firms from claiming this exemption.

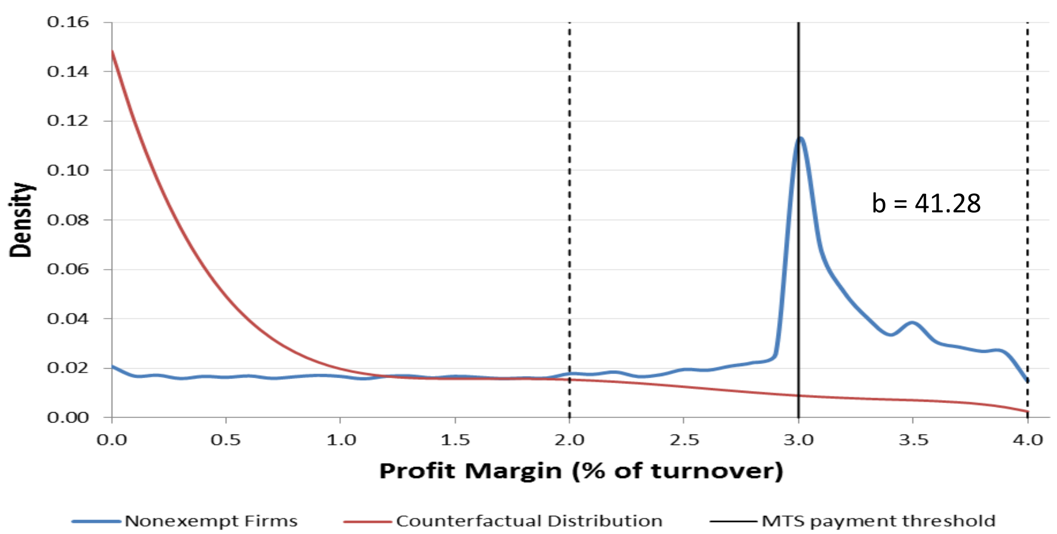


Figure 1.9 – Bunching Estimation for Non-exempt Firms at the MTS payment threshold. The figure above illustrates the empirical density of the profit margin (in % of turnover) for non-exempt firms, using a bin size of 0.1. The counterfactual density shown corresponds to that estimated from the empirical density of exempt firms as in Figure 1. This counterfactual density captures the fact that non-exempt firms would face similar incentives to exemption-eligible firms if they were not subject to pay the minimum tax. The estimated excess mass in this figure comes from the difference between the depicted densities in the range enclosed by the dashed vertical lines.

Table 1.1 – Corporate Income Tax Rates and Tax Bases under *Regimen Optativo*

	Firms reporting losses	Firms reporting profits	
	$0\% > \hat{p}$	$3\% > \hat{p} \geq 0\%$	$\hat{p} \geq 3\%$
Non-exempt $\hat{g} > 4\%$	0.93% of reported turnover and no loss carryforward	0.93% of reported turnover	31% of reported profits
Exempt $4\% \geq \hat{g}$	0% of reported profits and no loss carryforward	31% of reported profits	31% of reported profits

Notes: $\hat{p}$ denotes a firm's reported *profit* margin; $\hat{g}$ indicates a firm's reported *gross* margin.

Table 1.2 – Summary Statistics for Firms under *Regimen Optativo*

Indicator	Full Sample	2006	2007	2008	2009	2010	2011	2012
	A. Means (in millions of Quetzales)							
Profits	0.3	0.4	0.3	0.3	0.2	0.3	0.4	0.3
Turnover	10.1	8.3	10.0	9.8	9.7	9.9	10.9	11.6
Total Costs	9.7	7.9	9.6	9.5	9.5	9.6	10.6	11.3
COGS	6.0	4.8	6.2	5.9	5.7	5.8	6.4	6.8
Profit Margin	-1.2%	-0.1%	-0.5%	-1.4%	-1.7%	-1.8%	-1.3%	-1.5%
Gross Margin	59.4%	60.5%	59.8%	59.5%	59.2%	58.7%	58.9%	59.0%
	B. Other Characteristics							
Share of exemption-eligible firms	9.4%	8.5%	9.0%	9.4%	9.6%	10.2%	9.8%	9.4%
Share of returns filed electronically	44.9%	26.9%	37.3%	40.1%	45.1%	49.2%	53.4%	59.0%
Observations	133,122	17,222	18,404	18,606	19,068	19,767	20,103	19,952

Notes: The statistics above are calculated including only the sample of firms under analysis. “COGS” refers to the direct cost of goods sold.

Table 1.3 – Incentives to misreport the gross margin by firms' cost structure and profitability

	Firms reporting losses	Firms reporting profits	
	$0\% > \hat{p}$	$3\% > \hat{p} \geq 0\%$	$\hat{p} \geq 3\%$
$1\% \geq \frac{\hat{c}_o}{y}$	No incentives	No incentives	No incentives
$4\% \geq \frac{\hat{c}_o}{y} > 1\%$	No incentives	***Incentives to misreport***	No incentives
$\frac{\hat{c}_o}{y} > 4\%$	***Incentives to misreport***	No incentives	No incentives

Notes: $\hat{p}$ denotes a firm's reported profit margin; $\hat{c}_o$ indicates reported other costs, defined as the difference between total reported cost and reported COGS; y represents the firm's turnover.

Table 1.4 – Estimated evasion responses at the MTS payment threshold

	Observed responses		Model without Evasion	Model with Evasion (values show change in misreporting in % of reported profits)				
	Bunching (b)	Profit Margin Response ($\Delta\hat{p}$)	Estimated Output Elasticity (ε_y)	Given $\varepsilon_y = 0$	Given $\varepsilon_y = 0.5$	Given $\varepsilon_y = 1$	Given $\varepsilon_y = 5$	Given $\varepsilon_y = 10$
Exemption-eligible Firms	5.66	0.57	20.28	18.86	18.39	17.93	14.21	9.56
Ratio of reported-to-actual profits (upper-bound)				0.84	0.84	0.85	0.88	0.91
Non-Exempt Firms	41.28	4.13	147.96	137.60	137.14	136.67	132.95	128.30
Ratio of reported-to-actual profits (upper-bound)				0.42	0.42	0.42	0.43	0.44

Note: Evasion response estimates of more than 100 imply that the estimated cost misreporting is larger than *reported* profits. These values can be reconciled theoretically, insofar as reported profits are expected to be *lower* than actual profits in the presence of evasion. The reported estimates for the upper-bound of the ratio of reported-to-actual profits, $(y - \hat{c})/(y - c)$, are calculated as described in Section 5.3.

CHAPTER 2

Estimating the fiscal impact of extreme weather events

2.1. Introduction

Since 2000, the number of reported natural disasters around the world has ranged between 300 and 450 per year (Laframboise and Acevedo, 2014). Natural disasters can cause tremendous losses of human life and substantial economic damages. For instance, the death toll of the 2010 earthquake in Haiti was estimated around 160,000, while the economic damages from Hurricane Mitch in Honduras in 1998 were calculated at 38% of GDP.

From a fiscal perspective, natural disasters can also have negative effects as they tend to decrease government revenue and increase public expenditure.[1] In a recent study on the fiscal impacts of hurricanes in the US, Deryugina (2016) finds that the present value of transfers over a ten-year period increases by as much as $780-$1,150 per capita as a result of such an event, and estimates the direct aid relief expenses to average $155-$160 per capita.[2] To the extent that the resulting imbalance is financed with debt or by substituting planned public investment, these dynamics put pressure on the long-term sustainability of governments' finances.

[1] For a detailed discussion regarding the fiscal impact of natural disasters, see Chapter 3 of Benson and Clay (2004).
[2] These figures are expressed in 2013 dollars. As a point of comparison, the US federal expenditures per capita for 2013 are estimated at $10,910.

Surprisingly, despite its apparent importance for fiscal policy, relatively little is known about the magnitude of the fiscal response in the wake of a disaster. A large portion of the literature in the subject focuses on case studies, instead of a more systematic approach. However, there has been a renewed interest in the subject in recent years. Partly, the reason behind this change is that some studies have linked climate change with an increase in the frequency and intensity of extreme weather events.[3]

This paper is guided by two questions that arise in this context. The first one is to quantify the average impact of extreme weather events on the budget balance. While this in itself is not a novel question, the relative lack of research on this issue makes it an area still open for debate. The present analysis attempts to answer this question by using data on extreme weather events. The focus on this type of weather events is convenient from an analytical point of view, because of their exogeneity with respect to a country's fiscal policy goals, as well as the wide availability of statistical databases with information about their occurrence.

Provided that there is a significant impact, the second question pursued in this study focuses on what the main channels of transmission are. For instance, is the deterioration of the budget balance mainly a result of lower government revenues or higher public expenditure? From a policy perspective, it would be useful to have some guidance on this aspect. To the author's knowledge, there are no systematic studies in the literature that attempt to analyze this issue simultaneously.

The paper will proceed as follows. Section 2 provides a summary of the literature on natural disasters and its link to public finance. The theoretical framework on which the analysis

[3] Although the link between climate change and a higher frequency of extreme weather events is still under debate, recent studies suggest its existence. For a broader view of this literature, see Mann et al. (2017), as well as Huber and Gulledge (2011). Furthermore, IPCC (2012) provides a comprehensive review of the risks that such a relationship would imply.

is based is developed in Section 3. The description of the database and other methodological aspects are presented in Section 4. The empirical results are discussed in Section 4. Finally, the conclusions of the study are summarized in Section 5.

2.2. Literature review

Given the potential importance of natural disasters for fiscal policy, it is surprising that the number of studies that systematically analyze their impact on the public finances is relatively limited. Most of the current literature on natural disasters centers on broader macroeconomic outcomes, while a second group analyzes the benefits of insuring against such events.[4]

Among the studies that include the fiscal dimension, a large fraction relies on country cases. For instance, Benson and Clay (2004) look at data from Bangladesh, Dominica and Malawi, concluding that budget reallocation is a frequently used tool in the aftermath of a natural disaster. Moreover, Heipertz and Nickel (2008) use a sample of natural disasters that occurred in the US and the European Union, estimating a fiscal impact between 0.3% and 1.1% of GDP. Deryugina (2016) shows that, in the US, direct disaster-related public expenditure accounts for a relatively small proportion of the fiscal response. Instead, a more significant proportion corresponds to transfers, such as unemployment insurance and public medical payments. Besides

More recent studies attempt to carry out more systematic approaches to the problem. Lis and Nickel (2010) use a fixed-effects model with data from 138 countries, estimating an increase in the fiscal deficit of about 1.1% of GDP after the occurrence of an extreme weather event. However, their study neglects any lagged effects. Melecky and Raddatz (2011) use a vector

[4] For a review of the literature that studies the macroeconomic effects of natural disasters, see Cavallo and Noy (2010). Yang (2008) also provides an interesting discussion on these issues, focusing on the response of international financial flows. Additionally, see Borensztein et al (2008) for a perspective on the benefits of insurance against the risk of disasters.

autoregressive model (VAR), also estimating a negative effect on the budget balance, which they observe to be more widespread in lower-middle-income countries. Noy and Nualsri (2011) use a VAR model and find that, following large natural catastrophes, fiscal behavior is counter-cyclical in developed economies, but pro-cyclical in developing countries. Ouattara and Strobl (2013) analyze data from Caribbean countries, concluding that public expenditure rises after a natural disaster. Their study also estimates a lagged effect that persists up to two years after the shock. Finally, using Russian data, Leppänen et al. (2015) identify a negative non-linear relation between regional budget expenditures as a result of temperature increases.

The present study contributes to this literature in three dimensions. First, based on theoretical foundations, it expands the fixed-effects framework used by Lis and Nickel (2010) to include the possibility of lagged impacts of extreme weather events. Second, in addition to estimating the incidence of these weather events on the budget balance, it also analyzes their impact on government revenues and public expenditure, separately. Lastly, it uses a larger dataset than previous studies, covering 168 countries for the years from 2000 to 2015. The advantage of focusing on this period is the wider availability of macroeconomic and disaster data, which allows for a larger number of observations while keeping the panel dataset relatively balanced.

2.3. Theoretical Framework

2.3.1 Basic Model

The model that provides the foundation for the empirical analysis of this paper has its roots on the government's budget balance identity. Let B_t, T_t and G_t represent the budget balance, fiscal revenue and public expenditure at time *t*, respectively. The budget balance identity is:

$$B_t \equiv T_t - G_t. \quad (1)$$

The above equation can be expanded by expressing the right-hand side in terms of fiscal, macroeconomic and other variables, as follows,

$$B_t = \tau_t f(Y_t, X_t) - \left[r_t D_{t-1} + G^p(Y_t, X_t) + \sum_{s=0}^{n} E_{t,t-s}\right] \qquad (2)$$

where,

τ_t : average tax rate in period *t*,

$f(Y_t, X_t)$: tax base as a function of GDP (Y_t) and a vector of other characteristics (X_t),

$r_t D_{t-1}$: interest payments on past debt (D_{t-1}), with an average interest rate r_t,

$G^p(Y_t, X_t)$: primary "regular" expenditures (i.e. not disaster-related) as a function of GDP and other characteristics,

$E_{t,\ t-s}$: disaster-related expenditure in period *t* from an extreme weather event with occurrence in period $t - s$.

The first term on the right-hand side of equation (2) captures the fiscal revenue obtained by the government. Although not explicitly stated, this term is also indirectly determined by disasters, insofar as GDP is affected by their occurrence. The second term, enclosed by brackets, contains the typical components of government expenditure –debt interest payments and primary expenditure–, plus a final component that incorporates disaster-related expenditure. In this context, it is useful to think of the latter expenditure item as those expenses needed for the emergency response and reconstruction post-disaster. Finally, the vector of other characteristics,

X_t, represents variables such as inflation, interest rate, election cycles, etc. which can affect the levels of fiscal revenue and public expenditure at a given period.[5]

A helpful transformation of equation (2), for empirical purposes, is to express it in percentage of GDP, and then take a first difference. This yields,

$$\Delta b_t = \tau \, \Delta\left(\frac{f(Y_t, X_t)}{Y_t}\right) - r\Delta d_{t-1} - \Delta g_t^p - \left(\sum_{s=0}^{n} e_{t,t-s} - \sum_{u=0}^{n} e_{t-1,t-1-u}\right) \qquad (3)$$

where, for simplicity, τ and r are assumed to be constant over time, and lowercase letters indicate ratios to GDP. In words, equation (3) relates the change in the budget balance to changes in the tax base, public debt, primary expenditure, as well as current and lagged disaster-related expenses, all expressed as ratios to GDP.

2.3.2 Understanding the impact of disaster shocks in the budget balance

In order to complement the basic insights given by the relationship in equation (3), an understanding of the channels through which extreme weather events may affect the components of the budget balance is important. In what follows, the main avenues through which this impact takes place are discussed.[6]

On the one hand, the occurrence of a disaster is expected to negatively affect government revenues, on impact. This contemporary effect is a consequence of the adverse shock to GDP, which in turn automatically reduces the tax base. However, there may also be lagged effects on fiscal revenues, depending on the dynamics of GDP in the post-disaster period. For instance, there could be a positive lagged impact arising from the stimulus created by reconstruction activities,

[5] See Woo (2003), Tujula and Wolswijk (2004), and Zeng (2014) for a list of other budget balance determinants.
[6] This is not intended to be an exhaustive account. For a more detailed discussion, see Chapter 3 in Benson and Clay (2004).

which typically extend for more than one period. Moreover, there could also be a negative lagged impact if the economy is unable to bounce back quickly from the initial shock to GDP, a situation that can potentially lead to lower-than-planned investment. A further channel to be considered is financial aid. As shown by Yang (2008), official development assistance flows –a fraction of which enters the government's budget– tend to increase as a result of disaster occurrence, but this response seems to come with a lag of about two years. All in all, a weather event shock is expected to lower government revenues on impact, with an ambiguous effect on the post-disaster period.

On the other hand, disasters are also likely to provoke additional public expenditure, both through emergency and reconstruction expenses. The former category takes place in the immediate aftermath of the disaster, while the latter is expected to start with some lag, as it typically involves the repair and rehabilitation of public infrastructure. This potential increase in government expenditure may be attenuated by the reallocation of financial resources previously committed in the budget, with such a margin of response likely to be intensified in the presence of credit constraints.

Therefore, the general conclusion is that the overall effect of a disaster on the budget balance is expected to be negative on impact, but its lagged consequences remain ambiguous.

2.4. Data and Empirical Methodology

2.4.1 Data

The database built for this analysis merges information from three different sources, including a total of 168 countries for the period from 2000 to 2015.[7] As indicated before, the advantage of focusing on these years is the wider availability of macroeconomic and disaster data,

[7] The list of countries included is shown in Table B.1, in the appendix to this chapter.

which allows for a larger number of observations while keeping the panel dataset relatively balanced.

Detailed data on the occurrence of weather events comes from EM-DAT database. The information includes the number of deaths caused by each event, how many people were affected, as well as the estimated economic damage.

Macroeconomic and fiscal data comes from the World Economic Ouput (WEO) database, published by the International Monetary Fund. Among other variables, it contains information on a country's gross domestic product (GDP), real growth rate, and inflation rate, as well as its government's budget balance, total revenues, total expenditures, and public debt.

Finally, data on electoral years comes from the Database of Political Institutions (DPI), elaborated by the Inter-American Development Bank (IADB). This dataset includes both presidential as well as legislative election years.

2.4.2 Definition of extreme weather events

The EM-DAT database provides information on natural disasters, but it does not categorize the events based on their level of social or economic damage. In order to define what an extreme weather event is, three criteria were used for selection:[8]

Criterion 1: 100,000 or more affected people,

Criterion 2: 1,000 or more deaths,

Criterion 3: At least 2% of GDP in estimated economic damages.

[8] Other studies have used similar criteria. See, for instance, Lis and Nickel (2010).

For the purposes of this paper, if a weather event fulfills at least one of these three criteria, then it is classified as an extreme weather event.

Furthermore, it is important to mention that only the following categories of natural disasters were considered: landslides, storms (hurricanes, cyclones, typhoons, and tropical storms), droughts and floods. These categories were selected because of their high frequency and global incidence, as well as their potential relationship with climate change.

2.4.3 Benchmark econometric model

The empirical estimation relies on a fixed-effects model for panel data. Its basic formulation is based on the theoretical specification shown in equation (3), adapted to fit the availability of data. The model is,

$$\Delta b_{it} = \beta_0 + \beta_1 \Delta d_{i,t-1} + \beta_2 rgdpg_{it} + \beta_3 \pi_{it} + \beta_4 election_{it} + \sum_{s=0}^{n} \gamma_{s+1} ddisaster_{i,t-s} + \mu_i + \lambda_t + \nu_{it} \quad (4)$$

where,

Δb_{it}	:	change in the budget deficit, as a percentage of GDP, for country i in period t,
$\Delta d_{i,t-1}$	:	change in the (lagged) debt-to-GDP ratio,
$rgdpg_{it}$	:	real GDP growth rate,
π_{it}	:	inflation rate, measured by the percentage change in Consumer Price Index,
$election_{it}$	:	election dummy variable, with $election_{it} = 1$ in the event of either presidential or legislative elections, and $election_{it} = 0$ otherwise.

$ddisaster_{i,t-s}$: disaster dummy variable, for country i in period $(t-s)$, with $ddisaster_{i,t-s} = 1$ if at least one extreme weather event took place, and $ddisaster_{i,t-s} = 0$ otherwise.

μ_i : country fixed effects

λ_t : time fixed effects

ν_{it} : random error

The adapted model is purposely similar to the one used by Lis and Nickel (2010), with the objective of allowing for comparisons. The inclusion of lags of the disaster dummy reflects the possibility of multi-period effects, as discussed in previous sections.

In the empirical exercise, fixed-effects models were also estimated using the change in government revenues, Δrev_{it}, and the change in public expenditure, Δexp_{it}, as dependent variables. The aim of this exercise is to gain some knowledge regarding the relative impact of the disaster shock on each component of the budget balance.

2.5. Empirical Results

This section presents the empirical results obtained from estimating the benchmark model, as well as alternative models. In order to ensure comparability with other studies, each set of estimations was carried out twice. The first time the model is run without lags in the disaster variable, while the second these lags are added.

2.5.1 Benchmark model estimation

Table 2.1 shows the results of the fixed-effect model. Columns (1) and (2) correspond to the estimates of the model without and with lags, respectively, using the change in the budget balance as a dependent variable. As it can be observed, both sets of estimates provide similar results. According to the model without lags, the occurrence of at least one extreme weather event decreases the budget balance by 0.49% of GDP. This estimate is similar when allowing for lagged effects, as the coefficient on contemporary disaster occurrence implies a negative impact of 0.46% of GDP. Interestingly, the results also show an additional and significant effect two periods after the disaster took place.[9] The magnitude of this lagged effect is sizeable, at -0.56% of GDP. While the model does not allow us to distinguish the precise mechanism behind this latter impact, a hypothesis consistent with these results would be the completion of reconstruction work for public infrastructure.

The results using government revenues as a dependent variable are presented in columns (3) and (4) of Table 2.1.[10] In the model without lags, an extreme weather event is estimated to negatively affect government revenues by 0.58% of GDP. The model with lags provides a similar contemporary estimate, calculating the negative impact at 0.55% of GDP. There is no suggestion of statistically significant lagged effects on government revenues.

Finally, columns (5) and (6) display the estimates of the model that uses public expenditure as a dependent variable. Both the models without and with lags do not find any statistically significant effect of the contemporary disaster variable on public expenditure. Instead, the model with lags finds a significant impact two periods after the event. The magnitude of this effect suggests an increase of about 0.40% of GDP in public expenditure. As commented above, this

[9] The results presented in this paper only consider a model with two lags of the disaster variable. However, the results of models with further lags –not shown, but available from the author upon request– are largely consistent with the estimates displayed in Table 2.1. Moreover, in the majority of alternative specifications, estimates of the lagged disaster dummy greater than two periods after the event are not statistically significant.

[10] All models using government revenues as a dependent variable omit the debt-to-GDP ratio as a control variable. This is because there is no theoretical foundation that justifies a relationship between these two variables.

lagged impact is consistent with a hypothesis that considers the completion of reconstructed infrastructure but cannot be verified with the current data.

2.5.2 Results by per capita income classification

The results for the full sample, presented in Table 2.1, do not take into account the possibility that economic development may play a role in how large the fiscal impact of extreme weather events is. In order to consider this, the benchmark model was estimated separating the countries into four different groups. These categories classify countries according to their income per capita.[11] A priori, developed economies are expected to be better prepared to face natural disasters than developing countries. Thus, the fiscal impact should be higher in the latter group.

Panel A of Table 2.2 presents the results for the change in the budget balance. Columns (1) and (2) focus on the estimates for high-income countries; columns (3) and (4) include the results for upper-middle income countries; columns (5) and (6) display the estimation for lower-middle income countries; and, lastly, columns (7) and (8) contain the results for low-income countries. As shown in the table, the negative fiscal impact of extreme weather events concentrates on the two categories with the lowest income per capita. For these groups, the model without lags estimates the contemporary deterioration of the budget balance as a result of the disaster shock at 0.76% and 0.90% of GDP, respectively. Similarly, the model with lags also shows a statistically significant negative effect on impact of 0.75% of GDP for lower-middle income countries, and of 0.77% of GDP for the low-income group. On the contrary, the model does not show any significant effects for high-income and upper-middle income countries. Furthermore, the coefficients of the

[11] The categories used correspond to the World Bank's income classification for 2016. According to this scale, countries are considered to be low-income if their per capita GDP is below US$1,006; lower-middle income if it ranges between US$1,006 and US$3,955; upper-middle income if above US$3,955 and below US$12,235; and high income if it exceeds US$12,235.

disaster lags are also not statistically significant, despite their magnitudes going in the expected direction.[12]

The results for government revenues and public expenditure are presented in panels B and C. As before, the effect on the change in government revenues concentrates on lower-middle and low-income countries, with an estimated negative impact of 0.76% and 1.05%, respectively, in the model without lags. Adding the possibility of lagged effects leaves the estimates of this contemporary impact relatively unchanged, at 0.70% for the lower-income group, and 0.94% for low-income countries. The model results do not support the existence of multi-period effects on government revenues. For the case of public expenditure, none of the estimations show statistically significant coefficients on the disaster variables.

2.5.3 Robustness checks

Besides the benchmark specification, alternative models were estimated to validate the robustness of the results. A known problem of the benchmark model is that it may suffer from endogeneity due to the inclusion of the real GDP growth variable (Zeng, 2014). To avoid this problem, a common solution in the literature has been to estimate the model using lags of real GDP growth as instrumental variables. Table 2.3 displays the results of this alternative estimation. The general conclusions regarding the contemporary effect of disasters on the budget balance, government revenue and public expenditure, remain largely unchanged when compared to the benchmark model. However, this alternative model does not provide evidence of multi-period effects, as the coefficients on the lagged disaster variables are not statistically significant.

[12] The coefficient on the second disaster lag is statistically significant if the model is estimated pooling together the lower-middle and low-income groups. This suggests that splitting the sample by income groups may have an important effect on the precision of the estimates.

Additionally, two dynamic panel models were also estimated, using the methods of Arellano-Bond and Arellano-Bover/Blundell-Bond.[13] One of the advantages of these alternative specifications is that they allow the inclusion of lags of the depend variable. The results of these models are presented in Tables 2.4 and 2.5. As was the case of the fixed-effects model with instrumental variables, the conclusions derived from these results are largely consistent with the benchmark model. In other words, the coefficients on the contemporary disaster variable are statistically significant for the change in the budget balance and government revenues, but not for public expenditure. Interestingly, the dynamic panel models also support the existence of lagged effects from extreme weather events, particularly on public expenditure.

2.5.4 Other potential identification threats

Besides the endogeneity issue of the real GDP growth variable, and the inclusion of lags of the dependent variable as covariates, other potential identification threats are listed and discussed below:

- Misreporting of disaster severity: Yang (2008) argues that countries may have incentives to misreport the severity of disasters in order to receive more international aid. In the context of this analysis, this would result in the possibility of natural disasters being misclassified as extreme weather events. Thus, systematic misreporting of this sort would bias down the estimates of the fiscal impact, making the empirical estimates shown a lower bound of their true value.[14]

[13] See Arellano and Bond (1991), and Blundell and Bond (1998), respectively.
[14] Future work will deal with this issue by incorporating a hurricane index representing the average hurricane exposure of residents of a given country in a particular year, as in Yang (2008).

- Definition of the disaster variable: The definition of which disasters are identified as extreme weather events is key for the empirical analysis. Hence, it could be argued that results may be driven by the somewhat arbitrary definition of an extreme weather event. For instance, the criteria based in levels, and not proportions, may have very different consequences depending on population size. Changing Criterion 1 to "at least 1% of the population" removes the statistical significance of the expenditure lagged effect found in the benchmark model, but the contemporary effect on government revenues remains consistent with previous results.
- Period of analysis: As explained in previous sections, the 2000-2015 period was chosen to maximize data availability for the 168 countries in the analysis. The concern of extending this period was that an unbalanced panel could reduce the precision of the estimates. However, restricting the sample to these years may limit the external validity of the results, as the empirical evidence may be capturing what could be a temporary fiscal impact. Nonetheless, estimates obtained from extending the period of analysis (1980-2015, 1985-2015 and 1990-2015) yield similar results to the benchmark model, with some minor adjustments in the point estimates.
- Use of contemporary GDP in dependent variable: The benchmark model defines the dependent variables (budget balance, government revenues, and public expenditure) as percentage of contemporary GDP. This simplifies the interpretation of the estimated coefficients for the disaster variables. However, since contemporary GDP is also being affected by the disaster's occurrence, this procedure may create biases in the results. Using an alternative definition, where the denominator is the average of third, fourth and

fifth lagged GDP values[15], eliminates the statistical significance of the expenditure lagged effect, but the contemporary effect on government revenues is still consistent with the benchmark model (see Table 2.6).

2.6. Conclusions

The occurrence of natural disasters can have large costs in terms of human lives and economic damages. While the literature analyzing the incidence of natural disasters has mainly focused on their macroeconomic consequences, the fiscal dimension of this problem has remained relatively unexplored. The few available studies analyzing this issue point out that the effect on the public accounts can be important. This paper finds evidence consistent with this conclusion.

According to the empirical results, the occurrence of at least one extreme weather event is associated with an immediate deterioration of the budget balance of the order of 0.4%-0.9% of GDP. The estimated impact comes primarily from an immediate reduction in government revenues, as a percentage of GDP, with adverse effects ranging between 0.5% to 1.1% of GDP. This effect is larger for low-income and lower-middle income countries but is not significant for high-income and upper-middle income countries.

Moreover, the models support some evidence of a lagged effect on the budget balance two years after the event, with a benchmark estimate of 0.6% of GDP. This multi-period effect comes mainly from an estimated increase of 0.4% of GDP in public expenditure and seems consistent with the post-disaster completion of reconstruction work on public infrastructure. However, due to data limitations, this paper is unable to test this hypothesis.

[15] These GDP lagged values were chosen to allow for the use of the first and second lags of the disaster variable in the model.

It is important to remark that, despite showing significant fiscal impacts, there are margins of response that are not captured by the empirical evidence. For instance, to the extent that countries reallocate planned expenditure in the wake of a disaster, this response would tend to decrease the observed incidence of extreme weather events on total public expenditure.[16] Indeed, the lack of statistically significant effects for the contemporary impact of disasters on the expenditure seems likely to point in this direction.

[16] As mentioned earlier, Benson and Clay (2004) found strong evidence of reallocation in their country-specific analyses.

2.7. References

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2.8. Tables

Table 2.1 – Fixed-Effects Model Estimation

Explanatory Variable	Budget Balance		Government Revenues		Public Expenditure	
	(1) FE Model	*(2) FE Model with lags*	*(3) FE Model*	*(4) FE Model with lags*	*(5) FE Model*	*(6) FE Model with lags*
Δ(debt/GDP)$_{t-1}$	0.034*** (0.011)	0.035*** (0.011)			-0.016** (0.007)	-0.016** (0.007)
real GDP growth	0.278*** (0.080)	0.277*** (0.080)	0.155** (0.069)	0.154** (0.069)	-0.118*** (0.023)	-0.118*** (0.023)
inflation	0.031* (0.016)	0.030* (0.016)	0.011 (0.026)	0.011 (0.027)	-0.020 (0.018)	-0.020 (0.018)
ddisaster	-0.491** (0.218)	-0.457** (0.217)	-0.584*** (0.201)	-0.550*** (0.202)	-0.091 (0.195)	-0.094 (0.197)
ddisaster $_{t-1}$		0.400 (0.330)		0.365 (0.321)		0.021 (0.171)
ddisaster $_{t-2}$		-0.562* (0.299)		-0.145 (0.278)		0.402* (0.213)
election	-0.237 (0.190)	-0.241 (0.190)	-0.235 (0.170)	-0.233 (0.170)	0.007 (0.142)	0.011 (0.142)
constant	-1.265*** (0.343)	-1.235*** (0.337)	-0.406 (0.295)	-0.451 (0.288)	0.860*** (0.130)	0.788*** (0.140)
Observations	2,514	2,514	2,514	2,514	2,514	2,514
No. of countries	168	168	168	168	168	168
R-squared	0.0807	0.0829	0.0395	0.0413	0.0246	0.0275

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Table 2.2 – Fixed-effects model estimation, by per capita income classification

Panel A - Dependent variable: Change in the Budget Balance

	High-income		**Upper-middle income**		**Lower-middle income**		**Low-income**	
	(1) FE Model	*(2) FE Model with lags*	*(3) FE Model*	*(4) FE Model with lags*	*(5) FE Model*	*(6) FE Model with lags*	*(7) FE Model*	*(8) FE Model with lags*
Δ(debt/GDP)$_{t-1}$	0.109 ***	0.109***	0.028	0.028	0.032***	0.033***	0.028	0.028
	(0.030)	(0.030)	(0.019)	(0.020)	(0.011)	(0.011)	(0.018)	(0.017)
real GDP growth $_{t-1}$	0.508 ***	0.509***	0.294**	0.294**	0.143***	0.144***	0.138***	0.123***
	(0.090)	(0.090)	(0.123)	(0.123)	(0.037)	(0.037)	(0.043)	(0.037)
inflation	-0.028	-0.029	0.016	0.016	0.023	0.021	0.064**	0.066**
	(0.113)	(0.113)	(0.017)	(0.017)	(0.023)	(0.023)	(0.025)	(0.029)
ddisaster	-0.006	-0.040	-0.033	-0.042	-0.756**	-0.747**	-0.898**	-0.767*
	(0.235)	(0.219)	(0.471)	(0.450)	(0.369)	(0.349)	(0.423)	(0.419)
ddisaster $_{t-1}$		-0.324		0.341		0.087		1.046
		(0.387)		(0.508)		(0.439)		(0.913)
ddisaster $_{t-2}$		-0.315		-0.425		-0.501		-1.105
		(0.711)		(0.295)		(0.361)		(0.873)
election	-0.204	-0.214	-0.546*	-0.535*	-0.164	-0.176	-0.142	-0.130
	(0.231)	(0.229)	(0.312)	(0.309)	(0.421)	(0.423)	(0.862)	(0.862)
constant	-1.443 ***	-1.412***	-1.579***	-1.560***	-0.650**	-0.516	-0.743**	-0.707**
	(0.401)	(0.398)	(0.588)	(0.569)	(0.313)	(0.419)	(0.308)	(0.311)
Observations	773	773	693	693	644	644	404	404
No. of countries	49	49	46	46	44	44	29	29
R-squared	0.0900	0.0900	0.1856	0.1864	0.0284	0.276	0.0400	0.0538

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Panel B - Dependent variable: Change in Government Revenues

	High-income		**Upper-middle income**		**Lower-middle income**		**Low-income**	
	(1) FE Model	*(2) FE Model with lags*	*(3) FE Model*	*(4) FE Model with lags*	*(5) FE Model*	*(6) FE Model with lags*	*(7) FE Model*	*(8) FE Model with lags*
real GDP growth $_{t-1}$	0.102	0.103	0.198**	0.197**	0.052	0.053	0.096*	0.085*
	(0.070)	(0.071)	(0.098)	(0.098)	(0.039)	(0.039)	(0.051)	(0.049)
inflation	0.025	0.024	-0.029*	-0.028*	-0.014	-0.014	0.136*	0.137*
	(0.058)	(0.058)	(0.015)	(0.014)	(0.021)	(0.021)	(0.069)	(0.071)
ddisaster	-0.357	-0.416	-0.161	-0.166	-0.762**	-0.703**	-1.050**	-0.944*
	(0.314)	(0.345)	(0.155)	(0.176)	(0.371)	(0.345)	(0.456)	(0.493)
ddisaster $_{t-1}$		-0.396		0.217		0.279		0.857
		(0.321)		(0.469)		(0.398)		(0.956)
ddisaster $_{t-2}$		0.138		0.071		-0.151		-0.708
		(0.489)		(0.288)		(0.320)		(0.781)
election	-0.308*	-0.304*	-0.101	-0.096	-0.114	-0.119	-0.612	-0.605
	(0.170)	(0.166)	(0.245)	(0.250)	(0.383)	(0.382)	(0.824)	(0.817)
constant	-0.222	-0.213	-0.646	-0.697	0.247	0.181	-0.586	-0.606
	(0.248)	(0.245)	(0.437)	(0.431)	(0.288)	(0.308)	(0.527)	(0.561)
Observations	773	773	693	693	644	644	404	404
No. of countries	49	49	46	46	44	44	29	29
R-squared		0.0096		0.1659		0.0088		0.0651

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Panel C - Dependent variable: Change in Public Expenditure

	High-income		**Upper-middle income**		**Lower-middle income**		**Low-income**	
	(1) FE Model	*(2) FE Model with lags*	*(3) FE Model*	*(4) FE Model with lags*	*(5) FE Model*	*(6) FE Model with lags*	*(7) FE Model*	*(8) FE Model with lags*
Δ(debt/GDP)$_{t-1}$	-0.097***	0.097***	-0.021	-0.022	-0.013**	-0.013**	-0.010	-0.010
	(0.024)	(0.024)	(0.021)	(0.021)	(0.006)	(0.006)	(0.009)	(0.009)
real GDP growth $_{t-1}$	-0.400 ***	0.401***	-0.096***	-0.096***	-0.084*	-0.084*	-0.028	-0.024
	(0.041)	(0.041)	(0.030)	(0.300)	(0.043)	(0.043)	(0.050)	(0.050)
inflation	0.053	-0.054	-0.044**	-0.043**	-0.044**	-0.044**	0.072	0.072
	(0.080)	(0.080)	(0.017)	(0.017)	(0.020)	(0.020)	(0.046)	(0.045)
ddisaster	-0.342	-0.385	-0.128	-0.122	0.021	0.070	-0.159	-0.184
	(0.353)	(0.357)	(0.467)	(0.475)	(0.260)	(0.287)	(0.383)	(0.386)
ddisaster $_{t-1}$		-0.075		-0.117		0.208		-0.187
		(0.332)		(0.236)		(0.296)		(0.443)
ddisaster $_{t-2}$		0.461		0.493		0.304		0.407
		(0.575)		(0.352)		(0.353)		(0.477)
election	-0.109	-0.095	0.434	0.427	0.058	0.062	-0.373	-0.379
	(0.195)	(0.194)	(0.336)	(0.336)	(0.257)	(0.257)	(0.417)	(0.424)
constant	1.194***	1.171***	0.933**	0.863***	0.937***	0.752**	0.167	0.108
	(0.203)	(0.206)	(0.207)	(0.231)	(0.261)	(0.332)	(0.325)	(0.361)
Observations	773	773	693	693	644	644	404	404
No. of countries	49	49	46	46	44	44	29	29
R-squared		0.1671		0.0415		0.0166		0.0496

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Table 2.3 – Fixed-Effects Model Estimation with Instrumental Variables

	Budget Balance		**Government Revenues**		**Public Expenditure**	
	(1) IV-FE Model	*(2) IV-FE Model with lags*	*(3) IV-FE Model*	*(4) IV-FE Model with lags*	*(5) IV-FE Model*	*(6) IV-FE Model with lags*
Δ(debt/GDP)$_{t-1}$	0.016 (0.013)	0.016 (0.013)			-0.004 (0.007)	-0.004 (0.007)
real GDP growth $_{t-1}$	-0.079 (0.080)	-0.077 (0.081)	-0.013 (0.036)	-0.012 (0.036)	0.073* (0.043)	0.072* (0.043)
inflation	0.022 (0.017)	0.022 (0.017)	0.005 (0.027)	-0.005 (0.027)	-0.017 (0.018)	-0.017 (0.018)
ddisaster	-0.617*** (0.210)	-0.576*** (0.207)	-0.643*** (0.201)	-0.607*** (0.200)	-0.026 (0.184)	-0.029 (0.186)
ddisaster $_{t-1}$		0.476 (0.330)		0.430 (0.318)		-0.033 (0.170)
ddisaster $_{t-2}$		-0.502 (0.310)		-0.137 (0.276)		0.350 (0.216)
election	-0.174 (0.198)	-0.177 (0.199)	-0.196 (0.169)	-0.196 (0.169)	-0.026 (0.184)	-0.016 (0.146)
constant	0.240 (0.372)	0.231 (0.377)	0.318 (0.246)	0.255 (0.246)	0.019 (0.211)	-0.008 (0.216)
Observations	2,513	2,513	2,513	2,513	2,513	2,513
No. of countries	168	168	168	168	168	168

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Table 2.4 – Dynamic Panel Estimation (Arellano-Bond)

	Budget Balance		Government Revenues		Public Expenditure	
	(1) A-B Model	*(2) A-B Model with lags*	*(3) A-B Model*	*(4) A-B Model with lags*	*(5) A-B Model*	*(6) A-B Model with lags*
LD. balance	-0.243***	-0.238***				
	(0.033)	(0.032)				
LD. revenue			-0.287***	-0.285***		
			(0.040)	(0.039)		
LD. expenditure					-0.139***	-0.137***
					(0.043)	(0.044)
LD. debt	0.022**	0.023**			-0.013*	-0.014*
	(0.010)	(0.010)			(0.008)	(0.008)
realgdp_growth	0.271***	0.275***	0.139**	0.143**	-0.126***	-0.130***
	(0.068)	(0.070)	(0.060)	(0.060)	(0.019)	(0.020)
inflend	0.039*	0.042**	0.007	0.008	-0.033	-0.036
	(0.020)	(0.021)	(0.027)	(0.026)	(0.022)	(0.028)
ddummy	-0.391*	-0.470*	-0.458**	-0.524**	-0.128	-0.072
	(0.206)	(0.284)	(0.189)	(0.234)	(0.203)	(0.283)
L.ddummy		0.656		0.323		-0.190
		(0.498)		(0.448)		(0.278)
L2.ddummy		-0.392		-0.009		0.467**
		(0.261)		(0.234)		(0.218)
election	-0.311*	-0.331*	-0.201	-0.186	0.084	0.080
	(0.169)	(0.173)	(0.148)	(0.146)	(0.132)	(0.133)
constant	-1.294***	-1.359***	-0.293	-0.362	0.987***	0.958***
	(0.313)	(0.329)	(0.268)	(0.273)	(0.133)	(0.153)
Observations	2,440	2,440	2,486	2,486	2,442	2,442
No. of countries	168	168	168	168	168	168

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Table 2.5 – Dynamic Panel Estimation (Arellano-Bover/Blundell-Bond)

	Budget Balance		Government Revenues		Public Expenditure	
	(i) System GMM model	*(ii) System GMM model with lags*	*(i) System GMM model*	*(ii) System GMM model with lags*	*(i) System GMM model*	*(ii) System GMM model with lags*
LD. balance	-0.215*** (0.030)	-0.208*** (0.030)				
LD. revenue			-0.267*** (0.041)	-0.265*** (0.041)		
LD. expenditure					-0.099** (0.044)	-0.096** (0.045)
LD. debt	0.025** (0.011)	0.027** (0.012)			-0.017* (0.009)	-0.017* (0.010)
realgdp_growth	0.297*** (0.076)	0.301*** (0.078)	0.139** (0.068)	0.140** (0.069)	-0.128*** (0.019)	-0.133*** (0.020)
inflend	0.047** (0.022)	0.050** (0.023)	0.016 (0.036)	0.017 (0.036)	-0.022 (0.029)	-0.024 (0.030)
ddummy	-0.575** (0.226)	-0.805** (0.316)	-0.535** (0.211)	-0.713*** (0.252)	-0.058 (0.188)	0.083 (0.269)
L.ddummy		0.539 (0.490)		0.638 (0.437)		0.058 (0.262)
L2.ddummy		-0.521* (0.276)		0.180 (0.259)		0.696*** (0.237)
election	-0.384** (0.172)	-0.405** (0.176)	-0.196 (0.146)	-0.192 (0.146	0.129 (0.135)	0.132 (0.136)
constant	-1.393*** (0.344)	-1.387*** (0.377)	-0.334 (0.323)	-0.462 (0.353)	0.897*** (0.166)	0.765*** (0.191)
Observations	2,508	2,508	2,510	2,510	2,509	2,509
No. of countries	168	168	168	168	168	168

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

Table 2.6 – Fixed Effects Model Estimation with Average Lagged GDP Values in Dependent Variable

Explanatory Variable	Budget Balance		Government Revenues		Public Expenditure	
	(1) FE Model	*(2) FE Model with lags*	*(3) FE Model*	*(4) FE Model with lags*	*(5) FE Model*	*(6) FE Model with lags*
$\Delta(debt/avgLGDP)_{t-1}$	0.016 (0.022)	0.017 (0.022)			-0.030*** (0.012)	-0.030*** (0.012)
real GDP growth	0.364*** (0.050)	0.363*** (0.050)	0.856*** (0.126)	0.856*** (0.126)	0.493*** (0.118)	0.497*** (0.119)
inflation	0.060** (0.025)	0.059** (0.016)	0.057 (0.037)	0.056 (0.037)	-0.001 (0.039)	-0.002 (0.039)
ddisaster	-0.838* (0.435)	- 0.754* (0.433)	-1.248* (0.692)	-1.200* (0.680)	-0.361 (0.754)	-0.395 (0.755)
$ddisaster_{t-1}$		0.962 (0.602)		0.547 (0.703)		-0.398 (0.527)
$ddisaster_{t-2}$		-0.768 (0.505)		-0.722 (0.651)		0.045 (0.415)
election	-0.501 (0.344)	-0.507 (0.345)	-0.164 (0.404)	-0.170 (0.407)	0.392 (0.363)	0.391 (0.369)
constant	-1.677*** (0.271)	-1.712*** (0.263)	-3.650*** (0.606)	-3.615*** (0.656)	-1.970*** (0.576)	-1.904*** (0.592)
Observations	2,484	2,484	2,484	2,484	2,484	2,484
No. of countries	167	167	167	167	167	167
R-squared	0.0434	0.0456	0.1232	0.0413	0.0849	0.0849

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in parenthesis.

CHAPTER 3

Tax arbitrage and domestic profit-shifting in environments with co-existing income tax regimes

3.1. Introduction

This paper explores the consequences of having two co-existing corporate income tax regimes within a domestic tax system. This topic is interesting because, in such scenarios, a simple theoretical model predicts an optimal strategy involving tax arbitrage through income shifting across regimes. Until now, much of the literature on domestic income shifting has focused on advanced economies, and on the shifting between labor income and corporate income [e.g. Gordon et al. (1995), Slemrod (1995), Gordon and Slemrod (1998), Pirttilä and Selin (2011), Harju and Matikka (2016)]. Only recently, researchers have devoted their attention to the developing world [e.g. Shevlin et al (2012), Foremny et al. (2018)], where countries often harbor multiple income tax regimes, including special simplified regimes aimed at combating informality by reducing the costs of compliance.

The present study contributes to this body of literature by analyzing the case of Guatemala. Using tax administrative data from 2010 to 2015, the empirical analysis focuses on the identification of behavioral responses consistent with tax arbitrage between the two parallel income tax regimes in the country. Under Guatemalan tax law, firms are allowed to choose between a tax on profits –*Regimen Optativo*–, or a tax on turnover –*Regimen General*–. In theory, profit-maximizing firms are expected to choose the regime where their tax liability is lowest, conditional on output. In practice, there is anecdotal evidence that firms engage in tax arbitrage by creating a network of legal entities in both regimes. In its simplest form, firms start by creating one entity in each regime. Then, they take advantage of the tax arbitrage opportunity by carry out profit shifting from *Regimen Optativo* to *Regimen Simplificado*.[1]

The Guatemalan case provides an interesting setting for two reasons. First, contrary to what is usually found in other countries, there are no big barriers for firms to switch regimes after their initial choice. Firms are able to adjust their choice before the start of each fiscal year. This differs from the standard practice observed in other countries with co-existing regimes, where firms are unable to switch with such ease after their initial choice at the time of registration. Second, in 2013 there was an income tax reform that modified the marginal tax rates in each of the two existing regimes —from 31% to 25% in *Regimen Optativo*, and from 5% to 7% in *Regimen General*. As a result, firms' incentives to choose each regime changed differentially depending on their use of tax arbitrage schemes or not. On the one hand, the theoretical model developed in Section 2 predicts that, after the reform, firms belonging to a tax arbitrage network should not show any switching behavior. On the other, firms with no such networks should show some migration from *Regimen General* to *Regimen Optativo*.

To test this empirically, the analysis uses the variation in marginal tax rates introduced by the reform, as well as three different network definitions to group firms. Graphical evidence

[1] In other countries with similar regimes, it is also common to observe large marginal tax rate differentials between profit taxation and turnover taxation. See Section 3 for a full description of the Guatemalan case.

largely confirms the predicted patterns for the alternative network definitions. Following a difference-in-difference approach, where treatment and control groups are defined by whether firms belong to a tax arbitrage network or not, the results show differential behavior between the two groups. For the baseline model, firms that do not belong to a tax arbitrage network faced a decrease of around one percentage point more than the treatment group in the probability of registering in *Regimen General* after the reform. Extending the baseline model to a generalized difference-in-difference yields similar results. However, the analysis shows that the effect seems to be concentrated on lower income firms, despite higher income firms having larger incentives to react. Finally, it is acknowledged that, with data limitations preventing further analysis, these empirical results should only be interpreted as indirect evidence of profit shifting and the existence of tax arbitrage networks in Guatemala.

The rest of the paper is organized as follows. Section 2 develops the theoretical model used to obtain behavioral predictions for firms with and without tax arbitrage networks. Section 3 describes the data used in the analysis, the income tax regimes in Guatemala, and the implications of the 2013 income tax reform. Section 4 explains the empirical methodology, while the results are presented in Section 5. Finally, the conclusions and policy implications of these findings are discussed in Section 6.

3.2. Theoretical Model

To understand the factors affecting firm behavior, this section presents a theoretical framework in which firms face incentives created by a system with two parallel income tax regimes. First, a basic profit maximization model is used to understand incentives for firms under a tax on profits and a tax on turnover, separately. Then, the case of a network of two firms which operate jointly, one in each regime, is presented.

3.2.1. A simple model of profit maximization

Let y represent output, $c(y)$ the total cost function –increasing in output level–, τ_π the marginal tax rate on profits, and τ_y the marginal tax rate on turnover.[2] Furthermore, let us suppose that there are two alternative tax regimes that firms can opt for, one in which firms pay taxes on profits and another one in which firms pay taxes on turnover. Under this very simple framework, we can express the firm's profit maximization problem as follows.[3] Firms registering in the profit tax regime maximize[4],

$$\max_y \; y - c(y) - \tau_\pi(y - c(y)), \tag{1}$$

while for firms in the turnover tax regime, the maximization problem would be,

$$\max_y \; y - c(y) - \tau_y y. \tag{2}$$

The first order conditions for an interior solution to these problems are, respectively,

$$1 = c'(y) \tag{3}$$

$$1 - \tau_y = c'(y), \tag{4}$$

which imply that a profits tax is production efficient, but a turnover tax is distortionary.

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[2] The words output and turnover are used interchangeable in the models and equations of this paper. Although in reality these terms differ, the aforementioned convention follows from a normalization of the price level used to define turnover.
[3] For simplicity, the model presented here does not account for the possibility of turnover and/or cost misreporting. An extension including these margins of adjustment is shown further into the paper, yielding similar conclusions.
[4] Although the model assumes all costs are deductible (i.e. a pure profit tax), in practice, tax systems feature non-deductible costs.

Under profit maximization, firms will choose to register in the regime where their after-tax profits are expected to be higher. Hence, conditional on expected output, firms should opt to register in the regime that taxes profits if,

$$y - c(y) - \tau_\pi\big(y - c(y)\big) \geq y - c(y) - \tau_y y,$$

which implies,

$$\frac{\tau_y}{\tau_\pi} \geq \frac{\big(y - c(y)\big)}{y}. \tag{5}$$

The left-hand side of the inequality above is the ratio of marginal tax rates. The right-hand side is the firm's profit margin, a measure of profitability. In practice, it is common for τ_y to be significantly smaller than τ_π. Thus, this simple theoretical model implies that, other things equal, firms with low expected profitability are more likely to choose to pay taxes on profits, while firms with high expected profitability will prefer to pay taxes on turnover.

Suppose that the government approves a fiscal reform in which the marginal tax rate on profits decreases to $\tau_\pi{}'$ and the marginal tax rate on turnover increases to $\tau_y{}'$. In this scenario, there is a change in the threshold defined by the ratio of the marginal tax rates, since

$$\frac{\tau_y{}'}{\tau_\pi{}'} > \frac{\tau_y}{\tau_\pi}.$$

Therefore, under the assumption of stable profitability, it would be expected that firms with a profit margin just above the old threshold should now face incentives to switch regime. Specifically, these firms would have incentives to move from the turnover tax regime to the profit tax regime, as they would expect to pay less taxes by doing so. These incentives are asymmetric, in the sense that only firms above the profit margin threshold defined by the marginal tax rates will be affected. Firms below the threshold do not have any change in incentives.

3.2.2. Tax arbitrage and profit-shifting between regimes

In the previous framework firms are assumed to choose between two mutually exclusive income tax regimes. However, it is not uncommon to come across anecdotal evidence in developing countries pointing to strategies to carry out tax arbitrage between two co-existing regimes.

In order to analyze this possibility, let us consider a case where a firm decides to split its reported activities into two legal entities. One entity is registered as a firm in the profit tax regime and the other as a firm in the turnover tax regime. The joint maximization problem of these two newly created firms can be expressed as,

$$\max_{y,d}\ y - c(y) - \tau_\pi(y - c(y) - d) - \tau_y d - k(d), \tag{6}$$

where d represents the amount of profits transferred by the firm in the profits tax regime to the firm in the turnover tax regime.[5] Moreover, this group of firms incur transaction costs, $k(d)$, which account for the expenses involved in transferring profits between firms; these transaction costs are increasing in the amount being shifted.

Since the optimization is now carried out over two variables, namely turnover and transferred profits, there are two first order conditions associated with an interior solution,

$$\partial y: \quad 1 = c'(y) \tag{7}$$

[5] This model specification views profit shifting as an administrative arrangement. It implies that the production technology used by the firm is unaffected by its decision to split into two legal entities.

$$\partial d: \quad \tau_\pi - \tau_y = k'(d). \tag{8}$$

Equation (7) replicates the first order condition shown in equation (3) and indicates that under this arrangement the (joint) firm's production choice is still independent of the marginal tax rates. This is interesting, since a turnover tax is distortionary, as seen in equation (4). Yet, when firms are able to operate in both regimes through two legal entities, then the distortionary nature of turnover taxation does not affect the (joint) firm's decision.[6] On the other hand, equation (8) defines the optimal level of profits that should be shifted to the firm in the turnover tax regime. The left-hand side is a measure of the marginal benefit of profit transfers between the firms, while the right-hand side is the marginal cost of this transfer. The condition is intuitive, as it relates the amount shifted to the tax rate differential between the two regimes. In other words, the larger is the difference in the marginal tax rates, the greater are the gains to engage in tax arbitrage through profit shifting.

Let us consider what would happen with a similar tax reform as the one described in the previous section. Since now $\tau_\pi{}' < \tau_\pi$ and $\tau_y{}' > \tau_y$, then the tax differential has decreased,

$$\tau_\pi{}' - \tau_y{}' < \tau_\pi - \tau_y.$$

Firms will respond by reducing the amount of profits being shifted from the profits tax regime to the turnover tax regime. However, as long as the differential remains positive, firms will continue to have an incentive to engage in tax arbitrage. Provided that the amount of profits shifted is positive before and after the reform, the main implication is that these firms will not switch regimes as firms without a tax arbitrage network would do.

[6] The two key assumptions here are, (i) that production technology is unchanged by the firm's administrative arrangement, as discussed before; and, (ii) that the cost of profit shifting does not depend on output level.

3.2.3. Robustness of the model to turnover and cost misreporting

The simple model presented above can also be extended to account for the possibility of turnover and cost misreporting. Let $\hat{y}$ and $\hat{c}$ denote reported turnover and reported costs, respectively, and $h(y-\hat{y},\hat{c}-c)$ represent the convex costs of misreporting.

Firms that opt for the profits tax regime solve,

$$\max_{y,\hat{y},\hat{c}} y - c(y) - \tau_\pi(\hat{y}-\hat{c}) - h(y-\hat{y},\hat{c}-c), \tag{9}$$

where the firm has two additional margins of adjustment instead of only output. The following are the first order conditions for an interior solution,

$$\partial y: \quad 1 - h_{y-\hat{y}}(y-\hat{y},\hat{c}-c) = c'(y)[1 - h_{\hat{c}-c}(y-\hat{y},\hat{c}-c)] \tag{10}$$

$$\partial \hat{y}: \quad \tau_\pi = h_{y-\hat{y}}(y-\hat{y},\hat{c}-c) \tag{11}$$

$$\partial \hat{c}: \quad \tau_\pi = h_{\hat{c}-c}(y-\hat{y},\hat{c}-c). \tag{12}$$

As before, these conditions put together imply,

$$1 = c'(y),$$

which was the result obtained in the case with no misreporting.

On the other hand, firms opting to pay the tax on turnover evaluate,

$$\max_{y,\hat{y},\hat{c}} y - c(y) - \tau_y\hat{y} - h(y-\hat{y},\hat{c}-c), \tag{13}$$

which yields as first order conditions,

$$\partial y: \quad 1 - h_{y-\hat{y}}(y-\hat{y},\hat{c}-c) = c'(y)[1 - h_{\hat{c}-c}(y-\hat{y},\hat{c}-c)] \tag{14}$$

$$\partial\hat{y}: \quad \tau_y = h_{y-\hat{y}}(y-\hat{y}, \hat{c}-c) \tag{15}$$

$$\partial\hat{c}: \quad 0 \leq h_{\hat{c}-c}(y-\hat{y}, \hat{c}-c). \tag{16}$$

Once again, when taken together these conditions imply the same result as the case with no misreporting,

$$1 - \tau_y = c'(y),$$

since the optimal amount of cost misreporting, defined by equation (12), is $\hat{c} - c(y) = 0$.[7]

Finally, firms that engage in tax arbitrage by splitting into two legal entities solve,

$$\max_{y,\hat{y},\hat{c},d} \; y - c(y) - \tau_\pi(\hat{y} - \hat{c} - d) - \tau_y d - h(y-\hat{y}, \hat{c}-c) - k(d). \tag{17}$$

The first order conditions for an interior solution replicate equations (8), (10), (11), and (12), ensuring that the main properties of the model remain the same. In particular, the tax system continues to be non-distortionary to production for the same reasons discussed earlier in the paper.[8] Additionally, equations (8), (11), and (12) imply,

$$\tau_\pi = h_{y-\hat{y}}(y-\hat{y}, \hat{c}-c) = h_{\hat{c}-c}(y-\hat{y}, \hat{c}-c) = \tau_y + k'(d),$$

which simply states that the marginal benefit of turnover and cost misreporting should equal that of profit shifting, as otherwise the (joint) firms can rearrange its reporting and profit transferring decisions to increase overall profits.

[7] The functional form of $h(y-\hat{y}, \hat{c}-c)$ is assumed to be such that $h_{y-\hat{y}}(0, \hat{c}-c) > 0$, $h_{\hat{c}-c}(y-\hat{y}, 0) > 0$, and $h(0,0) = 0$.

[8] Besides the assumptions highlighted earlier, it is important to clarify that this theoretical result also relies on the profits tax being non-distortionary, a condition which may not be verified in practice.

3.3. Context and Data

3.3.1. Corporate income tax regimes in Guatemala

According to Guatemalan tax law, there are two coexisting and mutually exclusive income tax regimes where a firm can register to fulfill its tax obligations. The first is *Regimen General*, a regime in which taxes are paid on the amount of reported turnover. The second is *Regimen Optativo*, where taxes are levied on firms' profits.[9] When a firm enters the Tax Registry for the first time, it must choose which income tax regime to belong to. Once in the registry, firms are allowed to switch regime before the beginning of each fiscal year.

Prior to 2013, firms in *Regimen General* paid a flat marginal income tax rate of 5% on turnover, while in *Regimen Optativo* the marginal tax rate was 31% on profits. The 2013 fiscal reform altered these marginal tax rates. The marginal tax rate on the former regime increased up to 7%, depending on turnover, and the marginal tax rate on the latter regime decreased to 25%. Table 3.1 summarizes this information and shows the marginal tax rates during the transition period.

3.3.2. Data

The data used in this analysis comes from a panel database of Guatemalan tax administrative records. This dataset contains the universe of corporate income tax returns filed annually under *Regimen General* and *Regimen Optativo* for the years 2010 to 2015. Moreover, this data is complemented by a database with information on firms' registered accountant and legal

[9] After the 2013 tax reform, *Regimen General* was renamed to *Regimen Opcional Simplificado sobre Ingresos*, while *Regimen Optativo* became known *as Regimen sobre las Utilidades*.

representative.[10] As it will be explained in the empirical section, this latter dataset allows the creation of a proxy for whether firms belong to a network of related firms or not.

Consistency checks were carried out to ensure basic reliability of the data, which resulted in some observations being dropped. Non-commercial firms are excluded from the main sample due to their non-for-profit nature. Table 3.2 provides summary statistics for the final sample under analysis.

3.4. Empirical Strategy

This section discusses the empirical strategy to test some of the predictions of the theoretical model presented in Section 2, and shows the results found after carrying out this empirical exercise. First, it shows the procedure used to separate firms according to whether they are likely to be part of a network of related firms, or not. Then, it defines treatment and control groups, according to their network characteristics. Finally, it presents the difference-in-difference model which is used to obtain the empirical results.

3.4.1. Identification of networks of related firms

The model presented in Section 2 predicts that firms operating in only one income tax regime should respond differently to a change in marginal tax rates than firms belonging to a network of related firms operating in two income tax regimes simultaneously. As explained earlier, this is because the latter type of firms has incentives to engage in profit shifting between regimes and exploit tax arbitrage opportunities.

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[10] Following common practice, the information in both datasets has been anonymized by the Guatemalan Tax Authority.

Hence, one important step in the empirical exercise is to separate firms according to whether they are part of such networks or not. Direct identification would require, at a minimum, information about firms' transactions with each other. While records of these interactions may be accessible in advanced economies, one of the challenges of data from developing countries is that this information is either unavailable or incomplete. Such is the case for the Guatemalan setting studied here.

In the absence of a direct method to categorize firms, this paper follows an alternative –albeit indirect– identification strategy. Firms are grouped according to their *probability* of being part of a network of related firms. The reasoning followed here is that it seems plausible to argue that if two firms share (i) accountant, (ii) legal representative, or (iii) both accountant and legal representative, they are more likely to be related than two firms not sharing any of these individuals. Therefore, those three grouping definitions are used in the empirical analysis as indirect ways to identify tax arbitrage networks. Provided that separating firms using this procedure correctly identifies related firms *on average*, the empirical results should be informative about the differential behavior caused by the Guatemalan income tax reform on regime choice.

A further refinement to the above grouping definitions arises from the realization that some networks of firms may only operate in the same regime. These one-regime networks do not have observable direct opportunities to engage in tax arbitrage and, thus, are considered to have different incentives than two-regimes networks. In other words, the distinction between one-regime and two-regimes networks is important because only firms with a network that covers both regimes would be expected to benefit from income shifting.

3.4.2. Definition of treatment and control groups

For the rest of the paper, treatment and control groups are defined in the following manner. Conditional on the type of network (i.e. by accountant, by legal representative, or by both), the treatment group includes firms that belong to a two-regimes network. By definition, this excludes firms in one-regime networks, as well as all unrelated firms. Nonetheless, for practical purposes the control group only includes the latter firms.

There are two main arguments behind this rationale. First, from a conceptual point of view, firms in one-regime networks may still be indirectly involved in two-regimes networks. For instance, a firm related by its accountant only to a one-regime network, may also be related by its legal representative to a different network which operates in the excluded regime. Second, from a methodological perspective, one-regime networks seem to have different characteristics than the other two groups.[11] As a consequence, the parallel trends assumption needed by the differences-in-differences approach used in the empirical analysis is likely to be violated. Hence, both of these issues could lead to problems of identification if one-regime networks are included as either part of the control or treatment groups.

3.4.3. Empirical model

Based on the network definitions above, the empirical analysis relies on the following difference-in-difference model to identify the effect of the Guatemalan income tax reform on regime choice,

$$RG_{it} = \beta_0 + \beta_1 network_i + \beta_2 reform_t + \beta_3 network_i \times reform_t + \beta_4 turnover_{it} + \nu_{it} \quad (18)$$

[11] See the discussion about this issue in Section 5.

where, RG_{it} is a dummy variable that captures whether firm i is registered in *Regimen General*[12] or not at time t; $network_i$ is a dummy variable that equals one if firm i belongs to the treatment group under analysis; $reform_t$ is a dummy variable that equals one for the post-reform period (i.e. from 2013 onwards); $turnover_{it}$ corresponds to the value in Quetzales of firm i 's reported turnover at time t; and, ν_{it} is the error term. The coefficient β_3 is the object of interest, as it captures the differential behavior between treatment and control group caused by the introduction of the tax reform. The model's causal interpretation of β_3 relies on the assumption of parallel trends for both groups before the reform. The plausibility of this assumption will be discussed in the next section.

3.5. Empirical Results

3.5.1. Firms' registration in Regimen General by network type

Figure 3.1 shows the evolution over time of firm's registration in *Regimen General* by network type. The shaded area in each graph corresponds to the post-reform period. Panel (a) presents the share of firms registered in *Regimen General*, according to whether firms are related by a common accountant. As predicted by the model, the share of unrelated firms, and firms operating within a one-regime network, shows a marked decrease immediately after the 2013 reform. On the other hand, firms in a network covering both regimes seem to be less reactive to this change, but still show a significant fall in their share. Panel (b) repeats the same exercise for firms related by a common legal representative. As before, unrelated firms, and firms in a one-regime network experience a marked decrease after the reform, but in this case firms in two-regimes networks do not show any noteworthy response. Finally, panel (c) examines the shares for firms related by

[12] Since regime choice is mutually exclusive, a firm that is not registered in *Regimen General* must be registered in *Regimen Optativo*.

both a common accountant and a legal representative. Similar to panel (b), each group's behavior seems consistent with the theoretical predictions of the model.

A final observation regarding Figure 3.1, is that the graphical evidence suggests the existence of parallel trends between unrelated and two-regimes firms, but not for one-regime networks. This evidence supports the use of unrelated firms as a control group, and of firms in two-regimes networks as the treatment group. As this evidence is suggestive only, in the next section this intuition will be formalized by a more rigorous analysis of these patterns.

3.5.2. Results of the baseline difference-in-difference estimation

Table 3.3 summarizes the results of estimating the baseline difference-in-difference model presented in equation (18). According to these estimates, the impact of the income tax reform on regime choice ranges between 0.79 and 1.15 percentage points. Since in this setting the treatment group consists of firms belonging to a two-regimes network –which by the nature of the treatment remain unresponsive to the reform–, these coefficients represent a decrease in an unrelated firm's probability of registering in *Regimen General*. The direction of the effect is in line with the prediction of the theoretical model.

To test the parallel trends assumption in this model, a placebo reform dummy was introduced. This placebo reform dummy is equal to one for the year 2012, and zero for previous years. For the model to be consistent with the parallel trends assumption, the β_3 coefficient must not be significantly different than zero when the model is run for the pre-reform period only. As seen in Table 3.3, the estimated coefficients support this assumption for the cases of networks linked by accountant only, and by accountant and legal representative, but not when defined by legal representative only.

3.5.3. Results of the generalized difference-in-difference estimation

The baseline model estimates capture the effect of the reform on regime choice for the post-reform period as a whole. However, as shown in Table 3.1, the reform was rolled in between 2013 and 2015, with marginal tax rates changing every year during that period. For this reason, a generalized difference-in-difference model was estimated, with treatment and control groups as defined before, as well as dummies for each pre-reform and post-reform year.[13]

Figure 3.2 plots the difference-in-difference coefficients resulting from estimating this model. As seen in the graphs, the estimates suggest that the biggest impact occurred in 2013, with only slight differences in the following years. For networks linked by accountant (panel A), the average effect is around 1.2 percentage points; for networks linked by legal representative (panel B) this average is about 0.6 percentage points; and for networks linked by both accountant and legal representative (panel C), the estimated average impact is 1.1 percentage points. These magnitudes are similar to the baseline model.

3.5.4. Heterogeneity of the response by income groups

Besides the transitional adjustment of the marginal tax rates in the post-reform period, Table 3.1 also shows that income groups were affected differentially. Firms with a monthly income below Q.30,000 faced a slightly lower marginal turnover tax than firms with larger income. Since the available data does not contain monthly income data, firms were separated by their annual income into two categories to analyze the potential heterogeneous effect of the reform. The lower income category corresponds to an annual income below Q360,000 (about US$45,000 at the time), while

[13] The excluded period is 2012, so as to measure the impacts relative to that year.

the higher income category consists of firms with income larger than that amount.[14] The results for each income group are shown in Figure 3.3.

As shown in the graphs, there are heterogeneous effects of the reform. These effects concentrate on firms with lower income, while there does not seem to be any differential impact on higher income firms. For the former group, the magnitude of the coefficients is slightly higher than those obtained in the previous section, ranging between 0.6 to 1.6 percentage points, depending on the network definition. The results are somewhat surprising, because higher income firms faced larger adjustment in marginal income tax rates.[15] Part of the explanation could be that higher income firms also tend to have lower reported profit margins, which mean that, on average, fewer of them were closer to the switching threshold before and after the reform. On the other hand, higher income firms could also be more likely to belong to two-regimes networks *indirectly*. In such case, the distinction between treatment and control group would be difficult to attain by defining networks using accountants and legal representatives directly. Finally, higher income firms may also have additional margins of adjustment unavailable to lower income firms, and this may be playing a role in firms' behavior.

3.6. Conclusions

This paper explored the consequences of having two co-existing corporate income tax regimes within a domestic tax system. The theoretical model developed in Section 2, predicts that firms belonging to a two-regimes network should not alter their choice of regime in response to a change in marginal tax rates. Instead, the model predicts that unrelated firms should be the ones reacting to such a change. Following a difference-in-difference approach, where treatment and control

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[14] The chosen annual amount represents what a firm would earn per year if its average monthly income was Q.30,000.
[15] See Table 3.1.

groups are defined by whether firms belong to a two-regimes network or not, the results show differential behavior between the two groups as predicted by theory. According to the estimates, the reform had a negative effect of about one percentage point on the probability of registering in *Regimen General* for unrelated firms. Most of the impact seems to have taken place among lower income firms, despite higher income firms facing larger adjustments in the turnover marginal tax rates. While overall the behavioral responses of treatment and control groups are consistent with the theoretical predictions, it is acknowledged that these empirical results only provide indirect evidence of profit shifting and the existence of tax arbitrage networks in Guatemala.

3.7. References

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Figure 3.1 – Firms Registered in *Regimen General* by Network Type

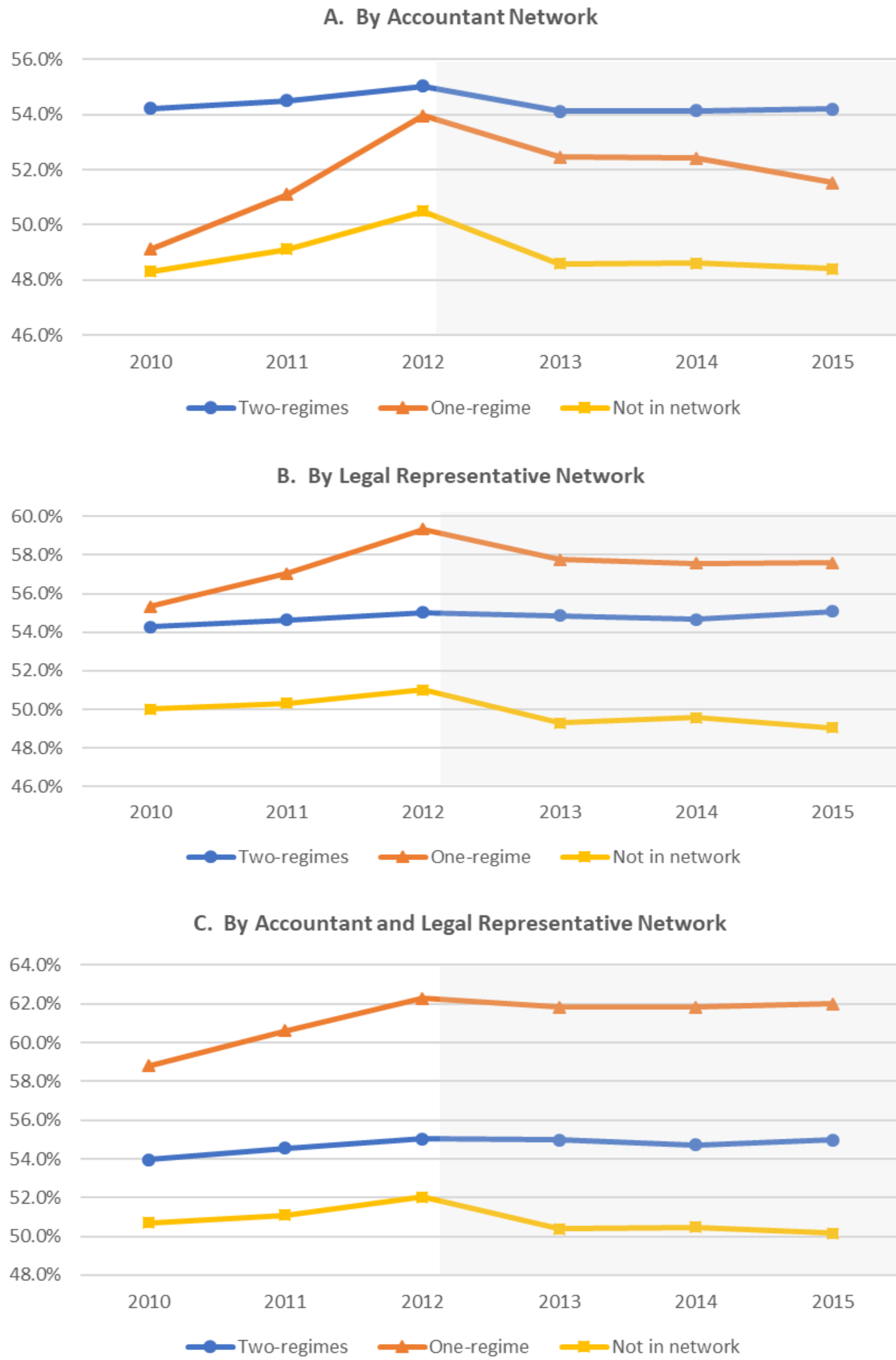


Figure 3.2 – Generalized difference-in-difference coefficients, by network type

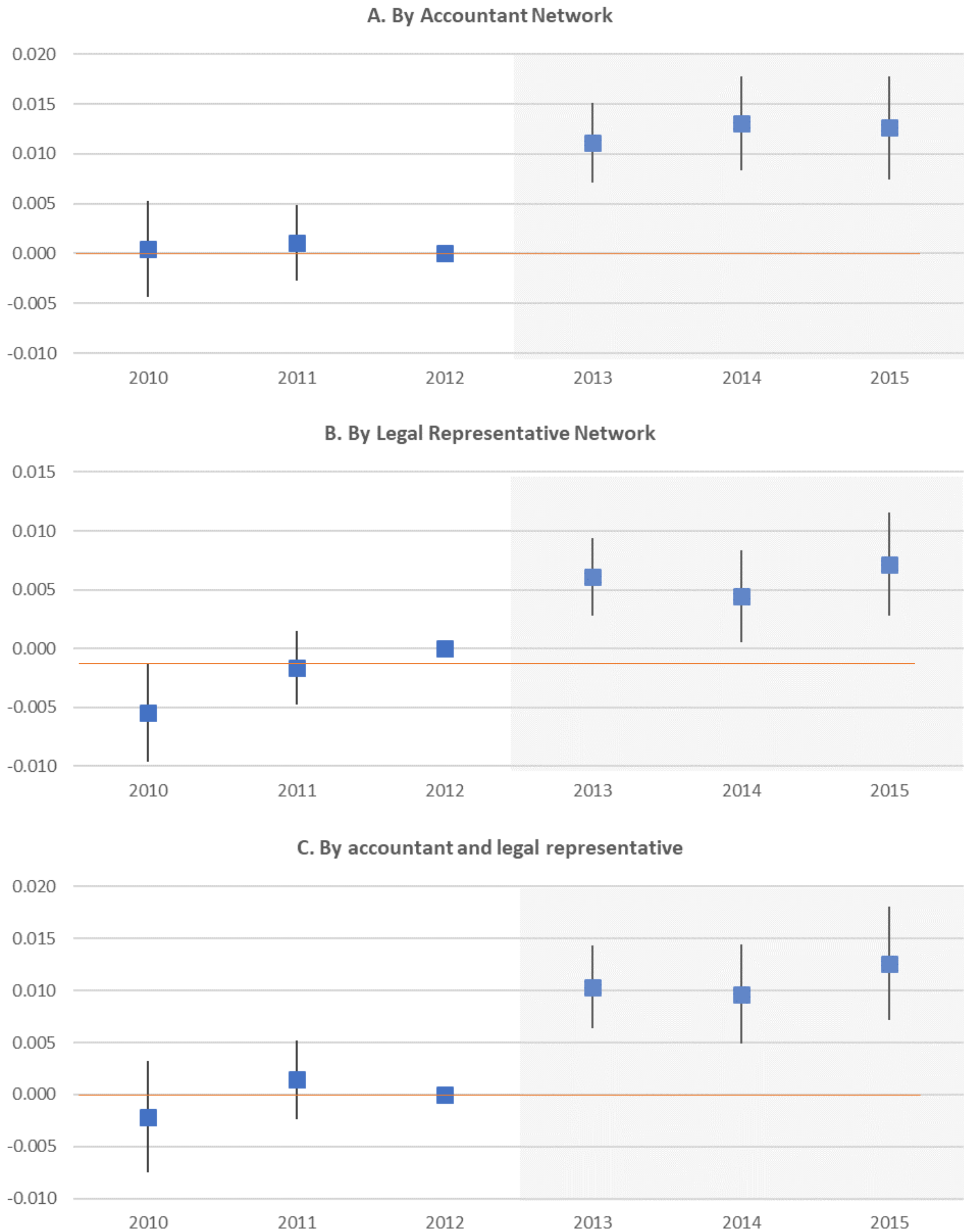
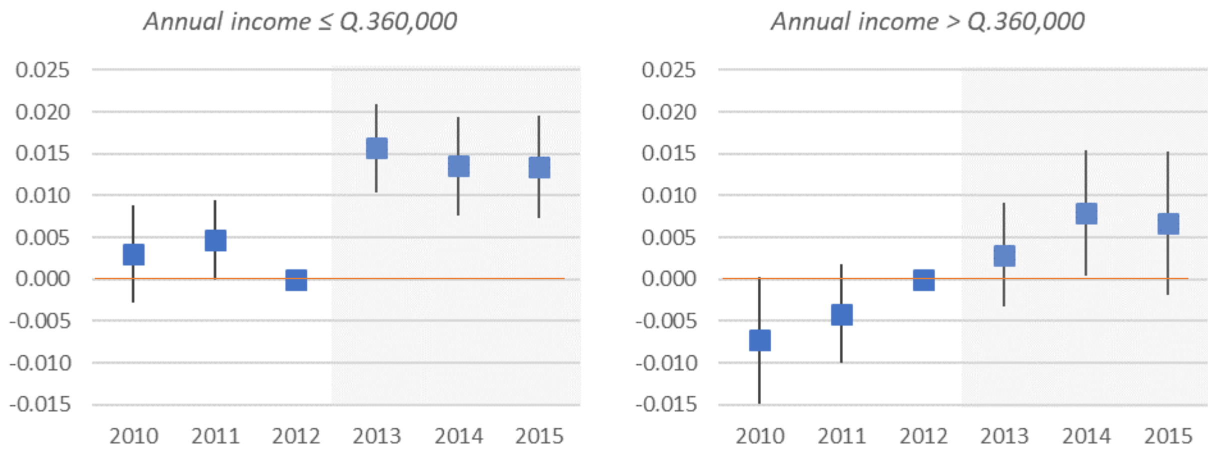
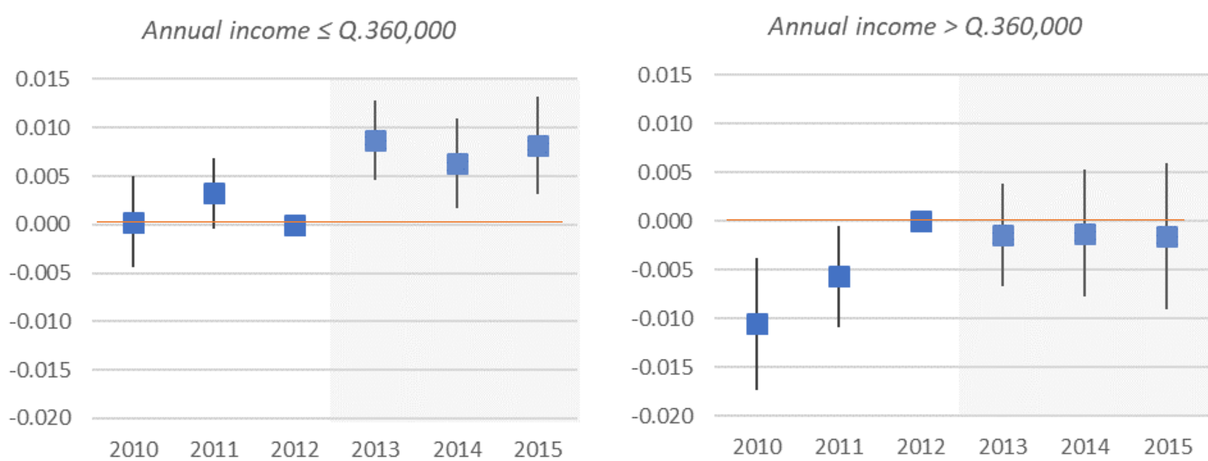


Figure 3.3 – Heterogeneity by income groups

A. By Accountant Network



B. By Legal Representative Network



C. By Accountant and Legal Representative Network

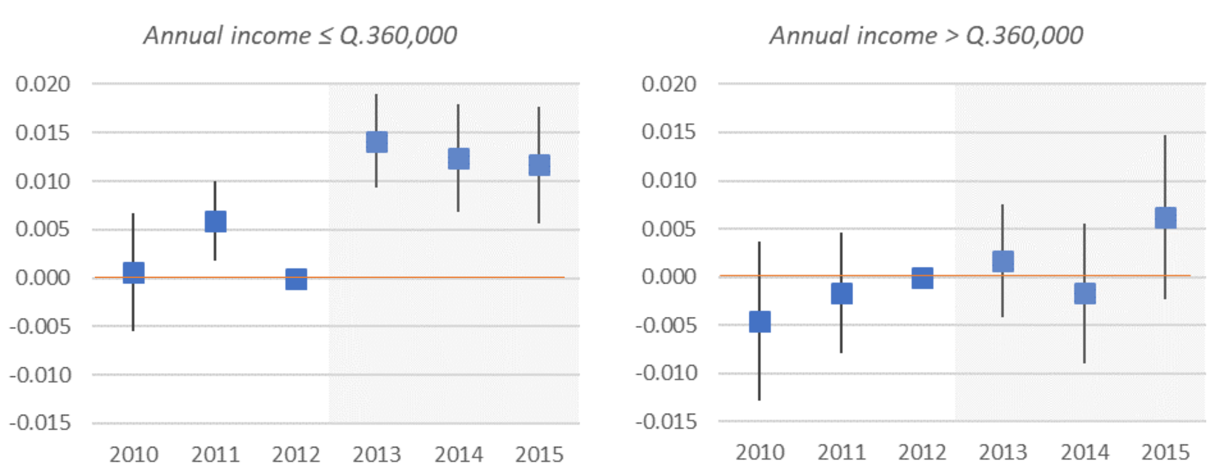


Table 3.1 – Marginal Income Tax Rates Before and After the 2013 Fiscal Reform

	Pre-reform	Post-reform		
	Up to 2012	2013	2014	From 2015
Regimen General	5% on turnover	5% for monthly turnover up to Q30,000; 6% for turnover in excess Q30,000	5% for monthly turnover up to Q30,000; 7% for turnover in excess Q30,000	5% for monthly turnover up to Q30,000; 7% for turnover in excess Q30,000
Regimen Optativo	31% on profits	31% on profits	28% on profits	25% on profits

Source: Superintendencia de Administración Tributaria

Table 3.2 – Summary Statistics for Firms under *Regimen General* and *Regimen Optativo*

Indicator	Full Sample	2010	2011	2012	2013	2014	2015
Observations	414,189	61,923	65,399	68,135	70,470	73,223	75,039
Share in *Regimen General*	53.0%	52.3%	53.0%	54.0%	52.8%	52.9%	52.7%
Related by accountant	80.4%	79.3%	80.0%	80.5%	80.9%	81.3%	80.0%
Related by legal representative	51.0%	48.9%	49.9%	50.7%	51.8%	52.5%	51.8%
Related by accountant and legal representative	28.4%	27.0%	27.6%	28.0%	28.9%	29.5%	29.2%

Table 3.3 – Summary baseline difference-in-difference estimates, by network type

	By accountant (1)	By legal representative (2)	By acc. & legal rep. (3)
β_3	0.0115*** (0.0022)	0.0079*** (0.0019)	0.0107*** (0.0023)
Observations	362,578	322,052	347,821
Treated	281,280	119,113	51,387
Parallel trends coefficient *(Placebo reform model)*	-0.0008 (0.0020)	0.0036** (0.0016)	0.0008 (0.0020)

Notes: Robust standard errors in parenthesis, clustered at the firm level. * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

APPENDIX A. Supplementary material for Chapter 1

A.1. Model with turnover and cost misreporting

A.1.1. Profit maximization under a pure profits tax

The basic model presented in Section 2 can be extended to account for turnover misreporting. In this case, the tax liability faced by firms, $T(\hat{y},\hat{c})$, depends on both reported turnover, $\hat{y}$, and reported cost, $\hat{c}$. Private costs of evasion, $h\big(y-\hat{y},\ \hat{c}-c(y)\big)$, depend on misreported turnover and misreported costs. Hence, the firm's problem is now,

$$\max_{y,\hat{y},\hat{c}}\ y-c(y)-T(\hat{y},\hat{c})-h\big(y-\hat{y},\ \hat{c}-c(y)\big). \tag{A1}$$

For the case of a pure profits tax, the tax liability function becomes $T(\hat{y},\hat{c})=\tau_{\pi}(\hat{y}-\hat{c})$. The firm's first order conditions for an interior solution are,

$$c'(y)\big[1-h_{\hat{c}-c}\big(y-\hat{y},\ \hat{c}-c(y)\big)\big]=1-h_{y-\hat{y}}\big(y-\hat{y},\ \hat{c}-c(y)\big) \tag{A2}$$

$$h_{y-\hat{y}}\big(y-\hat{y},\ \hat{c}-c(y)\big)=\tau_{\pi} \tag{A3}$$

$$h_{\hat{c}-c}\big(y-\hat{y},\ \hat{c}-c(y)\big)=\tau_{\pi}. \tag{A4}$$

Optimal turnover misreporting is governed by equation (A3), while optimal cost misreporting is determined by equation (A4). Combining all the conditions above yields,

$$c'(y)=1. \tag{A5}$$

This condition keeps the feature of a non-distortionary pure profits tax.

A.1.2. Profit maximization under a turnover tax

In the context of turnover and cost misreporting, the tax liability function takes the form $T(\hat{y}, \hat{c}) = \tau_y \hat{y}$. The first order conditions for an interior solution to this problem are,

$$c'(y)\left[1 - h_{\hat{c}-c}\big(y - \hat{y},\ \hat{c} - c(y)\big)\right] = 1 - h_{y-\hat{y}}\big(y - \hat{y},\ \hat{c} - c(y)\big) \tag{A6}$$

$$h_{y-\hat{y}}\big(y - \hat{y},\ \hat{c} - c(y)\big) = \tau_y, \tag{A7}$$

$$h_{\hat{c}-c}\big(y - \hat{y},\ \hat{c} - c(y)\big) = 0, \tag{A8}$$

which together imply,

$$c'(y) = 1 - \tau_y. \tag{A9}$$

As in the simplified model, a turnover tax has a distortionary effect, since equation (A9) relates the optimal output level to the tax rate. Thus, output will be lower than under a profits tax, and so will total evasion. The main difference with the simplified model is that now turnover misreporting still occurs, despite cost misreporting being zero. However, given that $h\big(y - \hat{y},\ \hat{c} - c(y)\big)$ is a convex function of the amount being evaded, and as long as $\tau_\pi > \tau_y$, a firm facing a turnover tax will be expected to misreport a lower amount of turnover than under a pure profits tax. In practice, this condition is often verified. For instance, for the Guatemalan setting $\tau_\pi \gg \tau_y$, since $\tau_\pi = 31\%$ and $\tau_y = 0.93\%$.

A.1.3. Profit maximization under a minimum tax

With turnover misreporting, the typical income tax liability function under a minimum tax has the form,

$$T(\hat{y}, \hat{c}) = \max\{\tau_\pi(\hat{y} - \hat{c}), \tau_y \hat{y}\}. \tag{A10}$$

Equation (8) indicates that a firm faces the largest tax liability between a profit tax and a turnover tax. For a given combination of reported turnover and reported cost, $(\hat{y}, \hat{c})$, the two liabilities are equal when,

$$\tau_\pi(\hat{y} - \hat{c}) = \tau_y \hat{y} \qquad \Leftrightarrow \qquad \hat{p} \equiv \frac{(\hat{y} - \hat{c})}{\hat{y}} = \frac{\tau_y}{\tau_\pi}. \tag{A11}$$

Hence, $\hat{p}$ is now defined in terms of reported turnover and reported cost, instead of actual turnover, as before. Given this threshold, firms with a reported profit margin above or equal to τ_y/τ_π will face the incentives shown in section A.1, while firms with a reported profit margin below this threshold will behave as described in section A.2.

A.2. Optimality conditions under *Regimen Optativo*

Equation (16), copied below, states the firm's problem under *Regimen Optativo*,

$$\max_{y,\, \hat{c}_{COGS},\, \hat{c}_o} \; y - c_{COGS}(y) - c_o(y) - T(y, \hat{c}_{COGS}, \hat{c}_o) - h\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big).$$

In this setting, firms choose output, reported COGS and reported other costs to maximize their after-tax profits. The cost of evasion function, $h\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big)$, considers misreporting of both types of cost. Assuming that the total cost function can be expressed as $c(y) = c_{COGS}(y) + c_o(y)$, this model yields the following optimality conditions,

$$c'_{COGS}(y)\left[1 - h_{\hat{c}_{cogs} - c_{cogs}}\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big)\right]$$
$$+ c'_o(y)\big[1 - h_{\hat{c}_o - c_o}\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big)\big] = 1 - T_y(y, \hat{c}_{COGS}, \hat{c}_o) \qquad \text{(B1)}$$

$$h_{\hat{c}_{cogs} - c_{cogs}}\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big) = -T_{\hat{c}_{cogs}}(y, \hat{c}_{COGS}, \hat{c}_o) \qquad \text{(B2)}$$

$$h_{\hat{c}_o - c_o}\big(\hat{c}_{COGS} - c_{COGS}(y), \hat{c}_o - c_o(y)\big) = -T_{\hat{c}_o}(y, \hat{c}_{COGS}, \hat{c}_o), \qquad \text{(B3)}$$

which are similar in nature to those shown in the theoretical section. The main difference arises from the fact that there are now two optimality conditions regarding cost misreporting.

Under a pure profit tax, the optimality conditions imply,[16]

$$c'(y) = c'_{COGS}(y) + c'_o(y) = 1, \qquad \text{(B4)}$$

while under turnover taxation, this changes to,

$$c'(y) = c'_{COGS}(y) + c'_o(y) = 1 - \tau_y. \qquad \text{(B5)}$$

[16] This is because, under a pure profit tax, $T_y(y, \hat{c}_{COGS}, \hat{c}_o) = -T_{\hat{c}_{cogs}}(y, \hat{c}_{COGS}, \hat{c}_o) = -T_{\hat{c}_o}(y, \hat{c}_{COGS}, \hat{c}_o) = \tau_\pi$.

Therefore, the general conclusions of the analysis of firms' responses, described in Section 2, remain largely unchanged.

A.3. Supplementary Tables and Figures

Table A.1 – Estimated evasion responses at the MTS payment threshold using Non-exempt firms to derive the counterfactual density distribution

	Observed responses		**Model without Evasion**	**Model with Evasion (values show change in misreporting in % of reported profits)**				
	Bunching (b)	Profit Margin Response ($\Delta\hat{p}$)	Estimated Output Elasticity (ε_y)	Given $\varepsilon_y = 0$	Given $\varepsilon_y = 0.5$	Given $\varepsilon_y = 1$	Given $\varepsilon_y = 5$	Given $\varepsilon_y = 10$
Non-Exempt Firms	5.69	0.57	20.38	18.95	18.49	18.02	14.30	9.65
Ratio of reported-to-actual profits (upper-bound)				0.84	0.84	0.85	0.87	0.91

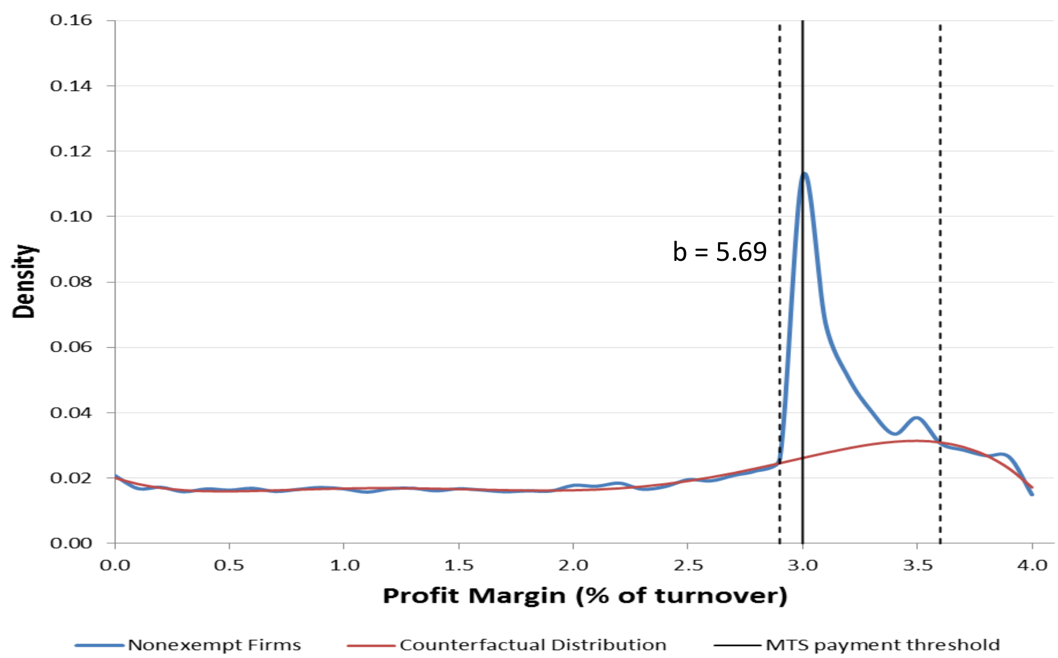


Figure A.1 – Bunching Estimation for Non-exempt Firms at the MTS payment threshold using the standard bunching methodology. The figure above illustrates the empirical density of the profit margin (in % of turnover) for non-exempt firms, using a bin size of 0.1. The counterfactual density shown corresponds to that estimated from the empirical density of non-exempt firms, as opposed to exemption-eligible firms. The estimated excess mass in this figure comes from the difference between the depicted densities in the range enclosed by the dashed vertical lines.

APPENDIX B. Supplementary material for Chapter 2

Table B.1 – List of countries included in the analysis

Afghanistan
Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Republic
Chad
Chile
China
Colombia
Comoros
Costa Rica
Croatia
Cyprus
Czech Republic
Côte d'Ivoire
Democratic Republic of the Congo
Denmark
Djibouti
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Estonia
Ethiopia
FYR Macedonia
Fiji
Finland
France
Gabon
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iraq
Ireland
Iran
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Korea
Kuwait
Kyrgyz Republic
Lao P.D.R.
Latvia
Lebanon
Lesotho
Liberia
Libya
Lithuania
Luxembourg
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Moldova
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Republic of Congo
Russia
Rwanda
Samoa
Saudi Arabia
Senegal
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands
South Africa
South Sudan
Spain
Sri Lanka
St. Lucia
Sudan
Suriname
Swaziland
Sweden
Switzerland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
The Bahamas
The Gambia
Togo
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Vanuatu
Venezuela
Vietnam
Yemen
Zambia
Zimbabwe

APPENDIX C. Supplementary material for Chapter 3

Table C.1 – Baseline difference-in-difference estimates

	By accountant (1)	By legal representative (2)	By acc. & legal rep. (3)
$network$	0.0082 (0.0076)	0.0097* (0.0051)	0 .0186** (0.0089)
$reform$	0.0025 (0.0020)	0.0054*** (0.0012)	0.0066*** (0.0010)
$network \times reform$	0.0115*** (0.0022)	0.0079*** (0.0025)	0.0107*** (0.0024)
$income$	-2.05e-10*** (5.29e-11)	-1.88e-10*** (3.92e-11)	-1.98e-10*** (5.08e-11)
$constant$	0.5204*** (0.0059)	0.5101*** (0.0020)	0 .5082*** (0.0014)
Observations	362,578	322,052	347,821
Treated	281,280	119,113	51,387

Notes: Robust standard errors in parenthesis, clustered at the firm level. * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Table C.2 – Generalized difference-in-difference estimates

	By accountant (1)	By legal representative (2)	By acc. & legal rep. (3)
$network$	0.0059 (0.0076)	0.0102** (0.0051)	0.0164* (0.0088)
$year2010$	-0.0197*** (0.0022)	-0.0147*** (0.0013)	-0.0176*** (0.0010)
$network \times year2010$	0.0004 (0.0024)	-0.0054** (0.0021)	-0.0021 (0.0027)
$year2011$	-0.0123*** (0.0017)	-0.0093*** (0.0010)	-0.0108*** (0.0009)
$network \times year2011$	0.0010 (0.0019)	-0.0016 (0.0016)	0.0014 (0.0019)
$year2013$	-0.0084*** (0.0018)	-0.0039*** (0.0011)	-0.0033*** (0.0009)
$network \times year2013$	0.0111*** (0.0020)	0.0061*** (0.0017)	0.0103*** (0.0020)
$year2014$	-0.0073*** (0.0022)	-0.0002 (0.0013)	-0.0010 (0.0010)
$network \times year2014$	0.0131*** (0.0024)	0.0045** (0.0020)	0.0097*** (0.0024)
$year2015$	-0.0070*** (0.0023)	-0.0018 (0.0014)	-0.0023* (0.0011)
$network \times year2015$	0.0126*** (0.0027)	0.0071*** (0.0022)	0.0126*** (0.0028)
$income$	-2.08e-10*** (5.34e-11)	-1.91e-10*** (3.96e-11)	-2.01e-10*** (5.12e-11)
$constant$	0.5320*** (0.0060)	0.5183*** (0.0020)	0 .5175*** (0.0015)
Observations	362,578	322,052	347,821
Treated	281,280	119,113	51,387

Notes: Robust standard errors in parenthesis, clustered at the firm level. * significant at 10% level; ** significant at 5% level; *** significant at 1% level.