

Not(ch) Your Average Tax System: Corporate Taxation Under Weak Enforcement

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Abstract

The corporate income tax typically allows for all production costs to be deducted; thus in a context with evasion opportunities, firms facing higher tax rates could reduce their tax base by both deflating revenue and inflating costs. Therefore, while the elasticity of profits is a sufficient statistic for the range of optimal tax *rates* given a tax base, separating the profit response into a revenue and a cost elasticity is needed to determine the optimal tax *base*. We take advantage of Costa Rica's corporate tax design, where firms with marginally higher revenue face discontinuously higher average tax rates. We apply a novel method, which combines bunching and a discontinuity design, to estimate the profit elasticity and, for the first time, separate it into a revenue and a cost elasticity. We find that firms facing a higher tax rate slightly decrease revenue, but considerably increase costs, generating a large profit elasticity. Using additional data, we show that firms' behavioral responses appear to occur through tax evasion with no evidence of production responses. Taken together, this implies that Costa Rican firms evade taxes on 70% of their profits when faced with a 30% tax rate. In this context, we estimate the revenue maximizing rate to be below 25%. In addition, alternative tax bases, which limit cost deductibility, are preferable since they reduce evasion opportunities on this crucial margin.

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1 Introduction

Lower-income countries only collect 20% of their GDP in taxes, compared to 35% on average for OECD countries (Gordon and Li 2009, Besley and Persson 2013). For the corporate income tax, the slope of the tax-take to GDP is similar: low-income countries collect 2% of their national income, while rich countries collect 3.5% (Figure 1A). A possible explanation for this pattern is that, in developing countries, the elasticity of corporate profits with respect to the tax rate is largely due to evasion. Unlike the personal income tax, the corporate tax typically allows for all production costs to be deducted; in a context with tax evasion opportunities, firms facing higher tax rates could reduce their tax base by both deflating reported revenue and inflating reported costs (Carrillo, Pomeranz and Singhal 2014, Slemrod, Collins, Hoopes, Reck and Sebastiani 2015). Therefore, while the elasticity of profits is a sufficient statistic for the range of optimal tax *rates* given a tax base, theory has shown that separating the profit response into a revenue and a cost elasticity is needed to determine the optimal tax *base* (Best, Brockmeyer, Kleven, Spinnewijn and Waseem 2015).

However, due to limited sources of exogenous variation in corporate tax rates, it has been challenging to *empirically* estimate the elasticity of corporate income and understand the mechanisms behind firms' responses to higher tax rates. First, corporate tax reforms are endogenous to the economic context and often happen simultaneously with changes in the tax base and in tax enforcement (Kawano and Slemrod 2016). Second, when using tax reforms, the most common methodology is to instrument the change in the tax rate with the counterfactual change in the tax rate assuming taxpayers earned their base-year income. This estimation is prone to mean reversion and sensitive to specification choices (Gruber and Saez 2002, Kopczuk 2005, Weber 2014). Third, corporate tax schedules are typically flat and hence less amenable to the discontinuity methods recently used with the personal income tax (Saez 2010, Chetty, Friedman, Olsen and Pistaferri 2011, Kleven and Waseem 2013).

In this paper, we instead take advantage of the unique corporate tax design in Costa Rica to estimate the elasticity of corporate profits, and use a novel method to separate, for the first time, the profit response into a revenue and a cost response. While most corporate tax systems tax profits at a flat rate, Costa Rica imposes increasing *average* tax rates on profits as a function of firms' revenue. This generates a notched tax schedule: the average tax rate jumps from 10 to 20%

at the first revenue threshold and from 20 to 30% at the second threshold. The change in average tax rates generates two distinct behavioral responses. First, some firms reduce their revenue below the threshold, in order to lower the tax rate they face on their entire profit base. This creates excess mass in the firm distribution just below the threshold, and missing mass above it, which we use to measure the elasticity of revenue by adapting the notch estimation technique in [Kleven and Waseem \(2013\)](#). Second, and more importantly, firms remaining above the revenue threshold respond to the higher tax rate by sharply reducing their reported profits. This is evidenced by a large “donut-hole” discontinuity in average profits by revenue on either side of each threshold, even for firms infra-marginal to the bunching behavior. This profit response is a mix of firms lowering their revenue and increasing their costs. Using the estimated revenue elasticity (obtained in the first stage with bunching), we hold revenue responses constant, such that the remaining profit discontinuity only identifies changes in reported costs. Finally, by combining the revenue and cost responses we estimate the elasticity of profits with respect to the net of tax rate. The resulting profit elasticities are very large: 5 at the first threshold and 3 at the second threshold. These are an order of magnitude higher than those of small firms in OECD countries, estimated at around 0.5 ([Devereux, Liu and Loretz 2014](#), [Patel, Seegert and Smith 2015](#)) and their size severely constrains the range of optimal tax rates: given the current policy environment, rates above 25% are on the wrong side of the Laffer curve for such firms in Costa Rica.

The reduced-form estimation provides a robust measure of the profit elasticity. Intuitively, the profit elasticity is identified from the discontinuity at the threshold, while the revenue bunching is used to separate the revenue and cost elasticities. Higher revenue responses mechanically lowers cost responses, leaving profit responses unchanged. In contrast, the revenue and cost elasticities are not as robust: under heterogeneity in revenue elasticities, bunching estimation recovers the response of the highest revenue elasticity firm, and hence is an upper bound to the average revenue elasticity. This implies that the estimated cost elasticity is a lower bound. Without further assumptions, these estimates are the tightest possible bounds. In a second part, we impose structure on the distribution of firms’ profit by revenue, in order to estimate opposite bounds on each of the revenue and cost elasticities. We assume that the counterfactual distribution of firms’ profit margin by revenue is stable around the threshold, and we show that this assumption holds for firms with revenue away from the threshold. This allows us to characterize the joint distribution of firms’ revenue and cost absent the tax change at the thresholds, and to model firms bunching de-

cision as a function of both revenue and cost. We jointly estimate the fixed-point revenue and cost elasticities to match the empirical bunching behavior and the profit discontinuity. By abstracting from optimization frictions, this estimation arguably provides opposite bounds to the reduced form estimates; including frictions would increase the revenue elasticity needed to match the observed bunching and lower the cost elasticity. We find that the cost elasticity is substantially larger than the revenue elasticity: cost responses account for 60 to 70% of the drop in reported profits and revenue responses for 30 to 40%. This highlights a novel mechanism; even though the tax administration partially observes firm revenue, observing business costs is so hard that the standard profit tax collects little income. In turn, firms’ ease in misreporting profits by inflating costs, rationalizes the use of tax bases with few deductions and tax policies determined by revenue, instead of profits. Such policies, while rare in rich countries, are in fact observed in lower-income countries.¹

We provide several robustness checks to support the main results. First, the “donut-hole” discontinuity relies on the credibly extrapolation to the thresholds of the average profit by revenue relation. We show that this relation is linear and very stable away from the thresholds. Second, we establish that the profit discontinuity at the thresholds is not driven by a few firms. Instead, it exists at all percentiles of the profit distribution, across years and across industries. Third, varying the bunching parameters (e.g. polynomial order, window size) and the regression discontinuity parameters has limited impact on the results. Finally, we show that firms’ dynamic behavior mirrors the static behavior. When firms’ grow past a threshold, their reported profit margin sharply drops, while firms with comparable revenue growth rates, but remaining within the same tax bracket, slightly increase their profit margin compared to the previous year.

Behavioral responses due to evasion, avoidance or real production decisions have the same impact on revenue collection, but call for different policies. To study the mechanisms of firms’ responses we draw on rich administrative datasets. In addition to the corporate tax returns, we use information on audits, the central bank’s registry of firms’ ownership, social security data on wages and employment, and monthly sales tax receipts. We find evidence that tax evasion is a key driver of responses for bunching firms: these firms are significantly more likely to display inconsistencies with third-party reported information and adjust revenue upwards following audit threats at the industry level. Furthermore, all statistical tests for real effects and avoidance responses are re-

¹Examples of such policies are presumptive taxes, which tax revenue instead of profits, enforcement and registration thresholds determined by revenue (e.g. Large Taxpayers Units), and corporate tax systems with different rates as a function of revenue.

jected: the social security data shows no discontinuity in the number of employees and wage bill at the threshold, monthly sales receipts do not display evidence of revenue shifting across fiscal years and the registry of economic groups only shows very modest evidence of firms dividing themselves into smaller firms. In a literature that often remains agnostic on the mechanisms of behavioral response, our paper takes innovative steps to support tax evasion as the key mechanism. Further, if we assume that profit responses are only due to evasion, then firms facing a 30% tax rate evade taxes on as much as 70% of their profits.

Our paper relates to the growing literature on tax design and tax enforcement in low and middle income countries. We are one of the first papers to estimate a corporate tax elasticity² in this context and find that it is substantially higher than in rich countries; [Devereux et al. \(2014\)](#) for the UK and [Patel et al. \(2015\)](#) for the US both estimate corporate elasticities of 0.5. These estimates are particularly relevant for comparison since they also concern small and medium firms. To make sense of the magnitude of our results one needs to consider the weak enforcement environment - an expanding empirical literature ([Pomeranz 2015](#), [Naritomi 2015](#)) shows that difficulties in monitoring transactions and missing third-party information lead to large evasion rates in developing countries.³ In our study, firms facing a 30% tax rate have an implied evasion rate on profits of 70%, which is comparable to the 60% evasion rate estimated with micro-data for large Pakistani firms by [Best et al. \(2015\)](#) and the 65% evasion for Costa Rican firms, estimated with aggregate data by the [IMF \(2012\)](#). Our results imply that lowering corporate tax rates could increase tax revenue for small and medium firms. This resonates with [Gorodnichenko et al. \(2009\)](#) and [Kopczuk \(2012\)](#), who both find that flat tax reforms in Eastern Europe, which decreased substantially the rate and simplified the tax code, led to a large increase in reported income.

Our paper also contributes to a recent literature on the two-dimensional aspect of the corporate tax base and provides the first separation of the elasticity of profit into cost and revenue responses. The relative ease to manipulate costs, compared to revenue, complements the findings of [Carrillo et al. \(2014\)](#) and [Slemrod et al. \(2015\)](#): both studies show that following tighter enforcement on revenue by the tax administration, firms' reported revenue increases to limit audit risks, but reported

²A large literature summarized in [Auerbach et al. \(2010\)](#) studies firms' responses to the tax code but few studies estimate corporate tax elasticities. An exception is [Gruber and Rauh \(2007\)](#) who estimate an elasticity of 0.2 for large US corporations, using panel data and an instrument for the effective tax rate change. With a similar methodology, [Dwenger and Steiner \(2012\)](#) estimates a corporate tax elasticity of 0.5 in Germany

³[Kleven et al. \(2011\)](#) and [Slemrod et al. \(2001\)](#) use randomized audits to estimate tax evasion in respectively Denmark and Minnesota - they find tax evasion rates as high as 40% on income not subject to third-party reporting

costs also increase, such that the overall tax liability remained unchanged. Regarding optimal tax policy, the result supports theoretical work on the desirability of “production inefficient” tax instruments under evasion (Emran and Stiglitz 2005, Gordon and Li 2009) and the results of Best et al. (2015): when evasion opportunities are large, limiting deductions or switching to a turnover tax with no deductions could be optimal.

Finally, from a methodological standpoint, we contribute to the literature using discontinuities in tax design to identify structural parameters. Saez (2010) and Chetty et al. (2011) developed the framework to recover taxable income elasticities from kink points, which was extended to notches by Kleven and Waseem (2013). In our setting, tax notches are determined by revenue, but the tax rate applies to profit. We develop a new estimation technique which uses this two-dimensional variation around a notch⁴ to estimate the profit elasticity, and to separate revenue and cost elasticities. Revenue-dependent policies, such as registration and enforcement thresholds,⁵ are common in low-income countries, and our methodology could be applied to these settings, with the caveat that it requires large sample sizes and regularity in the data.

The paper is organized as follows. Section 2 introduces the tax system and the theoretical framework. Section 3 presents the data, methods and results. Section 4 adds structure to refine the previous results. Section 5 shows evidence of evasion as a key mechanism, while Section 6 rejects specific real and avoidance mechanisms. Section 7 discusses policy implications and concludes.

2 Tax System and Theoretical Framework

2.1 Corporate Tax System in Costa Rica

Figure 2 presents the Costa Rican corporate tax schedule. A corporation pays an average tax rate of 10%, 20% or 30% on its profit as a function of its revenue - firms with revenue below the first threshold⁶ face a 10% average tax rate, firms with revenue in between the two thresholds face a 20% rate and firms with revenue above the second threshold face a 30% tax rate. A unique feature of this tax design is that the determinant of the tax rate, revenue, is different from the tax base, profits. Importantly, the revenue thresholds only determine tax liability and are not used to de-

⁴A similar method has since been applied to the test score literature (Diamond and Persson 2017)

⁵For example, Almunia and Lopez-Rodriguez (2016) study the impact of an enforcement threshold, the Large Taxpayer Unit, on Spanish firms’ reporting behavior.

⁶In 2014, the revenue thresholds are 49,969,000 and 10,0513,000 Colones, corresponding to 150,000 and 300,000 USD in Purchasing Power Parity. The thresholds are indexed on inflation and therefore grow 4% yearly, on average.

termine any other policy. Loss carry-forwards are limited to the manufacturing sector and a three year period, while loss carry-backs are never allowed.

The current tax design was implemented in 1988 and has remained unchanged since. Prior to 1988, corporations were taxed at increasing marginal tax rates on profits, with multiple brackets ranging from 5 to 50%: the original tax reform of 1987 proposed a flat 30% tax rate on profits, but was strongly contested by small and medium enterprises who would, on average, face an increase to their tax liability (Naranjo and Zúñiga 1990). The political pressure to apply preferential rates to these firms led to the addition of two tax rates, determined by firms' revenue.

2.2 Theoretical Framework: Baseline

We develop a simple theoretical framework of firm behavior, which considers simultaneous revenue and cost responses to tax changes, and allows for heterogeneity in revenue and in cost at a given revenue level. A representative firm decides how much to produce and can simultaneously evade taxes by under-reporting revenue and over-reporting cost. When evading taxes, the firm incurs resource costs and risks detection. We use this simple framework, to highlight the potential impact of the Costa Rican corporate tax system on firm behavior and to derive empirical predictions.

Consider a firm that produces good y , subject to a convex cost function $c(y)$. The costs incurred by the firm are fully tax-deductible and therefore a flat tax rate on profit is non-distortionary.⁷ The firm can under-report revenue, such that revenue evasion is $(y_i - \tilde{y}_i)$, where \tilde{y}_i is declared revenue, and over-report cost, such that cost evasion is $(\tilde{c}_i - c_i)$, where \tilde{c}_i is declared cost. In doing so it incurs resource costs⁸ and risks detection: this generates a convex cost of evasion $R(y_i - \tilde{y}_i, \tilde{c}_i - c_i)$. The convexity captures the idea that detection is increasingly likely for large amounts evaded. Finally, the firm faces the tax rate τ that applies to declared profit, $\tilde{\pi} = \tilde{y}_i - \tilde{c}_i$. The firm's expected profits are therefore:

$$E\pi_i = y_i - c(y_i) - \tau \cdot (\tilde{y}_i - \tilde{c}_i) - R(y_i - \tilde{y}_i, \tilde{c}_i - c_i) \quad (1)$$

To generate heterogeneity and simplify the exposition we make two more assumptions. First,

⁷We do not pretend that corporate taxation is generally non-distortionary but make this assumption for the tractability of the model. The corporate tax is non-distortionary in a cost of capital model (Jorgenson and Hall 1967) with immediate expensing: if all costs, including returns to capital, are immediately deductible, then the corporate income tax is a tax on pure profits and does not impact production decisions.

⁸Resource costs from evasion include, forgoing business opportunities with formal firms, keeping multiple sets of accounting records and limiting interactions with the financial sector. See Chetty (2009) for a discussion.

we assume that the cost function takes the following form $c(y_i; \phi_i, \alpha_i) = \alpha_i + \frac{k(y_i)}{\phi_i}$, where α_i are fixed costs, equivalent to a demand shifter, and ϕ_i is a productivity parameter, which scales variable costs $k(y_i)$. Second, we assume that the cost of evasion function is separable in revenue and cost evasion such that $R(y_i - \tilde{y}_i, c_i - \tilde{c}_i) = h(y_i - \tilde{y}_i) + g(\tilde{c}_i - c(y_i))$. Under these conditions the firm's expected profits are:

$$E\pi_i = y_i - c(y_i; \phi_i, \alpha_i) - \tau \cdot (\tilde{y}_i - \tilde{c}_i) - h(y_i - \tilde{y}_i) - g(\tilde{c}_i - c(y_i)) \quad (2)$$

The firm maximizes expected profits, by choosing the triple of revenue to produce, revenue to declare and costs to declare $(y_i, \tilde{y}_i, \tilde{c}_i)$. An interior optimum satisfies the following first order conditions:

$$1 = \frac{k'(y_i)}{\phi_i} \quad (3)$$

$$h'(y_i - \tilde{y}_i) = \tau \quad (4)$$

$$g'(\tilde{c}_i - c_i) = \tau \quad (5)$$

Equation (3) determines the revenue produced y . Since, in our model, taxation is non-distortionary, the production decision is independent of the tax rate. Equations (4) and (5) state that the marginal return to revenue and cost evasion, τ , equals the marginal cost, which is a function of the amount evaded. Firm revenue is a function of its productivity draw ϕ_i but independent of the fixed cost draw α_i , such that $\frac{dy_i^*}{d\phi_i} > 0$ and $\frac{dy_i^*}{d\alpha_i} = 0$. Firm costs are given by $c^*(y^*; \phi_i, \alpha_i) = \alpha_i + \frac{k(y^*)}{\phi_i}$ and depend both on the productivity draw ϕ_i and the fixed cost α_i , such that $\frac{dc_i^*}{d\phi_i} > 0$ and $\frac{dc_i^*}{d\alpha_i} > 0$. Finally, we define profit margin as profit over revenue, $\pi_{margin} = \frac{y^* - c^*}{y^*}$, and is determined jointly by ϕ_i and α_i .

Under a continuous and differentiable joint distribution of productivity and fixed cost parameters $f_0(\phi, \alpha)$ the distribution of revenue and cost is smooth. We assume that the cost of evasion functions $h(y_i - \tilde{y}_i)$ and $g(\tilde{c}_i - c_i)$ are continuous and differentiable and therefore the distributions of reported revenue, reported costs and reported profit margins are also smooth and differentiable.

2.3 Theoretical framework: Impact of the tax system

A noteworthy aspect of Costa Rica's corporate schedule is that the average tax rate applied on profits increases from τ to $\tau + d\tau$ when firms declare revenue above the threshold y^T . Tax liability

is a function of declared revenue \tilde{y} and declared costs \tilde{c} :

$$\begin{aligned}
T(\tilde{y}_i - \tilde{c}_i; \tilde{y}_i) &= \tau(\tilde{y}_i - \tilde{c}_i) && \text{if } \tilde{y}_i \leq y^T \\
T(\tilde{y}_i - \tilde{c}_i; \tilde{y}_i) &= (\tau + d\tau)(\tilde{y}_i - \tilde{c}_i) && \text{if } \tilde{y}_i > y^T \\
T(\tilde{y}_i - \tilde{c}_i; \tilde{y}_i) &= 0 && \text{if } \tilde{y}_i - \tilde{c}_i \leq 0
\end{aligned} \tag{6}$$

We consider that the above tax system is imposed as a tax reform over a previously flat corporate tax at rate τ . Since only the productivity parameter ϕ_i determines firm revenue and all firms face the same cost of evasion, there exists a productivity threshold $\underline{\phi}$ such that a firm with productivity $\phi_i = \underline{\phi}$ reports revenue exactly equal to the threshold $\tilde{y}_i = y^T$, and all firms with $\phi_i \leq \underline{\phi}$ declare revenue below the threshold $\tilde{y} \leq y^T$. These firms are not affected by the tax change. For firms with $\phi_i > \underline{\phi}$ there are two possible responses: (1) reduce revenue, declared or real, by an amount such that the new revenue equals the threshold (the ‘‘bunchers’’) or (2) stay above the threshold and face a higher tax rate. These firms then change their reporting revenue and cost such that the marginal cost of evasion equals the new tax rate.

Firms choose one of two responses depending on their *productivity* and *fixed cost* draw: for every productivity draw ϕ_i in an interval $[\underline{\phi}, \bar{\phi}_{max}]$ there exists a fixed cost α_i such that all firms within the interval $[\underline{\phi}, \bar{\phi}_\alpha]$ bunch at the threshold. $\bar{\phi}_\alpha$ is determined by the indifference condition between expected profits at the threshold and expected profits at the interior solution, $E\pi^{Threshold}(y, \tilde{y}^T, \tilde{c}|\bar{\phi}_\alpha, \alpha) = E\pi^{Interior}(y', \tilde{y}', \tilde{c}'|\bar{\phi}_\alpha, \alpha)$. Firms with $\phi_i > \bar{\phi}_\alpha$ remain above the threshold and adjust their reporting behavior.

To illustrate the effect of costs on the bunching decision we consider a firm with productivity $\phi_i > \underline{\phi}$ and fixed costs α_i mapping into true revenue and cost (y_0, c_0) and reported revenue and cost $(\tilde{y}_0, \tilde{c}_0)$ such that $\tilde{y}_0 > y^T$ before the tax change. To reach the threshold the firm can reduce declared income with a combination of real and reporting behavior. Real income reduction is dy and reported income is $d\tilde{y}$. The total change in revenue is $\Delta y = dy + d\tilde{y}$ such that Δy is the revenue distance to the threshold, $\Delta y = \tilde{y}_0 - y^T$. We compare the firm’s utility when it reports revenue at the threshold versus when it report its pre-tax change revenue - and approximate the expected gains from bunching as:

$$E \text{ Gains} \approx d\tau(y^T - \tilde{c}_0) + \Delta y(\tau + d\tau) - d\tilde{y}.h'(y_0 - \tilde{y}_0 + d\tilde{y}) - dy.[1 - c'(y_0 - dy)] \tag{7}$$

Where we have used the envelope condition and ignored intensive margin changes past the

threshold. The *first term* of equation (7) is a noteworthy feature of the Costa Rican setting: it shows that the gains from lowering revenue to reach the threshold are proportional to the change in the tax rate $d\tau$ and to the firm's declared tax base at the threshold, $y^T - \tilde{c}_0$. Therefore variation in cost, due to fixed cost heterogeneity, generate different incentives to bunch for firms of equal productivity. The other terms of equation (7) state that the firm directly gains by not paying taxes on undeclared and non-produced revenue Δy , but incurs larger resource costs, due to the additional revenue under-reporting (evasion responses) and loses profit due to its lower production level (real responses). Note that if all responses are due to revenue under-reporting, equation (7) simplifies to: $E \text{ Gains} \approx d\tau(y^T - \tilde{c}_0) + d\tilde{y}(\tau + d\tau) - h'(y_0 - \tilde{y}_0 + d\tilde{y})$

Prediction 1: Bunching at the revenue thresholds

From the distribution of productivity and fixed cost parameters $f(\phi, \alpha)$ we obtain a direct mapping into the distribution of declared revenue and declared costs $\psi_0(\tilde{y}_0, \tilde{c}_0)$ such that the total number of firms bunching at the revenue threshold is:

$$B = \int_{\tilde{c}_0} \int_{\tilde{y}_0=y^T}^{y^T+\Delta y(\tilde{c}_0)} \psi_0(\tilde{y}, \tilde{c}) d\tilde{y} d\tilde{c} \quad (8)$$

With knowledge of the joint distribution of revenue and cost we can estimate the elasticity of revenue ϵ_y that generates a given amount of bunching.

Absent the counterfactual cost distribution we can still estimate the revenue response of the marginal buncher, defined as the firm with the maximal revenue change. For firms with the same revenue distance to the threshold the marginal buncher is the firm with the lowest declared costs: given a support of costs $[\underline{c}_0; \bar{c}_0]$ the marginal buncher's revenue response is $\Delta y^{mb} = \Delta y(\tilde{c}_0 = \underline{c}_0)$. With knowledge of the lower support of the distribution of c_0 , we can identify the revenue response of the marginal buncher as the maximum revenue response, which in the model corresponds to the response of the firm with the lowest costs. Under homogeneous revenue elasticities the marginal buncher's revenue elasticity and the average revenue elasticity are the same.

Prediction 2: Missing mass above the thresholds but no strictly dominated region

A corollary to the first prediction states that some revenue intervals past the threshold display missing density, which corresponds to the excess density at the threshold. At each revenue level past the threshold, the missing density is a function of the distance to the threshold and the cost

distribution at that revenue level. In the standard notch setting (Kleven and Waseem 2013) there is a deterministic dominated revenue interval just above the threshold: firms that report revenue in that interval are making an irrational decision under any preferences, since lowering production would increase their after tax profits. Whereas, for the Costa Rican notches, only a subset of firms with sufficiently low costs are dominated. For example, a firm with zero profits has no incentives to lower its revenue since its tax liability is already null. Being dominated is not only a feature of the revenue distance to the threshold but also of costs and hence firm specific. As a consequence, even in a frictionless world, there will be firm density in revenue intervals just past the threshold.

Prediction 3: Increased Revenue and Cost Evasion Past the Thresholds

Infra-marginal firms do not bunch at the revenue threshold but face an increase in the marginal return to evasion, which jumps from τ to $\tau + d\tau$. They respond to the tax hike by increasing revenue and cost evasion such that the marginal resource costs of each evasion type equals the new tax rate. As a consequence firms above the threshold declare less revenue and more costs than under the counterfactual. As a consequence observed profits and profit margins by revenue, jump downwards discontinuously at the threshold.

Prediction 4: Excess Profit at the Thresholds (Under evasion responses)

On the one hand, firms selecting into bunching have higher profit than the average firm (Selection effect). On the other hand, by lowering declared revenue to reach the threshold, bunchers lower their profits (Evasion effect). Theoretically, the average declared profit margin of firms at the threshold could be higher or lower than that of firms below the threshold, depending on the variance of the distribution of costs, in the revenue bins above the threshold. Under homogeneous costs (no variance) then the Evasion effect dominates and the average observed profit margin of bunchers is lower than that of firms below the threshold. With sufficient heterogeneity in the cost distribution the Selection effect dominates and bunching firms display excess profit at the threshold. The domination of the selection effect is better understood from equation 7: while gains from bunching are linear in the firm's costs, the cost of bunching are convex in the firm's revenue distance to the threshold, due to the convexity of the resource cost of evasion. Therefore, for a sufficiently large revenue distance to the threshold, the revenue change is small compared to the cost difference between selected bunchers and the average firm.

3 Behavioral responses and tax elasticities

In this section, we estimate the firms' elasticity of profit with respect to the net of tax rate and separate the profit response into changes in revenue and changes in costs. To this end, we develop an estimation method which deals with the interlinked revenue and cost responses, without assuming a functional form for firms' utility. Elasticities are defined with respect to the net of tax rate, and when discussing size and bounds we refer to their absolute value. Under mild assumptions, we can estimate the profit elasticity and obtain an upper bound on the revenue elasticity and a lower bound on the cost elasticity. In section (4) we impose additional structure and obtain tighter estimates for each of the revenue and cost elasticities. The profit elasticity, which combines revenue and cost responses, is stable across the different estimation strategies.⁹ We summarize the different methodologies, elasticity estimates and assumptions in Table 1.

Our identification relies on two assumptions: first, absent the tax rate increase past the threshold, the distribution of firms by revenue would be smooth and continuous and therefore can be approximated by a flexible polynomial.¹⁰ Second, average cost by revenue would not jump discontinuously precisely at this revenue-size. Under these assumptions we develop a three step methodology: in a first step, we use bunching at the revenue thresholds to identify revenue responses to higher tax rates. In a second step, we use the discontinuity in average cost by revenue, on either sides of the thresholds, to estimate the cost response. The novelty of the approach is to adjust the cost discontinuity to take intensive margin revenue responses into account, using the revenue elasticity estimated in the first step. We then recover the average increase in reported cost at the threshold, holding revenue responses constant. In a third and final step, we combine the revenue and cost responses to compute the profit response at the threshold.

3.1 Setting and Data

Costa Rica is a middle-income country, with GDP per capita of 15,000 US dollars at purchasing power parity, and is considered to have stable and well-functioning institutions for its income level. Its government collects 21% of its GDP in revenue, of which 14% is tax revenue and 7% social

⁹The estimation strategy induces a mechanical negative correlation between the estimates of the revenue and cost elasticities. Since the profit elasticity combines the two, it is very robust to their respective separation.

¹⁰The ability to approximate the counterfactual density with a flexible polynomial is the standard assumption in the bunching literature and we show that in our data the parametric choices (polynomial order, bunching interval limits, etc.) have little effect on estimated parameters.

security contributions. Following several failed attempts at tax reforms, Costa Rica’s revenue collection has stagnated in the last decade: increasing it is considered a key priority by the main political parties, in order to reduce the large deficit.

We base our study on administrative data from the Ministry of Finance (Ministerio de Hacienda) and have access to the universe of corporate tax returns over the 2008-2015 period. All registered corporations are required to submit yearly tax declaration D101 (“Declaracion Jurada del Impuesto Sobre la Renta”) and report their profits, revenue and costs. The tax declaration can be filled electronically since 2008, and a large majority of firms have opted for this format. The data consists of 617,929 firm-year observations and 222,352 unique firms. As a whole, the corporate income tax raises around 18% of tax revenue,¹¹ around 2.5% of GDP. The firms we study are small enterprises with yearly revenue below 150 million Costa Rican Colones (\$450,000 in PPP). They represent 85% of the 80,000 firms filling taxes in a given year and declare 25% of total profits, which generates 15% of corporate tax revenue.

Figure 4 presents the key features of the data by revenue bins of half million CRC, pooling all years together. Panel A shows the number of firms by revenue. We observe a clear excess mass below each revenue threshold and missing mass just above, as predicted by theory. Panel B shows the average profit margin by revenue,¹² where profit margin is defined as profit over revenue. The striking observation from this figure, is that profit margin by revenue resembles a downward step function - constant within a given tax bracket and jumping down at the thresholds. Average profit margin within the first tax bracket is 16%, 7-8% in the second bracket and 4-5% in the third bracket. We also observe that firms reporting revenue at the thresholds display profit margins in excess of 22% and 9%, respectively at the first and second thresholds. As discussed in theory (Prediction 4), this could arise from the selection into bunching of firms with low costs.

The estimation strategy combines the distributions of Figure 4 to estimate profit elasticities and separate them between revenue and cost responses. Intuitively, the excess mass at the revenue thresholds provides evidence of revenue responses while the jump in profit margin combines revenue and cost responses. Therefore, in a first step we apply the bunching methodology to the firm density to estimate revenue elasticities. In a second step, we use the discontinuity in profit margin on either

¹¹This share concerns tax revenue only and excludes social security contributions

¹²Figure A1 shows average profits and average costs by revenue. We choose to present profit margin since it is unit free and very stable within tax bracket in our data, and therefore highlights the large discontinuity in the tax base at the threshold.

sides of the thresholds to estimate the cost elasticity, holding constant revenue responses. In a third step, we combine the revenue and cost responses to obtain profit elasticities.

3.2 Revenue elasticity estimation

3.2.1 Bunching methodology

To estimate the revenue elasticity, we use the distribution of firms by revenue and the point of convergence method described in Kleven and Waseem (2013)¹³. We slice the data in half million CRC bins. To obtain the counterfactual density, we fit a flexible polynomial of degree five¹⁴

$$F_j = \sum_{k=0}^5 \beta_k \cdot (y_j)^k + \sum_{i=y_l}^{y_u} \delta_i \cdot \mathbb{1}(y_j = i) + \nu_j \quad (9)$$

where F_j is the number of firms in revenue bin j , y_j is the revenue midpoint of interval j , $[y_l, y_u]$ is the excluded region and δ_i 's are dummy shifters for the excluded region. We use the estimated β_k 's to obtain the counterfactual firm distribution by revenue absent the tax change:

$$\hat{F}_j = \sum_{k=0}^5 \hat{\beta}_k \cdot (y_j)^k \quad (10)$$

The estimation procedure requires that the excess mass below the threshold (E) equals the missing mass past the threshold (M), defined as:

$$\hat{E} = \sum_{j=y_l}^{y^*} (F_j - \hat{F}_j) \quad \text{and} \quad \hat{M} = \sum_{j=y^*}^{y_u} (\hat{F}_j - F_j) \quad (11)$$

Where y^* is the revenue threshold and the bounds of the excluded region $[y_l, y_u]$ are obtained as follows: the lower limit y_l is *chosen* by the researchers as the revenue bin where excess density starts appearing.¹⁵ The upper limit, $y_u = y^* + dy$, is *estimated* using the identity that the excess mass (E) has to equal the missing mass (M). Starting from y_u just above the threshold, we estimate equation (9) and compute \hat{E} and \hat{M} . For a low value of y_u , the excess density is much larger than the missing density ($\hat{E} > \hat{M}$). We iteratively increase y_u until the excess mass equals the missing mass ($\hat{E} = \hat{M}$). The estimated upper bound, y_u , is the revenue of the marginal firm responding

¹³The notch estimation builds upon the kink method of Saez (2010) and Chetty et al. (2011)

¹⁴The order of the polynomial is chosen to maximize Akaike's criteria. Table A1 shows the impact on the results of using different orders of polynomial.

¹⁵We show in table A1 that changing y_l does not impact the results.

to the tax change. Under heterogeneity in revenue elasticities, this is the response of the highest elasticity individual and therefore provides an upper bound on revenue responses.

By forcing the excess mass to equal the missing mass, the point of convergence method generates two potential concerns¹⁶. First, it assumes that there are no extensive margin responses. Extensive responses could occur if firms decided to become informal when faced with higher tax rates. This would generate additional missing mass past the threshold and imply that $E < M$. In our setting extensive margin responses should play a limited role, as Costa Rica is one of Latin America's country with the least informality (ILO 2012), and it is unlikely that firms with growing revenue and already registered decide to reverse back to informality, after increasing their revenue past the threshold. In terms of results, if extensive margin responses exist, then the true revenue elasticity is smaller than the estimated one. Second, the standard bunching method ignores intensive margin revenue responses past the threshold. Intensive responses imply that, above the threshold, the counterfactual firm distribution should be higher than the observed distribution. We take into account this second order effect by shifting the counterfactual distribution above the threshold with the factor implied from the estimated revenue elasticity. The intensive margin adjustment occurs simultaneously with the point of convergence method and the iterative process of determining the upper bound on revenue y_u . In our setting where elasticities are substantial, this adjustment does have a modest impact on the results, reducing slightly the estimated revenue response.

In the case of a notch, and in particular of a notch with two-dimensional incentives, revenue distance to threshold and costs, obtaining the change in the marginal tax rate is less straightforward than with a kink. Given the tax liability $T(y - c; y)$, we define the implicit marginal tax rate τ^* , for an increase in revenue dy , as the change in tax liability over the change in revenue:

$$\begin{aligned}\tau^* &= \frac{T(y^* + dy) - T(y^*)}{dy} = \frac{(\tau_0 + d\tau)(y^* + dy - c) - \tau_0(y^* - c)}{dy} \\ \tau^* &= (\tau_0 + d\tau) + \frac{d\tau(y^* - c)}{dy}\end{aligned}\tag{12}$$

Where τ_0 , $d\tau$ and y^* are known parameters and dy is estimated with the bunching point of convergence method. However, the cost of the marginal buncher c is unknown. From the theory section we know that the marginal buncher is the firm with the lowest cost, within its revenue bin.

¹⁶These limitations are also noted in Kleven and Waseem (2013).

Therefore, the marginal buncher should have costs in the 1st percentile of the cost distribution for its revenue bin. To ensure that we obtain an upper bound on the revenue elasticity we assume the cost of the marginal buncher are at the 10th percentile. With this assumption, we obtain c and can compute the implicit marginal tax rate τ^* , given the estimate of the revenue response dy . The revenue elasticity is then defined as:

$$\epsilon_{y,1-t} = \frac{\%change\ revenue}{\%change\ (net\ of\ tax\ rate)} = \frac{dy}{y^*} \cdot \frac{(1-t_0)}{(t^* - t_0)} \quad (13)$$

3.2.2 Bunching results

Figure 5 shows the distribution of firms by revenue and the counterfactual density, estimated from the polynomial fit around each threshold¹⁷. The estimated parameters are displayed in the top right corner of each panel. For the first threshold (Panel A), the excess mass is 2.3 times the counterfactual, meaning that there is 3.3 times the density that should be expected. In the absence of the notch, the marginal buncher would have an income of 58.3 million CRC, 16% higher than the threshold. For the second threshold (Panel B), the excess mass is 1.1 times the counterfactual and the marginal buncher has revenue of 107.7 M CRC, 7.6% higher than the threshold.

Given the estimated revenue responses, we compute with equation (12) the implicit marginal tax rate faced by the marginal buncher: at the first threshold the resulting revenue elasticity with respect to the net of tax rate is 0.33. This implies that firms respond to a 10% reduction in the net of tax rate by reducing reported revenue by 3.3%. At the second threshold, the elasticity of revenue is 0.08. Table 3 reports the parameters and the resulting revenue elasticities at each threshold. Standard errors are estimated from 1,000 bootstrap iterations from residuals resampling of the polynomial fit¹⁸.

Despite being graphically compelling, the large behavioral responses to the revenue notches produce moderate revenue elasticities. Three points are worth mentioning. First, on a small profit base a modest change in revenue could generate a large profit elasticity, holding costs constant. Second, notches differ from kinks in that they generate sizable changes in implicit marginal tax rates and therefore large behavioral responses are consistent with moderate elasticities. Third,

¹⁷Due to the intensive margin adjustment above the threshold, the counterfactual does not exactly fit the observed density for revenue bins above y_u .

¹⁸Since the data contains the universe of corporate tax returns, the source of uncertainty arises from the functional form of the polynomial. When running the bootstrap iterations we therefore draw from the sample of residuals of equation 9 and obtain new firm densities, with which we repeat the point of convergence method.

firms can also reduce their tax liability by increasing reported costs and therefore lowering revenue is only one of two possible margins of response to an increase in the tax rate. We investigate the latter point in the next section.

3.3 Cost discontinuity

Figure 4, Panel B, presented the step-like pattern of average profit margins by revenue. Profit margins by revenue are visually attractive since unit free and, in our data, very stable within tax brackets. However, to quantify the jump in costs at the threshold, caused by the tax rate increase, we turn to the relation between reported costs and revenue. Figure 6 plots average reported costs by revenue at the first threshold. Importantly, some firms have selected into the revenue range around the threshold, as a function of their costs. From the bunching analysis, we know that selection occurs precisely in the revenue bins corresponding to the excess and missing mass intervals, $[y_l, y_u]$. Therefore, we exclude these intervals from the cost discontinuity analysis, with dummy variables for the excess and missing mass areas. We measure the discontinuity in cost at the threshold with the following specification:

$$cost_j = \alpha + \delta \cdot \mathbb{1}(\tilde{y}_j > 0) + \beta_1 \cdot \tilde{y}_j + \beta_2 \cdot \tilde{y}_j \mathbb{1}(\tilde{y}_j > 0) + \sum_{j=\tilde{y}_l}^{\tilde{y}_u} \gamma_j \mathbb{1}(\tilde{y}_j = j) + \epsilon_j \quad (14)$$

where $cost_j$ is firms' average cost in bin j , $\tilde{y}_j = y_j - y^*$ is the revenue distance to the threshold and γ_j are dummy shifters for firms with revenue in the excluded excess and missing mass intervals. β_1 provides the slope of average cost on revenue below the threshold and $\beta_1 + \beta_2$ the slope past the threshold. The parameter of interest is δ , the discontinuity in costs at the threshold. The specification directly provides the percentage change in cost at the threshold as $dc = \frac{\delta}{\alpha}$.

Our objective is to measure the discontinuity in costs, holding revenue responses constant. However, the cost discontinuity estimated from equation (14) could entirely be due to intensive margin responses of revenue. To understand this, note that the “running” variable is revenue, which is also distorted by the change in the tax rate: absent the tax change, firms in the upper tax bracket would have declared larger revenue. Since we have estimated the revenue elasticity in Section (3.2), we can adjust for intensive margin revenue responses. To illustrate the revenue adjustment, we consider firms belonging to revenue bin j , with revenue midpoint y_j . Absent the

tax change their counterfactual revenue would be:

$$\begin{aligned}
 y_j^{adj} &= y_j && \text{if } y_j \leq y^* \\
 y_j^{adj} &= y_j + \epsilon_{y,1-t} \cdot y_j \cdot \frac{dt}{1-t} = y_j + 0.33 * y_j * \frac{0.1}{0.9} = y_j * 1.037 && \text{if } y_j > y^*
 \end{aligned} \tag{15}$$

We clarify three aspects of the revenue adjustment. First, the adjustment only applies to firms with revenue above the threshold. Second, for firms with revenue sufficiently above the threshold the increase in the average tax rate is equivalent to an increase in the marginal tax rate. Since we exclude firms from the missing mass interval, this holds for the vast majority of firms. Third, the revenue adjustment assumes that the revenue elasticity is the average revenue elasticity. Since under heterogeneity in revenue responses the revenue elasticity is an upper bound of the average elasticity, the revenue adjustment is an upper bound of the true adjustment. We return to this point when interpreting the cost elasticity.

We apply the revenue adjustment, that is we replace $\tilde{y} = y_j - y^*$ with $\tilde{y}_j^{adj} = y_j^{adj} - y^*$, and then estimate equation (14). δ now measures the increase in reported costs due to the tax change, but holding revenue responses constant. The discontinuity in costs, with and without the revenue adjustment¹⁹, are reported in Table 2. Figure 6 presents graphically the results for the first threshold: Panel A plots average cost by revenue and shows the revenue adjustment, which shifts costs horizontally for firms past the threshold. We then fit separate lines to the right and to the left of the threshold, excluding the interval affected by bunching responses between z_l and z_u . The linear extrapolation to the threshold on the left provides a counterfactual average cost for firms at the threshold under a 10% tax rate and absent the notch. The linear extrapolation to the right, provides the average cost for a 20% tax rate, assuming no revenue responses. The resulting discontinuity is the change in reported costs that arises at the threshold due to the change in the tax rate. In Panel B, we zoom in on the discontinuity in the predicted average cost at the first threshold. We estimate a large jump in average cost of 2.5 million on a cost base of 42 million. Given the net of tax rate increase of 11%, the elasticity of cost is:

$$\epsilon_{c,1-t} = \frac{dc}{c^*} \cdot \frac{(1-t_0)}{dt} = \frac{-2.55}{41.97} * \frac{0.9}{0.1} = -0.55$$

¹⁹The revenue adjustment method shifts horizontally average costs, such that under a sufficiently large revenue elasticity, the entire cost discontinuity could arise due to intensive margin revenue responses. For this to be the case, the elasticity of revenue would have to be 0.83 at the first threshold and 0.21 at the second, slightly under three times what we estimated.

This implies that when the *net of tax rate* is reduced by 10%, firms respond by increasing their reported costs by 5.5%. At the second threshold costs jump by 1.2 Million on a 92 Million base. Together with the net of tax rate increase of 12.5% this implies a cost elasticity of -0.11.

The estimation is equivalent to a donut RD, with a local linear fit. Linearity is an important assumption to which we provide support in Appendix A. Figure A2 shows the linear and quadratic fits of average costs by revenue, above and below each threshold. The quadratic fit is indistinguishable from the linear fit. Table A2 displays the adjusted R-squared from the linear, quadratic and cubic regressions and shows that the linear model has the highest adjusted R-squared. In Table A3 we present the results of Equation (14) using a quadratic fit: the cost discontinuity is even larger than under the linear model, and therefore if the linearity assumption introduces bias, we would be underestimating the discontinuity in cost and the cost and profit elasticities. In addition, table A3 shows that the results are robust to variation in the revenue interval used to estimate the model and to the assumption that the revenue elasticity falls with revenue²⁰.

3.4 Profit elasticity

By combining the revenue and cost responses, we can now estimate the elasticity of profit with respect to the net of tax rate. The elasticity of profit is a central parameter to set optimal tax rates and a sufficient statistic for revenue collection under a flat tax rate. It is defined as:

$$\epsilon_{\pi,1-t} = \frac{\% \text{ change profit}}{\% \text{ change (net of tax rate)}} = \frac{\Delta\pi}{\pi} * \frac{1-\tau}{\Delta\tau} = \frac{(\Delta y - \Delta c)}{\pi} * \frac{1-\tau}{\Delta\tau} \quad (16)$$

We already estimated the change in cost at the threshold Δc and compute the change in revenue Δy using the revenue elasticity: $\Delta y = y * \epsilon_{y,1-t} * \frac{\Delta t}{1-t}$.

Table 3 summarizes the elasticity estimates and changes in revenue, cost and profit, at each threshold. At the first threshold, we estimate a profit elasticity with respect to the net of tax rate of 4.9, and at the second threshold an elasticity of 2.9. These are very large elasticities and imply that the revenue maximizing rate is 17% for micro firms and 25% for small firms²¹. Tax rates

²⁰The revenue adjustment uses the estimated elasticity at the threshold and applies it homogeneously to all firms with revenue above the threshold. Since the revenue elasticity is larger at the first than second threshold, an alternative is to assume a linearly decreasing elasticity as a function of the firm's revenue, with a slope proportional to the drop in revenue elasticities between the first and second threshold.

²¹Under a flat corporate tax, the government revenue maximizing rate is $\tau^* = \frac{1}{1+\epsilon_{\pi,1-\tau}}$

above these are on the wrong side of the Laffer curve and Pareto dominated, since government revenue would fall, as the base diminishes faster than the rate increases. These large elasticities are a function of the current policy environment and of evasion and avoidance opportunities, which we investigate in further detail in Sections 5 and 6. However, we highlight in Figure 7 that the estimated elasticities correspond to an interesting reporting behavior. The figure shows average tax payment as a share of revenue by revenue: despite the 10% tax rate increase at each threshold, tax liability as a share of revenue is continuous and stable, at roughly 1.5% of revenue. It appears that faced with a tax hike, firms adjust their reported profits such that tax payments represent a near constant share of their revenue.

Another novel result in Table 3 is the comparison between the cost and revenue elasticities. Slightly over 60% of the discontinuity in profit is due to an increase in costs and 40% from an increase in revenue²². The difference is statistically significant at the first threshold, and holds qualitatively at the second: reported costs react stronger to a change in the tax rate than reported revenue. This holds despite estimating a lower bound on the cost elasticity and an upper bound on the revenue elasticity. In Section 4 we add a counterfactual assumption on the distribution of costs by revenue to obtain average revenue and cost elasticities.

3.5 Robustness and heterogeneity

We discuss three important dimensions of robustness and heterogeneity: elasticity estimates, distributional results and industry variation.

The large drop in average profit margin on either side of the threshold is the key identifying variation for the total profit response, while the two step estimation decomposes this variation into revenue and cost responses. In doing so, a near perfect negative correlation mechanically arises, due to the revenue adjustment term applied to the cost discontinuity: a larger revenue elasticity implies a larger revenue adjustment, which reduces the cost elasticity. Accordingly, the profit elasticity is robust to results from the bunching estimation and hinges upon the assumption that average reported costs by revenue would have been smooth around the threshold, absent the tax change. Following the same logic, the cost to revenue elasticity ratio estimate is less robust and a lower bound of the true ratio: our preferred estimate of this ratio is this of Section (4).

²²In addition, costs are measured on a smaller base than revenue, therefore the cost elasticity is larger in absolute terms than the revenue elasticity at both thresholds ($\epsilon_{c,1-t} > \epsilon_{y,1-t}$).

Another robustness is whether the decrease in profit margins is driven by a few profitable firms or by an entire shift in the distribution. Figure B1 shows the quartiles of profit margin: the median profit margin starts at 6% below the threshold and drops to 3% above it. We observe similar proportional falls at the 25th and 75th percentiles. It appears that profit margin discontinuities arise from an entire downward shift of the distribution of profit margin and not only from a change in profit of a few high profitability firms.

Finally, some of the results could be driven by industry variation. Our estimation methodology relies on large sample sizes such that the firm distribution and average cost are smooth.²³ As a consequence we can not estimate precisely revenue and cost elasticities at the industry level. Instead, to summarize the revenue response at the industry level, we turn to the excess mass of bunchers²⁴ at the threshold, \hat{E}_s for industry s . The industry excess ratio \hat{E}_s is robust to the polynomial fit and provides a proxy for the size of revenue responses. We also estimate the profit margin discontinuity for each industry using equation (14). Table 5 shows the industry level responses (See also Figure B2): the key finding is that for all sectors, except NGOs and public administration²⁵, we observe a drop in profits past the threshold. Even though the levels of the drops vary across sectors, the proportional changes in profit margins are similar across sectors: firms above the threshold report margins 40 to 50% lower than firms below. The homogeneity in profit responses masks large differences in bunching behavior and revenue responses: sectors thought as high evasion “potential”, such as construction, real estate and consultancies, exhibiting stronger bunching than retailers and manufacturers. One possible conclusion is that for firms in sectors with a low cost of revenue misreporting, revenue responses are preferred, while in sectors with more constraints evasion occurs primarily through the cost channel.

4 Model-Based Estimation of Revenue and Cost Elasticities

The elasticity of profits with respect to the tax rate is robust to the separation into revenue and cost responses and if we make no assumption about the counterfactual distribution of cost by rev-

²³The main limitation to apply the two-step estimation method for each industry arises from the point of convergence method, which iteratively fits the polynomial to equate the excess mass with the missing mass. With small sample sizes the iterative process can fail to converge and multiple revenue bins can satisfy the equality condition.

²⁴We fit a new polynomial for each industry but do not re-estimate, y_u the upper bound of the excluded interval.

²⁵Public administration includes all local levels of government which have to withhold taxes on any transactions made to third-parties

enue, the estimation of Section 3 provides the tightest possible bounds on the revenue and cost elasticities. This estimation faces however several limitations: first, under heterogeneity in revenue elasticity, it provides an upper bound to the true revenue elasticity and a lower bound on the cost elasticity. Second, it does not take into account selection into bunching as a function of costs. Third, it does not consider the feedback effect of cost responses on revenue responses.

To address these limitations, we assume a counterfactual distribution of profit margins: absent the tax change, the distribution of profit margins by revenue remains constant within the revenue intervals around the threshold. We then combine the counterfactual *firm density* by revenue with the new counterfactual *profit margin distribution*, to determine jointly the revenue and cost elasticities at which the number of counterfactual firms which should be bunching corresponds to the observed bunching mass. The additional structure allows us to model responses to the notch as a joint function of the firms' revenue distance to the threshold and costs, as suggested by the model. It also considers the impact of cost responses on the bunching decision: we assume that firms' cost responses, if not bunching, would equal the average cost response, estimated with the discontinuity approach. With an additional counterfactual assumption, the numerical model-based method allows us to estimate average revenue and cost elasticities and hence obtain a more precise decomposition of profit responses into cost and revenue responses.

4.1 Main Estimation

We impose the restriction that absent the tax change, the entire distribution of profit margin by revenue would stay constant in an interval around the threshold. Under this restriction, we use the profit margin distribution of firms with revenue below the threshold, and away from the bunching zone, as the counterfactual for firms with revenue just below or just above the threshold. Specifically, this assumes that the profit margin distribution of firms with 45 million CRC in revenue, would apply to firms with revenue 10 to 20% larger, absent the tax change. We test if this assumption holds away from the first threshold. Figure 8, Panel A, plots several distributions of profit margin for revenue intervals below the threshold. The distributions of profit margin appear extremely stable across different revenue intervals 10 to 20% lower than the threshold, and we can never reject the Kolmogorov-Smirnov tests that profit margins are generated from identical distributions. Figure 8, Panel B, also shows that within revenue intervals 20 to 30% higher than the threshold, the new distributions of profit margins are stable. Firms in these revenue intervals

are not impacted by selection into bunching: therefore the stability of profit margin distributions across these intervals gives supports the assumption of locally constant counterfactual profit margin distributions. Thereafter, we use the distributions in Panel A as the counterfactual profit margin distribution for firms in the bunching impacted zone, under a flat 10% corporate tax rate.

By combining the constant counterfactual profit margin distribution within each revenue bin, with the distribution of firms by revenue from the polynomial fit, we obtain a joint counterfactual distribution of revenue and costs. This allows us to model selection into bunching as a common function of the firms' costs and revenue distance to the threshold. For each revenue bin past the threshold, and given an elasticity of revenue, we can compute the cost threshold at which the firm is indifferent between bunching and remaining above the threshold. To compute the cost threshold, we first return to the expression of the implicit marginal tax rate, t^* , and model cost responses, dc :

$$\begin{aligned}\tau_i^* &= \frac{T(y^* + dy_i) - T(y^*)}{dy_i} = \frac{(\tau_0 + d\tau)(y^* + dy_i - c_i - dc_i) - \tau_0(y^* - c_i)}{dy_i} \\ \tau_i^* &= (\tau_0 + d\tau) + \frac{d\tau(y^* - c_i) - (\tau_0 + d\tau).dc_i}{dy_i}\end{aligned}\tag{17}$$

The above equation states that the implicit marginal tax rate t_i^* , faced by firm i , is a function of the firm's revenue distance to the threshold dy_i , costs c_i , and the change in reported costs conditional on facing the higher tax rate dc_i . To understand this later term, consider a firm that can easily evade costs: facing the higher average tax rate hardly increases its implicit marginal tax rate, since it can freely adjust its tax liability by reporting higher costs (large dc). On the contrary, a firm facing large resource costs of evasion on costs, can not adjust its tax liability by over-reporting costs, and therefore faces a large increase in its implicit marginal tax rate (low dc). With the explicit marginal tax rate we can now express the revenue elasticity as:

$$\begin{aligned}\epsilon_{y,1-\tau} &= \frac{dy}{y} \cdot \frac{1 - \tau_0}{d\tau} = \frac{dy}{y} \cdot \frac{1 - \tau_0}{\tau^* - \tau_0} \\ \epsilon_{y,1-\tau} &= \frac{(dy)^2}{y} \cdot \frac{(1 - \tau_0)}{d\tau.dy + d\tau(y^* - c) - (\tau_0 + d\tau).dc}\end{aligned}\tag{18}$$

With knowledge of dc , then for a given elasticity of revenue, $\epsilon_{y,1-\tau}$, and distance to the threshold, dy , we can measure *the cost threshold*, \tilde{c} , such that all firms with cost lower than \tilde{c} bunch. dc is the change in reported costs of bunchers, had they remained above the threshold and faced the higher tax rate. In practice dc is unknown: our preferred estimation assumes that the cost response of

bunchers would have equaled the average cost response ($dc = d\bar{c}$). This is equivalent to say that bunchers, would have had the same cost response as infra-marginal firms, had they not selected into bunching²⁶. The average cost response, $d\bar{c}$, is estimated from the cost discontinuity, adjusted for revenue responses, following the methodology of section 3.3.

We rewrite equation 18 such that the cost threshold is a function of all parameters:

$$\tilde{c}_j = y^* + dy_j - \frac{(dy_j)^2 \cdot (1 - \tau_0)}{d\tau \cdot \epsilon_{y,1-\tau} \cdot (y^* + dy_j)} - \frac{(\tau_0 + d\tau) \cdot d\bar{c}}{d\tau} \quad (19)$$

Equation 19 states that firm i in revenue bin y_j , with distance dy_j to the threshold, will bunch under revenue elasticity $\epsilon_{y,1-\tau}$, if its costs are below the cost threshold, $c_{ij} < \tilde{c}_j$. With the counterfactual revenue distribution, we know the number of firms that would have declared revenue in bin y_j , absent the tax change. With the counterfactual profit margin distribution, we know the distribution of costs within each revenue bin. Therefore we can numerically estimate the number of bunching firms for a given elasticity of revenue.

The estimation is an iterative procedure: the initial values of the revenue elasticity, $\epsilon_{y,1-t}^{Step1}$, and of the cost response, $d\bar{c}^{Step1}$, are taken from our estimation in Section 3. This combination of revenue and cost responses predict substantially more bunching than observed. We estimate the new revenue elasticity $\epsilon_{y,1-t}^{Step2}$, such that the number of numerically estimated bunchers equates the excess mass at the threshold. With the resulting revenue elasticity, $\epsilon_{y,1-t}^{Step2}$, we measure the average cost response from the cost discontinuity equation (Equation 14), adjusted for the newly estimated revenue elasticity, and obtain a new average cost response, $d\bar{c}^{Step2}$. $d\bar{c}^{Step2}$ is then used as the average cost response to measure a new revenue elasticity $\epsilon_{y,1-t}^{Step3}$. We iterate this process²⁷ until we converge to the fixed point $(\hat{\epsilon}_{y,1-t}, \hat{\epsilon}_{c,1-t})$, where the revenue and cost elasticities are consistent with each other.

We report the iteration steps in table 4 and represents graphically the last iteration in Figure 9. In Panel A, The number of bunchers are represented by the area between the elasticity curve and the counterfactual density. We show the elasticity curves for three values of the revenue elasticities.

²⁶In our model, under heterogeneous cost elasticities, this assumption provides an upper bound on the elasticity of revenue: bunchers select into bunching because their revenue elasticity is large and because their cost elasticity is low. Therefore, assuming the average cost response over-estimates bunchers potential response, and under-estimates bunching for a given elasticity. However, with a resource cost of evasion function non-separable into revenue and cost responses the estimation is not necessarily an upper bound: if revenue and cost evasion are easily substitutable, then firms with large cost evasion can substitute for revenue evasion to reach the threshold.

²⁷At each iteration we also re-estimate the counterfactual density distribution of firms, since we applied a correction for intensive margin responses. This only has second order effects

On the one hand, even under a very small revenue elasticity, some firms with revenue just above the threshold bunch, since their implicit marginal tax rate is above one. On the other hand, even with a very large revenue elasticity some firms do not bunch since they have very large costs. As the revenue elasticity increase firms further away from the threshold bunch. Panel B shows the number of bunching firms by revenue bins, for the equilibrium revenue and cost elasticities.

At the first threshold, the resulting revenue elasticity is 0.22, while the cost elasticity is -0.65 and the profit response is practically unchanged at 4.9. This implies that 71% of the total profit responses are due to an increase in reported costs and only 29% to a decrease in reported revenue. The share of cost to revenue responses is substantially larger than the one estimated from the point of convergence bunching method. This result was expected since under heterogeneity in revenue elasticity, the point of convergence method estimated the revenue elasticity of the highest revenue elasticity firm. Instead the model-based estimation measures the average revenue elasticity, in a frictionless environment, which mechanically gives us the average cost elasticity via the discontinuity method. This comes at the price of two additional assumptions: first the profit margin counterfactual distribution by revenue is stable around the threshold and second the counterfactual cost responses of bunchers, had they not bunched, would equal the average cost response.

5 Mechanisms: Evasion Responses

Behavioral responses generated by evasion, real production effects or tax avoidance responses have similar impacts on the government's tax revenue collection, but entail different policy responses. In the literature, it has often been difficult to separate the different mechanisms: evasion responses are by nature secretive and measuring real responses requires precise production data linked to tax records. Using additional dimensions of the data and new data sources we perform a series of empirical test of the mechanisms. Even though these tests are not exhaustive, we believe that taken together they provide a convincing picture that evasion and misreporting is a key driver while real effects and avoidance responses appear limited.

In this section we study two direct channels to uncover evasion behavior. First we look at the percentage of firms being flagged in the internal data cross-checks and show that firms reporting revenue at the threshold are significantly more likely to be selected for discrepancies. Second we look at variation in audit intensity by sectors across years. We find evidence that bunching firms

under higher scrutiny increase their declared revenue and move past the threshold but also increase cost by a similar amount. Those empirical tests both support the idea that reporting responses are strong drivers of revenue bunching.

5.1 Audits and tax corrections in Costa Rica

Costa Rica undertakes five hundred in depth taxpayer audits every year, of which three hundred are targeted to firms. As a consequence, only 0.4 % of all firms are audited in a given year. Taxpayers are selected following a risk based analysis which incorporates information from third-parties, deviation from industry averages and the taxpayers' history. Figure ?? shows the number of audits performed and the percentage of firms audited for broad revenue bins for 2009 and 2010. The small and medium firms we study have revenue to the very left of the figure and are rarely audited: just above 100 audits over two years and a 0.2 percentage chance of being audited. The percentage of audited firms increases with firm revenue to reach over 3% for large firms.

The low capacity to conduct in depth audits is partly mitigated by the extensive automatic warning system: auditors send notification letters to firms raising "red flags" in the internal data intelligence process. Specifically, anytime a computer operated system observes discrepancies between self-declared revenue and revenue based on third-parties reports, it generates a correction letter. A large part of third-party information is collected through the D151 informative tax form, which requires all individuals and firms to declare purchases and sales to the same entity when the value within the tax year is above two million Colones (\$6,000 in PPP) and any commission, professional fee or rental agreement above fifty thousand Colones (\$150). Other third-party information such as sales tax retentions, credit card payments and insurance policies also enter the database.

The letters sent by tax auditors ask for a correction or justification of the tax declaration in order to match the amount assessed by the tax administration. Importantly, this process does not treat bunching firms differently. For legal reasons this information can not be linked to the individual tax records, however we obtained the number of correction letters sent by revenue bins for the year 2012. Figure 15 shows the proportion of firms receiving a letter by revenue bins of two Million CRC. The green line shows the linear fit excluding the revenue intervals around the thresholds. Around a third of small Costa Rican firms receive correction letters, which highlights that tax declarations are often incomplete and that the environment is prone to evasion. Bunchers face large and significant increase in the probability of receiving correction letters compared to their

expected probability: they are 8.3% more likely to receive correction letters at the first threshold and 11.5% at the second. This result highlights that bunching and revenue changes are most likely the result of tax evasion and that bunchers get noticed for inconsistencies at a higher rate but are willing to incur the expected costs²⁸.

Two other results are worth noticing. First, firms declaring revenue just above the threshold (potentially dominated firms) are less likely to get flagged and the joint F-test shows that the difference is significant at both thresholds. This might indicate that firms that do not adjust their revenue to the threshold do so partly because of honesty. Second the proportion of correction letters by revenue is fairly constant on either side of the threshold contrarily to profit margins. However we saw that the increase in declared costs explains a large share of the discontinuity. A possible explanation is that third-party information on costs is not sufficient to establish evasion as it only provides a lower bound on the true cost. On the contrary, third-party information on revenue provides an upper bound on true revenue, hence a clear signal of tax evasion. Carillo et al also observe this asymmetry and document it in the case of Ecuador.

5.2 Sectors of special audit attention

A second test of tax evasion uses the variation in audit probability generated at the industry level by the program of “Special audit attention”. In 2012 the tax agency determined during the first semester of the calendar year a list of industries assigned to special audit attention, which was posted on the ministry of finance website. In practical terms it implied that the selected industries are assigned a dedicated group of auditors and that their risk of an audit increased. Industries are not randomly selected but determined by the underlying evasion risk and the industry’s growth rate compared to its tax revenue growth. The twelve sectors selected in 2012 were real estate, private education, hotels and tour agencies, transport of merchandise, sale of vehicles, sports, production of pineapple, yucca, flowers and plants, casinos and betting, performances and recycling²⁹. The difference in difference analysis of firms within the audit sectors versus other sectors shows significant growth in reported profits following the assignment of the sector to “special audit attention”.

²⁸Measuring precisely the expected costs from tax evasion is a difficult task and from our discussions it is unclear how many firms actually make significant adjustments to their tax payment following a correction letter. Firms can certainly revise their tax payment at minimal cost and do not get systematically prosecuted. However failure to comply increases the risk of an in depth audit which is considered to be very costly for the firm.

²⁹The Sectors selected in 2013 were quasi-identical and therefore we do not perform a sector event study for each year of the variation

However it is difficult to establish causality due to the endogenous selection mechanism.

Instead we use a triple difference strategy to study firms' evasion behavior at the threshold: we compare the change in revenue, costs and profits reported by bunchers in the sectors of special audit attention with bunchers in other sectors and non-bunchers in the same sectors. Our hypothesis is that bunchers are evading more revenue compared to smaller firms and dominated firms. Therefore, when faced with a higher audit probability, bunching firms should lower revenue evasion and increase reported revenue by more than non-bunchers. We estimate the following equation:

$$y_{ist} = \alpha_i + \beta * Bunch_i * Audit_j * Post_t + \gamma * Bunch_i * Post_t + \delta * Audit_s * Post_t + Post_t + \epsilon_{ijt} \quad (20)$$

Where depending on the specification y_{ijt} is revenue, costs or profits of firm i in sector j at time t . *Bunch* is a firm level dummy equal to one if the firm declared revenue in the two Million revenue interval below the threshold in 2011 and zero otherwise. *Audit* is a sector level dummy that equals one if the firm belongs to the sectors of special audit attention and zero otherwise. *Post* is a time dummy equal to one in 2012 and 2013 and zero in 2011.

Table 8 presents two sets of results: one using firms with revenue in 2011 below the bunching interval (declared revenue 4 to 8 Million CRC below the threshold) as a control group in columns (1)-(3) and one using dominated firms (revenue 0 to 3 M Colones above the threshold) as a control group in columns (4)-(6). Columns (1) and (4) presents the main result: bunchers in special audit sectors increase revenue by 10% or more of their initial size compared to non-bunchers. However they simultaneously increase their reported costs by a large amount in columns (2) and (5), leading to a statistical significant decrease in declared profits of above 1 M Colones column (3) and (6). Placebo treatment effects for previous years are not significant on any of the three margin.

Those results support the idea that bunching firms are evading revenue since bunchers belonging to audit sectors increase their declared revenue substantially more than firms in the control groups following an increase in their audit probability. Interestingly, reported cost also increase by a large amount, which indicates that away from the bunching segment firms lower their tax liability by increasing cost. Firms with revenue just above the threshold have strong incentives for revenue evasion in order to decrease both their tax base and tax rate, while for firms with revenue further past the threshold it is equivalent to under-report revenue or over-report costs which only decreases the tax base.

6 Mechanisms: dynamic, real and avoidance responses

In this section we investigate four other dimensions of firm behavior: dynamic responses, firm division, labor input usage and time-shifting of monthly revenue.

First, we show that growing firms slightly increase their profit margin over time conditional on staying in the same tax bracket. However when changing tax bracket, firms display downward jumps in profit margin mirroring the cross-sectional results. Second, we investigate whether larger firms divide themselves and create subsidiaries with revenue below the threshold on which to offload their profits. We show that this is unlikely to be an important mechanism. Few firms repeatedly bunch which would be a prediction of this model. More importantly a dataset of economic groups collected by the central bank shows very limited excess profit of subsidiaries when compared to non-subsidiaries and no excess mass of subsidiaries at the threshold. Third, we explore responses to employment and wage bill using data from social security, which is considered to be well-reported information. Neither employment nor wage bill show any discontinuity at either threshold. Finally, looking at monthly revenue from sales tax receipts we do not observe reduced economic activity in the last month of the fiscal year nor any time-shifting to the first month of the next fiscal year.

6.1 Dynamic Responses

Do the discontinuous profit margins in the cross-section also apply to firms' dynamic reporting behavior? To answer this question we use the panel dimension of the data and look at the difference in reported profit margin as a function of the firm's tax bracket in a given year. Figure 10 shows the average profit margin difference between years $t+1$ and t , conditional on firms tax bracket in those years. Firms remaining within the same bracket in consecutive years do not change on average their profit margins. Whereas, growing firms jumping to a higher tax bracket declare lower profit margins and symmetrically, shrinking firms falling to a lower bracket declare higher profit margins.

A fair critique is that profit margins could decrease with revenue for structural reasons.³⁰ To investigate this claim, we regress firm revenue on profit margins controlling for the tax bracket:

$$margin_{it} = \alpha_i + \gamma_t + \beta y_{it} + \delta \mathbf{1}(\tau_{it} = \tau + d\tau) + \sum_{j=\tilde{y}_l}^{\tilde{y}_u} \psi_j \mathbf{1}(\tilde{y}_j = j) + \epsilon_{it}$$

Where α_i and γ_t are respectively firm and year fixed effects, y_{it} is the revenue of firm i at

³⁰In the model this corresponds to a positive correlation between changes in productivity ϕ and changes in fixed costs α .

time t , τ_{it} is the average tax rate faced by firm i at time t and the dummy variables are shifters for the revenue intervals impacted by bunching. Table (6) presents the results from the above regression. The coefficients on revenue $\hat{\beta}$ shows that conditional on staying within the same tax bracket, growing firms increase their declared profit margins rejecting the possibility that profit margin should be falling for a growing firms. The dummy coefficients for changing tax bracket measures the discontinuity that occurs at the threshold and are significant and negative at each threshold. A firm growing past the first threshold decreases its profit margin by 3.06% and a firms growing past the second threshold decreases its profit margin by 0.86%. For these results to be consistent with real responses under distortionary taxation firms would need to have increasing returns to scale such that lowering production would also lower profit margin.

6.2 Firm Division

Given the design of the corporate tax system, it seems attractive for a large “mother” firm to create a subsidiary firm on which to “offload” its profits: the small subsidiary then declares high profits, taxed at a 10% rate, while the larger firm declares low profits, taxed at a 30% rate. If there are large profits to shift, then the subsidiary should locate its revenue just below the threshold. Therefore, sufficient firm division and profit shifting could explain the revenue bunching and the discontinuities in profit margins. To test for firm division we use the registry of economic groups, a unique dataset, compiled by the Central Bank exclusively for statistical purposes. It links corporate groups and their subsidiaries by combining the registry of corporate ownership, the census and direct visits and calls to firms offices³¹.

Firms operating under common ownership are defined as forming part of an economic group. On the one hand, shared ownership structure of firms can exist for structural reasons and the existence of subsidiaries does not provide in itself evidence of tax avoidance. On the other hand, if avoidance motivations are important, the following hypothesis should hold: First, firms in the 10% tax bracket should be more likely to be subsidiaries compared to firms in the 20% tax bracket since they represent better tax instruments, while subsidiaries in the 30% tax bracket do not serve any tax goal. Second, there should be an excess number of subsidiaries with revenue in the bunching interval and few subsidiaries with revenue just above the threshold: if subsidiaries are

³¹This data project, named REVEC, was motivated by the re-estimation of the input-output matrix for Costa Rica in 2012 and to obtain an accurate view of corporate ownership structure. We provide additional information on this dataset in Appendix B.

tax-related vehicles, then changing their declared revenue should produce minimal resource costs, while generating large tax gains. Third, the profitability of subsidiaries should be large since these are profit-shifting vehicles while the profitability of mother firms should be low.

Figure 13 shows the share of subsidiaries by revenue bin and fits a linear relation on both sides of the threshold, excluding revenue bins in the bunching and dominated intervals. On average 4 to 5% of firms are subsidiaries of larger firms, however the relation appears rather continuous on either sides of the threshold: The estimated drops in the number of subsidiaries at the first threshold of 0.39% and 0.42% at the second threshold are not significant. Qualitatively this still represents a 10% decrease in the probability of being a subsidiary past the threshold, which indicates that the strategy might exist but is marginal in explaining our results. Bunchers do not exhibit a significant particularly large response. Finally, when comparing subsidiaries to non-subsidiary firms we only find very modest evidence of excess profitability.

To summarize, we only find modest evidence of firms dividing themselves and gaming the tax system. The results can not explain the excess bunching nor the large difference in profitability on each side of the thresholds. The absence of firm division could be a combination of several factors. The monetary and non-monetary costs of setting up a corporation and keeping it active are not trivial: In addition to cumbersome administrative work, Costa Rica has a registration fee and a yearly stamp duty payment. related to the above, the relative ease of evading taxes by inflating costs might make this avoidance strategy suboptimal. Finally, the data might not reveal the full extent of firm division. Economic groups might have hard to detect dilution ownership strategies, and the Central Bank dataset is a (large) subset of the universe of tax filling corporations (around 80% of firms filling a tax declaration).

6.3 Employment and wage bill

The breakdown of costs into the five categories reported on the tax return brings limited insights. In figure B4 we show the cost discontinuity by revenue, for three cost categories. The two main categories, “Administrative and Operational Costs” and “Material and Production Costs” explain respectively 60% and 40% of the cost discontinuity. The other three categories, interest deductions, depreciation and other costs do not display a discontinuity and together represent less than 15% of total costs.

In the above cost categorization, wages are reported as part of administrative and operational costs

and can not be separately identified. In order to study employment and wage bill we turn to data from social security records, a separate database obtained from the central bank. There are reasons to believe that labor inputs in social security records are better reported than deductible costs from the corporate tax returns. First, employees have incentives for accurate reporting of their wages as social security benefits depend upon it and are generous in Costa Rica. Second estimated evasion on payroll tax and personal income tax of wage earners is much lower than evasion on other margins: the International Labor Organization estimates that among formal firms, only 9% of employees are informal. Finally, the sum of personal income taxes and payroll taxes is larger than the corporate income tax within all tax brackets and, if anything, a firm has incentives to under-report labor and not over-report it.

Figure 12 plots the average number of employees and average wage bill by revenue around each threshold and shows the linear fit of employment on revenue on each side of the threshold, excluding revenue bins in the bunching and dominated intervals. We run the following regression:

$$E_j = \alpha + \delta \cdot \mathbb{1}(y_j > 0) + \sum_{j=y_l}^{y_u} \gamma_j \mathbb{1}(y_j = j) \beta_1 \cdot y_j + \beta_2 \cdot y_j \mathbb{1}(y_j > 0) + \epsilon_j \quad (21)$$

Where E_j is average employment or average wage bill in revenue bin j , y_j is the midpoint of revenue bin j and $[y_l, y_u]$ is the excluded revenue interval around the threshold. The estimated discontinuity and the bunchers dummy are reported on Figure 12: neither average employment nor the wage bill discontinuity are significant. The only possible indication of differential labor inputs usage is the significantly lower wage bill for bunchers at the second threshold³². Overall the absence of a dip in labor inputs for bunchers and of a downward discontinuity past the threshold suggests that firms are not limiting their labor input use and distorting their production. It also rules out a strategy where firm owner-managers increase their own wages when faced with a higher tax rate

6.4 Production and timing responses

Another potential strategy for bunching is to either limit production or shift revenue across fiscal years. For example, firms could limit their operations in September, the last month of the fiscal year and/or date September revenue in October, such that their revenue in the fiscal year remains

³²We are not controlling for average profitability which could minimize the significant lower tax bill estimated at the second threshold.

below the threshold. We use the subsample of firms liable for sales taxes³³ to obtain a monthly revenue for the years 2008 to 2013. We run the following specification:

$$y_{imt} = \beta_1 \mathbb{1}(m = \text{Sept}) * Bunch_{it} + \beta_2 \mathbb{1}(m = \text{Oct}) * Bunch_{it} + \delta * Bunch_{it} + \alpha_m + \gamma_t + \epsilon_{imt} \quad (22)$$

where β_1 measures the differential monthly revenue of bunchers in September and β_2 in October. Under limitation of production at the end of the fiscal year, we should observe β_1 to be negative and significant and under time-shifting we should observe β_2 to be positive and significant. Table 7 reports the results for the first threshold for all firms in columns (1)-(4) and for firms who's corporate income tax revenue equals the sum of the monthly sales tax in column (5)-(8) and who therefore have no revenue not subjected to sales tax. The regressions reject evidence of either responses: bunchers do not report revenue differently in September and October compared to other months and other non-bunching firms. The only significant coefficient shows a positive revenue increase of bunchers revenue in September - possibly a sign of reverse time-shifting: as firm realize their revenue fall in the lower tax bracket they decide to bring revenue forward due to uncertainty about next year's revenue. A caveat to keep in mind when interpreting this non-result is that sales tax liable firms belong to sectors with lower bunching intensity such as retails, restaurants and car dealers. Nonetheless those results support the limiting role of real production effects and time-shifting responses in bunching behavior.

7 Conclusion

This paper highlights the role of firms' behavioral responses to tax rates as a channel contributing to the low yield of the corporate income tax in developing countries. We show that even in a middle-income country, the capacity to tax small and medium enterprises is limited due to large evasion responses to higher tax rates. We also quantify a new mechanism: even though business revenue is relatively difficult to manipulate, manipulating business costs appears sufficiently simple, such that the corporate tax collects little tax revenue. In effect, firms pay a constant share of their revenue in taxes, between 1.5 and 2%, for any tax rate they face. Why this particular level? This question is left for future research, though we conjecture that it could be determined by firms fear of audits when declaring too low of a share of revenue, and potentially fairness concerns.

³³The sales tax in Costa-Rica works like an incomplete VAT: it exempts some industries (e.g. liberal professions) and only allows deductions of physically observable inputs, such as materials, and is therefore different from a full value-added tax.

Two key dimensions should be considered for the external validity of the results: the size of firms in our study and Costa Rica's institutional environment. First, our elasticity estimates concern small and medium firms and might not apply to large firms. Based on two observations, one at each threshold, the elasticity of profits with respect to the net of tax rate appears to decrease with firm revenue. However large firms could have access to more sophisticated evasion schemes, which makes it hard to conclude that the profit elasticity is falling with firm size. Second, tax elasticities are a function of the institutional and policy environment. On the one hand, Costa Rica's institutions are strong for its income level: for example, the country ranks well on Transparency International's corruption perception index. In weaker institutional environments, profit elasticities could be even larger. On the other hand, Costa Rica's tax structure is complex and fragmented,³⁴ which could contribute to the large profit elasticity and the ease of over-reporting costs.

With these caveats about interpretation in mind, how should lower income countries design their corporate income tax? We discuss four types of corporate tax design, and their potential implications for tax collection and efficiency. Across countries, the most common corporate schedule taxes profits at a flat rate and permits the deduction of most production costs. As a direct consequence of the large estimated elasticities, rates above 17-25% are on the wrong side of the Laffer curve and should be excluded.³⁵ Some countries have increasing marginal tax rates on profits, which reduce bunching incentives, but generate a loss in tax revenue, as infra-marginal firms with large profits lower their tax bill on the initial portion of their profits. This is particularly important if the profit elasticity falls with firm revenue, such that large firms with a lower profit elasticity, reduce their tax liability without increasing reported profits. In light of this plausible assumption, Costa Rica's tax system tags³⁶ firms based on revenue, which we show is relatively hard to manipulate, and assigns increasing tax rates, potentially satisfying an inverse elasticity rule. In addition, the low initial tax rate for small firms could contribute to firm formalization: once firms are registered it could be difficult to return to informality, and at this stage increasing enforcement could yield revenue gains. However, the current system does not satisfy horizontal equity (i.e. quasi-identical firms face different tax rates) and only imperfectly deals with large cost over-reporting. To this end the

³⁴In addition to the corporate and personal income taxes, Costa Rica has a self-employed regime and a micro-sellers regime, which applies to firms with revenue below the firms we study. In addition it does not have a fully fledged VAT system, even though its sales tax mimics some aspects of a VAT.

³⁵Gorodnichenko et al. 2009 and Kopczuk 2012 both find that flat tax reforms in Eastern Europe, which decreased substantially the rate and simplified the tax code, led to large increases in reported income.

³⁶See Ito and Sallee 2014 for a model of attribute based regulation and enforcement.

introduction of presumptive tax schemes could be beneficial. Under such schemes, tax liability is the maximum amount of a low rate applied on revenue and a higher rate on profits. [Best et al. \(2015\)](#) show that in Pakistan, the revenue gains from a presumptive scheme could outweigh the production distortion it generates. The large ratio of cost to revenue elasticity we estimate, further supports their empirical results on the desirability of using revenue as the tax base. More generally, a tax design which limits deductions and/or requires tangible evidence of incurred costs, such as electronic receipts, could generate a substantial increase in tax revenue. To conclude, [Figure 16](#) shows the types of corporate tax systems used by low, middle and high-income countries. Tax systems with flat rates or increasing marginal rates are the most frequent worldwide, and ubiquitous in OECD countries. Within low and middle-income countries, we observe variation in corporate tax policy: presumptive tax schemes are common, especially for lower-income countries, while schemes with revenue dependent rates, such as Costa Rica's, are sometimes used in middle-income countries. The use of non-standard corporate tax systems, highlights the needs of developing countries to collect revenue in the face of large behavioral responses of the type we document in this study.

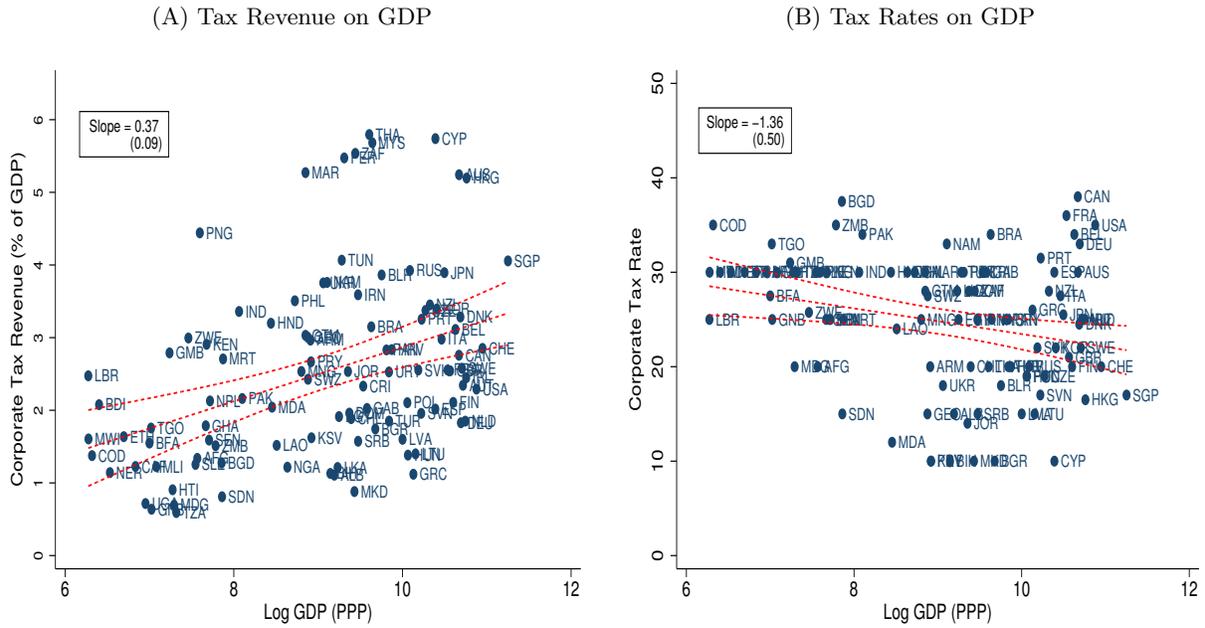
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Figure 1: Corporate Income Tax Across Countries



Source: Corporate tax revenue data from the International Consortium on Taxation and Development (ICTD). Top statutory corporate tax rates collected by the authors for the year 2013. GDP data in purchasing power parity from the World Bank indicators. N = 101, excludes countries with less than 1 Million in population. The dotted lines show the linear fit with the 95% confidence interval.

Figure 2: Costa Rica's Corporate Tax Schedule

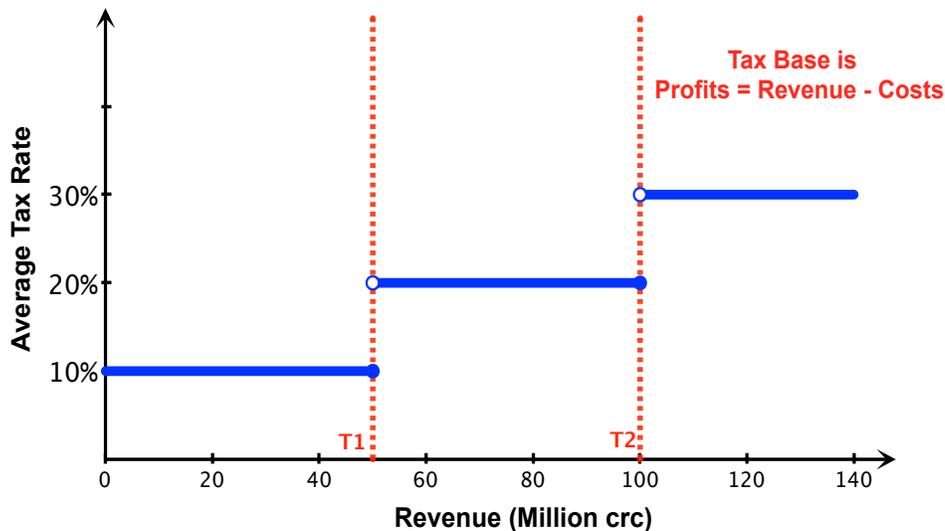


Figure 2 shows the design of the corporate income tax in Costa Rica. Firms face increasing average tax rates on their profits as a function of their revenue. When revenue exceeds the first threshold, the average tax rate jumps from 10% to 20% and from 20% to 30% past the second threshold.

Figure 3: Bunching Theory

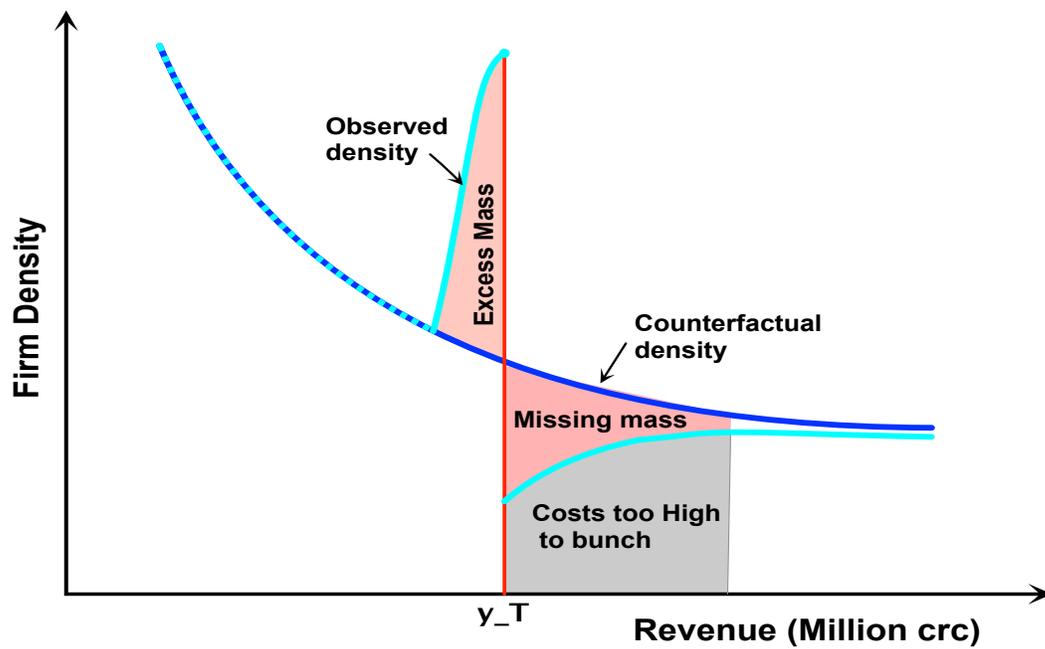


Figure 3 displays the density distributions. Under a flat 10% tax rate the counterfactual firm density follows a smooth distribution. The notch induces some firms, with counterfactual revenue above the threshold, to reduce their revenue and bunch just below the threshold. The bunching decision is a joint function of the firm's revenue distance to the threshold and costs, such that at each revenue bin, only firms with sufficiently low costs bunch.

Figure 4: Firm Density and Average Profit Margin

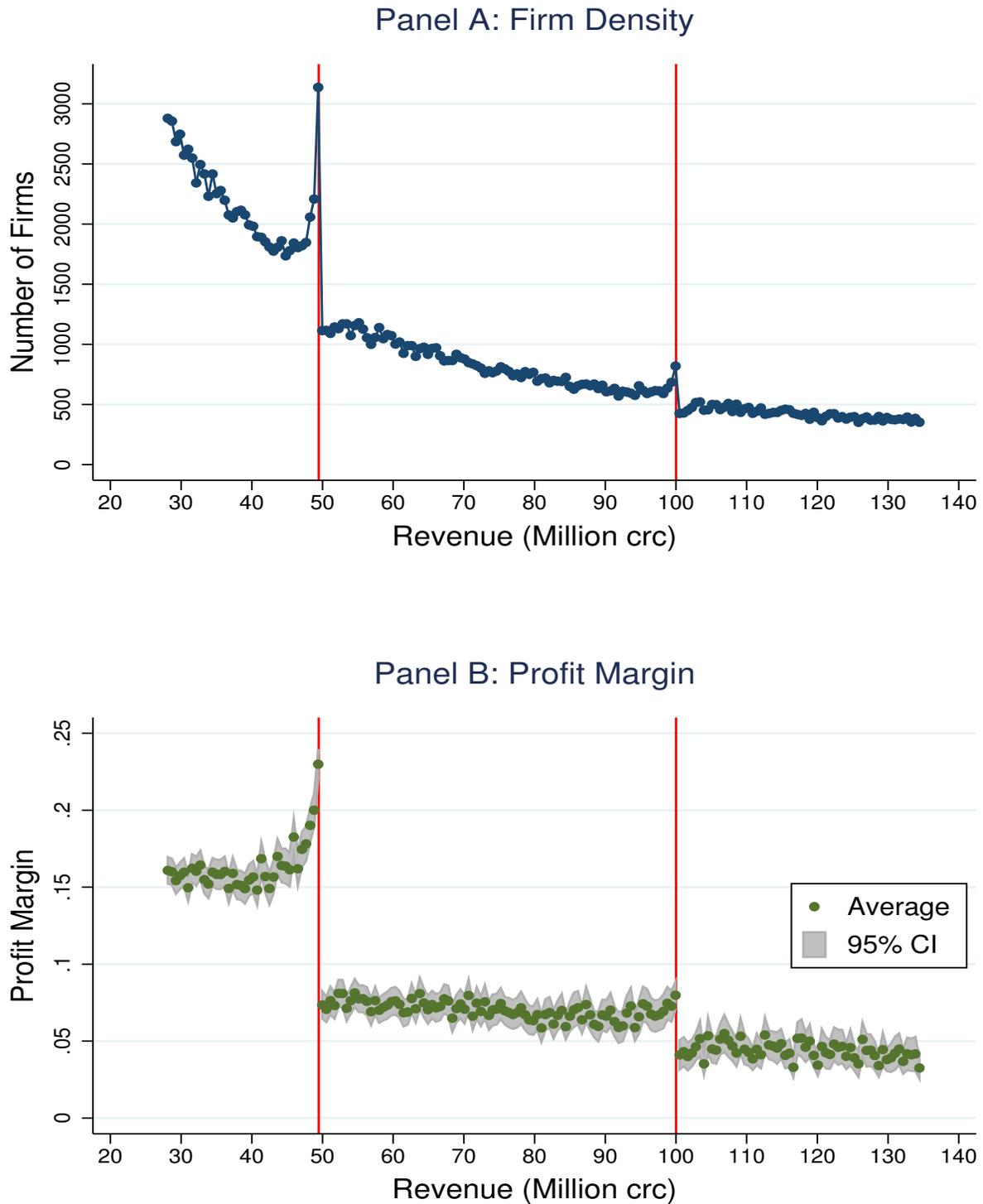


Figure 4 presents the key patterns of the corporate tax returns, pulling together the years 2008 to 2015. Panel A shows the density of firms by revenue. Panel B displays the average profit margin by revenue, where profit margin is defined as profits over revenue. The size of the revenue bins is 575,000 CRC.

Figure 5: Revenue Bunching Estimation

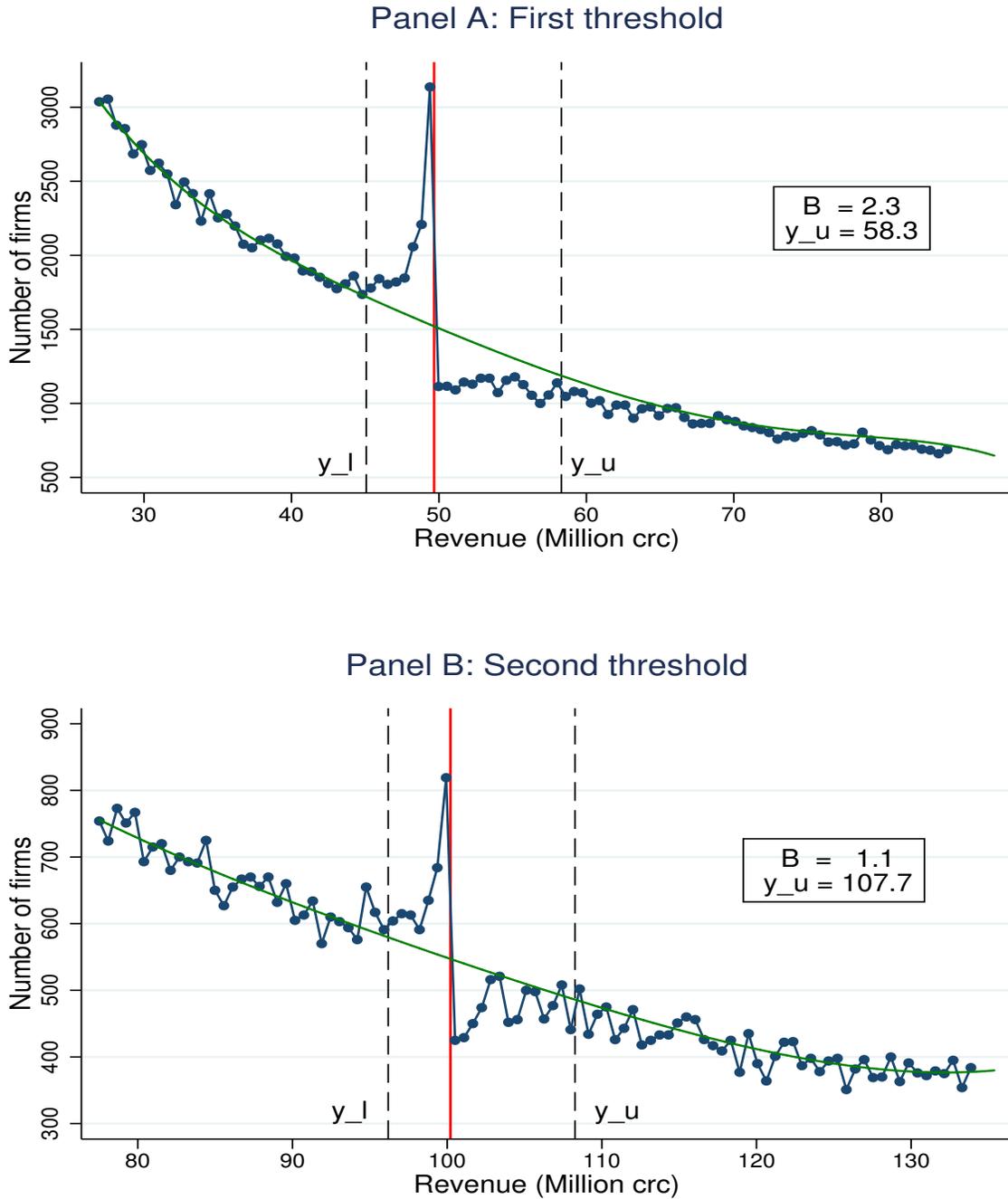


Figure 5 displays the density of firms by revenue and fits the counterfactual distribution for the first and second thresholds. In the boxes on the top right, B is the excess mass as a share of the counterfactual, and y_u the revenue of the marginal buncher, obtained with the point of convergence method. The counterfactual is obtained from the regression of a polynomial of degree 5 (maximizes Akaike criteria), on all data points outside the $[y_l, y_u]$ interval. The lower bound y_l is chosen by the researchers as the revenue bin which starts exhibiting excess. The upper bound y_u is estimated from an iterative process: starting from y_u close to the threshold, we obtain the counterfactual and estimate the excess mass (B) below the threshold and missing mass (M) above the threshold. For low y_u , the excess mass is larger than the missing mass, $B \gg M$. We increase y_u until the two masses are equal, $B = M$.

Figure 6: Cost Discontinuity

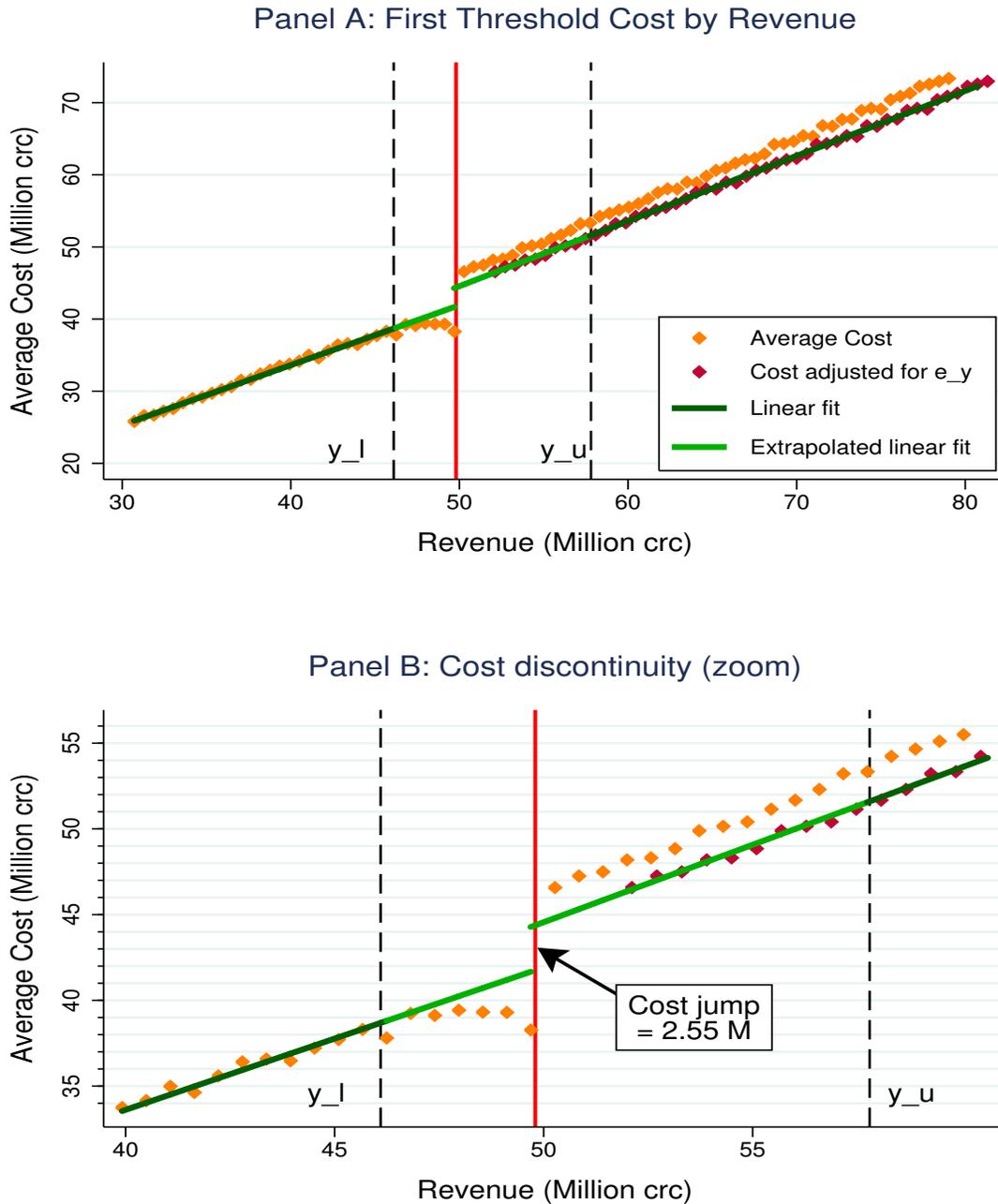


Figure 6 displays the average declared cost for each revenue bin around the first threshold. To estimate the cost discontinuity at the threshold, absent revenue responses, we adjust for intensive margin revenue responses: firms declaring revenue above the threshold reduced their declared revenue, due to the tax rate increase. To take intensive responses into account, we horizontally shift firms' costs proportionally to the elasticity of revenue, estimated from bunching. For example, given an elasticity of revenue of 0.25 and a firm with revenue of 60M: $revenue_{counter} = 60 + \epsilon_{y,1-t} \cdot y \cdot \frac{dt}{1-t} = 60 + 0.25 * 60 * \frac{0.1}{0.9} \approx 61.6$. We linearly fit costs by revenue, below and above the threshold. On either side, we exclude revenue bins impacted by bunching behavior. We then extrapolate the linear fits to the threshold. The resulting cost discontinuity represents the average increase in declared costs, for a firm at the threshold, due to an increase in the tax rate from 10 to 20%.

Figure 7: Effective Tax Rate on Revenue

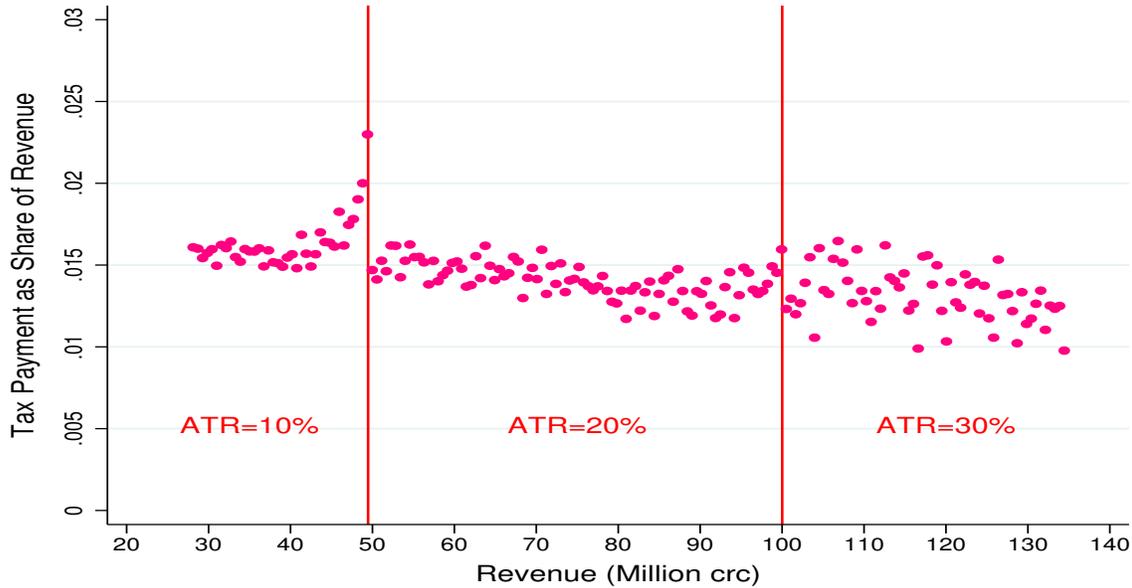


Figure 7 plots the average tax payment as a share of revenue by revenue bins of half million CRC. The large drop in declared profits past the thresholds implies that even though the tax rate increases by 10% past each threshold taxes paid as a share of revenue are close to constant.

Figure 8: Structural Assumption - Stable Profit Margin Distributions

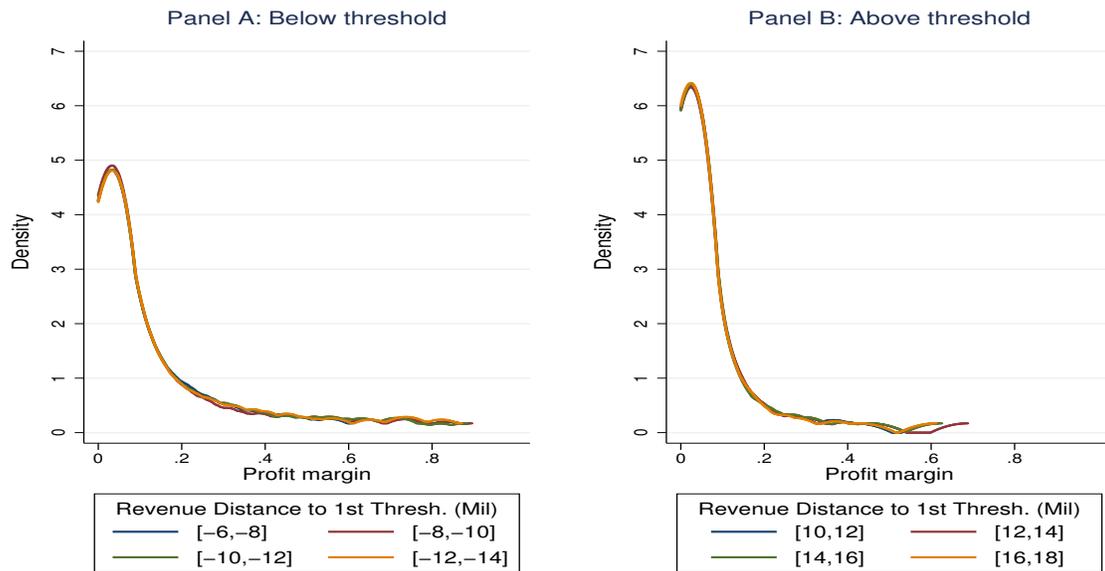


Figure 8 shows that the distribution of profit margin is stable across revenue intervals 10 to 20% below the threshold (Panel A), and revenue intervals 20 to 30% above the threshold (Panel B). The revenue distance to the threshold indicates the revenue intervals considered. We use an Epanechnikov kernel with bandwidth of 0.04 across all distributions. Within each panel, we never reject the Kolmogorov-Smirnov tests, that profit margins are sampled from populations with identical distributions across all pairs of revenue intervals.

Figure 9: Numerical Estimation of Bunching Behavior

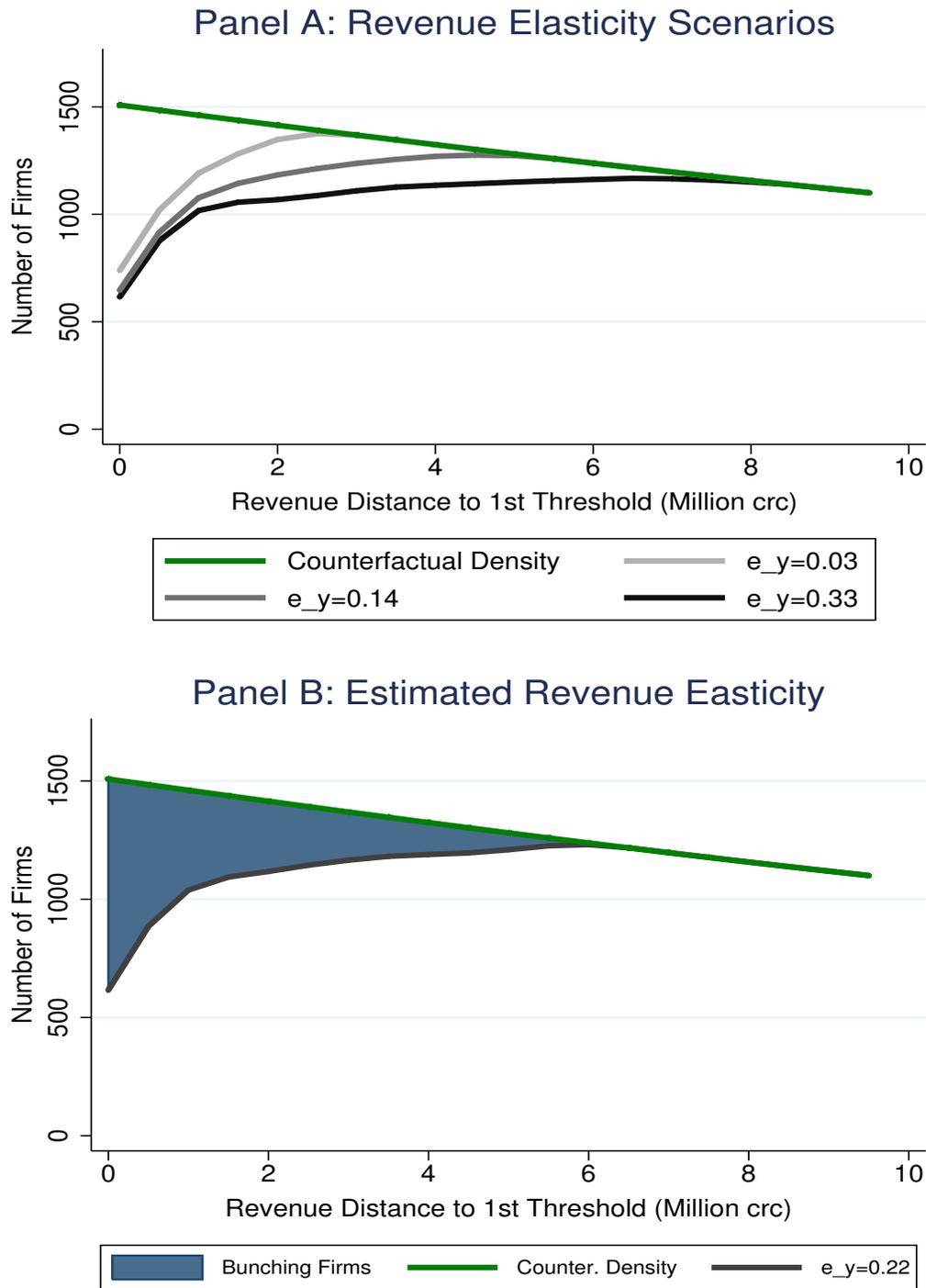


Figure 9 displays the results from the numerical model-based estimation, when assuming a joint counterfactual distribution of revenue and costs and that bunchers cost response correspond to the average cost response. For a given revenue elasticity, e_y and cost elasticity, e_c , the area between the counterfactual density and the curves represents the number of bunching firms. In panel A, we display the profile of these curves for several values of the revenue elasticity. Panel B, displays the result for the last iteration: the number of estimated bunchers equals the observed bunchers and the revenue and cost elasticity are in equilibrium.

Figure 10: Dynamic Firm Behavior by Tax Bracket

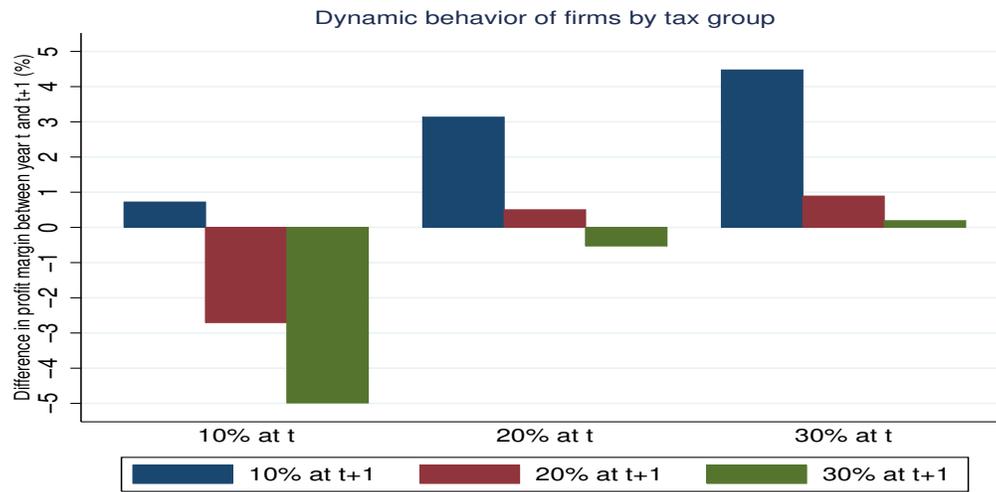


Figure 10 shows the average change in firms’ profit margins between year t and t+1 as a function of their tax brackets in year t and t+1. On the one hand, firms remaining within their initial tax bracket hardly change reported profits. On the other hand, firms jumping to higher tax brackets drop their profit margins and symmetrically firms falling to lower tax bracket increase their profit margins.

Figure 11: Profit Margin Change for Growing Firms

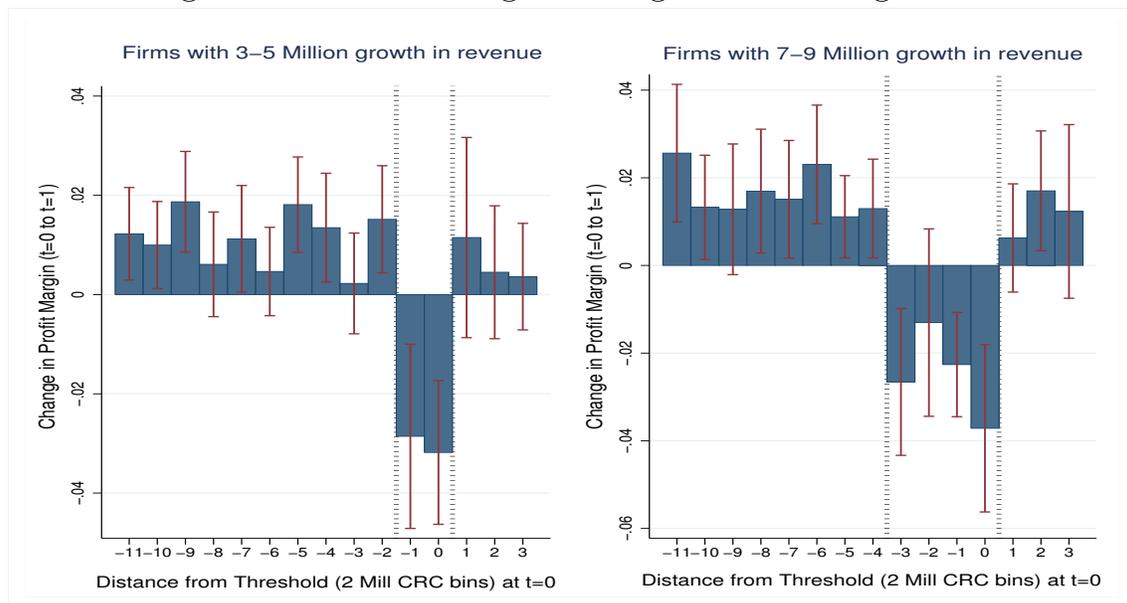


Figure 11 plots the average change in firms’ profit margins between year t and t+1 for the subset of firms who’s revenue grew by 3 to 5 Million (Left Panel) and by 7-9 Million (Right Panel). This figure visually shows the difference in differences across the group of firms that jumped past the threshold versus the firms that stayed within the same tax bracket, while controlling for revenue growth.

Figure 12: Employment and Wage Bill by Revenue

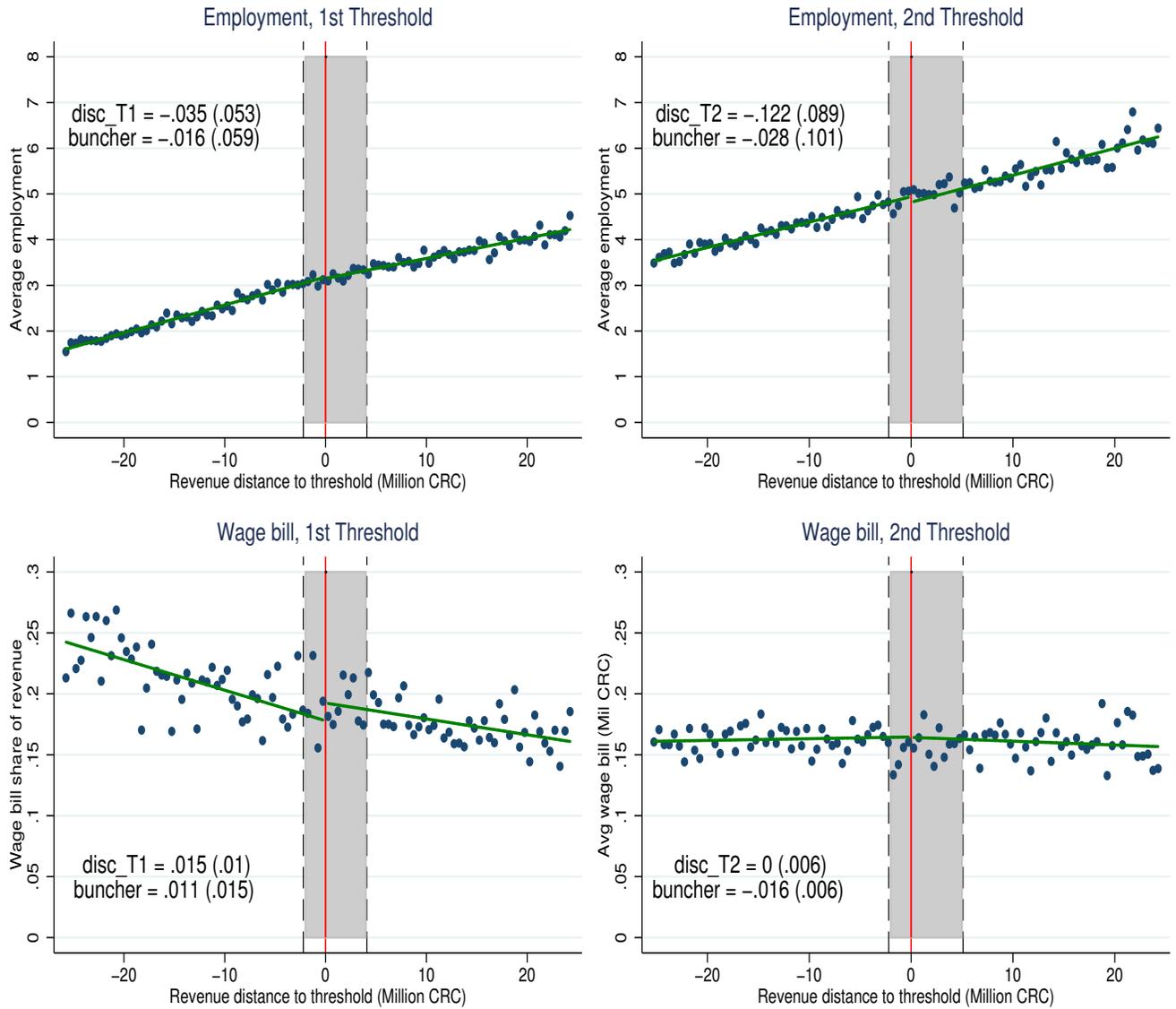


Figure 12 shows the average number of employees and wage bill by revenue around the first and second thresholds. The data is obtained from a merge of social security records with corporate income tax returns. We display the coefficient and standard errors from the discontinuity regression at the threshold and the dummy coefficient for firms in the bunching interval.

Figure 13: Share of Subsidiaries by Revenue

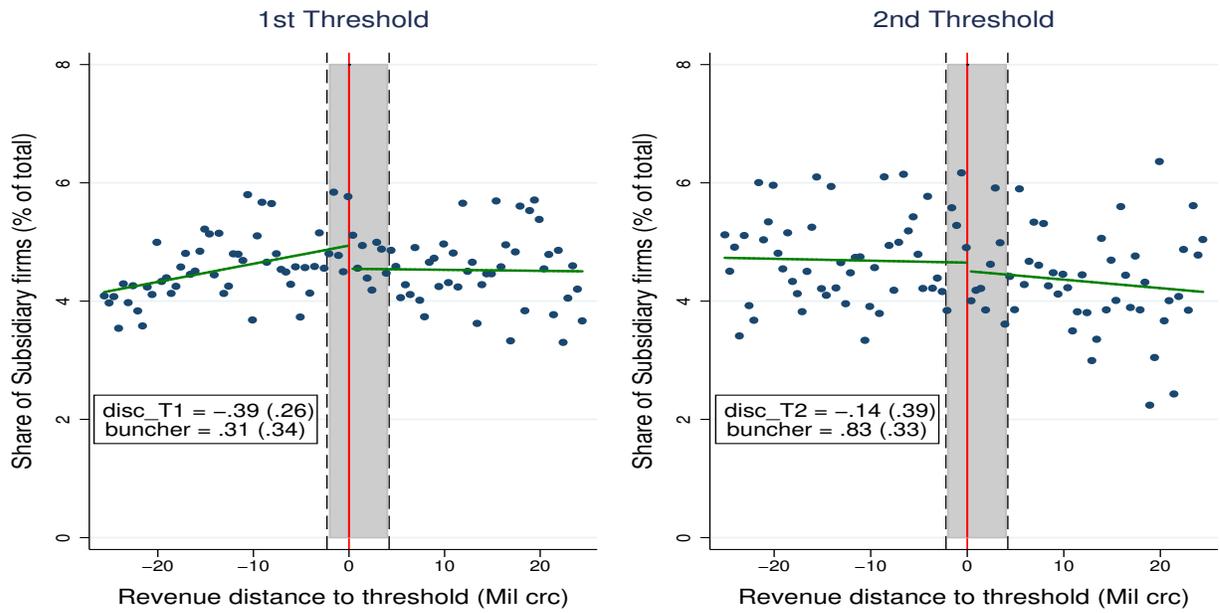


Figure 14: Capital Stock by Revenue

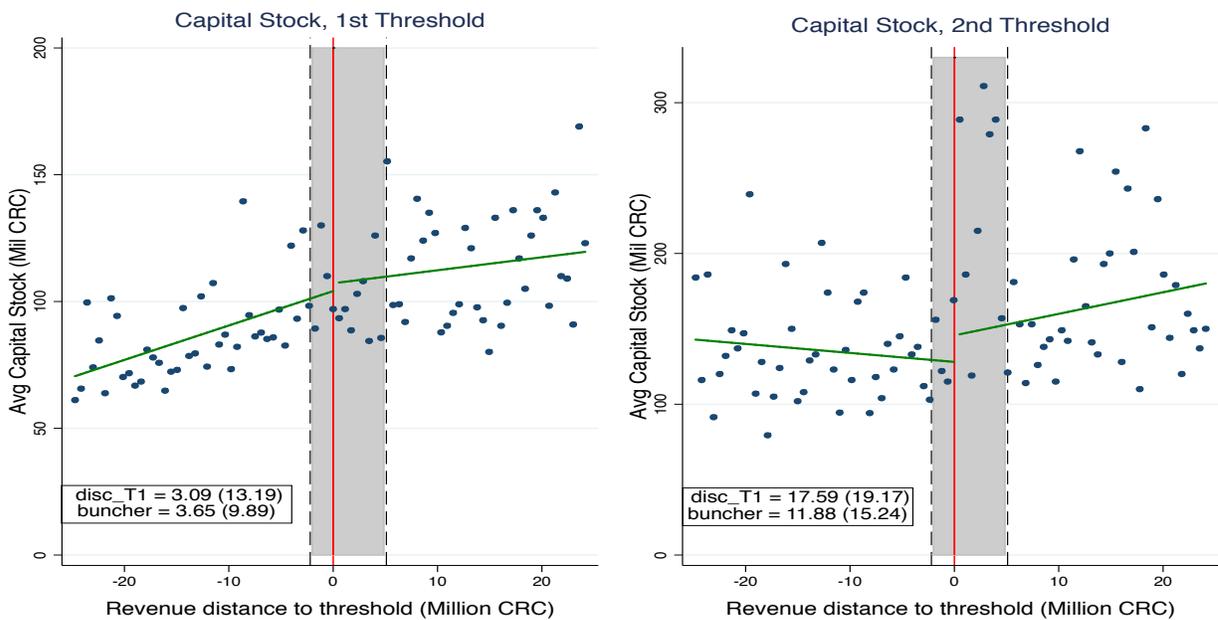


Figure 15: Correction Letters by Revenue (2012)

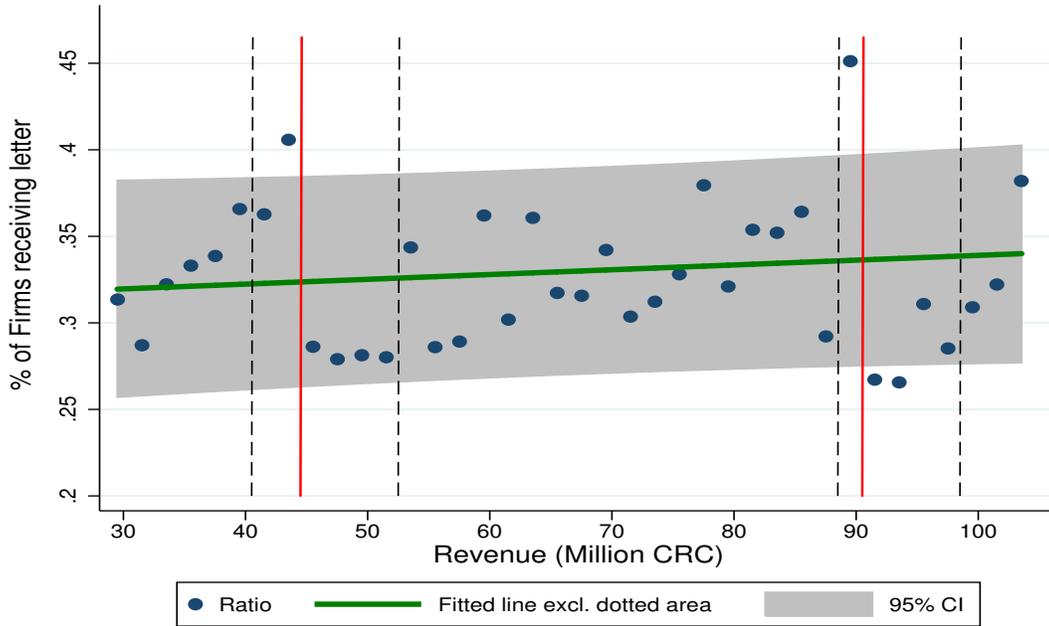
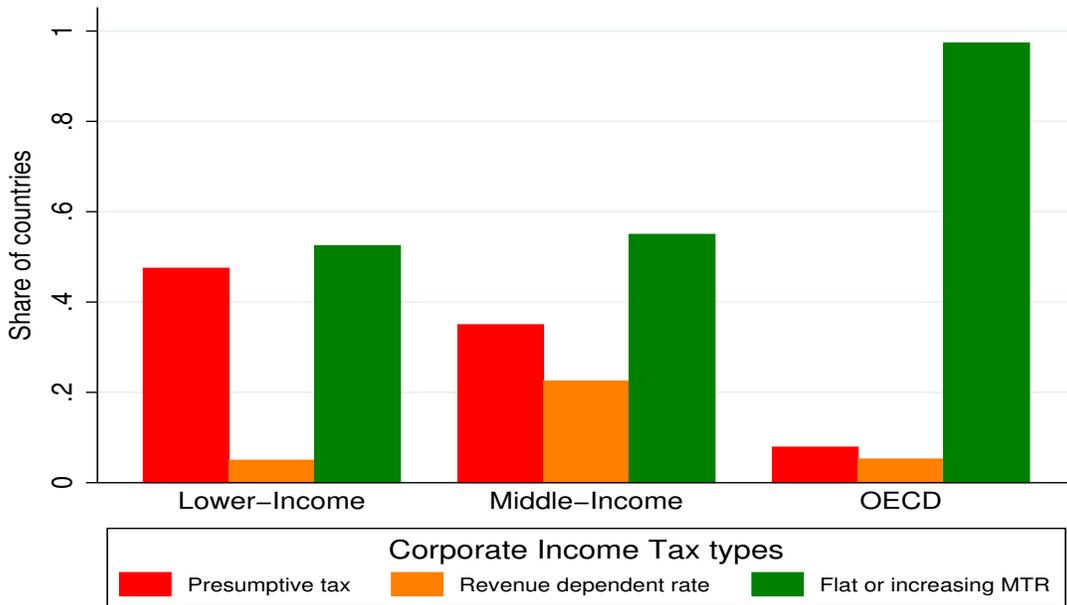


Figure 15 displays the percentage of firms receiving correction letters by revenue due to an inconsistency in their tax declaration or a discrepancy with third party information. Revenue bins represent 2 Million CRC. The fitted line excludes the revenue intervals impacted by the bunching selection.

Figure 16: Worldwide Corporate Tax Systems by Income Quintiles



Note: Authors' computation based on data collected by Abramovsky, Bachas & Jensen (2015)

Figure 16 shows the worldwide distribution of corporate income tax types, by countries' income levels. The sample contains 120 countries, with data on corporate incomes tax types collected from international tax guides by the authors, and per-capita income data from the World Bank. Presumptive tax systems are common in the lowest quintile, while CIT with revenue dependent rate, such as Costa Rica's, are sometimes used in middle-income countries. OECD countries, almost always taxed corporate income at a flat or increasing marginal rate.

Table 1: Summary of estimates and assumptions

Method	Estimation strategy	Elasticity	Bound	Assumptions
Reduced form				
Step 1 $\rightarrow \epsilon_y$ \Downarrow	Bunching: empirical point of convergence	$\epsilon_{y,1-\tau} = 0.33$	Upper bound: ϵ_y of marginal buncher	Counterfactual firm density by revenue is regular
Step 2 $\rightarrow \epsilon_c(\epsilon_y)$ \Downarrow	Cost discontinuity	$\epsilon_{c,1-\tau} = -0.55$	Lower bound: adjustment for $\hat{\epsilon}_y \rightarrow \hat{\epsilon}_c$ negative relation with $\hat{\epsilon}_y$	Linear cost extrapolation is correct
Step 3 $\rightarrow \epsilon_\pi(\epsilon_y, \epsilon_c)$	$d\pi = dy - dc$	$\epsilon_{\pi,1-\tau} = 4.93$		
Added structure				
Profit margin distribution of firms with revenue 10% below the threshold would apply to firms with revenue just above the threshold absent the tax change				
With $dc = d\bar{c}$				
Step 1 $\rightarrow \epsilon_y(\epsilon_c)$ \Updownarrow Iterate	Bunching: numerical elasticity ϵ_y	$\epsilon_{y,1-\tau} = 0.22$		Bunchers would have $dc = d\bar{c}$ if not bunching
Step 2 $\rightarrow \epsilon_c(\epsilon_y)$ \Downarrow	Cost discontinuity	$\epsilon_{c,1-\tau} = -0.65$		
Step 3 $\rightarrow \epsilon_\pi(\epsilon_y, \epsilon_c)$	$d\pi = dy - dc$	$\epsilon_{\pi,1-\tau} = 4.90$		
With $dc = 0$				
Step 1 $\rightarrow \epsilon_y$ \Downarrow	Bunching: numerical elasticity ϵ_y	$\epsilon_{y,1-\tau} = 0.095$	Lower bound: Assumption $dc=0$	Bunchers would have $dc = 0$ if not bunching
Step 2 $\rightarrow \epsilon_c$ \Downarrow	Cost discontinuity	$\epsilon_{c,1-\tau} = -0.79$	Upper bound: $\hat{\epsilon}_c$ negative relation with $\hat{\epsilon}_y$	
Step 3 $\rightarrow \epsilon_\pi(\epsilon_y, \epsilon_c)$	$d\pi = dy - dc$	$\epsilon_{\pi,1-\tau} = 4.90$		

Table 2: Cost on Revenue Distance to Threshold Relation

	1st Threshold		2nd Threshold	
	Cost	Cost(revenue adjust.)	Cost	Cost(revenue adjust.)
Jump in cost δ	4.203** (0.212)	2.548** (0.226)	2.223** (0.416)	1.277** (0.432)
Slope below T. β_1	0.834** (0.010)	0.834** (0.010)	0.933** (0.015)	0.933** (0.015)
Slope change above T. β_2	0.103** (0.014)	0.069** (0.014)	0.017 (0.026)	0.008 (0.026)
Intercept α	41.971	41.971	93.863	93.863
Observations	80	80	80	80
% Jump in Cost $\frac{\delta}{\alpha}$	+10.01%	+6.07%	+2.37%	+1.36%

Table (2) shows the results from the regression of average costs by revenue on revenue distance to the threshold, estimated from equation (14): $cost_j = \alpha + \delta \cdot \mathbb{1}(\tilde{y}_j > 0) + \beta_1 \cdot \tilde{y}_j + \beta_2 \cdot \tilde{y}_j \mathbb{1}(\tilde{y}_j > 0) + \sum_{j=\tilde{y}_l}^{\tilde{y}_u} \gamma_j \mathbb{1}(\tilde{y}_j = j) + \epsilon_j$

For each threshold we report the discontinuity in cost δ with and without the revenue adjustment. The revenue adjustment holds revenue responses above the threshold constant, using the revenue elasticity estimated with bunching, such that the discontinuity in the cost to revenue relation, after adjustment, only identifies cost responses: the results from column (2) & (4) are our main estimate of the cost discontinuity. An observation is a revenue bin of 0.575 Million Colones. Standard errors are shown in parentheses and stars indicate statistical significance level. *=5% level, **=1% level.

Table 3: Elasticity Estimates - Point of Convergence

y^*	Parameters			Elasticity			Threshold jump		
	dy^*	$1 - \tau_0$	τ^*	Revenue	Cost	Profit	Δy	Δc	$\Delta \pi$
50	8.3** (1.3)	0.9	0.55	0.33** (0.07)	-0.55** (0.06)	4.93** (0.28)	-1.84	2.55	-4.39
100.5	7.2** (1.8)	0.8	0.77	0.08* (0.04)	-0.11* (0.05)	2.92** (0.71)	-0.99	1.27	-2.26

Table (3) shows the elasticity estimates when the point of convergence method is used to estimate the revenue elasticities. Cost elasticities are estimated with the threshold discontinuity, holding constant revenue responses. The profit elasticity then combines the revenue and cost responses. Standard errors are obtained through 1,000 bootstrap iterations. y^* is the revenue threshold in Million CRC and dy^* is the revenue response of the marginal buncher estimated with bunching. $1 - \tau_0$ is the average tax rate below each threshold and τ^* is the implicit marginal tax rate faced by the marginal buncher. This is estimated with equation (12) and assumes that the cost of the marginal buncher corresponds to the 10th percentile of the cost distribution of this revenue bin. Standard errors are shown in parentheses and stars indicate statistical significance level. *=5% level, **=1% level.

Table 4: Model-Based Numerical Estimation: Iteration Steps

Iteration Step	Revenue Elasticity $\epsilon_{y,1-t}$	Cost Jump dc	Cost Elasticity $\epsilon_{c,1-t}$
1	0.33	2.55	-0.55
2	0.17	3.25	-0.70
3	0.26	2.83	-0.61
4	0.19	3.17	-0.68
5	0.24	2.93	-0.63
6	0.21	3.07	-0.66
7	0.23	2.98	-0.64
Final	0.22	3.02	-0.65

Table 4 shows the iteration steps of the model-based numerical bunching estimation. With a counterfactual firm density by revenue and a counterfactual profit margin distribution, the method numerically estimates the number of bunching firms as a joint function of their revenue distance to the threshold and costs. Step 1 uses as initial values the revenue and cost elasticity from section 3. Under those parameters the revenue elasticity of Step 2 is sufficient such that the number of bunchers equal that of the excess mass. With this new revenue elasticity we re-estimate the cost elasticity using the discontinuity method of 3.3. We iterate this procedure until we find the fixed point at which the revenue and cost elasticities are consistent with the observed bunching behavior.

Table 5: Industry Level Results 1st Threshold

Sector	Profit Margin (%)			Bunching Excess Mass	# Firms Total	# Firms % Below T1
	Drop	Base	% Drop			
Agriculture	-4.1	8.4	-48.8	1.95	33,095	59.5
Manufacture	-3.2	6.8	-47.1	2.34	34,799	45.4
Construction	-5.2	9.5	-54.7	3.17	26,410	51
Wholesale & Motor Vehicle	-3.5	7	-50	1.11	63,544	45.1
Retail	-4.9	8.5	-57.6	1.17	100,552	47.9
Hotel & Restaurants	-3.5	7	-50	1.41	21,483	49
Transport	-4.1	9.9	-41.4	2	36,294	54.7
Financial Activities	-10.3	21.8	-47.2	3.93	26,366	71.9
Real Estate	-13	36.4	-35.7	4.05	91,525	85.1
Legal & Econ. Consultants	-9.5	17	-55.9	6.27	64,617	73.3
Other Services	-9.3	14.6	-63.7	4.37	37,091	69.3
Education & Culture	-1.3	5.8	-22.4	2.64	14,228	56.8
Health	-8.4	17.1	-49.1	3.23	19,611	65.2
NGO & Public Admin.	.8	28.1	2.8	-1.19	10,608	68.8
Undetermined	-9.6	19.9	-48.2	3.66	36,044	80.8

Table 6: Dynamic Firm Behavior

	Profit Margin	
	1st Threshold	2nd Threshold
Revenue (Million CRC)	0.0115** (0.0039)	0.0071* (0.0029)
Higher Tax Bracket	-3.06** (0.17)	-0.86** (0.14)
Buncher (Narrow)	1.56** (0.27)	0.46** (0.14)
Bunching (Broad)	0.84** (0.20)	0.60* (0.27)
Above threshold (Narrow)	-0.33 (0.18)	-0.10 (0.17)
Above threshold (Broad)	-0.12 (0.11)	0.02 (0.10)
Constant (Avg across years)	14.63	5.62
Firm & Year fixed effects	YES	YES
Observations	289,744	88,493

All firms with revenue in a 70 Million CRC window centered around the thresholds are included in the sample. Profit margin is defined as profit over revenue. The Bunching and above threshold are dummies for declaring revenue in the intervals around the threshold. Bunching narrow is defined as the having revenue in the half Million interval below the threshold. Bunching wide as having revenue between 4 and 0.5 Million below the threshold. Above threshold narrow is defined as having revenue between 0 to 3 Million above the threshold and wide as having revenue 3 to 9M above threshold. Standard errors are shown in parentheses and stars indicate statistical significance level. *=5% level, **=1% level.

Table 7: Revenue Shifting at the End of the Fiscal Year

	Dependent Variable: Monthly Revenue (Million CRC)							
	All firms				CIT rev. = sales tax rev.			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Buncher*Sept	0.10 (0.12)	0.05 (0.09)			-0.17 (0.32)	0.30** (0.07)		
Buncher*Oct			-0.02 (0.12)	-0.21 (0.13)			-0.62 (0.48)	-0.12 (0.10)
Firm FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	596,705	596,705	596,705	596,705	115,649	115,649	115,649	115,649

Table 7 tests for revenue shifting at the end of the fiscal year using the revenue declared for the monthly sales tax payment. Robust standard errors are shown in parentheses and stars indicate statistical significance level. *=5% level, **=1% level.

Table 8: Threat of Audit Impact at the Industry Level

Outcome (Million CRC)	Control 1: firms too small to bunch			Control 2: Dominated firms		
	(1) Revenue	(2) Costs	(3) Profit	(4) Revenue	(5) Costs	(6) Profit
Bunch*Audit*Post	4.87 (2.39)**	6.43 (2.24)***	-1.23 (0.33)***	6.30 (3.99)	9.76 (3.63)***	-1.68 (0.57)***
Bunch*Post	-0.22 (2.13)	-0.48 (2.00)	-0.42 (0.31)	0.88 (3.20)	1.35 (2.81)	-1.50 (0.37)***
Audit*Post	5.55 (3.10)*	5.88 (3.01)*	-1.25 (0.29)***	6.98 (2.89)**	9.21 (3.29)***	-1.70 (0.65)**
Firm FE	YES	YES	YES	YES	YES	YES
Observations	7,203	7,203	7,203	4,672	4,672	4,672

Table 8 shows the results of the triple difference regression estimated from equation 20. The coefficient of interest is the triple interaction $Bunch * Audit * Post$ which shows the change in reported revenue, costs and profits of bunchers following an increase in their audit risk at the industry level. Standard errors are clustered at the industry level and shown in parentheses. Stars indicate statistical significance level. *=10% level, **=5% level, ***=1% level.

Appendix A Robustness of Elasticity Estimation

Figure A1: Average Profit and Costs by Revenue

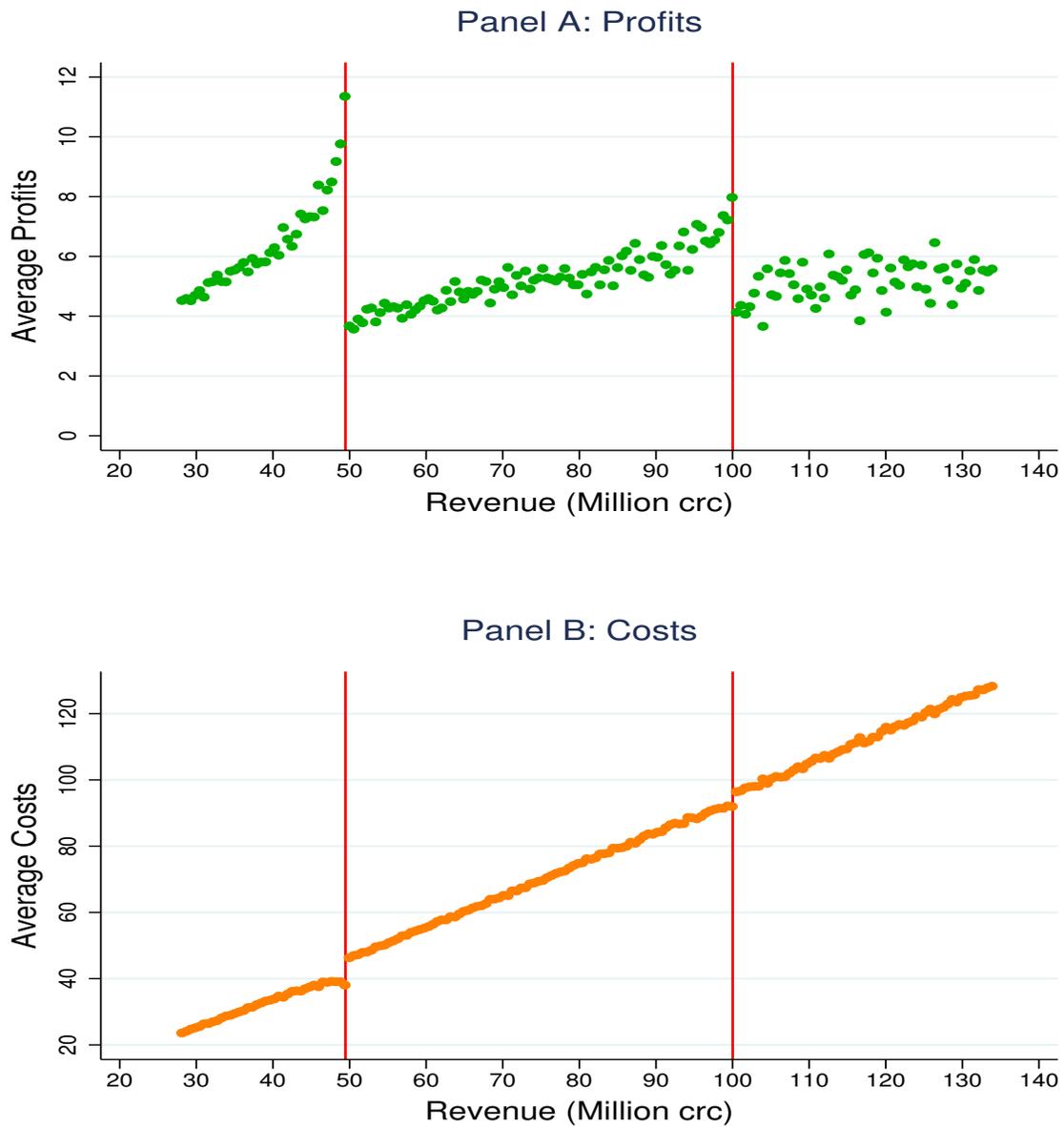


Figure A1 shows average profits (Panel A) and average costs (Panel B) by revenue, pulling together the years 2008 to 2014. The size of the revenue bins is 575,000 CRC.

Figure A2: Linear Relation of Average Costs by Revenue

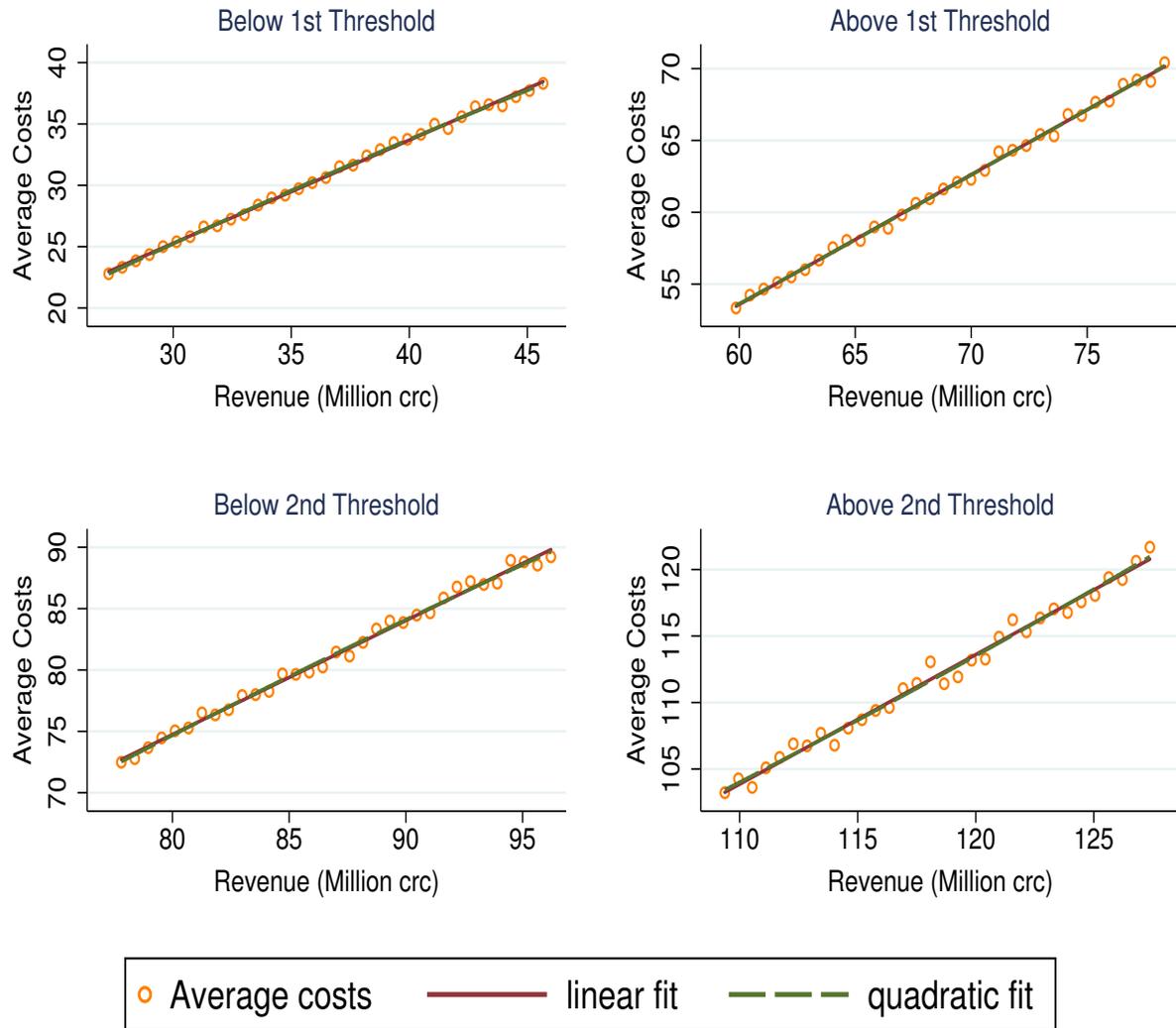


Figure A2 shows the linear relation of average costs by revenue. For each of four revenue intervals, below and above the first and second threshold, the linear and quadratic fit of the data. Quadratic fits are practically indistinguishable from Linear fits.

Table A1: Robustness of Bunching Estimates

Panel A: Varying the order of the Polynomial			
Order of Polynomial	4	5	6
First Threshold			
B	2.4	2.2	2.2
y_u	59.4	58.3	58.8
$\epsilon_{y,1-\tau}$	0.41	0.33	0.36
Second Threshold			
B	1.1	1.1	1.1
y_u	108.3	107.7	107.7
$\epsilon_{y,1-\tau}$	0.10	0.08	0.08
Panel B: Varying the excluded zone, y_l			
Number of excluded bins	6	7	8
First Threshold			
B	2.0	2.2	2.3
y_u	57.1	58.3	58.3
$\epsilon_{y,1-\tau}$	0.25	0.33	0.33
Second Threshold			
B	1.1	1.1	1.0
y_u	107.1	107.7	106.6
$\epsilon_{y,1-\tau}$	0.07	0.08	0.06

Table A1 shows under different scenarios the estimates of the excess mass B, the revenue of the marginal buncher y_u and the resulting revenue elasticity $\epsilon_{y,1-\tau}$. Panel A varies the order of the polynomial and Panel B the number of excluded bins on the lower side, which corresponds to y_u .

Table A2: Adjusted R-squared of Average Costs on Revenue Regression

Variable: Adj. R-squared	Order of Polynomial		
	Linear	Quadratic	Cubic
Below 1st Threshold	.9977	.9981	.9981
Above 1st Threshold	.9971	.9970	.9969
Below 2nd Threshold	.9933	.9933	.9932
Above 2nd Threshold	.9872	.9871	.9870

Table A2 shows the model fit for different specifications of the regression of average costs on revenue. The simple linear model fits the data well and higher order terms are superfluous based on the adjusted R-squared. Only below the first threshold could the quadratic fit be preferred.

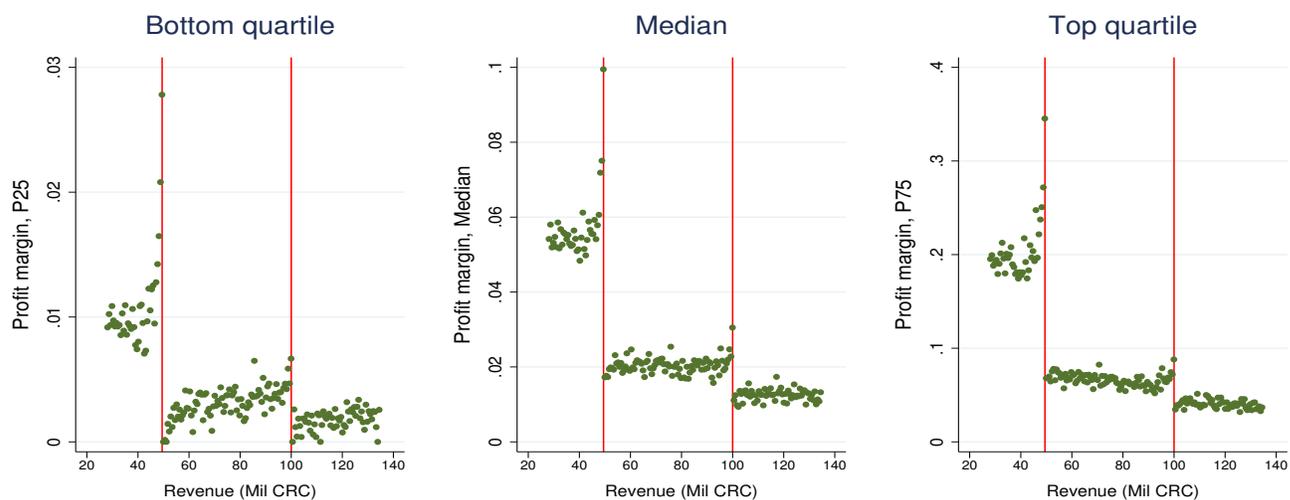
Table A3: Alternative Models for Cost Discontinuity by Revenue

Model Specification	1st Threshold				2nd Threshold			
	(1) Narrow Window	(2) Wide Window	(3) Falling ϵ_y	(4) Quadratic	(5) Narrow Window	(6) Wide Window	(7) Falling ϵ_y	(8) Quadratic
Jump in cost δ	2.688** (.249)	2.465** (.204)	2.326** (.246)	3.804** (.583)	1.389* (.591)	.85* (.392)	1.277** (.432)	3.113** (.726)
Slope below T.	.823** (.012)	.841** (.007)	.834** (.009)	.603** (.089)	.924** (.02)	.944** (.012)	.933** (.015)	.821** (.078)
Δ Slope above T.	.079** (.017)	.063** (.011)	.107** (.014)	.297** (.092)	.014 (.042)	.018 (.021)	.008 (.026)	-.052 (.098)
Quadratic below T.				-.009** (.003)				-.004 (.003)
Δ Quadratic above T.				.009** (.003)				.01** (.003)
Intercept, α	41.86	42.046	41.971	40.682	93.777	93.99	93.863	93.217
Observations	70	90	80	80	70	90	80	80
% Jump in Cost $\frac{\delta}{\alpha}$	+6.42%	+5.86%	+5.54%	+9.34%	+1.48%	+0.91%	+1.36%	+3.36%

Table A3 shows the regressions of average costs by revenue on revenue for different model specifications. The parameter of interest is the jump in declared costs at the threshold, δ , from Equation (14). Compared to the main specification of Table (2), Rows (1)-(2) & (5)-(6) vary the revenue interval over which the line is fitted. Rows (3) & (7) assume that the revenue elasticity is falling with revenue, at the speed estimated between the first and second threshold. Rows (4) & (8) assume a quadratic fit instead of a linear fit. An observation is a revenue bin of 0.575 Million Colones. Standard errors are shown in parentheses and stars indicate statistical significance level. *=5% level, **=1% level.

Appendix B Additional Figures

Figure B1: Quartiles of Profit Margin by Revenue



Note: The y-axis scale is not constant across figures

Figure B1 shows the distribution of profit margins by revenue for each quartile within a revenue bin. The discontinuous step pattern observed for average profit margins is observed at all quartiles of the within revenue bin profit margin distribution.

Figure B2: Excess Mass and Profit Discontinuity by Industry

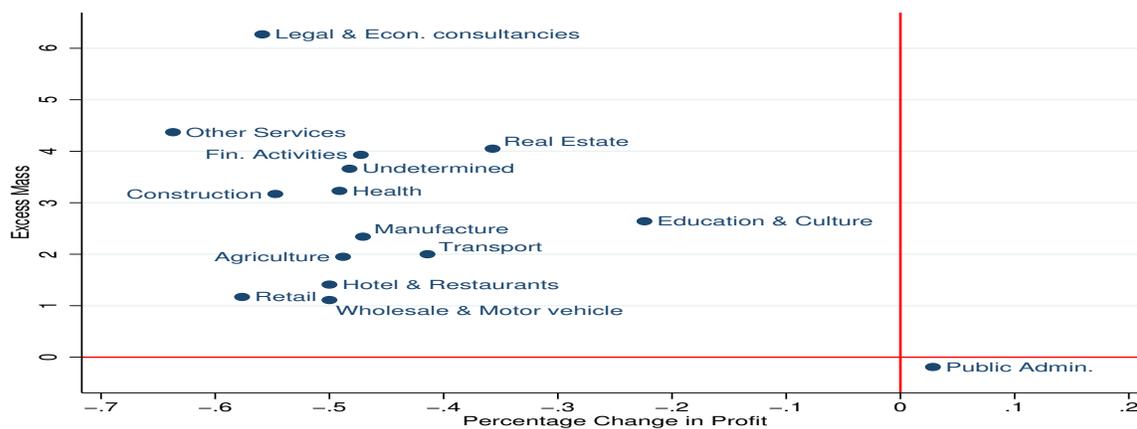


Figure B2 shows the relation between the profit margin discontinuity and the excess mass by industry, at the first threshold.

Figure B3: Industry Results

Within industry density(Blue) & profit margin(Green)

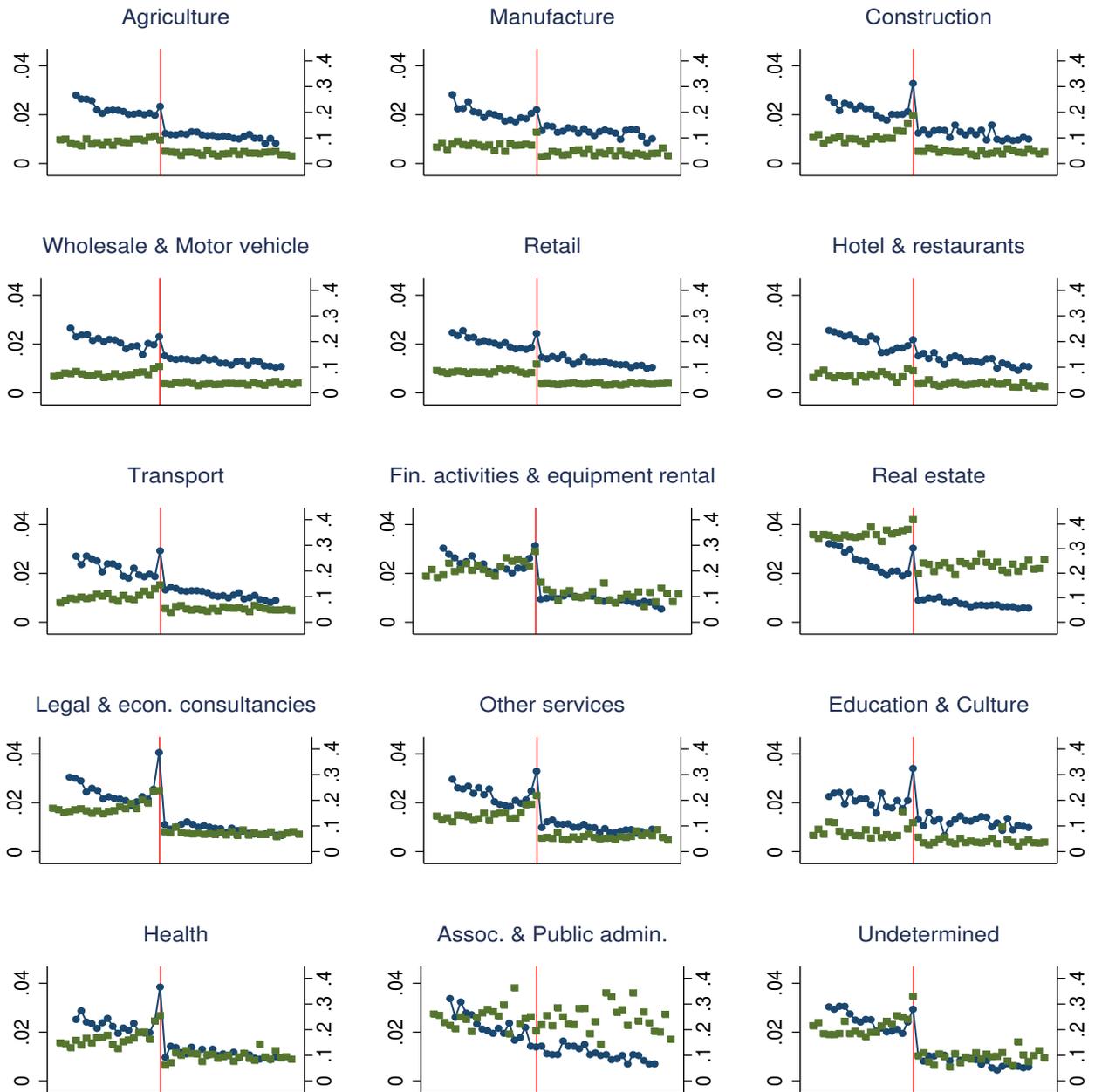


Figure B3 presents the firm density and profit margin by revenue, separating the economy in fifteen industries. In blue, the within industry firm density by revenue and in green the average profit margin by revenue.

Figure B4: Cost Categories Breakdown

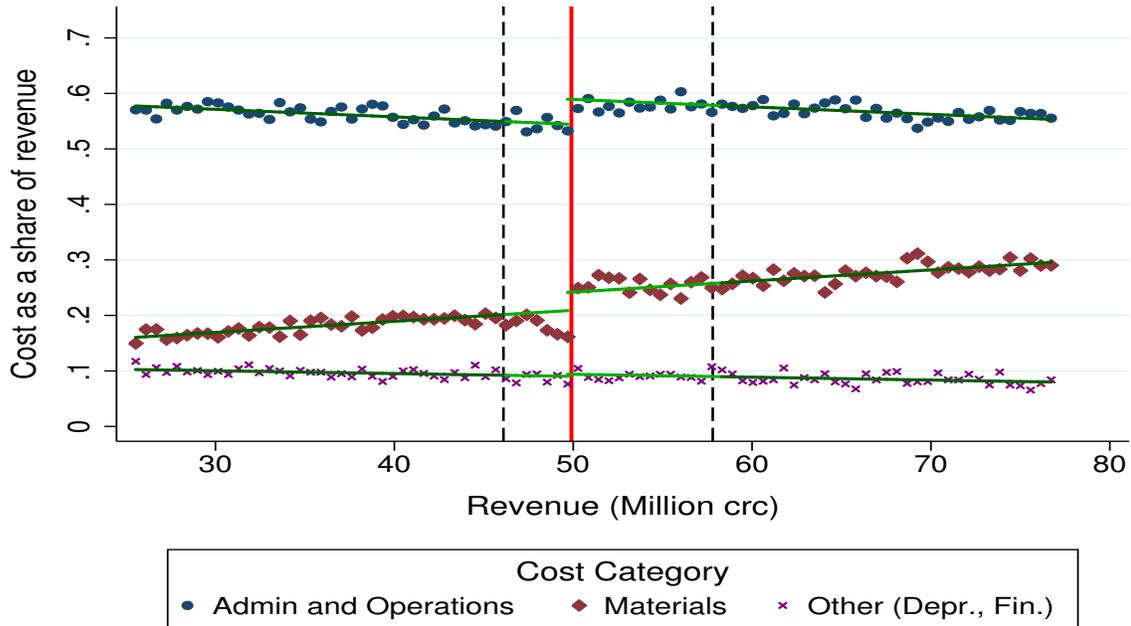
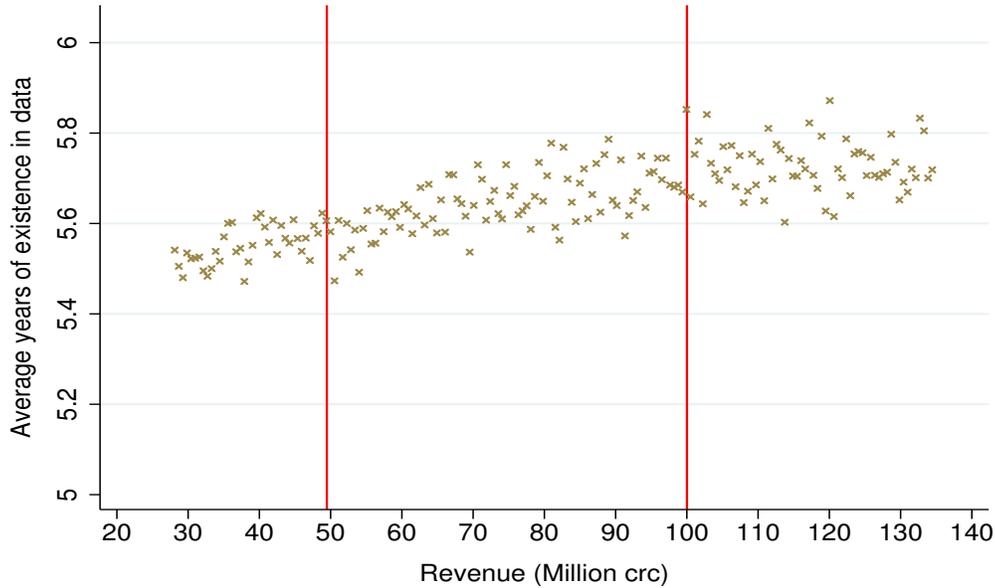


Figure B4 shows the cost discontinuity by revenue, broken down into the three main cost categories reported on the tax returns (“Formulario D101”). Each cost category is displayed as a percentage of revenue. The five categories on the corporate tax returns are: administrative and operational costs, material and production costs, depreciation, interest deductions and other costs and we group the later three categories together.

Figure B5: Number of Years of Existence in Data by Revenue



Note: the Y-axis is the average number of years that a firm filled taxes over 2008–2014

Figure B5 shows the number of years that a firm filled taxes by revenue, over the 2008-2014 period. We do not observe a difference in the propensity to fill taxes for bunchers and dominated firms. It is therefore unlikely that differential information and understanding of the tax system explains the observed behavior.

Figure B6: Yearly Results
 Firm density (Blue) & profit margin (Green)

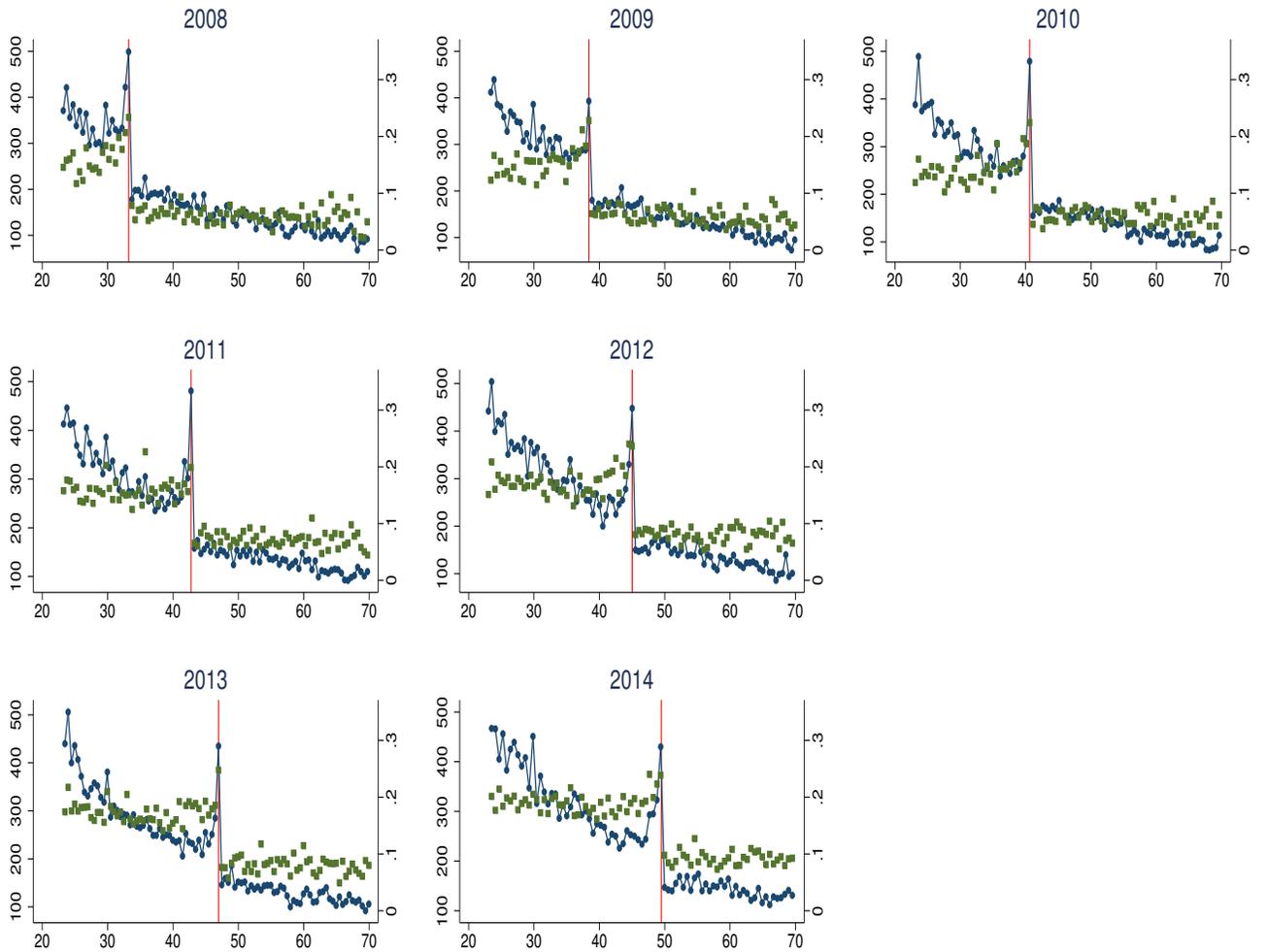


Figure B6 presents the firm density and profit margin by revenue, for each year in 2008 to 2014. In blue, the within industry firm density by revenue and in green the average profit margin by revenue.