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Corporate Taxation: Evasion, Incentives, and the Shadow Economy

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Abstract

In this thesis I examine two elements of firm behavior with respect to taxation: efforts to reduce tax liability, and responses to incentives in the tax code. In the first and second chapters I analyze how the tax and regulatory environment affect firm incentives to engage in tax evasion and avoidance. In the third and fourth, I examine the effectiveness of a tax credit in Portugal intended to stimulate business investment. The thesis advances our knowledge of how firms react to government intervention, with important implications for policy design.

Keywords: Corporate taxation, Tax evasion, Tax Incentives, Investment.

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Contents

Introduction

The efficient design of tax systems presents a constant challenge to governments around the world. They must set tax rates at a level to ensure adequate revenues without discouraging economic activity, and choose enforcement strategies that improve compliance at a reasonable cost. At the same time, governments use the tax system to achieve broader economic goals by providing incentives for certain behavior, such as savings or investment.

This thesis investigates two elements affecting policy design: firms' tax evasion strategies and their response to tax credits. I explore these issues using data from Portugal, a country that provides an interesting case study through measures taken to strengthen the economy and public institutions in response to the downturn of recent years.

In Chapter 1 I examine a tax planning strategy that has until recently been little studied: the mis-reporting of zero profits. I show that the phenomenon is related to the tax environment, using a unique identification strategy exploiting a reform in Portugal that creates an exogenous shock to the cost of tax evasion in certain sectors of economic activity.

A difference-in-differences estimation of the rate of excess bunching at zero profits shows that some firms in targeted sectors reduce their bunching post-reform, providing support for the consensus in the literature that this behavior is related to tax evasion. To further investigate heterogeneous effects, I analyze two subgroups of firms with different alternative options: foreign-owned and micro domestic firms.

Foreign-owned firms have a higher tax-planning capacity and the option of minimizing their global tax bill through profit shifting. I find that the rate of bunching of these firms is higher than the average in treated sectors and decreases more strongly after the reform,

with some indication of a difference in their mis-reporting strategies. Although the number of firms in the sample is small, the results support the findings of other studies that the reporting of zero profits by foreign-owned firms is related to tax evasion and avoidance.

Micro domestic firms, on the other hand, have less capacity to mis-report profits but the additional option of operating on the informal market, where they pay no taxes. These firms have received little attention in the literature on bunching at zero. I find that the rate of bunching for this subset is less affected by the reform, lending support to the hypothesis that the zero profits strategy is less relevant in their tax planning. A higher rate of exit for these firms in treated sectors post-reform suggests that the option of operating informally reduces the incentive to bunch at zero.

In Chapter 2, I provide context for the incentives of these small firms with an examination of the economic literature on the shadow economy. I give an overview of how researchers have approached the problem of studying a phenomenon that cannot be directly observed, and what information this has yielded regarding the nature of the shadow economy and informal firms.

I focus in particular on the relevant results for Portugal. Although the literature lacks a clear consensus on the structural causes or size of the shadow economy, some important elements emerge. First, social systems and labor market dynamics play an important role in determining the size of the shadow economy. A high rate of self-employment appears to be particularly relevant, as in other Southern European countries such as Italy and Greece. Additionally, results from the literature show that the Portuguese shadow economy is sizable and growing, representing 16-39% of GDP.

An important general conclusion from studies of the shadow economy is the contribution of strong public institutions to limiting its size. Where firms have stronger incentives to operate formally, the informal market loses its relative appeal. Chapters 3 and 4 investigate a program in Portugal that provides one such incentive: tax credits for investment. The initiative was part of an ambitious program to promote economic growth and employment, modernize firms, and make them more competitive.

In Chapter 3, I use a dataset of firms' administrative accounting records to test whether the reform led to increased investment and employment. I employ a difference-in-differences estimation based on sectoral and regional variation in eligibility for the tax credit. The results show significant positive effects on investment of the regional targeting, with some indication that firms shifted investment from non-eligible to eligible types.

Further investigation using a more detailed dataset with information on firm take-up, however, shows that the sectoral and regional eligibility are not binding, suggesting that these results were driven by specificities of the small set of control regions rather than a causal effect of the program. In Chapter 4, the enriched data is used in a matching estimation to establish a positive effect of the program on investment, employment, and growth in other key indicators of firm performance. The findings suggest that the program represents an effective type of stimulus that can be applied in other countries.

This thesis contributes important insights for the evaluation of public policy aimed at changing firm behavior. The results for Portugal provide valuable empirical evidence for the effectiveness of programs to reduce tax evasion and stimulate private investment, and highlight trends to be tested in other settings.

Chapter 1

Tax Evasion by Portuguese Firms: A Bunching Analysis

1.1 Introduction

Tax evasion and avoidance by firms have long presented a challenge to governments around the world. Tax authorities seek to to detect and deter mis-reporting, while firms always seem to find new strategies to circumvent them. In this paper, I investigate a phenomenon that has until recently attracted little attention: the mis-reporting of zero profits.

Firms have an incentive to report zero profits to avoid paying taxes while remaining in the formal market, where they can benefit from social security systems and access to credit. Zero is also an important point in most tax schedules just before the marginal tax rate increases by several percentage points. Discontinuities of this magnitude have been shown in the literature on evasion to induce bunching in the distribution of taxable income *(see e.g. Chetty et al. (2011); Saez (2010); Kleven and Waseem (2013))*.

Unlike at other points in the distribution, however, it is difficult to convincingly demonstrate that a high rate of firms reporting zero profits can be attributed to tax evasion. True profit and loss may be such that taxable income is close to zero for many firms, particularly in countries where small firms predominate or where there is a high rate of turnover in firm entry and exit. Firms may also mis-report zero profits for other

reasons, such as inter-temporal shifting of profits across fiscal years to maintain a record of consistent profitability (Burgstahler and Dichev, 1997). Additionally, in perfectly competitive markets profits should converge to zero in the long run.

In this paper I develop a unique identification strategy to isolate the evasion-related component of bunching at zero, using the exogenous variation provided by a reform in Portugal that increased the risk of detection in certain sectors of economic activity. I conduct a difference-in-differences analysis of the rate of bunching at zero before and after the reform, finding a relative decrease for firms in targeted sectors. The result suggests that mis-reporting of zero profits is indeed affected by the tax environment, providing confirmation that firms use this channel to evade.

I further investigate the effects for two subsets of firms to see whether differences in the availability of alternative tax planning strategies change the incentives to evade. I find that the rate of bunching by foreign-owned firms in treated sectors is higher than the average and is strongly affected by the reform, implying that they rely more heavily on this channel. I also test the results for micro domestic firms, which have been largely left out of the literature on bunching at zero. The rate of bunching by these firms is less affected by the reform, which suggests that it is less relevant for them as a channel of evasion. I further show that in treated sectors these micro firms are more likely to exit the formal economy, providing some support for the hypothesis that the option of operating informally reduces the incentive to bunch at zero.

This paper contributes to the literature on the mis-reporting of zero profits as a tax planning strategy, which has until recently been largely neglected – in part because many papers regress a logarithmic transformation of profits on the tax rate, implicitly excluding non-positive profits. Where the phenomenon has been studied, it has focused almost exclusively on the subsidiaries of large multinational corporations, which are subject to intense media scrutiny for their aggressive tax planning but are not the only firms with an incentive to report zero profits.

Johannesen et al. (2016) were among the first to analyze this practice. The authors

construct a dummy variable taking a value of one when firms report zero or near-zero profits, and regress it on the tax rate faced by foreign affiliates, with country-level fixed effects by headquarters location. They also test a specification with additional measures of governance and development. The authors find that a ten percentage point increase in the affiliate-country tax rate increases the likelihood of reporting zero profits by four percentage points in Eastern Europe and 1.5 percentage points in Western Europe. Their approach has the advantage of needing little additional financial information on firms and no parametric assumptions on production or profits. However, it lacks a convincing causal effect, with a lack of differentiation between the tax rate and other institutional factors affecting firm profitability.

Habu (2017) advances the literature on zero-profit reporting with a different approach. The author uses propensity score matching to test for profit shifting, comparing the reporting of zero profits by subsidiaries of multinational corporations with their matched domestic counterparts. Using a panel dataset of tax records, the author finds that 60% of UK-based subsidiaries of MNCs report zero profits in a given year, more than twice the rate among comparable domestic firms. This effect explains a large part of the observed aggregate difference in taxable profits between multinational and domestic firms. The use of propensity score matching allows her to control for some observable drivers of zero-profit reporting – year, total assets, and sector – to isolate the effect of foreign ownership.

Although the analysis demonstrates that foreign-owned firms systematically report zero profits at a higher rate, it lacks support for the hypothesis that tax evasion itself drives this difference. The validity of this approach rests on the strong assumption that the observable characteristics used in the matching fully capture the determinants of zero-profit reporting. Given that the phenomenon has as yet received little attention in the literature, not enough is known about the mechanism for this assumption to be fully credible. Differences in leverage are suggestive of internal debt transfer as a profit shifting mechanism, but explain at most 40% of the difference. Additionally, while the author focuses on various channels used by multinational corporations that could explain the

higher rate of zero-profit reporting, the behavior of domestic firms is not addressed.

The paper of Lediga, Riedel, and Strohmaier (2019) provides evidence that domestic firms also have incentives to report zero profits. Using data on South African firms from 2009 to 2016, the authors find significant bunching at zero profits consistent with an elasticity of taxable income of 0.79-1.22 at that threshold. With the exception of the work of this paper, the literature on bunching at zero has focused on developed economies. As a result, little to no mention is made of the shadow economy as an alternative vehicle for tax evasion. Small domestic firms in many countries, however, operate informally when the tax or regulatory environment makes it more profitable for them to do so.

Waseem (2018) in his paper on firms in Pakistan shows that an increase in the tax rate for certain types of firms induces many firms to exit to informality, providing the first micro-based study of this margin. The reform was implemented retroactively, allowing the author to separate the margin on the real and reporting responses. The response is large: 41% of firms of the targeted type exit in the first year of the reform. The results provide compelling evidence that changes in the tax environment can change the marginal choice of firms to operate in the formal economy.

Domestic firms that are likely to report zero profits, namely those with levels of profit low enough that they can plausibly manipulate their taxable income to that threshold, are also those with the most realistic alternative in the shadow economy. Without accounting for this, measures of profit shifting derived from comparison of zero-profit reporting by multinational and domestic firms are likely to overestimate its magnitude. Although the shadow economy is much smaller in developed than developing economies it is still very much present, accounting for as much as 10-20% percent of GDP on average and 16-39% in Portugal (Schneider and Enste, 2013; World Bank, 2019; Missiou and Psychoyios, 2017; Soares and Afonso, 2019; Schneider, 2016; Dell'Anno, 2007; Bovi, 2003; Schneider, Raczkowski, and Mróz, 2015; Lacko, 1999; Afonso and Goncalves, 2011).

This paper brings together these two strands of the evasion literature – the misreporting of zero profits and exit to the informal economy – with an examination of how

tax enforcement penalties change the incentives for different tax planning strategies. I use data from Portugal, which presents a unique case study of efforts to combat tax evasion and avoidance as a result of the reforms implemented during its economic assistance program from 2011-2014 (European Commission, Directorate-General for Economic and Financial Affairs, 2011). Additionally, Portugal is a small but developed economy characterized by the presence of both an informal economy and foreign investment, allowing for the study of policies aimed at reducing tax evasion both by domestic firms and multinationals engaging in profit shifting. Furthermore, the natural experiment provided by the Portuguese reform allows for identification of a causal effect, providing support both for the efficacy of such enforcement strategies and the prevailing consensus in the literature that bunching at zero profits is related to tax evasion.

The remainder of the paper is organized as follows. I lay out the theoretical framework and identification strategy in Sections 1.2 and 1.3. In section 1.3.1 I present the particularities of the corporate tax system in Portugal, including the natural experiment which I use to test for evasion around zero profits, and I describe the data I use in Section 1.4. Finally, I present my results and conclusions in Sections 1.5 and 1.6.

1.2 Model

To explain firm motivations for bunching at zero I follow the model of Best et al. (2015), where the firm chooses its optimal levels of production and tax evasion. Where Best et al. (2015) examine tax evasion through cost mis-reporting, I model evasion through manipulation of reported revenue, with a convex and differentiable cost of mis-reporting that depends on the magnitude of the difference between actual and reported revenue.[1] This cost is assumed to be monetary and non-tax deductible. Such mis-reporting can be conducted through tax evasion – reduction of the tax bill through illegal means – or tax avoidance, where firms take advantage of features of the tax code to legally reduce their

[1]The results of Best et al. (2015) are equivalent across both channels of evasion. I therefore choose revenue mis-reporting as a more realistic representation of the reform tested in the empirical application.

tax liability.

I extend the model by incorporating two additional tax planning strategies: misreporting zero profits, and operating informally. I define the informal market or shadow economy as that part of legal economic activity that is mis- or under-reported by firms in an illegal way, leading to a corresponding reduction in tax revenue from what the government would expect to collect with perfect compliance.

When a firm i exists entirely in the shadow economy, I say that it is a *ghost*, after the terminology used for example by Cowell and Gordon (1995). Its after-tax profit in a given year is given by:

$$\tilde{\Pi}_i^s(y) = R(y) - \alpha_i C(y) - \beta_s \tag{1.1}$$

where y is the output level. $R(y)$ is total revenue as a linear function of price and output, assuming for simplicity that market conditions are the same and therefore all firms face the same price.[2] $C(y)$ represents total costs, which are strictly convex and differentiable. The fixed cost of underground business activity is sector-specific, and measured by β_s. This allows for the fact that operating without detection by tax authorities is much easier for firms in some sectors, such as household services, than in others, such as banking. I assume that only domestic firms operate as ghosts.[3]

Each firm also has a cost penalty given by α_i. If $\alpha_i = 1$, the firm faces the baseline market cost of production for all firms. As α_i increases above one, i.e. as the firm becomes less efficient, the impact of costs on the profit function increases and profit declines. The firm chooses the level of activity that maximizes equation 1.1, which satisfies:

$$\frac{R'(y_i^*)}{C'(y_i^*)} = \alpha_i \tag{1.2}$$

Since $\alpha_i \in [1, \infty]$, in equilibrium when the cost penalty α_i increases, firms produce less.

[2] $R(y_i) = py_i$

[3] Although firms with cross-border activities can also choose not to register their subsidiaries in a given country, this type of informal activity is much different than that of self-employed individuals or small businesses operating in the shadow economy as ghosts.

Each firm also faces a fixed cost k of entry into the market, which I assume has been paid in a previous year and therefore enters into neither the firm's production or evasion decision in equation 1.1. This accounts for the possibility that a firm's annual profit may be negative in a given year, but it will continue to operate so as not to lose its investment in k with the expectation that it will return to profitability in a future period, as in Dixit (1989). It also implies that a firm operating in the formal market will prefer to shift to the shadow economy than go out of business if it has that option.

A firm i can also choose to report some activity in the formal sector. I call such a firm an *iceberg* after the work of Keen (2012), with after-tax profit given by

$$\Pi_i^s(y, e) = R(y) - \alpha_i C(y) - \eta_s \gamma_j g(e) - \tau[R(y) - \mu\alpha_i C(y) - e] \tag{1.3}$$

where τ is the tax rate. Each firm chooses some amount e of its revenue to under-report to the tax authorities, with an associated increasing and convex cost of mis-reporting given by $g(e)$. This type of cost could include hiring extra accountants and lawyers, managing two sets of books, and dealing in cash transactions rather than going through a bank. It is also associated with the probability of being caught, with the firm facing a penalty if mis-reporting is detected.

The parameter η_s captures the difference in the cost of tax evasion in the formal market from one sector to another. For example, businesses with large amounts of small cash transactions, such as corner grocery stores or small cafes, will find it easier to hide transactions from the tax authorities than those in other sectors.

The cost of mis-reporting is scaled by γ_j, which depends on whether the firm is domestic, d, or an affiliate of a multinational, m, with $\gamma_m = \upsilon\gamma_d$, $[0 < \upsilon < 1]$, so that $\gamma_m < \gamma_d$. This reflects the relative ease of evasion in the formal and informal markets. While domestic firms have more familiarity with the tax environment and reality of the underground economy in a given country, they do not have the option of shifting profits between tax jurisdictions to take advantage of differential tax rates, as multinational firms do. Firms with a presence in more than one location are also more likely to be aggressive tax planners,

giving them a greater capacity to use features of the tax code to reduce their taxable profits.

As in Best et al. (2015), I also allow a share $\mu \leqslant 1$ of the firm's reported costs to be tax deductible. To simplify the analysis, I set $\mu = 1$ throughout, representing the case of full cost deductibility.[4]

Iceberg firms may report zero profits or positive profits, depending on which yields the highest net-of-tax return.[5] Firms falsely reporting zero profits, which I call *bunchers*, engage in special case of iceberg evasion where they mis-report the entirety of their income. For both, the production decision is the same as that of ghosts, so lower-cost firms will produce more *(see equation 1.2)*.

The *iceberg* optimally chooses e and y so as to maximize equation 1.3. When $\mu = 1$, the optimal evasion and activity levels satisfy:

$$\begin{aligned} \frac{R'(y_i^*)}{C'(y_i^*)} &= \alpha_i \\ g'(e_i^*) &= \frac{\tau}{\eta_s \gamma_j} \\ where\ j &= m, d \end{aligned} \tag{1.4}$$

The optimal mis-reporting for *iceberg* firms results from a trade-off between mis-reporting costs and the tax rate. As seen in equation 1.4, evasion decreases with γ_j and η_s, hence it is lower for domestic firms ($\gamma_m < \gamma_d$) and for firms in sectors with a high cost of formal-market evasion. It also increases with the tax rate τ, implying that firms will mis-report to a greater extent when taxes are higher.

The final tax planning strategy is that of *bunchers*, who choose a level of evasion $\hat{e}$ such that reported profits equal zero:

[4] This is reasonable for the empirical application, as firms in Portugal are generally allowed to deduct all business-related expenses.

[5] *Iceberg* firms can also earn negative profits. However, the risk of audit is higher for firms reporting negative profits and therefore the associated cost of evasion will be higher, as for example in Saez (2010). This implies that a firm will only report negative profits if it actually earns negative profits, and will never choose e such that it reports negative profits when its profits are actually positive.

$$\begin{aligned} & R(y_i^*) - \mu\alpha_i C(y_i^*) - \hat{e} = 0 \\ & \hat{e} = R(y_i^*) - \mu\alpha_i C(y_i^*) \\ & \frac{d(\widehat{e})}{d(\alpha)} < 0 \end{aligned} \tag{1.5}$$

with y_i^* given by equation 1.2.

Because *bunchers* mis-report the totality of their profit, the associated cost of formal-market evasion will always be higher for *bunchers* than *icebergs* at a given α_i:

$$\begin{aligned} & \widehat{e} = R(y_i^*) - \alpha_i C(y_i^*) \\ & e_i^* < R(y_i^*) - \alpha_i C(y_i^*) \\ & g(\widehat{e}) > g(e_i^*) \end{aligned} \tag{1.6}$$

Respective after-tax profits for the three types of firm are given by:

- *Ghosts:* $\pi_g = R(y_i^*) - \alpha_i C(y_i^*) - \beta_s$
- *Bunchers:* $\pi_z = R(y_i^*) - \alpha_i C(y_i^*) - \eta_s \gamma_j g(\widehat{e})$
- *Icebergs:* $\pi_p = R(y_i^*) - \alpha_i C(y_i^*) - \eta_s \gamma_j g(e_i^*) - \tau[R(y_i^*) - \alpha_i C(y_i^*) - e_i^*)]$

Domestic firms will choose between the three options based on which yields the highest after-tax profits, given the relative costs of formal and informal evasion in the sector. Foreign-owned firms will choose only between acting as *bunchers* and *icebergs*. The results follow those for example of Virmani (1989) for small firms in the distribution of firms across the spectrum of evasion channels.

A domestic firm in a given sector will choose to operate in the formal market and mis-report some level of its profits rather than conducting all activity in the informal market when the expected return is strictly higher. This depends on the relative costs η_s of mis-reporting and β_s of operating informally. For *icebergs*, it will also depend on the tax rate.

A domestic firm will operate in the formal market rather than as a *ghost* when it expects to earn higher profits by doing so, i.e. when the cost η_s of mis-reporting is less than the fixed cost β_s of moving to the informal sector. The level of evasion represented by the special case of bunching at zero is given by $e_i^* = \widehat{e}$. Because a *buncher* is always evading its full pre-tax profit, the associated cost of formal market evasion will always be higher than for an *iceberg*, and it will therefore always be closer to the margin of choosing to evade as a *ghost*. The firm will choose this level of evasion where $\hat{e} = R(y_i^*) - \alpha_i C(y_i^*)$ rather than moving directly to the informal market when the associated cost is strictly less than the fixed cost of being a *ghost*:

$$\eta_s \gamma_d g(\widehat{e}) < \beta_s \tag{1.7}$$

Within a given sector, lower-cost firms will earn higher profits from operating in the informal market as *ghosts*, while higher-cost firms gain more from operating in the formal market. Intuitively, this follows from the fact that high-cost firms benefit more from being able to deduct their costs from their total tax bill, making it relatively more advantageous for them to report some positive taxable profit.

The choice between evading as a *buncher* or an *iceberg* depends also on the multinational status of the firm, which affects its cost of mis-reporting. A foreign-owned firm of a given α_i producing y_i^* will always face a lower cost of mis-reporting e^*i than a domestic firm in the same sector, because it has a greater capacity for tax planning and the additional option of profit shifting:

$$\eta_s \gamma_m g(e_i^*) < \eta_s \gamma_d g(e_i^*) \tag{1.8}$$

This implies that there will always be fewer domestic than foreign-owned *icebergs* in a

given sector.[6] Since the cost of evading all profit as a *buncher* represents the case where the cost of evasion is highest, there will also always be fewer domestic than foreign-owned *bunchers*, where the remaining domestic firms evade by operating informally.

In summary, the main results of the model for domestic firms are that within a given sector the lowest-cost firms will be *ghosts* and the highest-cost *icebergs*, with *bunchers* in between. Each firm chooses its tax planning strategy based on the tradeoff between the cost η_s of mis-reporting profits in the formal market, the tax rate τ, and the cost β_s of operating informally. High-cost foreign firms will operate as *icebergs* and low-cost as *bunchers*, depending on η_s and τ. There will always be more foreign-owned than domestic *icebergs* and *bunchers* in a given sector, while only domestic firms will operate as *ghosts*.

1.2.1 Exogenous shock to the cost of evasion in the formal market

An increase in the cost η_s of mis-reporting will affect both *icebergs* and *bunchers*. When firm efficiency α, the tax rate τ, and cost of evasion in the informal sector β_s remain unchanged, we can differentiate the firm's response according to its foreign ownership status, which determines the relative costs of reducing its tax burden through different tax planning strategies.

Marginal domestic *bunchers* will respond to the increase in η by either moving to the informal market - i.e., becoming *ghosts* - or beginning to report positive profits as *icebergs*. The lowest-cost *bunchers* will become *ghosts*, while the highest-cost *bunchers* will become *icebergs*. Multinational *bunchers*, on the other hand, will only become *icebergs* – i.e., stop reporting zero profits.

Domestic firms' decision comes from the tradeoff between η_s and β_s, i.e. the relative costs of evasion in the formal and informal market. When firms are forced to report more transactions to the tax authorities, it may become unprofitable for them to operate in the formal market at all, and they will prefer to pay the fixed cost of moving to the informal market. The overall impact on measured bunching at zero will be ambiguous, as some

[6] I assume that both foreign-owned and domestic firms are normally distributed in α within a sector.

firms respond by increasing their reported taxable profits while others drop out of the formal market completely.

For a foreign-owned firm, the increased risk of detection makes it relatively more difficult to mis-report sales in the country where the cost of evasion increases vis à vis the country of its headquarters or other affiliates. Zero-bunching will decrease as foreign-owned firms report more profits in the country of the shock. This may increase their reported worldwide profits, or they may compensate by shifting reported profits between other affiliate or headquarter countries.

The effect on observed bunching at zero for all firms will depend on the tradeoff between the two channels of the response: more non-zero profits reported by both domestic and foreign-owned firms that were previously bunching at zero, and fewer domestic firms present in the distribution of firms in the formal market.

1.3 Identification Strategy

To test the predictions of the model, I develop an identification strategy based on a reform passed in Portugal in 2012 to reduce tax evasion in certain sectors of economic activity, introducing just such a shock to the cost of evasion η_s. According to the results of the model, we should see a decrease in bunching at zero for all firms, and an increase in informality for domestic firms. We can observe the decrease for foreign-owned firms, but will only observe a part of the response of domestic firms because we cannot directly measure the exit to informality.

To isolate a causal impact of the reform that corresponds to the predictions of the model, I measure the rate of excess bunching at zero profits by firms and compare the estimates across targeted sectors in a difference-in-differences analysis. Bunching analysis is used to obtain a non-parametric estimator of the difference between the distribution of firms' actual reported income and what they would have reported in the absence of any discontinuity in the tax schedule. I follow the approach of Emanuel Saez (2010) in his examination of bunching at zero of personal taxable income in the United States, with

subsequent refinements of the bunching technique developed by Chetty et al. (2011) and Kleven and Waseem (2013).

Where corporate tax rates are uniform and firms vary continuously along a given characteristic such as profitability, we expect firms to locate smoothly along the distribution of taxable income. The existence of discontinuities in the corporate tax schedule, however, changes the incentives for firms' profit reporting. There are two types of discontinuities: kinks, where the marginal tax rate applied to the first dollar above the discontinuity changes; and notches, where the average tax rate applied to all income changes. In both cases, firms with profits above but close to the threshold have an incentive to reduce their reported income to just below to reduce their tax liability, with a stronger incentive for notches than for kinks. By testing for an excess mass of firms around the discontinuity, we obtain an estimate of the share of firms changing their behavior.

In the case of the kink at zero in Portugal, the tax rate for most Portuguese firms jumps from zero to 25% *(see section A in Appendix A for more details on corporate taxation in Portugal).*[7] To avoid facing a positive tax rate, some firms can be expected to falsely report their profits as zero, acting as *bunchers*.

Such mis-reporting is not without risk, however. Firms for example face costs associated with hiring extra accountants and lawyers, managing two sets of books, or dealing in cash transactions rather than going through a bank. Another type of cost is associated with the risk of an audit, as for example in Almunia and Lopez-Rodriguez (2012). Because of these costs, not all firms will bunch at zero.

The share B of active firms whose profits are maximized by falsely reporting zero profits can be estimated through $\int_{K}^{K+\Delta z} h(z)dz$, where K is the point of discontinuity in the income distribution where the tax rate changes from τ_1 to τ_2. In the case of zero profits, both K and τ_1 are equal to zero. The density distribution of reported firm profits in the absence of any discontinuity in the tax rate is represented by $h(z)$, the case where all firms face τ_1 regardless of reported income. $K + \Delta z$ represents the highest point along

[7]Some Portuguese firms are subject to a "special payment on account" assessed on the minimum of one percent of their previous year's turnover and equal to at least €850. Inspection of the distribution at this threshold shows no visible bunching.

the income distribution where firms chooses to move below K to avoid facing the higher tax rate τ_2.

To estimate the counterfactual distribution of firm taxable income, a flexible polynomial is fitted to the observed empirical distribution, with firms grouped into j bins by their reported pre-tax net profits:

$$c_j = \sum_{i=0}^{p} \beta_i (y_j)^i + \sum_{i=y_L}^{y_U} \gamma_i \mathbf{1}[y_j = i] + \nu_j \tag{1.9}$$

where c_j is the number of firms in bin j, p is the order of the polynomial, and y_j is the upper limit of the profits in bin j. To accurately construct the counterfactual, the contribution of firms around K must be excluded, setting a lower limit of y_U and an upper limit of y_L on the excluded range. This ensures that the counterfactual distribution reflects the profits of firms around the threshold as they would behave if the tax rate remained the same above and below–effectively, if the tax rate were τ_1 for all firms.

The counterfactual distribution on the intensive margin is therefore obtained by estimating the regression with only the included firms:

$$\widehat{c_j} = \sum_{i=0}^{p} \beta_i (y_j)^i \tag{1.10}$$

The resulting parameter $b(\tau_1, \tau_2)$ represents the excess mass of firms in the distribution located below the kink point K, given as the fraction of firms below the kink relative to the density in the counterfactual situation of a constant tax rate τ_1 throughout the entire distribution, i.e. the share of *bunchers* among active firms.

There may of course be a higher mass of firms at zero profits for reasons other than tax evasion. For example, firms in their first year of activity may not have activity to report, or may still be mastering the complexities of the reporting process. It is therefore particularly important for bunching analysis at zero to exclude these types of firms, where reporting of zero profits is more likely reflect the adjustment process to starting up a business or errors in reporting than for more established firms.

I further distinguish the bunching analysis between two subgroups with different alternatives for tax planning: foreign-owned and micro domestic firms. The cost of bunching at zero is lowest for foreign-owned firms, whose headquarters can use profit shifting to manipulate their global tax bills. We expect that these firms will bunch more at zero pre-reform, and that the drop post-reform will be greater as they are forced to report more sales in Portugal.

I examine small domestic firms to test for the presence of *ghosts*, using the EU definition of micro businesses: firms with less than ten employees and either annual turnover or balance sheet total less than or equal to €2 million *(see section 2.4 in Chapter 2 for more detail on the selection of micro domestic firms)*. While it is relatively more difficult for these small firms to bunch at zero than for foreign-owned firms, they have the additional option of operating informally. We expect that they will bunch less at zero pre-reform, and that the rate of bunching will be less impacted by the reform – in part because the evasion strategy is less relevant to them and in part because some firms exit to the informal sector, affecting the underlying distribution.

To test for these extensive margin effects, I complement the difference-in-differences with a survival analysis comparing the probability of exit for micro domestic firms before and after the reform and across sectoral treatment. Survival analysis is used to track outcomes where the period of observation ends before all individuals have experienced the event of interest, in this case a firm ceasing operation in the formal market. The technique accounts for the fact that the probability of survival in a given period is conditional on the proportion of firms surviving in all previous periods, while correcting for the skew in the underlying distribution coming from firms exiting before the end of the observation period. If firms exit to informality as predicted by the model, we will see a higher rate of exit in treated sectors post-reform.

1.3.1 Natural Experiment: Shock to Evasion Costs in Portugal

The sectoral treatment is defined according to a law passed in Portugal in August 2012. The reform establishes incentives for consumers to ask for receipts associated with their individual taxpayer identification number for transactions in sectors particularly prone to tax evasion:

- Automotive vehicle maintenance and repair
- Maintenance and repair of motorcycles and motorcycle parts
- Lodging, restaurants, and similar businesses
- Hair salons and beauty institutes

When individuals fill out their personal income tax returns, they can see a list of the transactions which were reported by businesses with their taxpayer identification number. If there are any transactions missing, consumers can flag them to the tax authorities.

The law, which went into effect at the beginning of 2013, allows consumers to deduct from their personal tax bill 15% of the VAT paid in these transactions, up to €250 per household member. Starting in 2014, consumers could also enter a lottery to win a car with their eligible receipts. By doing so, the government effectively increased the risk of detection for firms, with the goal of decreasing mis-reporting of business-to-consumer transations and increasing overall VAT collection.

Fiscal receipts provide an official record of transactions for tax authorities. However, consumers have little incentive to ask for such receipts and often dispose of them immediately, and businesses seeking to evade taxes have a high incentive not to issue them. Programs such as the one implemented in Portugal seek to give fiscal receipts some value to consumers, creating a conflict of interest between the consumer and the seller that it riskier and more costly for firms to evade taxes (Kofman and Lawarree, 1996).

The campaign was heavily publicized in Portugal. The first draw for the lottery included receipts from more than 200 million transactions, and drew 600,000 viewers to the

television broadcast. It also had an immediate impact on the number of receipts issued in targeted sectors — a 40% increase in the first year alone (Fooken, Hemmelgarn, Herrmann, et al., 2015).

This policy, with high visibility and takeup rates, provided an exogenous shock to the cost of evasion by increasing the probability of detection of under-reported revenue, corresponding in the model to an increase in η_s. I use this as a natural experiment to test the predictions of the model regarding the effects of an increase in the cost of tax evasion on bunching at zero, allowing me to identify the tax-evasion component of the phenomenon. Assuming that other determinants of bunching at zero remained unchanged or changed to the same extent for firms in targeted and non-targeted sectors, the difference in the magnitude of bunching at zero before and after the reform can be attributed to the change in evasion costs.

1.4 Data

I use data from the administrative accounting records of Portuguese firms covering the period 2010-2015.[8] Firms are required to submit these records annually to the financial authorities.

I first test the results using firms' pre-tax net profits as reported in their annual accounts. This variable reflects evasion through the type of sales mis-reporting targeted by the law. As an additional check for the use of alternative channels of mis-reporting, I also construct an approximation of taxable income using the approach of Graham and Kim (2009), who use this method for firms in the United States. The authors test the validity of this specification using information from firms' actual tax returns, finding that the constructed variable yields the same results. This approach is similar to that used by Chetty (2012) for Denmark, and Gruber and Saez (2002) for the US to simulate personal taxable income from administrative datasets.

[8]The dataset is available from 2006. I use information from years prior to 2010 to calculate the age of the firm.

Table 1.1: Number of firms by category and year

	2010	2011	2012	2013	2014
Total	334721	330691	326910	323836	329174
Treated Sector	13902	15222	12994	11250	9974
Foreign-Owned	221	257	258	317	327
Micro Domestic	10405	12065	10688	9653	8841

Note: Totals are restricted to matched firms used in the bunching estimations.

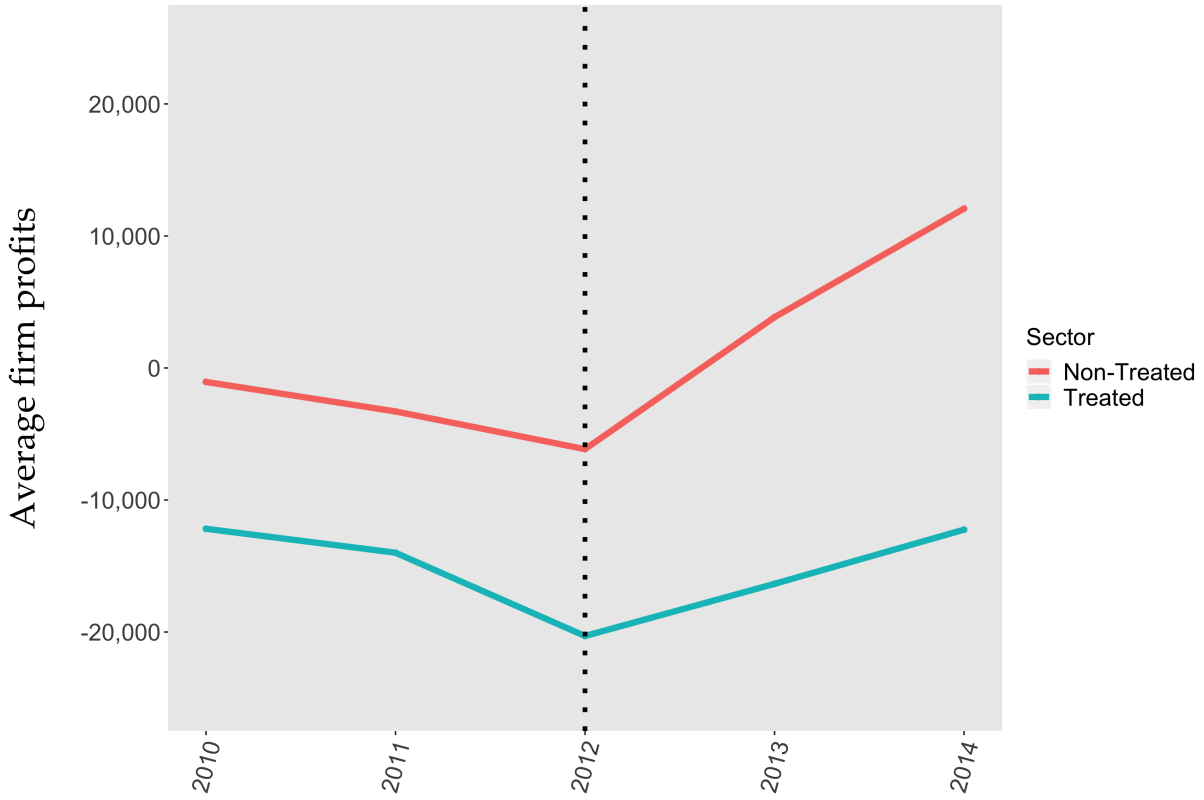
To construct this variable, I begin with firms' pre-tax profits minus losses. I then add interest and similar earnings, supplemental earnings, earnings from royalties, other unspecified earnings, and deferred tax liabilities. From this total, I subtract interest paid and similar losses and deferred tax credits. This follows as closely as possible the formula used by the Portuguese tax authority to calculate income assessed for corporate tax *(see Figure A.1 in appendix A)*. I am able to capture most parts of the calculation with the available data, although I do not have information on tax credits and deductions claimed by the firm during the current period. I use the variable as a robustness check for the results using pre-tax profits. Where the results using the two variables differ, it signals a difference in the channels through which firms manipulate their profits to bunch at zero.

I classify each firm as foreign-owned or domestic using the variable describing the country of ultimate ownership, where a firm reporting any country other than Portugal is defined as a subsidiary of a multinational firm. The estimates for foreign-owned firms therefore reflect the behavior of the overseas owners of an international conglomerate in conjunction with their Portuguese subsidiaries. Table 1.1 shows the number of firms by category and year.

The validity of both the difference-in-differences and survival analysis rest on the assumption that unobserved differences between the treatment and control groups remain stable over time. As an indication of whether this assumption holds, I graphically examine the trends in pre-tax profits and taxable income of firms in treated and non-treated sectors *(see Figure 1.1, and figures A.2 and A.3 in Appendix A for foreign-owned and domestic firms)*. It appears that the trends across treatment were decreasing and generally comparable before the reform, although the average profits of firms in treated sectors had

a slightly sharper downturn in the year before. The trends were the same when plotted for taxable income *(not shown)*.

Figure 1.1: Common Trends in Average Pre-tax Profits: Control and Treated Firms



Note: Blue line represents firms in sectors targeted by the reform.

One weakness in the identification strategy is the non-random selection of firms into treatment. The sectors targeted by the reform are among those most prone to tax evasion, and firms may have chose to operate in these sectors specifically because of the greater ease of mis-reporting. This would imply that they differ from the control group in one important unobservable characteristic, namely the tendency to evade.

Although I cannot control for this selection bias, I do seek to bolster the comparability of the results by restricting the control group in non-treated sectors through nearest-neighbor matching on key characteristics of firm performance: leverage, return on assets, ratio of cashflow to assets, ratio of cash to assets, ratio of PPE to assets, the number of employees, and firm age. Tests for the quality of the match are presented in tables

1.2, 1.3, and 1.4, and show that the two groups are generally well-matched in observable characteristics.

Table 1.2: Summary Statistics: Control Variables by Sectoral Treatment Status (2010)

	Control	Treated	Difference	Unit
Employees	4.40	4.46	-0.06	*nr.*
Age	3.16	3.13	0.03	*yrs.*
Assets	11.49	10.92	0.57***	*log*
Leverage	1.33	1.54	-0.22	*ratio*
Cashflow/assets	-1.20	-1.52	0.32	*ratio*
Cash/assets	0.17	0.16	0.01	*ratio*
PPE/assets	0.40	0.43	-0.03 ***	*ratio*
ROA	-1.11	-1.40	0.29	*ratio*
Profit	.41	-12.5	12.9 ***	*1,000 euro*
Taxable Income	10.1	-9.1	19.2 ***	*1,000 euro*
N	11373	13902	25275	

Note: Totals are restricted to firms used in the bunching analysis, i.e. those matched across sectoral treatment status. Matching with replacement is allowed. Leverage is measured as the ratio of debt to assets, and ROA as the ratio of EBITA to assets.
*** p<0.01, ** p<0.05, * p<0.1

Firms in treated sectors are small on average, with less than five employees in 2010 *(see Table 1.2)*. They report negative income as measured by both pre-tax net profits and constructed taxable income, significantly lower than that reported by the control group in non-treated sectors. They are well matched on age, leverage, the ratio of cash and cashflow to assets, and return on assets. They are slightly smaller than control firms as measured by the log of assets, but have a slightly higher ratio of PPE to assets.

Foreign-owned firms in treated sectors are much larger than other firms with nearly 100 employees on average, highlighting the importance of finding comparable firms in non-treated sectors *(see Table 1.3)*. They are well-matched to the selection of matched non-treated firms on all variables, although they have a slightly higher ratio of PPE to assets. They report higher pre-tax profits and taxable income than the matched firms in non-treated sectors.

Finally, micro domestic firms represent the majority of firms in treated sectors – 91%. They report lower profits and taxable income than those in non-treated sectors *(see Table 1.4)*. They have higher employment and lower assets, but a higher ratio of PPE to assets.

Table 1.3: Summary Statistics: Control Variables for Foreign-Owned Firms by Sectoral Treatment Status (2010)

	Control	Treated	Difference	Unit
Employees	108.00	99.70	8.3	*nr.*
Age	3.44	3.09	0.36	*yrs.*
Assets	14.69	14.51	0.18	*log*
Leverage	0.33	0.46	-0.12	*ratio*
Cashflow/assets	0.01	-0.10	0.11	*ratio*
Cash/assets	0.12	0.11	0.02	*ratio*
PPE/assets	0.42	0.52	-0.1 **	*ratio*
ROA	0.05	-0.06	0.11	*ratio*
Profit	587.7	121.8	466.0	*1,000 euro*
Taxable Income	1264.5	280.5	984.0	*1,000 euro*
N	111	140	251	

Note: Totals for firms in non-treated sectors are restricted to those matched to firms in treated sectors. Matching with replacement is allowed. Leverage is measured as the ratio of debt to assets, and ROA as the ratio of EBITA to assets.
*** p<0.01, ** p<0.05, * p<0.1

Table 1.4: Summary Statistics: Control Variables for Micro Domestic Firms by Sectoral Treatment Status (2010)

	Control	Treated	Difference	Unit
Employees	2.76	2.94	-0.18 ***	*nr.*
Age	3.13	3.10	0.03	*yrs.*
Assets	11.31	10.75	0.56 ***	*log*
Leverage	1.43	1.65	-0.22	*ratio*
Cashflow/assets	-1.29	-1.65	0.35	*ratio*
Cash/assets	0.17	0.16	0.01	*ratio*
PPE/assets	0.40	0.43	-0.03 ***	*ratio*
ROA	-1.20	-1.52	0.32	*ratio*
Profit	-3.1	-8.8	5.6 ***	*1,000 euro*
Taxable Income	.76	-5.3	6.1 ***	*1,000 euro*
N	10405	12786	23191	

Note: Firms are matched with replacement across sectoral treatment status. Leverage is measured as the ratio of debt to assets, and ROA as the ratio of EBITA to assets.
*** p<0.01, ** p<0.05, * p<0.1

1.5 Results

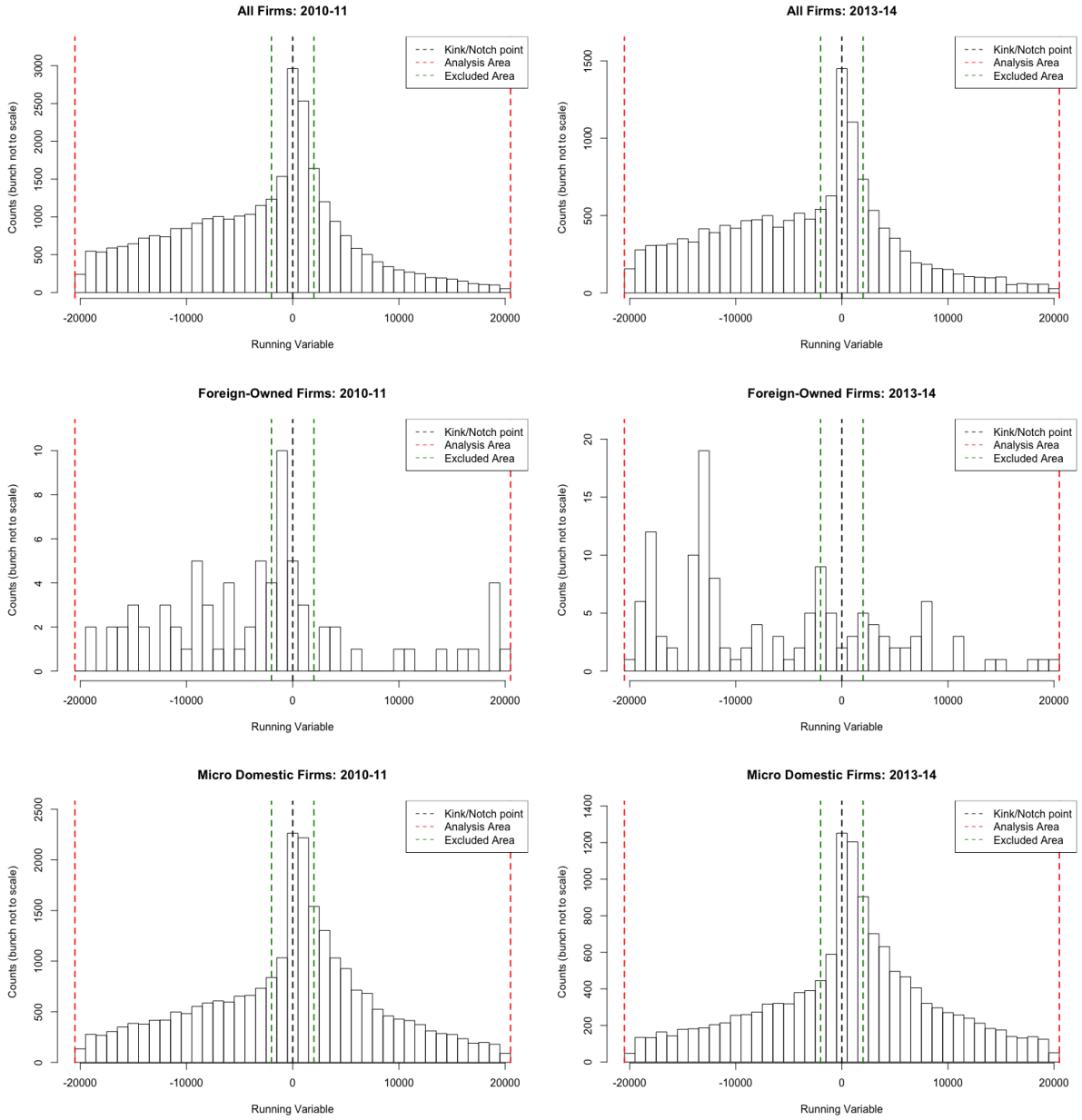
I find statistically significant bunching at zero for all firms in all time periods, using both the net profit and taxable income measures.[9] The results are reported below in tables 1.5, 1.6, and 1.7, with bunching mass defined as the height of the empirical distribution proportional to the estimated counterfactual. The pre and post-reform differences are reported as the percentage change in bunching mass, and the difference in differences for firms in treated and non-treated sectors as the difference in percentage points. Figure 1.2 graphically shows the pre- and post-reform bunching in pre-tax net profits for firms in treated sectors.

The results for net profits are in line with the predictions of the model and suggest that the reform decreased tax evasion through bunching at zero. We see 2.3-2.53 times more firms reporting zero pre-tax profits than we would expect under the counterfactual scenario. The rate of bunching decreases by 2.23% in treated sectors after the reform, compared with a 2.7% increase in non-treated sectors, with an average differential of five percentage points between the two differences. The decrease is small but statistically significant, suggesting that the reform decreased bunching at zero in these sectors. The rate of bunching is much lower than the 11.98 obtained by Lediga, Riedel, and Strohmaier (2019) for domestic South African firms, suggesting this strategy may be less relevant for firms in Portugal.

Comparison of the results with those for taxable income suggest that mis-reporting of sales or costs plays a bigger role in tax-related bunching at zero for most firms than manipulation of other items in the tax report, although it is difficult to draw conclusions from this evidence alone. For the universe of firms in treated sectors and their matched counterparts, the rate of bunching is similar when measured by pre-tax profits and taxable income. However, there is no significant change in the bunching rate in taxable income for treated sectors when compared to non-treated sectors. This suggests that firms bunching in taxable income use deductions and other items in the tax bill to manipulate their

[9]Bunching estimates are obtained using the R package *bunchr* (Trilnick, 2017).

Figure 1.2: Bunching at Zero in Treated Sectors, Pre and Post Reform (Pre-Tax Profits)



Note: Bunching in pre-tax profits of firms in treated sectors, pre and post-reform. The decrease for foreign-owned firms is visible, while the changes for all firms and micro domestic firms are much smaller.

Table 1.5: Bunching Results: Sectoral Treatment

Treated sectors	Pre-tax net profit	Taxable Income
Pre	2.53***	2.61***
	(0.002)	(0.002)
Post	2.47***	2.25***
	(0.003)	(0.005)
Difference	-2.23%***	-13.6%***
	(0.000)	(0.000)
Non-treated sectors		
Pre	2.3***	2.36***
	(0.004)	(0)
Post	2.36***	2.05***
	(0.005)	(0)
Difference	2.7%***	-13.4%***
	(0.001)	(0)
Difference in differences *(pp)*	5***	0***
	(0.001)	(0.001)

Note: Bunching is estimated as the excess density of firms in the empirical distribution reporting zero profits relative to the counterfactual. Firms are excluded from the analysis in the year of their creation when the likelihood of reporting zero profits for non-tax related reasons is higher. Firms are also excluded if they report no employees, and either no sales or no assets. Estimates for non-treated sectors are restricted to firms matched to treated firms through nearest neighbor matching on return on assets, leverage, ratio of cashflow to assets, ratio of cash to assets, ratio of employees to assets, number of employees, and age in 2010. Binwidth is 1,000 euros. Means and standard errors are obtained through bootstrapping.
*** p<0.01, ** p<0.05, * p<0.1

taxable income to zero, while those bunching in pre-tax profits are only able to mis-report sales or costs, where mis-reported sales are more likely to be detected post-reform.

1.5.1 Foreign-owned Firms

Both the initial rate of bunching and the post-reform decrease for foreign-owned firms is much higher. The initial bunching rate of 5.33 drops by almost half post-reform in treated sectors, compared to a 14% increase in non-treated sectors. The magnitude of the differences should be treated with caution, however, as there are very few firms in the sample – the corresponding estimate of the excess number of firms bunching at zero in treated sectors drops from 46 pre-reform to 2 post-reform, and in non-treated sectors from 11 to 10.

The results for taxable income are very different, although the reason why is unclear. The rate of bunching pre-reform and in non-treated sectors is much higher than that estimated using pre-tax net profits, consistent with the finding of Habu (2017) that bunching at zero by foreign-owned firms in the UK is higher when measured with tax return data than when using administrative accounts. The differential for treated and non-treated firms is 81 percentage points as measured by taxable income, compared with a 55 percentage point differential as measured by pre-tax profits.

It could be the case that foreign-owned firms have a more aggressive tax planning strategy of foreign-owned firms focused on both shifting reported sales away from Portugal, and compensating for Portuguese profits through deductions or other items in the tax report. If this is the case, then the decrease in bunching in taxable income post-reform suggests that these firms were not able to adjust for the forced higher reporting of sales in Portugal. With such a small sample and no information on these firms' worldwide profits, however, we cannot draw definitive conclusions.

Table 1.6: Bunching Results: Foreign-Owned Firms

Treated sectors	Pre-tax net profit	Taxable Income
Pre	5.33***	41.53***
	(0.161)	(20.281)
Post	3.1***	0.99***
	(0.095)	(0.07)
Difference	-41.75%***	-99.54%***
	(0.10)	(0.90)
Non-treated sectors		
Pre	5.4***	7.65***
	(0.186)	(0.567)
Post	6.13***	6.52***
	(0.146)	(1.65)
Difference	13.39%***	-14.42%***
	(0.2)	(0.30)
Difference in differences *(pp)*	55***	81***
	(0.10)	(0.30)

Note: Bunching is estimated as the excess density of firms in the empirical distribution reporting zero profits relative to the counterfactual. Firms are excluded from the analysis in the year of their creation when the likelihood of reporting zero profits for non-tax related reasons is higher. Firms are also excluded if they report no employees, and either no sales or no assets. Estimates for non-treated sectors are restricted to firms matched to treated firms through nearest neighbor matching on return on assets, leverage, ratio of cashflow to assets, ratio of cash to assets, ratio of PPE to assets, number of employees, and age. Binwidth is 1,000 euros. Means and standard errors are obtained through bootstrapping.
*** p<0.01, ** p<0.05, * p<0.1

1.5.2 Micro domestic firms

Finally, for micro domestic firms there is an increase in bunching at zero of 8.5% in treated sectors as measured in pre-tax profits, which is on average 7 percentage points higher than the increase of 1.56% in non-treated sectors. The direction of the results is even larger for taxable income, although it is difficult to find a plausible explanation for this when compared to the full sample of firms.

Although the rate of bunching increases, the absolute number of bunching firms drops from 3,170 to 1,340 in treated sectors. This means that the remaining bunchers have more weight in the distribution of active firms in treated sectors post-reform. This corresponds with the predictions of the model, which suggest that this will be the case for domestic firms because the incentive to bunch at zero as a tax planning strategy is affected by the availability of another option: exiting to informality – i.e., becoming *ghosts*.

To test for this effect, I conduct a survival analysis on the same subset of micro domestic firms, comparing their outcomes before and after the reform and across sectoral treatment status. I use nearest-neighbor matching on baseline sales, number of employees, cash flow, assets, and investment in 2009 to restrict the analysis to firms that were comparable in observable indicators of performance and financial health before the period of analysis[10].

The parameter of interest is the estimated coefficient on sectoral treatment status, representing the impact on the probability of firm survival of being in a sector targeted by the reform. I also include factors shown in the literature to influence firm survival that are available for all firms in the baseline year of 2009: firm age in 2009 and the yearly values of turnover, number of employees, assets, and investment (Jensen, Buddelmeyer, and Jensen, 2006; Mata and Portugal, 2002; Pérez, Llopis, and Llopis, 2004).[11]

I first specify the model with a time-fixed coefficient on sectoral treatment status, to test the assumption that the effect of being in a treated sector is unchanged over time. A

[10]Survival analysis is conducted using the R package *survival* (Terry M. Therneau and Patricia M. Grambsch, 2000) and matching with the R package MatchIt (Ho et al., 2011)

[11]Firm age in the baseline year is calculated using the full 2004-2015 panel, based on the first observation for the firm in the dataset. If the firm is present in 2004 and not flagged as established in that year, the age is imputed using the industry mean plus the time lag.

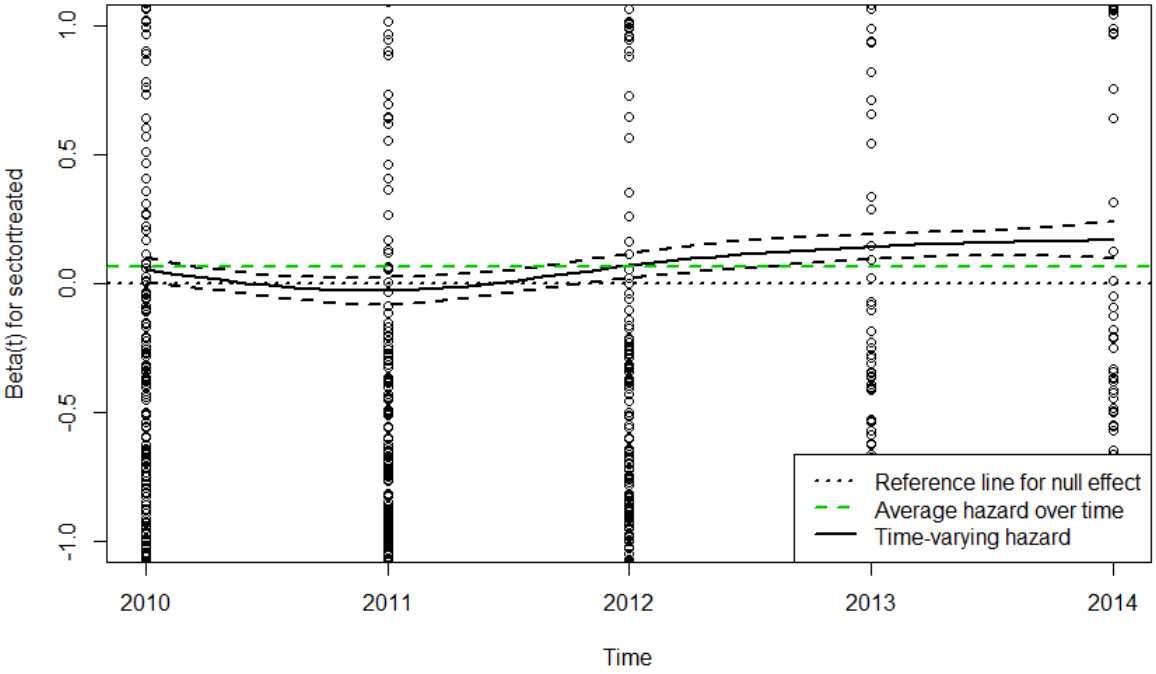
Table 1.7: Bunching Results: Micro Domestic Firms

Treated sectors	Pre-tax net profit	Taxable Income
Pre	2.62***	2.89***
	(0.003)	(0.003)
Post	2.84***	2.91***
	(0.005)	(0.008)
Difference	8.54%***	0.81%***
	(0.001)	(0.001)
Non-treated sectors		
Pre	2.35***	2.36***
	(0.004)	(0.004)
Post	2.39***	2.05***
	(0.004)	(0.005)
Difference	1.56%***	-13.1%***
	(0.001)	(0.001)
Difference in differences *(pp)*	-7***	-14***
	(0.001)	(0.001)

Note: Bunching is estimated as the excess density of firms in the empirical distribution reporting zero profits relative to the counterfactual. Micro firms are defined as those with less than 10 employees and either turnover or assets less than €2 million. Firms are excluded from the analysis in the year of their creation when the likelihood of reporting zero profits for non-tax related reasons is higher. Firms are also excluded if they report no employees, and either no sales or no assets. Estimates for firms in non-treated sectors are restricted to those matched to firms in treated sectors through nearest neighbor matching on return on assets, leverage, ratio of cashflow to assets, ratio of cash to assets, ratio of employees to assets, number of employees, and age in 2010. Binwidth is 1,000 euros. Means and standard errors are obtained through bootstrapping.
*** p<0.01, ** p<0.05, * p<0.1

test of the scaled Schoenfeld residuals shows that the Cox proportional hazards assumption – that the ratio of the baseline rate of survival for firms in treated vs. non-treated sectors is constant over time – is violated, with a statistically significant variation for the coefficient on sectoral treatment at the 1% level. Figure 1.3 shows divergence starting in 2012, the year the law was passed.

Figure 1.3: Estimated Beta for Sectoral Treatment Status: 2010-2014



In the second stage, I allow the coefficient to vary over time. The test of the scaled Schoenfeld residuals confirms that the proportional hazards assumption is satisfied in this specification.[12] Before 2013, firms in treated sectors were weakly more likely to exit than firms in non-treated sectors. In the first two years of the anti-evasion law, however, the hazard ratio for treated firms becomes significantly greater than for non-treated firms *(see Table 1.8)*. In the treatment period, a firm in a treated sector was was 1.15-1.18 times more likely to exit than a comparable firm in a non-treated sector.

[12]The proportional hazards assumption is also satisfied only when allowing for time variance for the firm's baseline age and its yearly lagged number of employees, sales, and investment. The coefficient on yearly lagged assets is time-fixed.

Table 1.8: Hazard Ratios

Year	**Treated Sector**	Younger firms	Smaller firms	Low sales	Low investment
2010	**1.01**	1.83***	1.45***	1.68***	1.6***
2011	**.96**	1.88***	1.41***	1.94***	1.52***
2012	**1.05**	1.59***	1.39***	2.06***	1.86***
2013	**1.15*** **	1.71***	1.58***	2.04***	1.88***
2014	**1.18*** **	1.65***	1.57***	2.02***	1.77***

Each value represents the predicted probability of exit for a firm when compared to the reference value. Where the hazard ratio is greater than one, a firm has a higher probability of exiting. Splits for categorical variables are computed automatically using the *surv_cutpoint* procedure in R, which identifies the threshold value having the largest impact on survival probability and splits observations into 'low' and 'high' accordingly (2018). Firm size is based on number of employees.

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

As in for example Saez (2010) and Waseem (2018), it can plausibly be assumed that firms will prefer to move to the informal market rather than cease operations in response to an increase in the cost of tax evasion. In conjunction with the model and the fact that the bunching response of these small firms differs from the global trend in the targeted sectors, the result suggests that the impact of the Portuguese reform on these firms is to increase the probability of becoming a ghost. The analysis captures the full extensive margin of firm response, meaning that I cannot distinguish between firms moving to the informal market and those going out of business. However, the use of matching to restrict the sample for analysis lends support to the hypothesis that the divergence in outcomes is driven at least in part by movement to the informal sector, as firms in sectors where the cost of evasion increased are compared to those with similar performance pre-reform.

1.6 Conclusions

The results are consistent with tax-related bunching at zero for both foreign-owned and domestic firms in Portugal. The overall decrease in bunching in targeted sectors post-reform suggests that firms experienced the reform as an increase in the cost of mis-reporting in this way, and responded by changing their tax planning strategies. Bunching at zero appears to be a less relevant strategy for small domestic firms with the option to exit to informality, as suggested by a higher rate of exit for firms in targeted sectors when compared to similar firms in other sectors.

An interesting avenue for further exploration is presented by the difference between the results for foreign-owned firms as measured by the constructed taxable income variable. Although the small sample and data limitations make it difficult to draw conclusions, the results suggest that the channel of mis-reporting differs for these firms. Bunching by foreign-owned firms decreased more sharply after the reform by this measure than for pre-tax profits, possibly because they were not able to anticipate that they would be forced to report more profits in Portugal and adjust through inter-temporal or cross-border shifting. The constructed taxable income variable is missing some key information to fully explore this dynamic, however – most prominently tax credits and deductions, of which many were enacted during this period of recession and economic stimulus. The mechanism underlying the differential between the channels used by foreign-owned and domestic firms bunching at zero would benefit from a more detailed theoretical examination as well.

Understanding how firms change their tax planning strategies in response to changes in the tax environment can inform the efficient use of resources by tax authorities charged with combatting evasion. This paper provides an important contribution to existing research on tax evasion by firms. Using exogenous variation in the cost of evasion, I am able to show that the rate of bunching at zero is affected by the tax environment, that the dynamic differs for foreign-owned and domestic firms, and that the option to operate informally may change the incentives to bunch at zero.

Chapter 2

Firms in the Shadow Economy: A Survey

2.1 Introduction

In Chapter 1, I differentiate three types of firms based on their tax planning strategies: *icebergs*, which mis-report a percentage of their portion of their profits to reduce their tax bill; *bunchers*, which report no profits to bring their tax bill to zero; and *ghosts*, which operate in the informal economy and also pay no taxes. The chapter is focused on *bunchers*, about whose behavior little is known.

In this chapter, I turn my focus to gaining a better understanding of the *ghosts*. Understanding and quantifying the activities of these firms has drawn much attention from governments and researchers, but there are many challenges to empirical work on an activity designed to avoid detection. In the literature on tax evasion and avoidance, much more is known about the intensive margin response of firms to changes in the tax rate and enforcement than the decision-making of firms on the extensive margin of the formal economy – those with the option to go underground.

This margin is particularly relevant in the wake of the recent financial crisis in Europe, as many governments have enacted measures to shift activity from the shadow to the official economy. In Portugal, the rescue package provided by the Eurogroup, European Central

Bank, and IMF in 2011 included a clause to raise at least €175 million by increasing efforts against tax evasion, fraud, and informality (European Commission, Directorate-General for Economic and Financial Affairs, 2011). This prompted a series of measures including the provision of incentives for consumers to ask for receipts from businesses *(see section 1.3.1 in Chapter 1 for more details)*, the improvement of resources and information sharing by the tax authority, and the strengthening of tax reporting obligations for businesses (European Parliament, 2017).

The presence of a shadow economy erodes the tax base, draws workers and firms away from the formal economy, and makes it more difficult for governments to make public policy decisions by distoring official figures on the economy (Çule and Fulton, 2009; Schneider and Enste, 2000; Dell'Anno, Gómez-Antonio, and Pardo, 2007). Additionally, firms that operate in the shadow economy lose access to institutions such as the judicial system, making their production and investment decisions less efficient (Dabla-Norris and Feltenstein, 2005). The presence of a shadow economy can also act as an obstacle to economic progress. Without the ability to collect tax revenues, governments cannot build the strong institutions that are necessary to sustain growth, or – in the case of developing countries – to reduce reliance on international aid (Cobham, 2005).

Academic research has an important role to play in improving the design of policy interventions aimed at reducing illicit activity and increasing tax revenues. Measuring the size of the shadow economy has been a primary focus of the economic literature on the topic, and has led to the exploration and testing of various assumptions. The results differ depending on factors such as the choice of parameters, institutional context, and time period, making it difficult to judge the credibility of a single additional measurement or to use results from different methods as robustness checks for one another. However, the extensive body of work on the topic has led to findings on the determinants and characteristics of the shadow economy that provide important information to researchers and policymakers.

The primary purpose of this paper is to give context on the literature that informed the

extension of the model in Chapter 1 to include firms in the shadow economy – the *ghosts*. Other survey papers have evaluated how researchers approach the topic, including the difficulty of defining the problem, the range of measurements obtained in different settings, and the strengths and weaknesses of different techniques *(see e.g. Schneider and Enste (2000); Fuest and Riedel (2009); Georgiou (2007); Gerxhanti (1999); Beer, Mooij, and Liu (2018); Riedel (2018); Schneider and Buehn (2018))*. This survey will cover some of the same ground, with a focus on how researchers have approached the difficulties inherent to study of the shadow economy, what information this has yielded on the nature of the shadow economy and the firms that participate in it, and what can be learned about the shadow economy in Portugal. I start in Section 2.2 by laying out the foundations for study of the shadow economy with an overview of different definitions used. In Section 2.3 I then address the different approaches to measuring its size, and the pros and cons of each. In Section 2.4 I present the key insights from the measurement literature, and I conclude in Section 2.5 with an assessment of the relevant results for Portugal and areas for further development.

2.2 Defining the shadow economy

In Chapter 1, I take as a definition of the shadow economy that part of legal economic activity that is mis- or under-reported by firms in an illegal way, leading to a corresponding reduction in tax revenue from what the government would expect to collect with perfect compliance. There is no consensus on a definition in the economic literature, however, and each study on the topic starts from a different baseline depending on the estimation method and institutional context.

Many authors use a starting point similar to that of Schneider and Enste (2000), who defines the shadow economy as "unreported income from the production of legal goods and services, either from monetary or barter transactions, hence all economic activities that would generally be taxable were they reported to the tax authorities" (pp. 78-79) (Cebula, 1997; Hudson et al., 2012; Çule and Fulton, 2009). Others broaden the scope even more,

as in for example in Bhattacharyya (1999), who includes all unrecorded national income — i.e. the difference between "potential" and recorded national income. These very general definitions fail to make the important distinction between tax evasion and tax avoidance, which is the underpayment or nonpayment of taxes through loopholes or inconsistencies in the legal tax system.

Many researchers narrow their scope according to the type of activity, excluding for example illegal activities or household work. This is a cleaner setup theoretically, but cannot always be delineated in practice. For example, legal and illicit activities cannot be distinguished in studies based on macroeconomic indicators. Moreover many activities cannot be easily classified as formal or informal, such as money laundering – where income from illegal activities is legitimized through use in legal business – or the illegal smuggling of legitimate goods (Georgiou, 2007; Schneider, Raczkowski, and Mróz, 2015; Schneider et al., 2015; Pedersen, 2003).

Others consider the motivation of the evader in their definition, which is nearly impossible to tease out in aggregate studies. Schneider and Buehn (2018), for example, define the shadow economy as all legal production of goods and services to avoid payment of taxes, social security contributions, or labor market standards; or avoiding complying with administrative procedures. Not only is it very difficult to assess which of these reasons motivates firms to operate in the shadow economy, but it also opens questions regarding the definition of the drivers themselves – for example, it could make sense to further differentiate firms based on whether they are primarily motivated to avoid income or VAT taxes.

There is no real answer as to which definition is best, and it depends on the nature of the research question at hand. For the purposes of the study in the first chapter of this thesis, the most important element is the legal nature of the business engaged in by the *ghost* firms – because they are on the margin of the formal and informal economy, they must plausibly be able to transition their business from one to the other. The distinction between illegal mis-reporting and avoidance through legal channels is also important for

distinguishing the *ghosts* from *bunchers* and *icebergs*. While *ghosts* conduct all of their business in the shadow economy and thus by default through illegal tax evasion, *bunchers* and *icebergs* conduct some of their business in the formal economy and have the additional option of avoidance to reduce their tax bills. Finally, the reduction of tax revenue captures the policy relevance of the question at hand, namely the effectiveness of the intervention aimed at increasing the reporting of income subject to taxation.

2.3 Measurement

By far the most extensive branch in economic literature on the shadow economy is devoted to its measurement. Over the years, researchers have developed increasingly complex techniques for addressing the biggest obstacle inherent to this task: namely the fact that its illicit nature makes it impossible to observe directly. The struggle to agree on a consistent definition for the shadow economy stems in part from this difficulty, and has contributed to a large variation in estimates obtained using different definitions and techniques. In Portugal, for example, estimates of the size of the shadow economy between 2000 and 2012 using three of the primary measurement techniques range from 16 to 39% of GDP *(see Figure 2.1 in section 2.5)*.

The two main methods of measurement are indirect approaches that use macro-level indicators to tease out the aggregate size of the shadow economy in a single country or group of countries, and direct approaches that use micro-level indicators such as surveys to elicit small-sample estimates for extrapolation. While indirect approaches use widely-available data, they rest on strong assumptions that cannot always be confirmed. Direct methods of measurement can help provide support for these assumptions, but rely on data that are not easily obtained, are costly to collect, and have limited external validity. For these reasons, indirect methods are still the most widely used in the literature.

2.3.1 Indirect Methods

The most prominent indirect approach is the Multiple Indicator Multiple Cause (MIMIC) method, a type of latent variable model where the unobserved variable is the size of the shadow economy. The method, a variant of structural equation models often used in social science, was first applied to the shadow economy in the early 1980s by Frey and Weck-Hanneman (1984).

In the MIMIC approach, two types of observable variables are used as proxies in a set of structural equations: "causes" of the shadow economy's size linked in a structural model, and "indicators" of its existence linked in a measurement model. Commonly-cited causes include rates of direct and indirect taxation, the regulatory burden, citizens' morality and trust in government, employment and self-employment rates, and corruption or rule of law. Indicators generally include the currency ratio and other monetary transactions, labor market participation rates, and real GDP (Schneider and Enste, 2000; Schneider, Raczkowski, and Mróz, 2015; Dell'Anno, Gómez-Antonio, and Pardo, 2007).

The MIMIC approach has several advantages over other types of estimation. It allows for the construction of a structural theory underlying the relationship between observable and unobservable features of the shadow economy, including non-linear and cyclical relationships. It also has the advantage of flexibility, as different causes and indicators can be selected depending on the setting of the analysis and data availability (Dell'Anno and Schneider, 2009; Karlinger, 2009). The data needed to consistently quantify these crucial causes and indicators is highly country-specific, however, and researchers often have only weak measures of key elements such as cultural norms or trust in government (Bovi, 2003; Gokalp, Lee, and Peng, 2017; Albulescu, Tamasila, and Taucean, 2016). The selection procedure therefore depends heavily on the availability of data and is necessarily somewhat piecemeal. This means that results from different studies cannot be easily compared or tested for robustness, as even those looking at the same country or time period may select different causes and indicators or different variables to represent them.

Another limitation of the MIMIC method is that its output is an index rather than a

level, meaning that the results must be calibrated using past results of other estimation approaches to obtain an absolute value for the size of the shadow economy. Its validity therefore rests not only on the credibility of the choice and estimation of causes and indicators, but also on the assumptions of the other estimation methods with which it is calibrated. It also offers no answer as to causation – namely whether the growth rate in selected causes causes the growth in the shadow economy, or is merely produced by the same dynamics.

Another common method for estimating the size of the shadow economy is the Electricity Consumption Approach (ECA). The method relies on the empirical observation that in nearly every economy, GDP and electricity consumption grow together and at similar rates. Measured electricity consumption can therefore be used to construct a hypothesized magnitude for economic activity in a given country, from which official GDP estimates are subtracted to obtain an estimate for activity in the shadow economy. The approach first came into the literature in the mid 1990s with the work of Kaufmann and Kaliberda (1996) and has since evolved with the work of for example Eilat and Zinnes (2002), who develop a modified multi-step procedure to control for variations in electricity consumption growth at the industry level.

This evolution has been crucial for maintaining the credibility of measurement using ECA, as technological progress and ecological considerations render economies more efficient in their use of energy. Without accounting for this the size of the shadow economy will always be underestimated, and indeed some studies using the ECA have implausibly found negative values for the size of the shadow economy (Onnis and Tirelli, 2010). Estimates can be further confounded by the fact that developing countries seeking to stimulate their economies often engage in programs to rapidly expand access to electricity, and that electricity distribution and production has also been recently privatized in many countries (Karlinger, 2009).

With these advances, the ECA is still in use because it has the advantage of relying on data that is widely available and generally reliable, namely official GDP and electricity

consumption – making it particularly useful in less developed economies where data availability is limited (Chong and Gradstein, 2007; Onnis and Tirelli, 2010; Garvanlieva, Andonov, and Nikolov, 2012). It also does not rest on any prior assumptions about the causes of the shadow economy, unlike the MIMIC method.

The Currency Demand Approach (CDA) shares the same advantage of relying on data that is generally available and reliable, and is still a popular method in the literature despite its foundations on an assumption that is increasingly challenged by technological advances – namely that informal economic activity is conducted principally in cash. With this method, the discrepancy between cash used in the official economy and total currency demand is used to calculate the magnitude of the shadow economy (González-Fernández and González-Velasco, 2015). It gained popularity in the early 1980s with the formulation of Tanzi (1980), who expanded earlier models by adding the demand for currency as an explicit function of variables such as the tax rate.

This approach again relies on very strong assumptions: that informal transactions are solely conducted in cash, that the velocity of currency circulation is the same in the formal and informal economies, that there is some baseline year in which the size of the shadow economy was zero, and that the only determinant of the shadow economy is the tax burden. Advances such as those of Ardizzi et al. (2012) and Ahumada, Alvaredo, and Canavese (2006) allow for more flexibility by for example including other covariates that measure tax evasion and controlling for the income elasticity of cash demand, but the main weakness of the approach remains the assumption that all underground payments are conducted in cash.

In reality, transactions in the informal economy can be conducted with non-cash means such as barter or checks. Additionally, factors other than shadow economic activity can drive changes in currency demand – for example, individuals often hold more cash in larger denominations in times of high inflation (Georgiou, 2007). Another growing challenge to the credibility of estimates obtained using the CDA comes from the advent of new technology such as crypto-currencies and peer-to-peer payment methods that make it

easier to conduct non-cash transactions in the shadow economy (Gaspareniene et al., 2017; Marian, 2013; Slattery, 2014). The literature on measurement has yet to address the challenges presented by such digital payments, which have becoming increasingly relevant in recent years.

2.3.2 Direct

The other main subgroup of approaches to measurement is that which relies directly on micro data to observe behavior, most commonly through surveys and audits. Although the necessary assumptions are less strong than for indirect measurement techniques, data challenges call into question the external validity of the results. Even the best-designed surveys will measure only self-reported behavior, while audit data captures not only the behavior of firms, but also the enforcement behavior of the tax authority.

The main strength of surveys is that they can very precisely pinpoint the type of informal activity that they are identifying, and who is engaging in it. Because of the cost of conducting surveys, however, they are often very small-scale and limited to certain sectors of economic activity. The fact that very few have been conducted at all limits the ability to prove that the results hold across different time periods and countries.

Additionally, surveys of illicit economic activity must be very carefully worded to elicit honest responses. Researchers must use strategies such as beginning with non-sensitive questions or framing the questions about illicit activity to ask about activity by firms in their industry, as in for example Putnins and Sauka (2015). Regardless of the framing of questions, however, respondents are understandably reluctant to disclose their own activity in the shadow economy and are likely to be wary even if anonymity is guaranteed. This means that magnitudes of the shadow economy based on surveys are almost certainly underestimations.

The other main source of data in direct estimation methods comes from tax authority audits. Much of the information from audits comes from the United States, where the Internal Revenue Service provides information from audit and appeals programs to

researchers (GAO, 1995; IRS, 2017; Slemrod et al., 2017; Hanlon, Mills, and Slemrod, 2005). While this has yielded important insights into how firms interact with the tax authorities, differences in audit procedures have made it difficult to validate these results in other countries. Some countries do not conduct randomized audits of corporate taxpayers, while others use them for purposes other than measuring reporting compliance, such as allocating resources and balancing the workload of auditors (Tanzi, 1999; OECD, 2004).

An additional issue with the use of audit data is that audit selection itself is far from random. In the case of Finland, for example, one-fifth of firms selected for audit have had some earlier inspection abnormality, while many others are selected based on irregularities turned up by other public authorities such as customs officials (Viren, 2015). Although this bias can be corrected for by conducting randomized audits or adjusting the audit selection procedure to account for observable characteristics that are known to increase the rate of noncompliance, such as self-employment status, it can be costly and administratively complex to do so. In general, randomized programs are rarely implemented because they require a large administrative investment from the tax authority and yield little benefit for tax inspectors whose career objectives are often tied to the magnitude of evasion they detect (Feinstein, 1999).

2.4 Key Insights: characterizing the shadow economy and informal firms

The extensive body of work on measuring the shadow economy has yielded important insights on the factors that characterize it in different institutional settings and time periods. These insights formed the basis for the addition of *ghosts* to the tax evasion model in Chapter 1, and informed the identification strategy for micro firms.

Measurement using the MIMIC method has led to the isolation of certain structural causes that contribute to the size of the shadow economy. The tax burden is almost universally found to contribute to the size of the shadow economy, as higher tax rates

raise the cost of operating formally (Schneider and Enste, 2000; Schneider, Raczkowski, and Mróz, 2015). The effect of weak public institutions and corruption lend support to the theoretical literature, which predicts that higher levels of corruption distort tax collection and reduce the provision of public goods that can incentivize firms to participate in the formal economy (Hindriks, Keen, and Muthoo, 1999; Medina and Schneider, 2018; Schneider, 2016). Findings on labor market dynamics also support theoretical predictions that the unemployed turn to the shadow economy as an alternative source of work, as higher levels of unemployment are generally associated with growth in the shadow economy Medina and Schneider (2018); Bitzenis, Vlachos, and Schneider (2016); Schneider, Raczkowski, and Mróz (2015).

Another important insight from the literature is the characterization of firms operating in the shadow economy, which I use in Chapter 1 to select micro domestic firms as the subgroup most representative of *ghosts* in the empirical application. Results have shown that firms operating underground in developed countries are small firms without the resources to hire tax managers or exploit the complexities of the tax system (Gerxhanti, 1999). These firms can more easily evade in the shadow economy because their transactions are often conducted in cash, their record-keeping is less methodical, and they have fewer external financial reporting requirements (Slemrod et al., 2017). Additionally, small informal firms have an incentive to move their business to the formal economy as they expand to gain access to institutions such as the banking and legal systems, meaning that the population of firms remaining in the shadow economy should generally be composed of smaller businesses (Levenson and Maloney, 1998).

A more general application of research differentiating firms in the shadow economy has been to distinguish between the incentives for firms in developed and developing countries, and the characteristics of typical informal firms in each context (1998; Fuest and Riedel, 2009; Blackburn, Bose, and Capasso, 2012; Gerxhanti, 1999; Saunoris, 2018). In developed countries, firms face a tradeoff between a reduction in their tax bill and the cost of operating informally, which includes the probability of detection, expected penalty,

and loss of access to institutions such as banks and government tax incentives. Moreover, workers in developed countries face a significant constraint to participation in the shadow economy: namely, the loss of access to social welfare systems. Since these institutions are stronger in developed than in developing countries, the relative loss is greater when compared to the gains in tax savings and employment flexibility and workers are therefore less likely to agree to work for a firm that cannot guarantee them a contract.

As a result, informal wage work in developed countries tends to be concentrated in sectors such as hotel and restaurant work, and domestic work such as gardening and childcare (Chen, 2005; 2012). These types of activities are often conducted through word-of-mouth business practices, are notably hard to detect by tax authorities, and can be easily concealed through cash-only transactions – the same type of activities targeted by the Portuguese intervention outlined in Chapter 1.

2.5 Results for Portugal

Most measurements of the shadow economy in Portugal have come in larger global overviews and those covering OECD and EU countries, such as those of Lacko (1999), Schneider and Enste (2000), Bovi (2003), and Schneider, Raczkowski, and Mróz (2015). The estimates for the shadow economy in Portugal generally fall in the range of those for Italy, Spain, and Greece – the Southern European countries often grouped with the acronym "PIGS" that are characterized by high levels of public debt, high unemployment, and low GDP growth.

The MIMIC method is the most frequently-used among papers looking specifically at the Portuguese case, notably by Dell'Anno (2007) and more recently by Afonso and Goncalves (2011) and Soares and Afonso (2019). The results signal the importance of social systems and self-employment in determining the dynamics of the Portuguese shadow economy, but differ considerably on estimates of its magnitude and lack consensus on the sign and significance of some important causes in the structural model.

Dell'Anno (2007) finds that the Portuguese shadow economy as a share of GDP fell

Table 2.1: Causes of the Portuguese Shadow Economy in MIMIC models

Cause	Dell'Anno (2007)	Afonso and Goncalves (2011)	Soares and Afonso (2019)
Tax burden	No	**Yes:** positive	**Yes:** positive
Share of government	**Yes:** positive	**Yes:** positive	No
Self-employment rate	**Yes:** positive	**Yes:** positive	
Unemployment rate	**Yes:** positive	**Yes:** negative	
Social benefits	No		**Yes:** negative
Labor force participation	**Yes:** positive	No	
Capital formation		**Yes:** negative	
Disposable income			**Yes:** positive

Note: The results from three papers applying the MIMIC model to Portugal differ on the sign and significance of some key selected causes, notably the tax burden, the unemployment rate, and labor force participation. There is also a lack of alignment on the selection of the causes and the variables used to measure them. Dell'Anno (2007) and Afonso and Goncalves (2011) both find positive and significant effects of the self-employment rate, which Soares and Afonso (2019) do not include in their model. Where the sign is positive, a higher level of the cause is associated with a larger shadow economy. Where missing, the cause was not included in the specification.

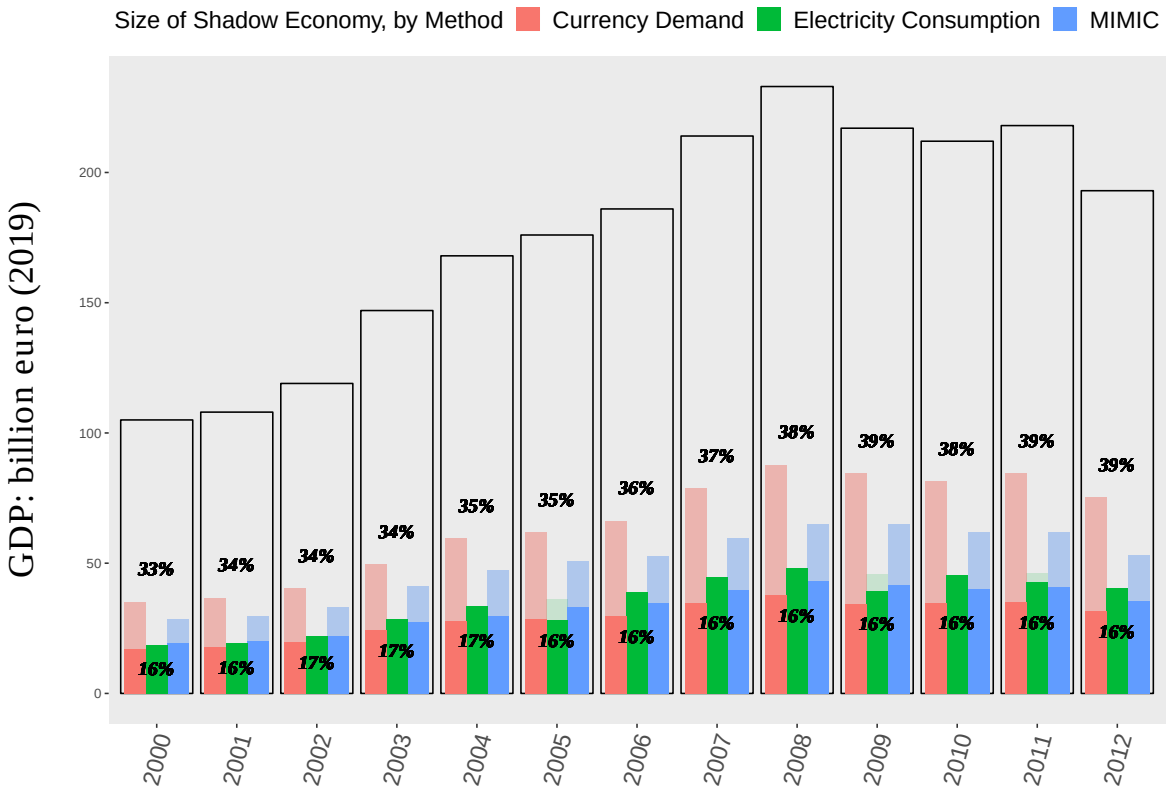
from an average of 28.8% in 1977-79 to 17.6% in 2004, with an increase in the first years of the 1990s as Portugal worked to enter the European Monetary Union (EMU). Afonso and Goncalves (2011) obtain the opposite result regarding the trend, finding that the share of the shadow economy in GDP dropped slightly from 16.9% at the end of the 1980s before beginning to climb from the early 1990s, reaching 22.8% in 2008. Soares and Afonso (2019) find a smaller magnitude for the overall size of the shadow economy but a similar trend, with an overall increase from 6 to 29% and periods of shrinking in the early 1970s – in the years before the 1974 revolution that led to the end of the dictatorship in Portugal – and late 1980s to early 1990s, a period of tax reform that included the introduction of the VAT and lowering rates. Although the MIMIC application alone cannot show the causal mechanism of these effects, it does allow for the identification of trends in the growth rate of the shadow economy that can be matched to such historical events.

Dell'Anno (2007) and Afonso and Goncalves (2011) both find that a higher weight of the public sector in the market and more self-employed in the labor force contribute to a larger shadow economy, although Soares and Afonso (2019) find no effect of the share of government and do not include the self-employment rate. The three papers also lack

consistency on other key causes, making it difficult to draw conclusions about its drivers in Portugal *(see table 2.1)*.

Soares and Afonso (2019) also apply two specifications of the currency demand method, finding a trend consistent with their results for the MIMIC model but a larger magnitude for the shadow economy – from 9 to 39% with one approach and 6 to 24% with the other. Although the authors note the difference in the size of the estimates, they concentrate more on the similarity in trends and offer little explanation of why the sizes differ so considerably.

Figure 2.1: Estimates of the Size of the Shadow Economy in Portugal: 2000-2012



Note: Outer bars represent total Portuguese GDP in billion euro. Inner bars show the range of estimates of the absolute size in billion euro of the shadow economy using three of the key measurement techniques: the currency demand approach, and electricity consumption approach, and the MIMIC method. The equivalent in percentage of GDP for the minimum and maximum of each year's estimate are shown above and below the bars for absolute values. Estimates for the size of the shadow economy in Portugal between 2000 and 2012 range from 16 to 39% of GDP. Source: author's own calculations from the results of World Bank (2019); Missiou and Psychoyios (2017); Soares and Afonso (2019); Schneider (2016); Dell'Anno (2007); Bovi (2003); Schneider, Raczkowski, and Mróz (2015); Lacko (1999), and Afonso and Goncalves (2011).

According to the results of these Portugal-specific studies applying indirect methods and larger samples that include Portugal, the upper and lower bounds of the estimates of the shadow economy as a percentage of GDP have remained fairly consistent over time, even as GDP has increased *(see figure 2.1)*. The maximum value by year across the different measurement techniques has a wider range, however – in 2012, for example, the highest estimate was 39% of GDP for the currency demand approach, 27.5% for the MIMIC method, and 21% for the electricity consumption approach.[1]

In regards to direct methods, the most extensive surveys covering informal economic activity in Portugal are the Eurobarometer polls from 2007 and 2013 (European Commission, 2007; 2014). The findings corroborate those of indirect approaches that the dynamics of the shadow economy in Portugal are similar to those in other Southern European countries characterized by high tax rates and unemployment, and yield some interesting insights on consumers' interactions with underground firms. For example, 10% of respondents in the 2013 survey had purchased goods that they believed were undeclared, with a higher-than-average proportion reporting that they had purchased undeclared food. This may explain in part why the restaurant and hospitality industry was targeted by the law examined in Chapter 1, which provided incentives for consumers to ask for fiscal receipts in certain sectors of economic activity prone to evasion in Portugal. Among those reporting that they had purchased undeclared goods or services, 30% had done so from firms, further support for the presence of *ghosts* in Portugal despite its level of economic development.

No randomized controlled audits have been conducted in Portugal, likely due at least in part to the resource constraints of tax authorities (Jensen and Wöhlbier, 2012; Governo de Portugal: Secretary of State for Tax, 2014). One survey of tax administrators in Portugal highlights a potential effect of the law explored in Chapter 1, finding that although the rate of desk audits is less than 1% for corporate income tax returns in 2015, the rate of administrative penalties is much higher - 26% (Heitmuller, Harari, and Meinzer, 2018).[2] If

[1] See Figure B.1 in Appendix B for trends in the mean estimate as a percentage of GDP between 1970 and 2012.

[2] Desk audits are defined as an intervention based on the in-office review of tax returns by tax authorities,

historical data were available it could be used to check whether the rate of administrative penalties rose after the reform, with the additional non-audit information available to tax authorities in consumers' tax reports.

To my knowledge, there has as yet been no attempt to use the results from either surveys or audits to obtain a point estimate for the size of the shadow economy in Portugal. Although there are significant limitations to the use of direct approaches for such calculations, they could provide a robustness check for the lower bound of the estimates found with indirect approaches, which cover a much wider range of informal activity and cannot distinguish as precisely as direct methods between tax evasion, tax avoidance, and illegal activities.

2.6 Conclusions

This paper examines the literature on the shadow economy, with a focus on insights that are relevant for the work on *ghosts* in Chapter 1 of this thesis. High tax burdens, weak public institutions, corruption, and unemployment are all generally found to contribute to a larger shadow economy. Firms in the shadow economy tend to be smaller, and are more concentrated in industries where there are many cash transactions and few financial reporting requirements – the type of sector targeted by the anti-evasion law in Portugal that shapes the identification strategy in Chapter 1.

Studies on Portugal have relied on indirect measurement approaches, and on average show growth in the shadow economy from the 1970s. The findings of studies using the MIMIC method suggest several factors that may be contributing to this trend, including persistently high levels of unemployment and self-employment, and a strong presence of the government in the market. Differences across studies in the selection and specification of causes in the structural models make it difficult to draw definitive conclusions, but the general consensus of continued growth does highlight the importance of continuing to

usually by email or phone contact with the taxpayer. No information for Portugal is reported on the number of resulting on-site audits, which are generally conducted at much lower rates.

implement and evaluate policy interventions designed to reduce the size of the Portuguese shadow economy.

Results from surveys are limited, but provide some information to corroborate the results of indirect measurements and give context to the institutional setting explored in Chapter 1. If audit information were made available, it could lend further support to the findings from other techniques. Given the resource constraints of the Portuguese tax authority, however, it is unlikely that such data will be easily obtained or collected in a way that could lead to robust results.

Despite the lack of consensus on a definition or optimal measurement approach, the extensive body of research on estimating the size of the shadow economy in various countries and time periods has led to important findings on the nature of the shadow economy, the firms of which is it composed, and what it looks like in Portugal.

Chapter 3

Effects of a Temporary Investment Tax Credit in a Periphery Eurozone Country [1]

3.1 Introduction

One way that governments can make it more beneficial for firms to operate in the formal economy is by providing incentives in the corporate tax code. Primarily used to stimulate sluggish economic growth, incentives can also have the side effect of reducing the size of the shadow economy by lowering the effective tax rate and strengthening public institutions, factors highlighted in Chapter 3 as contributing to lower levels of informality.

Several different features of the corporate tax code have been manipulated by governments in the aftermath of the recent recession in the United States and Europe. Empirical work evaluating their effectiveness has focused on how firms react to the tax reforms in terms of investment, employment, or wage bill. While initial attempts to estimate corporate tax base elasticities were plagued by methodological challenges and lack of appropriate data, the recent availability of comprehensive firm-level datasets has prompted a surge in the empirical literature on tax elasticities (Cummins, Hassett, and Hubbard,

[1] This is a joint work with Miguel Ferreira, Ana Gouveia, and Susana Peralta.

1996). The most difficult task remains the distinction between new investment spurred by incentives, and investment which firms would have undertaken even in the absence of the credit.

This paper contributes to this recent literature by analyzing a corporate tax reform implemented by the Portuguese government in 2009. In an attempt to boost corporate investment and employment in the midst of a recession, the government introduced a tax credit on several categories of investment expenditures, which could be claimed by firms in particular sectors and regions. The share of the investment expenditure that could be claimed as tax credit varied from 10 to 50%, depending on firm characteristics and location. We exploit this sectoral and regional variation to obtain causal estimates of the effect of the investment tax credit.

Our analysis nicely complements the existing body of knowledge on firms' response to investment stimulus, which focuses mainly in the United States, since it examines an investment tax credit in a small country in the periphery of the Eurozone, where the average firm is much different than in the US. In particular, the average Portuguese firm is relatively small and very indebted. This contributed to a particularly strong impact of the global financial crisis on investment in Portugal, where as many as one-third of firms were unable to meet their demands for bank loans (Farinha and Félix, 2015; Monteiro and Priftis, 2017; Felix, 2018). The rate of investment by non-financial corporations dropped by half in just two years, from 24% in 2008 to a low of 12% in 2010 (Eurostat, 2019).

This paper is related to the extensive literature that uses quasi-experimental tax reforms to obtain causal evidence of the impact of several features of the tax code on firm behaviour. Researchers have tried several methodological approaches to estimate investment undertaken in response to different types of incentives, obtaining mixed results. The results highlight some interesting factors that influence firm take-up.

Blattner, Farinha, and Rebelo (2017) analyze an investment tax credit that was enacted in 2014 in Portugal, using an instrumental variable linear probability model. The authors are interested in the the extent to which the demand faced by Portuguese firms and their

level of indebtedness affect the probability of taking up the tax credit, finding that the latter is particularly relevant in firms' investment decisions. The instrumental variable for foreign demand for exporting firms allows the authors to more plausibly capture the exogenous variation in firm sales.

Another line of research has looked at the impact of carryback rules, according to which firms may claim immediate tax refunds for taxes paid in previous years when facing negative net operating income. Dobridge (2016) analyses the extension of a two to five year carryback deduction in the US in 2002 and 2009, using a regression kink design based on the fact that firms can only offset past tax liability up to the point where previous-years' taxable income is equal to current losses. The main conclusion of the paper is that firms increase investment when given larger tax refunds in 2002, but not in 2009, in which they use refunds to pay down debt and increase cash holdings, reducing bankruptcy risk.

Bethmann, Jacob, and Müller (2016) use country-level variation in two types of provisions: carryback, where firms get a refund on their previous tax bill, vs carryfoward, where firms get a tax credit for the future. They show that firms that make consecutive losses and thus cannot benefit from carryforward invest more in the five OECD countries that follow carryback provisions.

Accelerated depreciation schedules of investment in equipment allow firms to pay less taxes in the period following the acquisition. The findings for this type of incentive are more conclusive than for other types. House and Shapiro (2008) use a depreciation bonus of 2002–2003 to estimate a structural model of investment choices and find large elasticities of investment. Zwick and Mahon (2017) also find a positive response of investment, using administrative tax data to estimate a difference-in-differences specification where the treatment group is made of firms with "long" depreciation duration type of investment and focusing on two depreciation bonus periods: 2002–2003 and 2008–2010.

The impact of dividend tax cuts has been studied by Yagan (2015), who focuses on the 2003 individual dividend income tax cut in the US from 38.6 to 15%. This paper also uses a difference-in-differences strategy based on the fact that S-corporations are unaffected

by the tax change while C-corporations are not, and finds no impact in investment or wages. Alstadsæter, Jacob, and Michaely (2017), on the other hand, find a positive impact of a similar tax cut implemented in Sweden in 2006, with a stronger increase for cash-constrained firms. The authors use a triple difference strategy that compares cash-constrained firms with those that own internal resources. The authors also exploit the fact that "closely-held" corporations faced a more generous tax cut of 10 percentage points, compared with 5 percentage point for "widely-held" ones.

Another feature of the tax code with implications for investment is the US 2004 tax holiday for foreign earnings repatriation. The studies of Blouin and Krull (2009) and Dharmapala, Foley, and Forbes (2011) find no real effects on investment, but an increase in shareholder payouts. Faulkender and Petersen (2012), on the other hand, find that highly financially constrained firms do increase investment.

In this paper, we analyze a more direct incentive than the types explored in many other papers, using a difference-in-differences approach to isolate its causal impact on investment. Our main results are as follows: first, we find a significant positive effect on investment from a program intended to stimulate investment in the poorer regions of Portugal. This effect appears to alleviate an overall negative trend for investment by Portuguese firms post-2009. Eligible firms also shifted some investment from eligible to non-eligible types, with effects largely driven by geographical targeting of the incentives. Although information obtained with a more detailed dataset later revealed issues with the variation used to develop the identification strategy, the results of this paper highlight some important trends that inform the approach used in an extension with the new data in Chapter 4.

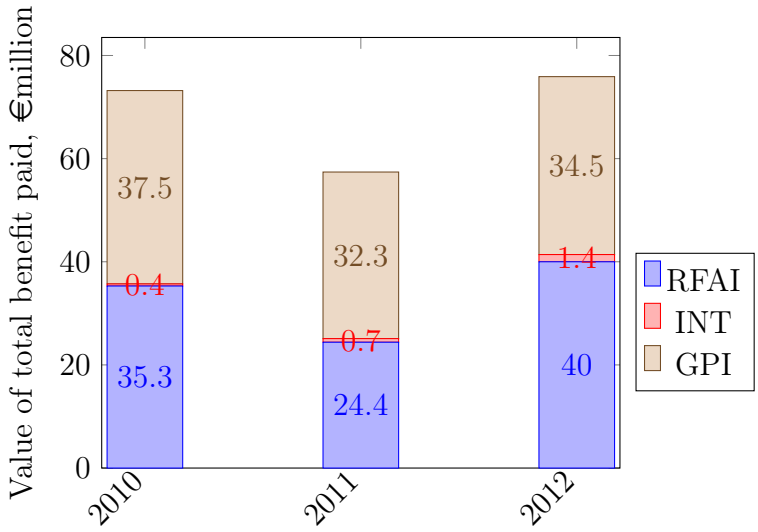
The remainder of the paper is organized as follows. In Section 4.2 we briefly describe the Portuguese corporate tax system and the investment tax credit introduced in 2009. In Section 3.3 we describe the data used in the analysis, and provide some descriptive statistics. Section 3.4 lays out the identification strategy. In Sections 3.5 and 3.6 we outline the results, conclusions, and next steps. Additional tables are provided in Appendix C.

3.2 Institutional Context

The Fiscal Regime for Investment Support (in Portuguese "Regime Fiscal de Apoio ao Investiment," hereafter RFAI) was introduced as part of a broader "Initiative on Investment and Employment" which had the very ambitious goal of promoting economic growth and employment, modernizing firms, and making them more competitive in the aftermath of the 2008 crisis (Assembleia da Republica Portuguesa, 2009a; 2009b; Grupo Moneris, 2009). The initiative was part of a broader movement to stabilize and structure investment activities in Portugal for both domestic and international investors, codified in September of the same in year in the "Fiscal Code for Investment" (CFI). [2]

The aggregate take-up of the incentives introduced in 2009 reached 75 million euro in 2012, with about half claimed under RFAI *(see figure 4.1)*.

Figure 3.1: Aggregate Tax Credit Takeup: 2010-2012



Note: RFAI accounted for about half of the total take-up of tax incentives introduced in 2009, including a program aimed at large investment projects (GPI) and one targeting internationalizing firms (INT). The total take-up accounted for about 1.6% of total corporate tax revenue in 2012 (2016).

The RFAI allows the firms to claim a tax credit of up to 25% of their total tax bill. The tax credit is equal to 20% of the total investment up to five million euros, and 10% of

[2]The RFAI was introduced in number 13 of the Law 10/2009 (March 10, 2009) and subsequently modified in 2013. The broader "Codigo Fiscal do Investimento" was subsequently defined in law 249/2009 of September 2009. In this paper we highlight the conditions of RFAI in its first iteration. For more details, see tables D.3, D.4 and D.5 in Appendix D.

the amount above five million. In the event that the firm cannot claim the full credit in the year of the investment, it can defer it up to four years, giving it a total of five years to claim the credit. The eligible investment in intangibles is limited to technological transfer (patents and licences). As regards tangible investment, it includes: all types of machinery and equipment; vehicles are excluded; furniture is eligible for firms in the hotel sector; land is eligible for firms in extractive industries; social equipment which the firms are required to have by law are also eligible. In other words, the tax credit is limited to acquisition of tangible investment goods that are directly related to the firm's activity. The tax credit is limited to firms in the following sectors: extractive and transformative industry (with the exception of steel industry, shipbuilding, synthetic fabric); tourism; broadband; agriculture and forestry; energy; telecommunications *(see table C.1 in Appendix C for the corresponding NACE codes).* [3]

Moreover, if the investment involves buildings, the firms are granted a 5-year exemption of the municipal property tax and are exempt from paying the indirect tax and the stamp tax on real estate purchases.[4]

In addition, the RFAI imposes the following conditions

- eligibility is conditional upon the firm not having debts towards the tax authority or social security and enjoying good financial health
- firms must keep the investment in the firm and in the region for a minimum of five years
- the investment project should create at least one job vacancy
- firms which do not qualify as micro, small or medium cannot claim more than 50% of investment in technology transfer, such as patents or licences.[5]

[3] Additional eligible sectors under CFI were IT services, research and development, and audio-visual production.

[4] These exemptions are subject to the approval of municipal authorities of the "regional interest of the investment".

[5] According to the official EU definition, micro firms have less than 10 employees and an annual cash flow or balance sheet below 2 million euros; small firms have less than 50 employees and an annual cash flow or balance sheet below 10 million euros; medium firms have less than 250 employees, and an annual cash flow below 50 million euros or an annual balance sheet below 43 million euros.

Importantly, the RFAI entails NUTS 3 regional variation which we shall use in our identification strategy. The regional limits respect the general EU rules on regional aid, and are based on the so-called "aid intensity", which is present value gross aid expressed as a percentage of present value eligible costs, before any deduction of tax or other charge. It includes not only the corporate income tax credit but also the exemptions in property real estate purchase taxes.

The aid intensity caps vary between ten and fifty percent of investment spending in the eligible regions.[6] The NUTS 3 areas not eligible for RFAI were those in the larger regions of Grande Lisboa (with the exception of Alhandra, Alverca do Ribatejo, and Vila Franca de Xira), and Setubal (with the exception of Setubal, Palmela, Montijo, and Alcohete).

Despite the fact that only a few NUTS 3 regions were excluded from those covered by the credit, much economic activity is concentrated in these areas. Of the firms in our database, about 30% were located in the excluded regions during the relevant time period, but these firms accounted for about 45% of total annual turnover and more than 50% of total annual operating profit.

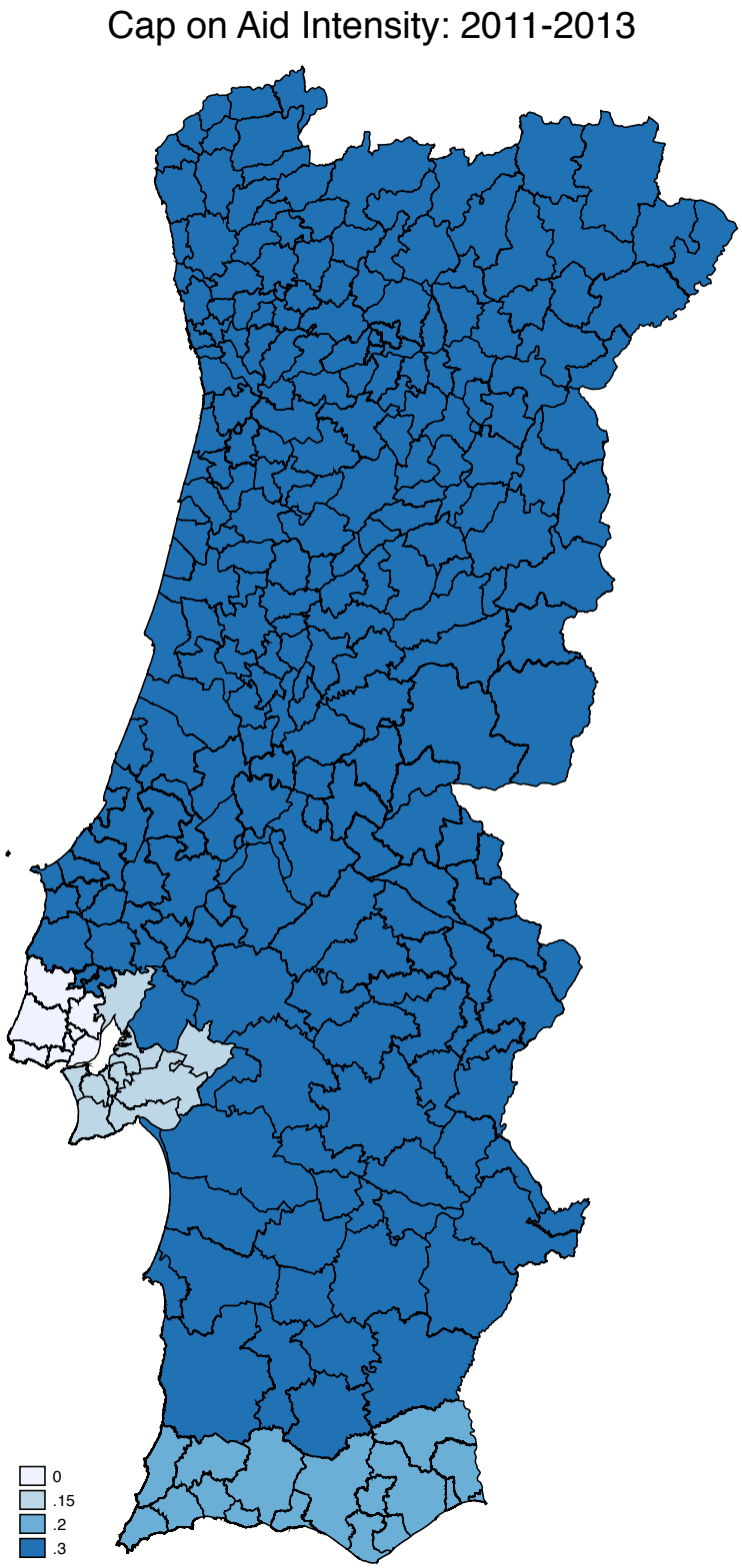
The caps are increased by 10 percentage points for medium firms, and by 20 percentage points for small firms. Figure 3.2 shows the variation in the baseline aid intensity (regardless of firm size) in the Portuguese municipalities in 2010.

For a rough back-of-the-envelope estimate of the magnitude of the implied tax credit, we take the case of a small firm located in the North of Portugal, where the maximum credit was 30% of the eligible investment. Because of the firm's size, its maximum credit is increased by 20 percentage points to 50%. Assuming this firm has taxable profits of €1 million in 2010, it faces a statutory corporate tax rate of 25% and a tax bill of €250,000, with a maximum potential credit of €62,500 (*see table D.6 for relevant corporate tax rates in Portugal from 2010-2014*).[7] If the firm makes an eligible investment of €100,000, it can claim a credit of €50,000, reducing its total tax bill to €200,000 and its effective tax rate

[6]There is a change in the cap for some NUTS 3 in 2011, but the control group of municipalities remains the same.

[7]The rates cited here are for resident entities and permanent establishments of non-resident entities that exercise commercial, industrial, or agricultural activities as their main activity in Portugal.

Figure 3.2



to 20%.

Table 3.1: Corporate Taxation in Portugal: 2010-2014

		2010-2011		2012	2013	2014	
		< €12,500	> €12,500			< €15,000	> €15,000
BASE RATE	Continent	12.5%	25%	25%	25%	23%/17%*	23%
	Madeira	10%	25%	25%	25%	23%/17%*	23%
	Azores	8.75%	17.5%	17.5%	17.5%	18.4%/13.6%*	18.4%

Note: Tax rates as reported by PWC in their annual summary of corporate taxation in Portugal. SMEs are micro, small, and medium-sized enterprises, defined by the European Commission as firms with less than 250 employees and either less than €50 million in annual turnover or a balance sheet total of less than €43 million. *Second set of numbers in 2014 for firms with less than €15,000 taxable profit applies to firms with SME designation.
Source: PricewaterhouseCoopers (2014)

Our data does not allow us to compute a comprehensive measure of aid intensity for each firm, since we do not have individual tax records. We use the regional variation for two purposes. First, we use the regions that do not benefit from any aid to create a control group. Secondly, we use the aid intensity caps as a measure of treatment intensity.

Without individual tax records, we are also not able to distinguish which of the specific tax credits introduced in 2009 a firm in an eligible sector and region may have claimed. Separately estimating a difference-in-differences regression on only the sectoral treatment, however, can give an indication of whether the region-based eligibility restrictions had an impact or not.

3.3 Data

We obtained the anonymized set of firms' annual account data from 2004-2012 from the Portuguese National Statistical Office (INE). Firms' names are removed and fictional ids are assigned. Any category with too few firms is also removed, to prevent identification of

firms through these characteristics.

This data allows us to identify the sector of economic activity of each firm through its NACE code, as well as its location at the NUTS-II level. For reasons of anonymity, however, more detailed location information of the firms is not included in the INE dataset. To assign the NUTS 3 level needed to divide the firms on geographical eligibility, we used a more detailed confidential dataset available in INE's SafeCenter facility. With this dataset we are able to identify the region of each firm, but beacuse of confidentiality constraints we could not export it at the firm-level NUTS 3 level. We instead constructed a variable taking a value of one if the firm was located in an eligible region, and zero if located in the control regions in Grande Lisboa or Setubal. We also created a variable representing the aid intensity cap according to the firm's location.

The main limitation of this approach is the inability to add location fixed effects to the regression estimation to control for specific shocks in any municipalities. We instead include the aid intensity cap as a control variable in the regression as an attempt to partially capture these effects.

Table 3.2: Summary Statistics Pre-Treatment: Treated vs Non-Treated Sectors

	Control		Treated		Difference	
	mean	sd	mean	sd	b	t
Total Investment	5.71	4.76	6.80	4.85	-1.19***	(-166.56)
Investment in tangibles	5.22	4.53	6.27	4.65	-1.14***	(-166.80)
Investment in intangibles	0.97	2.31	1.27	2.75	-0.30***	(-81.96)
Staff	7.13	83.31	12.29	49.10	-5.02***	(-60.03)
Turnover	10.27	4.07	10.55	4.20	-0.29***	(-48.14)
Third-party supplies & services	9.69	2.34	9.99	2.49	-0.33***	(-94.99)
Personnel costs	8.41	4.09	9.11	4.14	-0.68***	(-112.34)
Operating profit	9.22	1.81	9.51	1.88	-0.32***	(-89.45)
Net earnings	8.63	1.95	8.86	2.01	-0.25***	(-65.57)
Observations	1393566		388277		2855383	

Note: All values except Staff in logs.

Summary statistics are presented in tables 3.2 and 3.3. For the estimations on the interaction between sectoral and geographic eligibility, only the sectors eligible for RFAI were selected for the sectoral treatment. The estimations on sectoral eligibility alone

Table 3.3: Summary Statistics Pre-Treatment: Treated vs. Non-Treated Regions

	Control		Treated		Difference	
	mean	sd	mean	sd	b	t
Total investment	5.52	4.86	6.14	4.76	-0.68***	(-108.86)
Investment in tangibles	5.04	4.60	5.64	4.55	-0.65***	(-109.09)
Investment in intangibles	0.94	2.38	1.08	2.43	-0.11***	(-35.53)
Staff	9.48	110.71	7.70	55.36	1.92***	(14.78)
Turnover	10.15	4.24	10.41	4.02	-0.28***	(-51.73)
Third-party supplies & services	9.85	2.44	9.71	2.35	0.14***	(45.56)
Personnel costs	8.27	4.34	8.70	4.00	-0.46***	(-84.36)
Operating profit	9.33	1.96	9.26	1.77	0.07***	(20.37)
Net earnings	8.77	2.09	8.64	1.91	0.12***	(35.48)
Observations	560742		1221101		2855383	

Note: All values except Staff in logs.

include the full set of sectors eligible under the CFI. [8]

Firms in sectors eligible for tax credits under CFI make up about 20% of those in our dataset. In the pre-treatment period, these firms were significantly larger in all measures of profit and in personnel costs, invested more, and had more employees *(see table 3.2)*.[9] This is a sign that these firms are already more prone to invest, an effect that could confound the difference-in-difference estimates.

70% of firms in our sample are located in NUTS 3 regions eligible for the tax credit. and tended to be smaller and less profitable than those in the non-eligible regions pre-RFAI *(see table 3.3)*. They also invested less before 2009, which could bias treatment effects upwards.

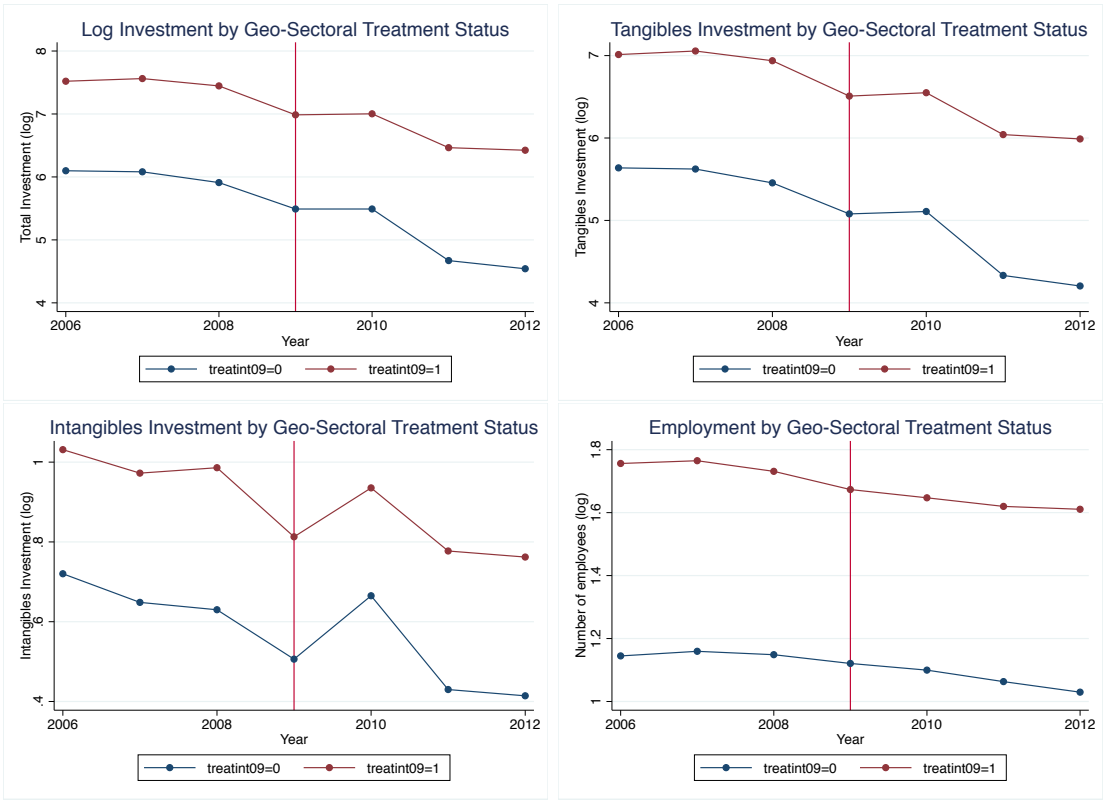
The pool of firms eligible to claim the tax credit under both the sector and geographical requirements of RFAI represents about 16% of those in the dataset. When compared to firms in non-eligible regions and sectors in the years just before RFAI, they were larger and invested more.

[8]The definition of sectoral eligibility under RFAI and CFI was aligned in later revisions to RFAI. To account for uncertainty in when and how the alignment was applied, we tested specifications with both configurations. The sign and statistical significance of the coefficients on treatment variables is robust to either specification.

[9]To account for the subjective financial health criteria, we look only at firms with operating income above zero.

We use graphical analysis of pre-treatment trends in the variables of interest to determine whether trends in the outcome variables were comparable between control and treatment firms, as seen in figure 3.3. Although trends appear parallel pre-reform, the treatment effects may reflect differences in underlying propensities to invest rather than an effect of the program, particularly as firms' capacity to invest may affect their selection of sector or location. Additionally, firms with more baseline investment may have a greater capacity to recover from an economic shock such as the one that hit Portugal precisely at the time period of the policy intervention, a further challenge to the isolation of treatment effects.

Figure 3.3: Common trends between control and treatment groups: Sectoral and geographical eligibility



Note: Common trends in the dependent variables appear to be parallel between control and treatment groups, for both the sectoral and geographical treatments. Firms in targeted sectors and municipalities are designated by treatint09=1. The treatment period is defined as 2010 to 2012. See table C.1 in Appendix C for separate plots by sectoral and geographical treatment.

3.4 Identification Strategy

We follow the theoretical approach of House and Shapiro (2008) to model the firm's investment decision in response to RFAI.

In this model, the firm chooses its gross investment in capital I of type m in time t, and its stock of capital K in time $t + 1$, to maximize its present discounted value of profits. The firm's profit maximization function is given by:

$$\sum_{j=0}^{\infty}\{(1-\tau_{t+j}^{d})(1-\tau_{t+j}^{\pi})F(K_{t+j}^{1},K_{t+j}^{2},...K_{t+j}^{M})-\sum_{m=1}^{M}\varphi_{t+j}^{m}(1-\zeta_{t+j}^{m})\} \tag{3.1}$$

where $F(K_{t+j}^{1},K_{t+j}^{2},...K_{t+j}^{M})$ is the firm's production function measured in units of a good K, τ^{π} is the tax rate on profit, τ^{d} is the tax rate on the distribution of capital income, φ^{m} is the real relative price of capital of type m, and ζ^{m} represents any subsidies on new purchases of capital of type m, including tax credits such as RFAI.

The firm is subject to the constraint that next-period capital is equal to the depreciated value of the current period's capital plus investment in the current period:

$$K_{t+1}^{m}=K_{t}^{m}(1-\delta^{m})+I_{t}^{m} \tag{3.2}$$

When the government announces a policy to temporarily increase the subsidy on purchases of a type m of capital that has a low rate of depreciation, this subsidy has a direct impact on the price of type m capital relative to other types of capital, and the firm will increase its investment in this type of capital during the period of the subsidy. At the expiration of the subsidy, the firm's investment will return to its pre-subsidy steady-state levels.

The model is directly applicable to RFAI, which provided a tax credit largely aimed at investment in tangible goods. Eligible firms can therefore be expected to increase their

overall levels of investment during the period covered by RFAI, and could also be expected to shift some investment from ineligible to eligible types as the relative prices change.

To empirically test this hypothesis, we use a difference-in-differences regression analysis on sectoral eligibility for RFAI and a triple differences estimation with geographical eligibility. We test the effects on four different dependent variables: total investment and investment in tangibles (largely eligible for the credit), investment in intangibles (largely ineligible), and number of employees.[10]

The difference-in-differences regression equation for sectoral treatment is given by:

$$\log(Y)_{it} = \alpha_i + \beta_1 D_t^{Year} + \beta_2 D_{it}^{sector} + \beta_3 D_t^{Year} D_{it}^{sector} + \beta_4 X_{it-1} + \beta_5 i.year + \epsilon_{it}$$

The triple-differences equation with the additional geographical treatment is given by:

$$\begin{aligned}\log(Y)_{it} =& \alpha_i + \beta_1 D_t^{Year} + \beta_2 D_{it}^{sector} + \beta_3 D_{it}^{location} + \beta_4 D_t^{Year} D_{it}^{sector} + \\ & \beta_5 D_t^{Year} D_{it}^{location} + \beta_6 D_{it}^{location} D_{it}^{sector} + \beta_7 D_t^{Year} D_{it}^{sector} D_{it}^{location} + \\ & \beta_8 X_{it-1} + \beta_9 i.year + \epsilon_{it}\end{aligned}$$

where α represents a set of firm-specific characteristics and the treatment variables are D_{Year} for the treatment peirod, D_{sector} for eligible sectors, and $D_{location}$ for eligible regions.

The control variables X_{it-1} are turnover, third-party supplies and services, personnel costs (excluded when the dependent variable is number of employees), operating profit, and net earnings.[11] They are selected after review of the literature on key performance indicators of firms, with the restriction that data must be available in all years for the

[10] All variables are taken in log form.

[11] Portuguese terms used in the data are as follows: Turnover - *Volume de negocios (vendas e servicos prestados)*. Third-party supplies and services - *Fornecimentos e serviĉs externos (FSE)*. Personnel costs - *Gastos com o pessoal*. Operating profit - *Resultado operacional*. Net earnings - *Resultado liquido do período*. Staff - *Pessoal ao servico*.

firms in scope.[12] All of the control variables are taken in T-1 with relation to the outcome and treatment variables.

The time treatment is set to one from 2010-2012, and zero in all preceding years. To account for the subjective financial health eligibility criteria, we restrict the analysis to firms with operating profit above zero in all years.

Firm and sectoral fixed effects are also included, and standard errors are clustered by sector. Different outcome variables are tested, including total investment, investment in tangible and intangible goods, and the number of employees.

3.5 Results

We first estimate the effect of RFAI on total investment by firms. The sectoral difference-in-differences estimation, shown in table 3.4, shows a significant and positive effect of being in a treated sector after 2009, counterbalancing a significant negative effect overall post-2009. This suggests that while overall, firms decreased their investment after 2009, firms in targeted sectors were better able to recover than those in non-targeted sectors.[13] While this could reflect an impact of RFAI, it could also be due to the fact that these firms had a higher inherent capacity for investment, which may have helped them bounce back more quickly.

Differentiation between eligible and ineligible types of investment gives some suggestion that RFAI played a role in driving the effects, but the results are not conclusive. When looking at investment in fixed tangible goods, which were the main category of eligible investment, there is a positive and significant effect of being in a treated sector, again counteracting an overall negative time effect in the post-2009 period. The relationship is reversed for intangible investment, which was for the most part ineligible. This suggests that firms in eligible sectors may have indeed shifted investment to eligible types to take

[12] Information on other firm characteristics known to influence investment decisions were not consistently available in the IES dataset, notably leverage, assets, cash holdings and flow, and PPE. These variables are included in the extension applied in Chapter 4.

[13] The size, sign, and significance of the results varies only slightly where the sectoral treatment is restricted to the same subset of firms eligible only for RFAI.

advantage of the credit. The positive trend in tangibles could again be due to inherent recovery capacity, although the negative effect on intangibles – in which treated firms also invested more pre-reform – suggests there may be some switching effect.

Investment in intangibles can be an imprecise measure, as firms have latitude in determining what is an intangible and how to value it. However, the general conclusions based on this variable hold if we assume that this variation is captured by the firm-level fixed effect, i.e. that firms tend to classify their intangibles in the same way over time.

We tested several specifications of the regression equation with different combinations of controls to see whether certain variables changed the results when added to the model[14]. Being in a treated sector alone is not statistically significant in any specification, but the trend post-reform is always statistically significant and negative, meaning that firms overall decreased their investment in tangibles and overall in the post-treatment period *(see table C.9 in Appendix C)*. The interaction between sectoral treatment and the time dummy is statistically significant on its own, but not with every combination of control variables – its magnitude and sign are however similar on their own as in the full model. This suggests that we are capturing some noise in the interaction between the impact of the sectoral treatment and trends in other control variables on investment, although without a more detailed sector-by-sector investigation we cannot know for certain what this dynamic is.

[14]See tables C.9, C.10, C.11, and C.12 in Appendix C for results of key specifications. The conclusions from the sequential addition of variables are the same for investment in tangibles and intangibles as for total investment – the sectoral treatment alone is not statistically significant, the post-treatment period has a significant and negative effect in all specifications, and the interaction is significant when all controls are taken into account.

Table 3.4: Effect on Investment: Sectoral Treatment

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.01	0.01	0.00
	(0.010)	(0.010)	(0.002)
Third-party supplies	0.13***	0.13***	0.00
	(0.011)	(0.011)	(0.004)
Operating profit	-0.02*	-0.02**	-0.01**
	(0.009)	(0.009)	(0.004)
Net earnings	0.12***	0.12***	0.01***
	(0.006)	(0.006)	(0.003)
Personnel costs	0.01**	0.01*	0.00***
	(0.005)	(0.004)	(0.002)
Treated sector	-0.01	0.02	-0.13
	(0.107)	(0.099)	(0.095)
post-ITC09	-0.90***	-0.83***	0.18***
	(0.090)	(0.084)	(0.020)
Treated sector & post-ITC09	0.14*	0.13*	-0.06**
	(0.077)	(0.073)	(0.029)
Treatment intensity	0.44	0.55	0.27
	(0.446)	(0.415)	(0.281)
Constant	4.11***	3.75***	0.40***
	(0.286)	(0.271)	(0.086)
Observations	1,025,624	1,025,626	1,025,624
R^2	0.040	0.039	0.002
Number of firms	302,499	302,501	302,499

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

When geographical eligibility is added to the model it dominates the sectoral effect, as seen in table 3.5. While neither the coefficient on sector or geographical location is significant on its own or in combination with the time treatment variable, the triple interaction is statistically significant and positive for overall investment and investment in tangibles. The estimated coefficient on investment in intangibles is not statistically significant.

The fact that the interaction between sectoral and time treatment loses its statistical significance when the regional treatment is added to the model indicates the dominance of the geographical effect, supported by the sequential specifications *(see table C.10 in Appendix C)*. A difference-in-differences estimation of the sectoral effect among only firms in ineligible regions also shows no significant effect *(see table C.2 in appendix)*, a further indication that the difference between treated and non-treated sectors is concentrated outside of the non-eligible regions. However, it also highlights the difficulty in disentangling the effects of the different incentives introduced in 2009, particularly as many firms in sectors eligible under one of the other programs were also located in one of the regions covered under RFAI. Again, the results are robust to specifications of the sectoral treatment variable using either the CFI or RFAI definitions.

Treatment intensity, defined as the maximum baseline aid cap in the firm's municipality, does not have a statistically significant effect in any estimation. We keep the variable as a very general proxy for the firm's location, given the limitations on use of the geographical data and the inability to add municipal-level fixed effects. However, the fact that the variable is never significant reflects the imprecise nature of the proxy and the large variation in the cap based on firm characteristics, which are captured in the firm fixed effects. The results do not change when this variable is excluded from the model.

The coefficient on the post-RFAI variable is significant in all of the investment estimations and highlights an overall negative trend in total and tangibles investment from 2010 to 2012, and a positive trend in investment in intangibles.

Table 3.5: Effect on Investment: Geo-Sectoral Treatment

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.01	0.01	0.00
	(0.010)	(0.010)	(0.002)
Third-party supplies	0.13***	0.13***	0.00
	(0.011)	(0.011)	(0.004)
Operating profit	-0.02*	-0.02**	-0.01**
	(0.009)	(0.009)	(0.004)
Net earnings	0.12***	0.12***	0.01***
	(0.006)	(0.006)	(0.003)
Personnel costs	0.01**	0.01*	0.00***
	(0.005)	(0.004)	(0.002)
Treated sector	-0.00	0.01	-0.23
	(0.149)	(0.135)	(0.143)
Post-ITC09	-0.88***	-0.81***	0.19***
	(0.100)	(0.094)	(0.024)
Treated sector & Post-ITC09	-0.07	-0.08	-0.01
	(0.093)	(0.089)	(0.050)
Treated region	-0.13	-0.06	0.38
	(0.392)	(0.371)	(0.282)
Treated sector & Treated region	0.01	0.01	0.10
	(0.158)	(0.147)	(0.101)
Post-ITC09 & Treated region	-0.03	-0.03	-0.00
	(0.046)	(0.043)	(0.019)
Treated sector & region & Post-ITC09	0.28***	0.28***	-0.07
	(0.076)	(0.074)	(0.049)
Treatment intensity	0.80	0.70	-0.92
	(1.326)	(1.254)	(0.889)
Constant	4.12***	3.76***	0.41***
	(0.284)	(0.269)	(0.089)
Observations	1,025,624	1,025,626	1,025,624
R^2	0.040	0.039	0.002
Number of firms	302,499	302,501	302,499

Robust standard errors in parentheses

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

Firm and time FE with SE clustered by sector

As seen in Table 3.6, RFAI does not appear to have had any effect on employment in firms in treated sectors and regions as measured by the log number of employees. The estimated coefficient on sector alone is positive and significant in both regressions, reflecting the larger size of firms in targeted sectors when compared to the control group. The same holds for region on its own, and for the interaction between sector and region. However, the statistical significance drops away when the time interaction is added.

The geographical treatment itself has a significant and positive effect on its own, which disappears with the inclusion of firm-level control variables *(see table 3.6, and tables C.11 and C.12 in Appendix C)*. This suggests a differential trend in hiring between eligible and non-eligible regions that is driven by trends in firm performance, although without the ability to include location fixed effects it is difficult to known more about why this is the case.

Table 3.6: Effect on number of employees (log)

	(1)	(2)
VARIABLES	Sectoral Treatment Effect	Geo-Sectoral Treatment Effect
Turnover	0.03***	0.03***
	(0.008)	(0.008)
Third-party supplies	0.06***	0.06***
	(0.004)	(0.004)
Operating profit	0.02***	0.02***
	(0.001)	(0.001)
Net earnings	-0.01***	-0.01***
	(0.001)	(0.001)
Treated sector	0.08***	0.08***
		(0.021)
Post-ITC09	0.00	0.00
	(0.011)	(0.009)
Treated sector & Post-ITC09	-0.00	-0.01
		(0.014)
Treated region		0.02
		(0.058)
Treated sector & Treated region		0.03
		(0.020)
Treated sector & region & Post-ITC09		0.01
		(0.012)
Treatment intensity	0.18***	0.09
	(0.060)	(0.183)
Constant	0.10	0.10
	(0.104)	(0.103)
Observations	1,025,632	1,025,632
R^2	0.049	0.049
Number of firms	302,504	302,504

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Third-party supplies and services and net earnings have a statistically significant effect in all regression equations, with net earnings estimated with a positive effect on the investment variables and a slightly negative effect on employment. Operating profit is also significant and negative in the investment regressions, and positive in the estimation on employment. This confirms the importance of firm health and performance in investment decisions.

The results are robust to several specifications using different sub-samples of the data. We ran the regression on a sub-sample of 58,589 firms in eligible sectors matched to comparable firms in non-eligible sectors in 2009, using one-to-one nearest-neighbor matching on the set of control variables *(see tables C.3, C.4, and C.5 in Appendix C)*.[15] Although the matching lends some control for inherent differences in investment capacity, it does so only to the extent that the selected observable matching variables capture this effect. The sign and statistical significance of the results remain the same for the investment variables, although the magnitude of the estimated coefficients for the treatment variables is slightly higher for the sectoral treatment and slightly lower for the geo-sectoral treatment in the restricted sample. There is again no estimated impact on employment for the restricted sample.

The results for the triple-differences interaction also held when using a sub-sample of firms matched by geographical treatment status, i.e. firms in treated regions matched to counterparts in non-treated regions, using the same matching technique *(see tables C.6, C.7, and C.8 in Appendix C)*. [16] However, the sectoral treatment on its own became statistically insignificant, suggesting again that the geographical effect dominates the sectoral one.

Finally, the statistical significance of all treatment interactions drops away when using a placebo interaction time that takes only the pre-reform period 2005-2009 and defines treatment years as 2007-2009. Unfortunately this provides only a weak support for the time trend, as the placebo period is not characterized by a concurrent crisis as the treatment period is.

[15] Matching is conducted using the R package *MatchIt* (Ho et al., 2011)

[16] We were only able to find a suitable match for slightly less than 50% of the firms in treated regions.

The very low R-squared (less than 5%) in all of the regression equations indicates that many determinants of investment and employment are not accounted for by the control variables. The fact that the treatment variables are still strongly statistically significant suggests that despite high variation in investment between firms, the difference-in-differences estimations capture within-firm variation related to the effect of being in a sector and region targeted by RFAI. However, this means it also captures inherent differences in firms' capacity to invest which may both bias selection into treated sectors, and affect their ability to recover post-crisis.

Event studies of the estimated treatment dummy coefficients alone on the various dependent variables provide a graphical depiction of this relationship *(see figure C.2 in Appendix C).*

3.6 Conclusions

To better understand the results of the paper, we obtained a dataset from the Portuguese Tax Authority which matched each firm to its take-up of the RFAI. With this matching, we were able to identify the sectors and locations of firms actually taking advantage of the credit. We discovered that many firms in non-eligible sectors and locations were granted a credit under RFAI, invaliding the difference-in-differences identification strategy. This is likely due to the provision in the law which allowed firms in non-eligible sectors to claim the credit for investment in broadband equipment and infrastructure, which gives the tax authorities more latitude in granting the credit. There is an additional mismatch in the geographical identification strategy, since the restrictions on the geographical eligibility apply to the location of the firm's investment while the variable in our dataset indicates the headquarters location of the firm itself. Using the matched dataset, we also found that many firms with headquarters in ineligible locations claimed the RFAI credit, suggesting that they or their subsidiaries were undertaking investment in eligible regions to take advantage of RFAI. We also find that take-up rates within treated sectors were very low – at most 3% – diluting the treatment effect to an extent that presents a further challenge to a difference-in-differences approach.

The extension of this paper with the results from the matched dataset can be found in Chapter 4. We use nearest neighbor matching to estimate the average effect of the treatment on the treated firms, defined as those who claimed the RFAI at least once between 2009 and 2015. We find significant and positive effects on investment and employment. While this approach allows us to use the information on firm take-up, it relies on the strong assumption that the measurable attributes used in the matching capture all determinants of investment other than the tax credit. A clean difference-in-differences estimation where firm eligibility was truly determined by sector or location would have allowed us to use the panel data structure to control for inobservable firm characteristics.

Given the information obtained from the tax authority, the results found in this paper

are likely to reflect general conditions in the targeted sectors and regions rather than a specific effect of the RFAI, highlighting the importance of controlling for these dynamics as we do in the matching estimation. Because investment in nearly all regions is eligible for the RFAI, and because the information from the matched dataset suggests many firms are not investing in their headquarters location, the strength of the geographical result is more indicative of specific negative trends for firms located around Lisbon, which were probably more exposed to the international downturn in the same time period.

Empirical analysis of public policy plays an important role in the effective design of policies to aid economic recovery. This paper informs our selection of variables for the matching estimation used in the next phase of the study, contributing to the literature on the efficacy of temporary credits to investment.

Chapter 4

Can tax credits raise investment and employment? An empirical assessment in a crisis-hit country [1]

4.1 Introduction

As highlighted in Chapter 3, it is difficult to demonstrate empirically whether and how policy interventions stimulate investment by firms. It becomes even more difficult when these interventions come in a time of crisis. The question becomes whether firms invested more because of the intervention, or whether the effects reflect natural recovery from recession.

In this paper, we examine the effects of a Portuguese investment tax credit. We are able to combine administrative data on firm characteristics with the exact amount of their take-up for a matching estimation. The availability of this dataset allows us to overcome some of the challenges to the identification strategy in the analysis of the same credit in Chapter 3. We use results from the literature pointing to the importance of cash

[1] This is a joint work with Miguel Ferreira, Ana Gouveia, and Susana Peralta.

constraints and leverage in firms' take-up of tax credits to refine our selection of variables for the matching. Our identification strategy and rich administrative dataset allow us to assess the efficacy of a program which is available to all type of firms and could easily be implemented in other countries seeking to stimulate investment. Additionally, the type of investment targeted by the program – spending on tangibles – can be measured more reliably than for example spending on R&D. We find significant and positive effects on investment, employment, and growth in other key indicators of firm performance for firms taking advantage of RFAI.

This paper contributes to the recent literature on the effectiveness of different ways in which governments use the corporate tax code to stimulate investment. Thanks to detailed information from the combination of tax authority data and administrative accounting records, we are able to directly link firm-level characteristics to takeup of the incentive in Portugal to estimate its incremental impact on employment and investment. The use of the tax code to stimulate corporate investment figures prominently in the Portuguese government's efforts to rebuild and strengthen its economy in the wake of the crisis – indeed in February 2019, Portuguese Prime Minister Antonio Costa affirmed publicly that "Portugal has the second best tax regime to support corporate investment." Empirical tests of the effects of tax reforms such as those implemented in Portugal in recent years help in evaluating and fine-tuning such policies.

The literature has examined several different types of tax reform, including different types of tax loss deductions, changes to depreciation schedules, dividend income tax cuts, tax holidays for the repatriation of foreign earnings, and credits for investment in research and development *(see table 4.1)*. The results are mixed, with variation depending on factors including the country, general economic conditions, and the financial position of firms.

Dobridge (2016) analyzes the extension of a two to five-year carryback deduction in the US in 2002 and 2009 using a regression kink design. The main conclusion of the paper is that firms increase investment when given larger tax refunds in 2002 but not in

2009, in which they use refunds to pay down debt and increase cash holdings, reducing bankruptcy risk. The author concludes that the characteristics of the two recessions drive the differential behaviour of the firms.

Bethmann, Jacob, and Müller (2016) use country-level variation in the use of carryback and carryfoward provisions in 21 European countries. Using a difference-in-differences design, they exploit the fact that firms making losses in consecutive years would be unable to claim a refund in countries allowing for only carryforward deductions. The authors find that these firms invest more in the five countries that allow for carryback provisions, where they can have easier access to liquidity. The same type of cross-country variation is used by Langenmayr and Lester (2017) to estimate the impact of such offset provisions on firm risk-taking, finding a positive correlation with both types.

House and Shapiro (2008) use a depreciation bonus of 2002–2003 in the US to estimate a structural model of investment choices, finding large elasticities of investment. Zwick and Mahon (2017) extend the results of House and Shapiro (2008) by adding a second period of analysis from 2008–2010, and using administrative tax data for a difference-in-differences setup. They compare the investment response of firms with short vs. long-duration investment, who benefit to different extents from the bonus, and find a positive response consistent with the results of the previous study. They also find that firms only respond when the cash flow benefits accrue immediately.

Yagan (2015) focuses on the 2003 individual dividend income tax cut in the US that reduced the rate from 38.6 to 15%. The author uses a difference-in-differences strategy based on the fact that S-corporations are unaffected by the tax change while C-corporations are not, but finds no impact on investment or wages. A similar tax cut was implemented in Sweden in 2006, and is analysed by Alstadsæter, Jacob, and Michaely (2017) with a triple difference strategy that compares cash-constrained firms with those that own internal resources. The authors also exploit the fact that "closely-held" corporations faced a more generous tax cut of 10 percentage points, compared with 5 percentage points for "widely-held" ones. In contrast to Yagan (2015), the authors find a positive impact of the

tax cut on investment by cash-constrained firms.

The studies of Blouin and Krull (2009) and Dharmapala, Foley, and Forbes (2011) on a tax holiday for repatriation of foreign income in the US in 2004 find no real effects on investment, but an increase in shareholder payouts. Faulkender and Petersen (2012), on the other hand, find that highly financially constrained firms do increase investment. This is in line with the most recent contributions analyzing carryback and accelerated depreciation schedules, which point to the importance of heterogeneity in the firms' financial situation and market position in determining their takeup of such benefits. The results again highlight the importance of financial frictions in firm decision making, since they show real effects of the intertemporal allocation of the tax bill, which should be of little importance with perfect capital markets.

There is also a large body of research examining tax incentives for research and development. This type of subsidy is often provided directly as a tax credit to firms, similar to the Portuguese reform considered in this paper. Earlier work found that such credits tended to crowd out private investment, while more recent work has shown that this is not always the case. A persistent measurement challenge, however, comes from the fact that firms have flexibility in how they report R&D spending, and definitions also differ widely from country to country (Hall and Van Reenen, 1999; Becker, 2015). R&D spending is also a very specific type of investment that few firms have the capacity to engage in.

Blattner, Farinha, and Rebelo (2017) analyse a more general investment tax credit enacted in Portugal in 2014, which retroactively allowed firms in all sectors and regions a tax credit of up to 20% of any type of investment undertaken between June and December 2013. The credit could be deferred for up to five years, and the administrative barriers to take-up were extremely low. The authors are interested in the extent to which the demand faced by Portuguese firms and their level of indebtedness affect the probability of taking up the tax credit, instrumenting demand through exogenous variation from product-destination changes in foreign demand. They find a non-linear effect of financial

Table 4.1: Tax Incentives in the Literature

Tax incentive	**Description**	**Results**
Deductions of net operating losses	Stimulate economic activity during periods of recession by temporally shifting tax benefits from more prosperous periods, either through carryback (using a given year's loss to offset tax bill for previous years) or carryforward (using a given year's tax loss to offset taxable income in future years)	Depending on economic conditions, firms may use refunds to pay down debt and increase cash holdings rather than invest
Depreciation bonus	Accelerate depreciation schedule to reduce tax bill in the period after acquisition and stimulate acquisition of new equipment	Firms taking the benefit invest more with a high elasticity; effects attenuated when cashflow doesn't come immediately
Dividend tax cuts	Reducing tax rate on individual dividend income to boost corporate investment by reducing firms' cost of capital	Mixed: some studies show no effect, some show positive effect on investment
Repatriation holidays	Reduce firms' capital constraints and boost investment by allowing temporary tax holidays for overseas earnings that are brought back within national borders	Some firms use repatriated earnings for investment, others for shareholder payouts
R&D tax credits	Tax credits for investment in research and development to close the gap between socially optimal levels of R&D and those that yield the highest private rate of return	Positive effects on investment, but in some cases public subsidies crowd out private funding

constraints, mediating the demand effects.

The remainder of the paper is organized as follows. We discuss the particularities of the tax credit in section 4.2. We explain the details of the dataset and identification strategy in section 4.3, and give our results in section 4.4.

4.2 The Portuguese Investment Tax Credit

Many details of the investment tax credit of interest (Fiscal Regime for Investment Support, hereafter RFAI) have been explained in Chapter 3. This section gives broader context and details on subsequent changes to the program. RFAI was introduced as part of a broader "Initiative on Investment and Employment," a countercycical initiative with the accompanying structural goals of promoting economic growth and employment, modernizing firms, and making them more competitive in the aftermath of the 2008 crisis (Assembleia da Republica Portuguesa, 2009a; 2009b; Grupo Moneris, 2009). The policy came as part of a broader movement to stabilize and structure investment activities in Portugal for both domestic and international investors, codified in September of the same year in the "Fiscal Code for Investment" (CFI).[2] It first came into effect in 2009, and was renewed in 2013 with modifications to some conditions *(see table 4.2 for key characteristics, and tables D.3, D.4, and D.5 in Appendix D for full details on the law over time).*

The general conditions of RFAI allow firms to claim a tax credit for up to ten years of at most 50% of their total tax bill for the cost of total productive investment in certain administrative regions approved by the European Commission.[3] The eligible investment in intangibles is limited to technological transfer (patents and licences). As regards tangible

[2]The RFAI refers to the Portuguese "Regime Fiscal de Apoio ao Investimento", introduced in number 13 of the Law 10/2009 (March 10, 2009). The broader "Codigo Fiscal do Investimento" was subsequently defined in law 249/2009 of September 2009, and also introduced changes to two existing programs: Large Investment Projects (GPI) and Internationalization (INT), contractual tax arrangements which depend on negotiation between the firm and tax authority. GPI was a tax credit of 10-20% of the cost of investment in production facilities of at least €5 million, while INT allowed a tax credit of up to five years for 10% of costs associated with direct investment abroad by Portuguese firms. In the case of INT, projects had to entail at least €250,000 in spending, and the credit could not exceed 25% of annual tax liability or €997,595.79. Eligibility for both varied by sector of economic activity.

[3]For new firms, the limit is raised to 100%.

investment, it covers acquisition of goods directly related to the firm's activity, namely: all types of machinery and equipment; furniture for firms in the hotel sector; land for firms in extractive industries; and social equipment which firms are required to have by law. Vehicles are excluded.

The value of the tax credit can be at most 25% of the total eligible investment up to five million euros, and 10% of the amount above five million. Firms are required to keep the investment goods in the region for at least five years (three for SMEs), and to create and keep at least one job position.

The regional limits respect the general EU rules on regional aid, and determine the so-called "aid intensity", which is present value gross aid expressed as a percentage of present value eligible costs, before any deduction of tax or other charge. It includes not only the amount of RFAI but also certain other exemptions in property real estate purchase taxes.[4]

For a rough back-of-the-envelope estimate of the magnitude of the implied tax credit, we take the case of the median small firm claiming RFAI and assume that it is located in the North of Portugal, where the maximum credit was 30% of the eligible investment. Because of the firm's size, its maximum credit is increased by 20 percentage points to 50%. Assuming this firm has taxable income of €60,000 in 2010 – the value for the median treated firm in this year – it faces a statutory corporate tax rate of 25% and a tax bill of €15,000, with a maximum potential credit of €3,750 (*see table D.6 for relevant corporate tax rates in Portugal from 2010-2014*).[5] The firm can claim the maximum tax credit by making an investment of €7,500, reducing its total tax bill to €11,250 and its effective tax rate to 18.75%. In the event that the firm cannot claim the full credit in the year of the investment, it can defer it up to ten years.

Eligibility is in principle limited to firms in the following sectors: extractive and

[4]If the investment involved buildings, the firms were granted a 5-year exemption of the municipal property tax and an exemption from paying the indirect tax and the stamp tax on real estate purchases. These exemptions are subject to the approval of municipal authorities of the "regional interest of the investment".

[5]The rates cited here are for resident entities and permanent establishments of non-resident entities that exercise commercial, industrial, or agricultural activities as their main activity in Portugal.

transformative industry (with the exception of steel industry, shipbuilding, synthetic fabric); tourism; broadband; agriculture and forestry; energy; and telecommunications. However, thanks to a provision allowing firms in other sectors to claim the credit for investment related to broadband equipment and infrastructure development, we find that in fact nearly all sectors of economic activity had access *(see table 4.3)*.

In addition, eligibility for RFAI is conditional upon the firm not having debts towards the tax authority or social security and enjoying good financial health. Firms which do not qualify as micro, small or medium cannot claim more than 50% of investment in technology transfer, such as patents or licences.[6]

Take-up of the RFAI was low in the first years of the reform, both in terms of overall spending and the number of firms claiming the credit, with an increase in later years *(see figure 4.1)*.

4.3 Data and Identification Strategy

We use administrative longitudinal data on private non-financial Portuguese firms provided by the Bank of Portugal. The individual records include all the information from the income statement and balance sheet that the firms report to the Ministry of Finance, the Bank of Portugal and Statistics Portugal, i.e., it includes financial data, information on employment, and sales for all Portuguese private firms. The data is available as of 2006, but for the purposes of our study we concentrate on the period 2008–2015, starting from the year prior to the introduction of the tax credit. On average, about 900 firms per year claimed the credit, with a steady increase over time. The data has been merged with the amounts of the tax credit per year and per firm provided by the Portuguese Tax Authority.[7] The merging was done by the Bank of Portugal, using each firm's unique fiscal identifying number.

[6]Micro firms have less than 10 employees and an annual cash flow or balance sheet below 2 million euros; small firms have less than 50 employees and an annual cash flow or balance sheet below 10 million euros; medium firms have less than 250 employees, and an annual cash flow below 50 million euros or an annual balance sheet below 43 million euros.

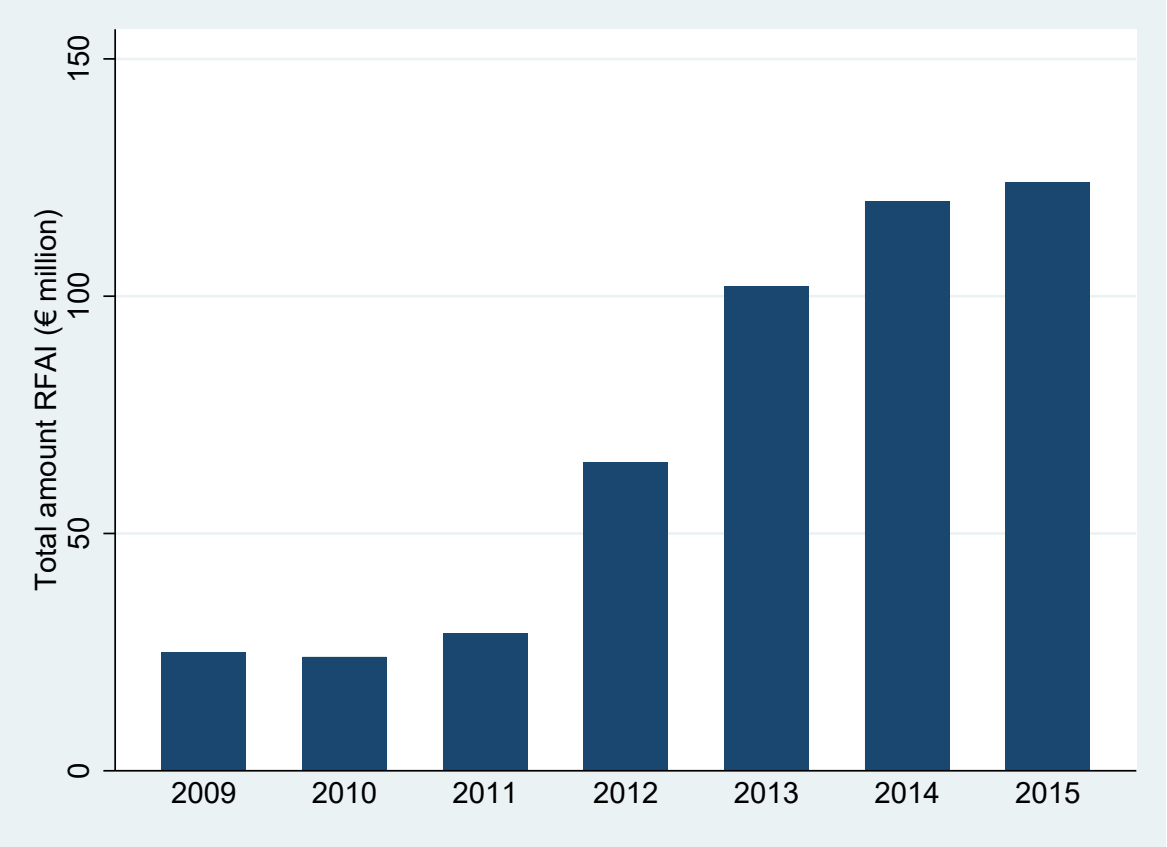
[7]The Tax Authority data is available up to 2015.

Table 4.2: Key Characteristics of the RFAI: 2009 – 2015

Period in Effect	**2009 – 2012**	**2013 – 2015**
Eligible Investment	Acquisition of tangible goods directly related to the firm's activity: all machinery and equipment; land for firms in extractive industries; furniture and decoration for firms in the hotel sector; social equipment which firms are required to have by law. Vehicles excluded. Intangible goods: technological transfer (patents and licenses); maximum 50% of investment for firms not considered micro, small, or medium	No change
Conditions for the investment	Must be maintained in the region for at least **five** years; must lead to the creation of at least one job which is maintained until the end of the deduction period	Must be maintained in the region for at least **three** years for micro, small and medium firms; **five** years for all other firms; must lead to the creation of at least one job which is maintained until the end of the deduction period
Maximum deduction	**25%** of total tax bill	**100%** of total tax bill for investments in the first three years of activity for new firms; **50%** for all other firms
Percentage of investment	**20%** up until 5€ million; **10%** above 5€ million	For investment in the North, Center, Alentejo, Madeira, and Azores regions: **25%** up until 5€ million; **10%** above 5€ million For investment in eligible municipalities in Algarve, Grande Lisboa, and Península de Setúbal: **10%**
Deferral period	Up to **five** years	Up to **ten** years

Source: Assembleia da Republica Portuguesa (2009); Assembleia da Republica Portuguesa (2009)

Figure 4.1: Aggregate Tax Credit Takeup: 2009-2015



Note: The year the firm claims the credit. Since the firm can defer the tax credit for up to ten years, this is not necessarily the year it invests.

Table D.1 *(in Appendix D)* provides some descriptive statistics of the program take-up, showing an increase in the take up of the tax credit throughout the years. This is probably an effect of the deferrals, as the tax base of firms in the crisis period of 2009-2011 may not have permitted them to take advantage of the credit. It is also a likely result of learning about the program, and a gradual recovery in investment from the 2008 crisis. The total number of firms that benefit from the tax credit is 3,137, and its distribution according to the number of years in which the tax credit is granted is shown in Table D.2 in Appendix D. Approximately one half of the firms benefit from the tax credit in more than one fiscal year, reflecting either a spreading out of the claim through deferrals or the undertaking of different investment projects.

The distribution of firms across sectors of activity is shown in Table 4.3. The largest sec-

Table 4.3: Distribution across sectors: 2008

Sector	Number of obs.	Treated	% treated obs.
Agriculture, Fishing &Forestry	3865	89	2.3%
Mining & Quarrying	394	17	4.3%
Manufacturing	20525	1677	8.2%
Electricity, Gas, Steam & Air Conditioning	100	12	12.0%
Water, Sewage, Waste Manag. & Remediation Activ.	369	19	5.1%
Construction	13321	67	0.5%
Wholesale & Retail, Motor Vehicles & Motorcycles Repair	41810	278	0.7%
Transportation & Storage	8925	29	0.3%
Accommodation & Food Services	12296	79	0.6%
Information & Communication	2434	50	2.1%
Real Estate Activities	2552	8	0.3%
Professional, Scientific & Technical Activities	11883	63	0.5%
Administrative & Support Services	3745	29	0.8%
Education	1883	5	0.3%
Human health and social work	7397	32	0.4%
Arts, entertainment & recreation	985	9	0.9%
Other Service Activities	3101	6	0.2%
Other	17	0	0.0%
Total	135602	2469	1.8%

Note: Number of observations in 2008. Firms in scope are those existing in 2008 that survived until 2016.

tor is wholesale and retail, motor vehicles and motorcycle repair; followed by manufacturing and construction. In 2008, the highest shares of treated firms were found in electricity, gas, steam and air conditioning (although the sector is very small); manufacturing; and water, sewage, waste management and remediation activities.

Because the take-up rates are so small and nearly all sectors had in practice some take-up of the tax credit, the treatment effect was too diluted for a difference-in-differences estimation. We therefore use a nearest-neighbor matching approach, which allows us to construct a plausible counterfactual for how much firms taking advantage of the RFAI would have invested if the tax credit had not been available. The key assumption for the matching approach is that the observables used for matching capture determinants of investment other than the variation caused by take-up of the RFAI. Although the approach does not allow us to control for unobservables, we use several key firm performance and financial health indicators in the matching, as well as variables shown in the literature to influence investment. We can then take the difference in the outcome variables of interest between the two groups as the basis for estimating the causal effect of the law. We analyze

the impact on the two main areas targeted by the law, namely the investment rate and employment. We also look at changes in turnover, wages, market share, exports, and leverage.

Treatment is defined for a given firm if their take-up of RFAI was greater than zero and less than €1 million at any point between 2009 and 2015.[8] The pool of potential control firms are those who are never treated.

We do a series of exclusions to lay the ground for a good match. We exclude financial holding companies. We also exclude firms with non-positive sales and assets, no employees, no reported hours worked by employees, and those that are inactive.[9] This leaves a baseline total of 262,853 firms.

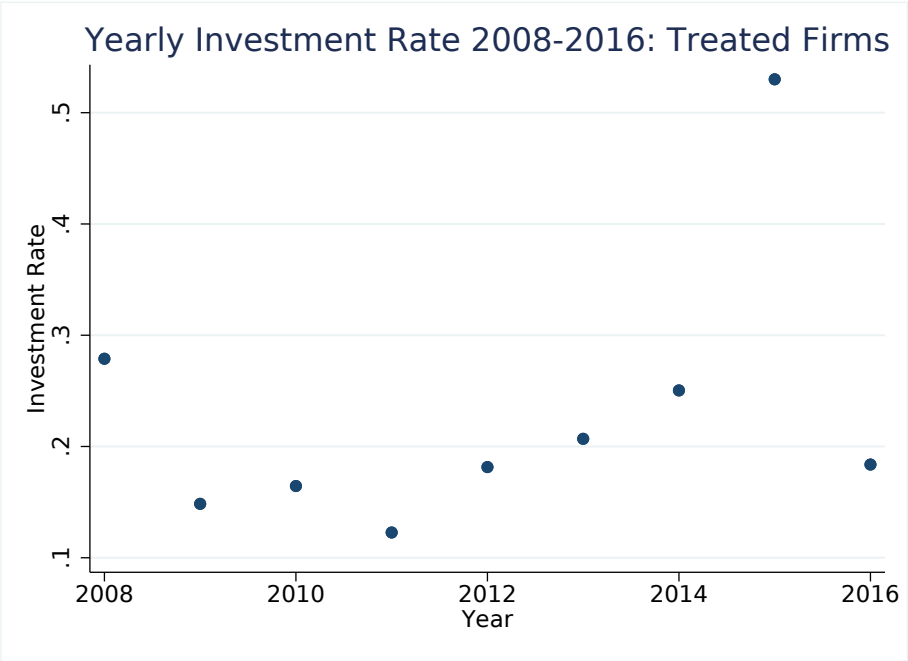
We further restrict the analysis to those firms that are present in 2008 and survive until the end of the observation period in 2016, which allows us to define our outcome based on total investment and employment over the time period for which the firm could have claimed the credit and for which we have comparable information for both treated and non-treated firms. This approach yields a more stable measure of the overall impact of the reform than one based on yearly investment flows, which can be very volatile from year to year depending on fluctuations specific to the circumstances of the firm that are not easily observable *(see Figure 4.2)*. Changes in long-term investment, on the other hand, are more relevant to assessment of the effectiveness and economic impact of RFAI. The approach also allows us to overcome the difficulty in distinguishing between the exact year of the firm's investment, and deferral of the credit from investment in previous years.[10]

[8]Firms with investment of more than €1 million fell into the 99th percentile of all firms, and had no good match in the pool of non-treated firms.

[9]We allow firms to remain if they report zero sales, assets, employees, or hours worked in their first year of operation. We exclude them if any of these variables are ever missing or negative, or are zero in subsequent years of operation. The intention is to examine only firms that are stable and operating under the usual standards of financial health, the general criteria for a firm to take advantage of an incentive like the RFAI.

[10]The information in our database contains the year the firm claims the tax credit. Because the firm can defer the credit for five to ten years, this does not necessarily correspond to the year of the firm's investment. To estimate a lower bound on how many firms were taking deferrals, we computed the ratio of the credit to total eligible investment per year and compared it to the applicable cap *(see table D.4 for caps by year)*. Between 2009 and 2015, at least 13-26% of firms in each year had ratios of credit to investment in a single year more than 10 percentage points above the limit, meaning that they were deferring some amount of eligible investment from previous years. The actual share of firms taking deferrals is higher, as even firms with investment within the limit in a single year could be deferring the credit from previous

Figure 4.2: Average yearly investment rate for treated firms



Source: Authors' calculations using data on RFAI take-up and investment. The yearly investment rate is calculated as the ratio of investment in tangibles to assets in year t-1.

Out of the 3,137 firms with positive take-up of RFAI, there are only 20 firms that go out of business before 2016. It can be argued that by excluding these firms we are left with a subset of firms that are better-performing in the first place, and therefore overestimating the impact of the reform. However, the same survival condition is also imposed on the control firms to which they are matched. We also exclude from the analysis the 509 firms that were created after 2008 and had positive take-up of the RFAI, to ensure that we can make an accurate match on pre-treatment observables *(see table 4.4 for summary statistics on the pool of treated firms vs. the pool of firms with positive take-up created after 2008, which are excluded from the matching)*.

After all preliminary restrictions and data cleaning, we are left with 2,469 firms in scope for matching out of the 3,137 with positive take-up of RFAI, representing 78% of the total.

years where they were not able to claim the RFAI. This makes it impossible to compose an accurate control and treatment group using the yearly take-up of the credit, as we cannot be sure of the year in which the firm actually conducts the eligible investment, which is the actual time of treatment.

Table 4.4: Summary Statistics:
Treated Firms Established and Surviving vs. Treated Firms Created After 2008

	Established		Post-2008		Difference	
	mean	sd	mean	sd	b	t
Log assets	14.38	1.73	11.72	1.81	2.39***	(26.75)
Log turnover	14.49	1.66	11.67	1.85	2.52***	(26.43)
Log employees	3.17	1.32	1.35	1.26	1.65***	(22.73)
Leverage	0.14	0.18	0.19	0.68	-0.05**	(-3.19)
Cashflow_assets	0.14	0.12	-0.04	1.04	0.17***	(7.75)
Cash_assets	0.11	0.15	0.24	0.29	-0.14***	(-15.36)
PPE_assets	0.34	0.21	0.29	0.29	0.05***	(4.58)
ROA	0.14	0.12	-0.05	1.04	0.17***	(7.75)
Observations	2469		503		2973	

Note: Values for established firms that survived the full observation period until 2016 are taken in 2008, and for those created after 2008 in their first year of operation. Most established firms were created before 2008, and are therefore measured when their business is more stable. They are on average larger, more profitable, and more highly leveraged.

4.3.1 Matching estimations

The outcome variable for investment is calculated as the cumulative investment in tangibles from 2009 to 2016, divided by the assets in the baseline pre-reform year of 2008.[11] We focus on the intensive margin for investment because the majority – 78% – of treated firms were already investing in the pre-treatment period. We also examine investment in tangibles, the most reliably measured type of investment and the main focus of the RFAI[12]. Growth in employment, turnover, wages, and exports is calculated as the difference between the 2016 and 2008 values, divided by the baseline in 2008. The change in leverage – ratio of debt to assets – and market share – the firm's share of turnover in their four-digit sector – is calculated as the difference between the 2016 and 2008 values.

Firms are matched on their age, number of employees, leverage, sales, assets, ratio of cashflow to assets, ratio of cash to assets, ratio of PPE to assets, and return on assets in the pre-treatment year of 2008. We also tested a specification with exact matching on the geographic location (district) of the firm. The magnitude of the results is robust, but we lose precision on matching on other variables because some districts in Portugal have very few firms. Portugal is a small country where national dynamics tend to have a stronger effect than region-specific ones. We therefore chose not to include geographic location in the matching specification to maintain close matches on other firm-level attributes. All firm-level values are taken in the baseline pre-reform year of 2008. They are also matched exactly on 2-digit sector.

For the matching estimations, the pool of treated firms is trimmed at the 1st and 99th percentiles of treated firms on all firm-level outcome variables. We also only consider treated firms that had a positive level of investment in tangibles during the period of

[11] We scale the investment to assets because our investment variable is a flow that measures additions to capital stock each year. Taking the ratio allows us to normalize for the initial position of the firm, where firms with very large assets to begin with have a larger capacity for investment each year.

[12] Although we also have a variable measuring investment in intangibles, it does not have a level of detail that would allow us to determine whether a firm was investing in technology transfer – eligible for a credit – or other types of intangibles. Additionally, the latitude that firms have in reporting intangibles means that including this in our estimations would introduce noise in the outcome. Very few firms in our database report any positive non-missing values.

treatment, as this is the primary type of investment targeted by the law and the most cleanly measurable. We additionally restrict the sample to those firms that have at least 10 employees in 2008, to avoid extreme values in the growth rate from firms that are very small in the baseline period. There are 645 treated firms satisfying all other conditions for selection that have nine employees or fewer in 2008. The effects for these firms will be tested separately in further extensions.

Table 4.5 shows descriptive statistics of the matching variables for treated firms used in the matching and those in the pool of potential controls. Treated firms differ notably on all characteristics, highlighting the importance of using matching to select an appropriate group of control firms. Treated firms are on average larger, older, more profitable, and more highly leveraged than the pool of never-treated firms. They also have higher cash flow and a higher return on assets, although they have lower liquidity.

Table 4.5: Summary Statistics: Firms Used in Matching and Pool of Potential Controls

	Treated		Control		Difference	
	mean	sd	mean	sd	b	t
Log assets	14.91	1.42	13.95	1.50	-0.95***	(-26.32)
Log sales	15.02	1.33	14.14	1.38	-0.88***	(-26.27)
Employees	3.71	0.95	3.11	0.84	-0.60***	(-29.23)
Leverage	0.15	0.18	0.14	0.22	-0.02**	(-3.29)
Cashflow to assets	0.14	0.09	0.11	0.18	-0.03***	(-7.22)
Cash to assets	0.09	0.13	0.12	0.16	0.03***	(7.29)
PPE to assets	0.34	0.20	0.30	0.24	-0.04***	(-6.99)
ROA	0.14	0.09	0.11	0.19	-0.03***	(-7.56)
Age	19.55	14.98	18.50	14.39	-1.05**	(-2.99)
Observations	1804		27692		29496	

Note: All values are taken in the baseline year of 2008.

The matching greatly reduces these differences, as seen in examination of the equality of distribution and median of the matching variables between control and treated firms *(see table 4.6)*. Firms are well-matched on most characteristics. We find that there are more firms with more employees, more younger firms, and more firms with a higher ratio of PPE to assets in the distribution of treated than matched control firms. However, visual

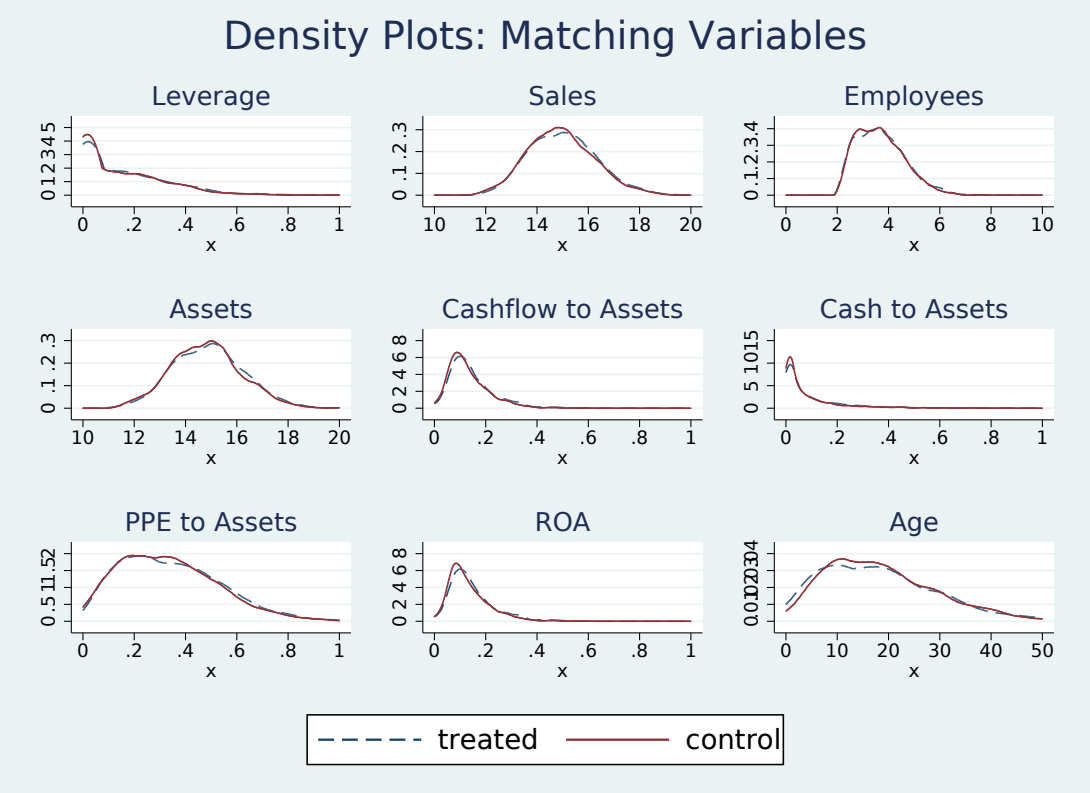
inspection of the distributions shows that the discrepancies are small, and lack skew that would indicate a particular bias in the matching estimation *(see figure 4.3)*.

Table 4.6: Tests of goodness of match: p-values

Matched v. treated	Kolmogorov-Smirnov test equality of distribution	Equality of median test
Leverage	0,098*	0,099*
Turnover	0,008*	0,029**
Employees	0,532	0,662
Log assets	0,098*	0,024**
Cashflow to assets	0,000***	0,000***
Cash to assets	0,053*	0,047**
PPE to assets	0,21	0,400**
ROA	0,000***	0,000***
Age	0,058*	0,686

Note: The Kolmogorov-Smirnov tests whether the distribution of the parameter between treated and matched control observations is equal. It is stricter than the median test, which tests only that the median value of the parameter is equal. When significant for a given variable, the two groups are well matched. *** p<0.01, ** p<0.05, * p<0.1

Figure 4.3: Density plots of variables used in matching estimations



Note: Plots represent the distribution of each variable used in the matching estimation across control and treated firms. They show no bias that would indicate a problem in the match for particular firm attributes.

4.4 Results

We find significant positive effects on investment, employment, turnover, market share, and wages for treated firms. We find no significant effect for leverage or export growth. In table 4.7 , the average treatment effect on the treated (ATT) is shown. The ATT measures the incremental impact of the program on the outcome variables for treated firms, where the set of matched control firms are used as the counterfactual for the outcome if treated firms would not have taken up the tax credit. Because our sample consists of stable firms that survived the entire period of observation, the estimated ATT is likely biased upwards when compared to the average treatment effect (ATE).

The magnitude of the investment and employment effects are sizeable. On average, treated firms doubled their investment relative to baseline assets during the treatment period. The estimated coefficient on treatment means that half of this increase can be attributed to their take-up of the RFAI.

The effect on employment growth is similar. Firms taking advantage of RFAI increased employment by 50% on average from 2009 to 2016, 45 percentage points higher than the growth rate for matched control firms. The control firms had a low rate of employment growth during the same time period, increasing employment by only 3% relative to the baseline in 2008. There was an accompanying treatment effect on wage growth, which was on average six percentage points higher for treated firms.

Treated firms also saw higher growth in turnover and market share during the treatment period. Their turnover grew on average by 81%, relative to only 7% for the matched firms with no take-up of RFAI. Although the growth in market share was small in absolute terms – 0.8 percentage points – it is large relative to baseline market share, which was at most 3%. This suggests that firms using the RFAI to invest gained an advantage against other firms in their sector.

The lack of a significant effect on leverage suggests that the treated firms did not necessarily use the credit to offset debt financing of investment, as would have been

Table 4.7: Results

	(1) Investment	(2) Employment	(3) Turnover	(4) Market Share	(5) Wages	(6) Leverage	(7) Exports
SATT	0.521***	0.457***	0.735***	0.00827***	0.0605***	-0.0278	-9.969e+12
	(0.0267)	(0.0235)	(0.0335)	(0.00115)	(0.0126)	(0.0229)	(1.408e+14)
Mean *(treated)*	1.01	0.504	0.81	0.006	0.235	.009	-7.50e+10
Mean *(control)*	0.477	0.034	.072	-0.002	0.178	.049	8.30e+12
Observations	29,453	29,455	29,454	29,454	29,399	29,454	13,949

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Average treatment effect on the treated. One match per treated firm is used for calculating coefficients, and four for robust standard errors. Investment is measured as the cumulative growth rate of the ratio of investment from 2009 – 2016 to assets in 2008. Employment, turnover, wages, and exports are measured as the difference between the 2016 and 2008 values, divided by the baseline in 2008. The change in leverage – ratio of debt to assets – and market share – the firm's share of turnover in their four-digit sector – is calculated as the difference between the 2016 and 2008 values.

indicated by a negative estimated coefficient. We also find no effect on exports, possibly because firms that were investing to boost their export potential took advantage of another tax credit specifically aimed at internationalization.

4.5 Conclusions

Using a rich dataset combining information from the tax authority and administrative accounting records, we find significant positive effects of a tax credit in Portugal aimed at stimulating investment. The effects extend not only to investment but also to employment, turnover, wage growth, and market share. On average, firms taking advantage of the credit doubled their investment and employment during the eight years in the scope of this study. With the matching estimation, we find that half of the growth in investment and employment for treated firms over eight years can be explained by claiming the credit. We are able to show that firms are well matched across treatment and control groups on variables known from the previous literature to be key firm-level determinants of investment. The remaining differential in outcomes can be attributed to the effect of take-up of RFAI. The findings suggest that the program was not only successful in meeting its goals of increasing investment and employment, but also improved performance and

competitiveness for those firms that took advantage of the credit. The findings on wage growth are also a positive indicator of the quality of the additional employment that can be attributed to the program.

The magnitude of the effect is large compared with studies of other types of policy interventions, suggesting that a direct stimulus to investment is more effective than depreciation bonuses, dividend tax cuts, or other commonly used incentives. The low administrative barriers and nature of the incentive, provided as a tax credit applied directly to the targeted investment, was designed to be easy for firms to understand and access. There remains therefore an open question of why the control firms did not take advantage of such a successful program, particularly if they saw other firms on the market benefiting. These firms may have been investing in categories that were not eligible under RFAI, may not yet have learned about the credit, or may not have had the administrative capacity to meet the filing requirements. However, the drawback of the matching estimation is that we can only capture observable determinants of firm investment, leaving much to understand about these unobserved dynamics.

In future work, we will further explore the findings through several robustness checks, including restricting the analysis to those firms in sectors explicitly targeted by the law, cutting off the end of the treatment period before the enactment of the other large investment incentive in 2014, and changing the thresholds for selection of treated firms for the matching. We will also seek to better understand the mechanism behind our results by examining heterogeneous effects of firm size, leverage and cash constraints.

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Appendix A

Appendix: Chapter 1

Margins: buncher to ghost

A domestic firm in a given sector will choose to report zero profits as a buncher rather than conducting all activity in the informal market as a ghost when the expected return is strictly higher, which occurs when the cost of evading at the level $\widehat{e}$ is strictly less than the fixed cost of being a ghost:

$$\begin{aligned} &\eta_s \gamma_d g(\widehat{e}) < \beta_s \\ &where \\ &\hat{e} = R(y_i^*) - \alpha_i C(y_i^*) \end{aligned} \tag{A.1}$$

with the following indifference condition:

$$\begin{aligned} &\eta_s \gamma_d g(\widehat{e}) - \beta_s = 0 \\ &\tilde{\eta}_z(\alpha) = \frac{\beta_s}{\gamma_d g(\widehat{e})} \\ &\widehat{e} = R(y_i^*) - \alpha_i C(y_i^*) \\ &\frac{d(\tilde{\eta}_z)}{d(\alpha)} > 0 \end{aligned} \tag{A.2}$$

where $\tilde{\eta}_z$ represents the values along the spectrum of possible η within sector s at which a firm of a given α would be indifferent between operating as a ghost or a buncher. A firm of α_i facing $\eta_s > \tilde{\eta}_z$ prefers to be a ghost, while the same firm facing $\eta_s < \tilde{\eta}_z$ can expect higher profits from operating as a buncher.

Within a given sector, therefore, $\tilde{\alpha}_z$ represents the value of alpha at which the actual cost of evasion in the formal market in sector s is low enough for firms to prefer to operate as bunchers than as ghosts. This occurs where $\tilde{\eta}_z$ intersects with η_s. Firms with $\alpha < \tilde{\alpha}_z$, i.e. lower-cost firms, will earn higher profits as ghosts, while higher-cost firms will be bunchers.

At a given η and β, higher-cost firms bunch and lower-cost firms will operate as ghosts.

Margins: Iceberg to Ghost

A domestic firm will operate as an iceberg, producing at the optimal y_i^* and evading at the optimal level e_i^*, rather than a ghost when it expects to earn higher profits by doing so:

$$\begin{aligned} &R(y_i^*) - \alpha_i C(y_i^*) - \eta_s \gamma_d g(e_i^*) - \tau[R(y_i^*) - \alpha_i C(y_i^*) - e_i^*] > \\ &R(y_i^*) - \alpha_i C(y_i^*) - \beta_s \end{aligned} \tag{A.3}$$

A firm in a given sector will be indifferent between operating as a iceberg or a ghost when:

$$\begin{aligned} &R(y) - \alpha_i C(y) - \eta_s \gamma_d g(e_i^*) - \tau[R(y_i^*) - \alpha_i C(y_i^*) - e_i^*] - \\ &[R(y) - \alpha_i C(y) - \beta_s] = 0 \\ &\tilde{\eta}_p(\alpha) = \frac{\beta_s - \tau[R(y_i^*) - \alpha_i C(y_i^*) - e_i^*]}{\gamma_d g(e_i^*)} \\ &\frac{d(\tilde{\eta_p})}{d(\alpha)} > 0 \end{aligned} \tag{A.4}$$

where $\tilde{\eta}_p$ represents the value at which firms are indifferent between being icebergs and

ghosts. Firms facing $\eta_s > \tilde{\eta}_p$ will prefer to be ghosts, while those facing $\eta_s < \tilde{\eta}_p$ can expect higher returns by operating as icebergs.

Within a given sector, therefore, $\tilde{\alpha}_p$ represents the value of alpha at which the actual cost of evasion in the formal market in sector s is low enough for firms to prefer to operate as icebergs than as ghosts. This occurs where $\tilde{\eta}_p$ intersects with η_s.

$$\begin{aligned} \eta_s = \tilde{\eta}_p(\tilde{\alpha}_p) &= \frac{\beta_s - \tau[R(y_i^*) - \alpha_p C(y_i^*) - e_i^*]}{\gamma_j g(e_i^*)} \\ \tilde{\alpha}_p &= \frac{\eta_s \gamma_j g(e_i^*) - \beta_s + \tau[R(y_i^*) - e_i^*]}{\tau[C(y_i^*)]} \end{aligned} \tag{A.5}$$

Firms with $\alpha < \tilde{\alpha}_p$, i.e. lower-cost firms, will operate as ghosts, while higher-cost firms will be icebergs.

As for $\tilde{\eta}_z$, $\tilde{\eta}_p$ is increasing in β_s, meaning that there will be a higher share of firms choosing to be ghosts rather than icebergs in sectors where η_s is higher, and icebergs than ghosts when β_s is higher.

Margins: Buncher to Iceberg

Finally, I look at the margin between bunchers and icebergs, which represent the universe of active firms operating in the formal market. This decision is relevant for both multinational and domestic firms.

A firm will choose to be a buncher rather than an iceberg if the expected profit from evading at the level $\widehat{e}$ is less than or equal to that obtained at the optimal level of evasion e_i^*, with the following indifference condition for the firm on the margin between evading as a buncher or an iceberg:

$$
\begin{aligned}
&R(y_i^*) - \alpha_i C(y_i^*) - \eta_s \gamma_j g(\widehat{e}) - \\
&[R(y_i^*) - \alpha_i C(y_i^*) - \eta_s \gamma_j g(e_i^*) - \tau[R(y_i^*) - \alpha_i C(y_i^*) - e_i^*]] = 0 \\
&where \\
&\widehat{e} = R(y_i^*) - \alpha_i C(y_i^*) \\
&\tilde{\eta} = \frac{\tau[R(y_i^*) - \alpha_i C(y_i^*) - e_i^*]}{\gamma_j[g(\widehat{e} - e_i^*)]} \\
&\frac{d(\tilde{\eta})}{d(\alpha)} < 0
\end{aligned}
\tag{A.6}
$$

Within a given sector, $\tilde{\alpha}$ represents the value of alpha at which firms can expect higher returns from operating as icebergs than as bunchers.

Firms facing $\eta_s > \tilde{\eta}$ will prefer to be icebergs, while lower-cost firms will expect higher post-tax returns as bunchers. Intuitively, this follows from the fact that high-cost firms benefit more from being able to deduct some portion of their costs from their total tax bill, making it relatively more advantageous for them to report some positive taxable profit. Additionally, since bunchers always have a higher level of evasion than icebergs and the firm-specific cost of formal-market evasion is always scaled by the sector-specific cost η_s, firms will only choose bunching over iceberg evasion when η_s is low enough to do so.[1]

Additionally, $\tilde{\eta}$ is decreasing in γ_j, meaning that of a smaller share of active domestic firms in a given sector will be bunchers than that of multinational firms. This also implies that domestic firms will need to be relatively more efficient than multinational firms to expect higher profits as bunchers than icebergs, reflecting the overall lower cost of formal-market evasion faced by multinational firms with the additional options for evasion provided by profit shifting.

I assume that both multinational and domestic firms are normally distributed in α within a sector.

[1]Firms earning negative profits will be the least profitable, i.e. those with the highest α, and therefore those to the rightmost spectrum of the distribution of icebergs. Therefore on the margins between bunchers and icebergs and ghosts and icebergs, we should expect only firms earning positive profits.

Corporation Taxation in Portugal

As in most developed economies, Portuguese companies are subject to different effective tax rates based on their taxable income. The top statutory corporate tax rate in Portugal has been decreasing for several decades, falling from over 50% in 1985 to 23% in 2015. As part of Portugal's efforts to consolidate its public finances in the wake of the 2009 European financial crisis, it has introduced a series of reforms to its corporate income tax code, including a federal surtax on income above a certain level.[2] Table A.1 shows corporate tax rates in Portugal during the relevant period 2010-2014 for entities resident in Portugal or permanent establishments of non-resident entities.[3][4] (PricewaterhouseCoopers, 2014)

Table A.1: Corporate Taxation in Portugal: 2010-2014

		2010-2011		2012	2013	2014	
		< €12,500	> €12,500			< €15,000	> €15,000
BASE RATE	Continent	12.5%	25%	25%	25%	23%/17%*	23%
	Madeira	10%	25%	25%	25%	23%/17%*	23%
	Azores	8.75%	17.5%	17.5%	17.5%	18.4%/13.6%*	18.4%

Note: Tax rates as reported by PWC in their annual summary of corporate taxation in Portugal. SMEs are micro, small, and medium-sized enterprises, defined by the European Commission as firms with less than 250 employees and either less than €50 million in annual turnover or a balance sheet total of less than €43 million. *Second set of numbers in 2014 for firms with less than €15,000 taxable profit applies to firms with SME designation.
Source: PricewaterhouseCoopers (2014)

[2] "Derrama Estadual"

[3] The rates cited here are for resident entities and permanent establishments of non-resident entities that exercise commercial, industrial, or agricultural activities as their main activity in Portugal.

[4] SMEs are micro, small, and medium-sized enterprises, defined by the European Commission as firms with less than 250 employees and either less than €50 million in annual turnover or a balance sheet total of less than €43 million.

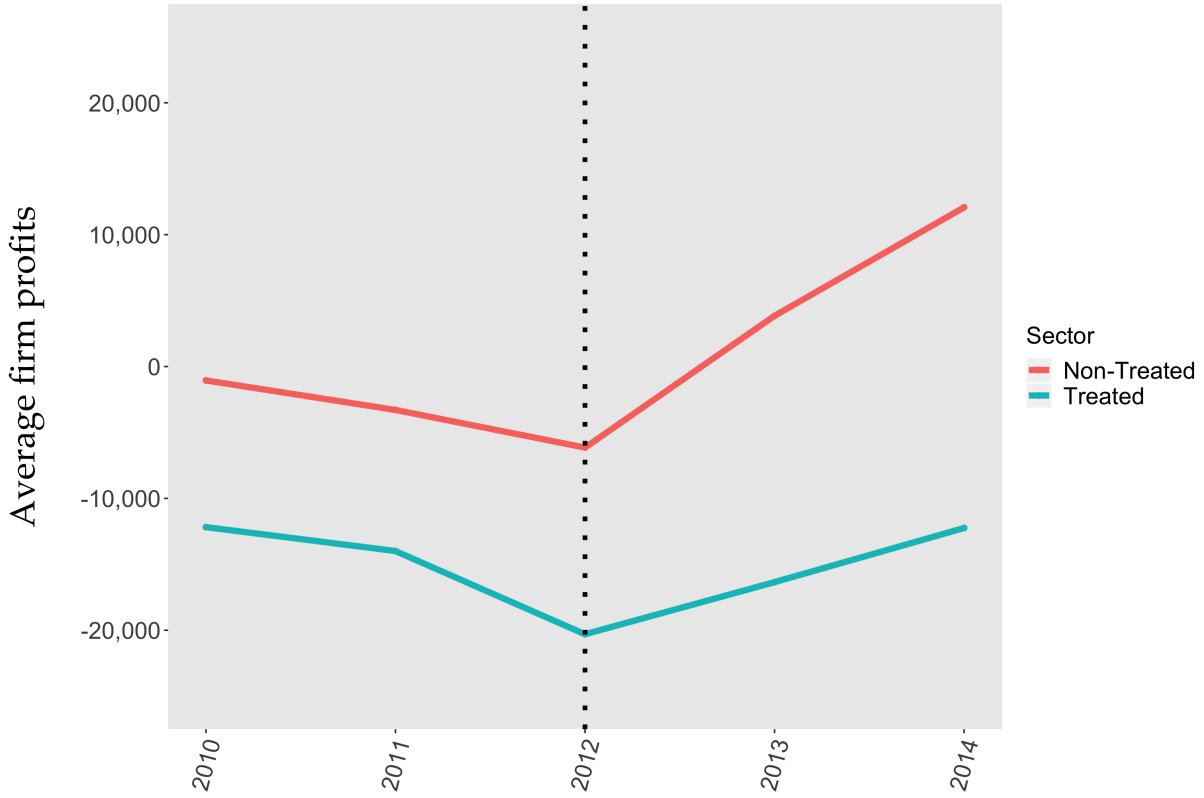
Figure A.1: Portuguese Tax Authority Definition of Corporate Taxable Income and Tax Payable

Taxable profit = *Net income + Positive changes in net equity not reflected in the income - Negative changes in net equity not reflected in the income ± Fiscal corrections (e.g. non-deductible costs or non taxable proceeds)*
Taxable income = *Taxable profit - Tax losses from previous accounting periods - Tax Incentives*
Income assessed for corporate tax (IRC) = *Taxable income*Tax rate*
Assessed IRC = *IRC assessed income - Tax credit*
Payable IRC = *Assessed IRC - Withholding at Source - Advance Payments*

Note: Unlike pre-tax profits, taxable income also includes tax deductions and credits for which the company is eligible under Portuguese tax law, and tax credits or losses carried forward from previous accounting periods. A tax loss is defined as negative net profits in a given year. In this case the company reports no taxable income in that year and pays no taxes, but can carry forward the negative balance to reduce its taxable income in a following year in which it has positive net profits. A company can also defer tax credits for which it would be eligible in a year in which it has no taxable income.

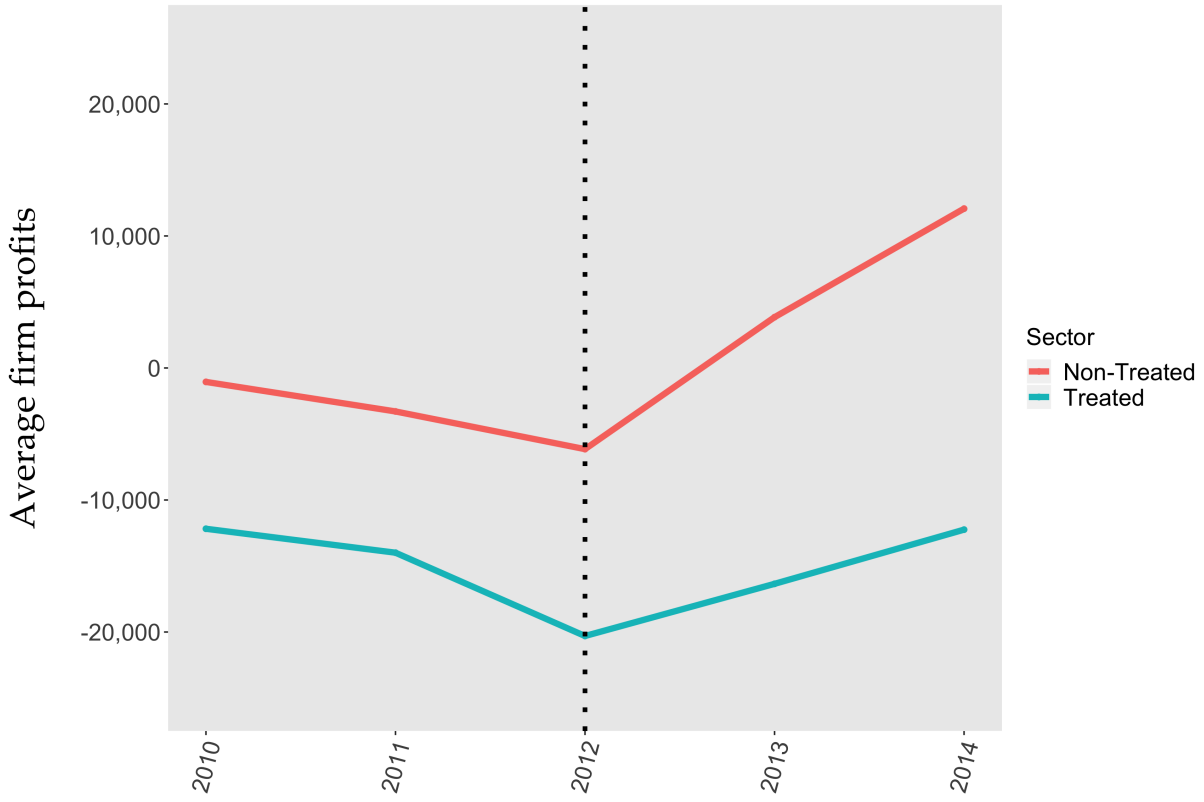
Figures

Figure A.2: Common Trends in Average Pre-tax Profits: Foreign-Owned Control and Treated Firms



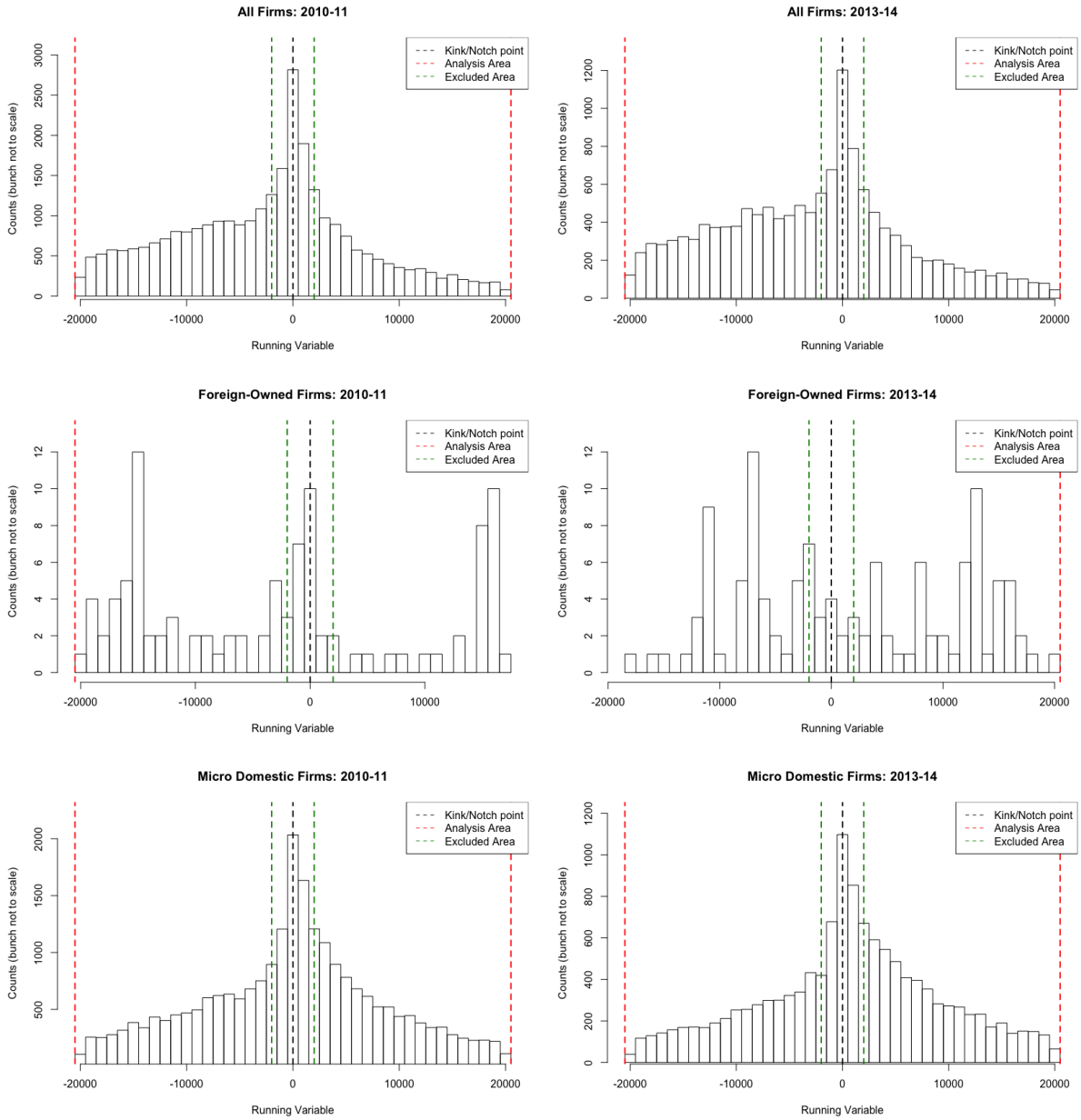
Note: Blue line represents firms in sectors targeted by the reform.

Figure A.3: Common Trends in Average Pre-tax Profits: Micro Domestic Control and Treated Firms



Note: Blue line represents firms in sectors targeted by the reform.

Figure A.4: Bunching at Zero in Treated Sectors, Pre and Post Reform (Taxable Income)

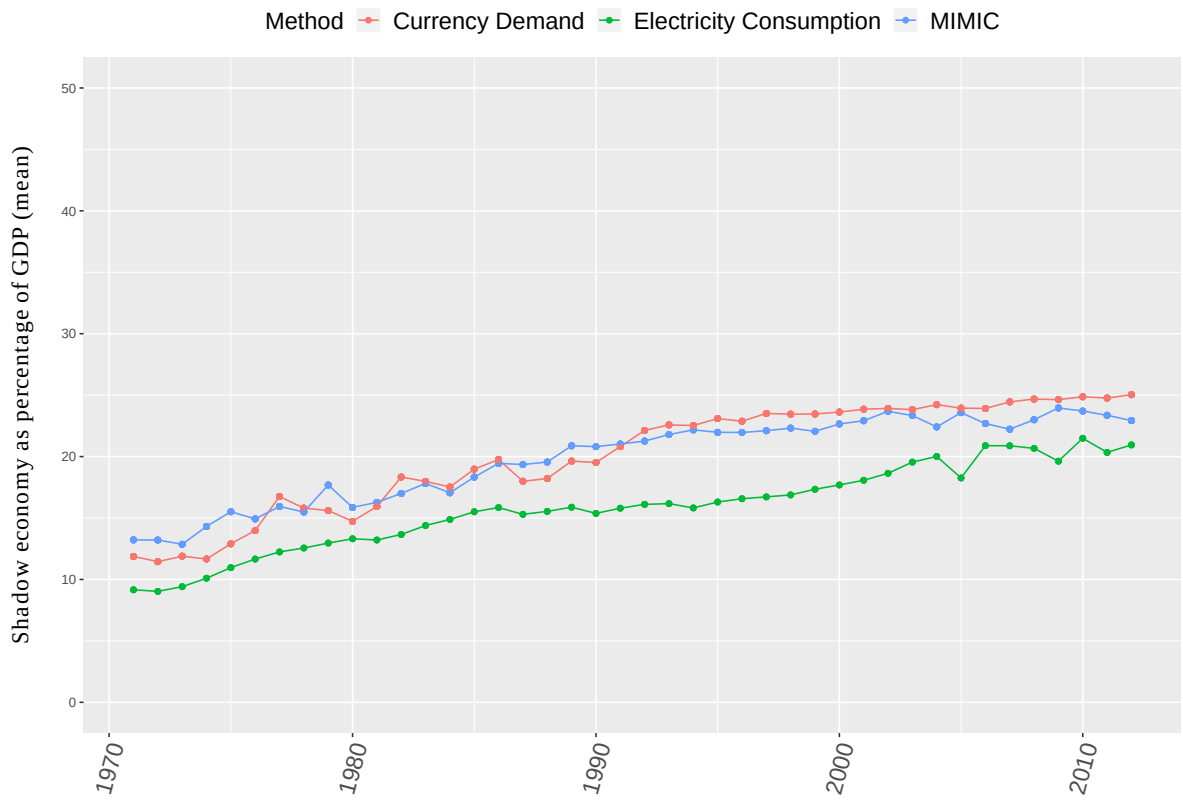


Note: Bunching in taxable income of firms in treated sectors, pre and post-reform.

Appendix B

Appendix: Chapter 2

Figure B.1: Estimates of the Portuguese Shadow Economy as a Percentage of GDP (means): 1970-2012



Note: Trends represent the mean of estimates for the size of the Portuguese shadow economy using three indirect measurement approaches. Each shows a gradual increase from 1970, with a stabilization of the growth rate from the mid-2000s. The results from the electricity consumption method are the lowest, while the currency demand and MIMIC methods are on average fairly similar, with some divergence in the first half of the 1970s and late 1980s. Source: author's own calculations from the results of World Bank (2019); Schneider (2016); Missiou and Psychoyios (2017); Soares and Afonso (2019); Schneider (2016); Dell'Anno (2007); Bovi (2003); Schneider, Raczkowski, and Mróz (2015); Lacko (1999), and Afonso and Goncalves (2011).

Appendix C

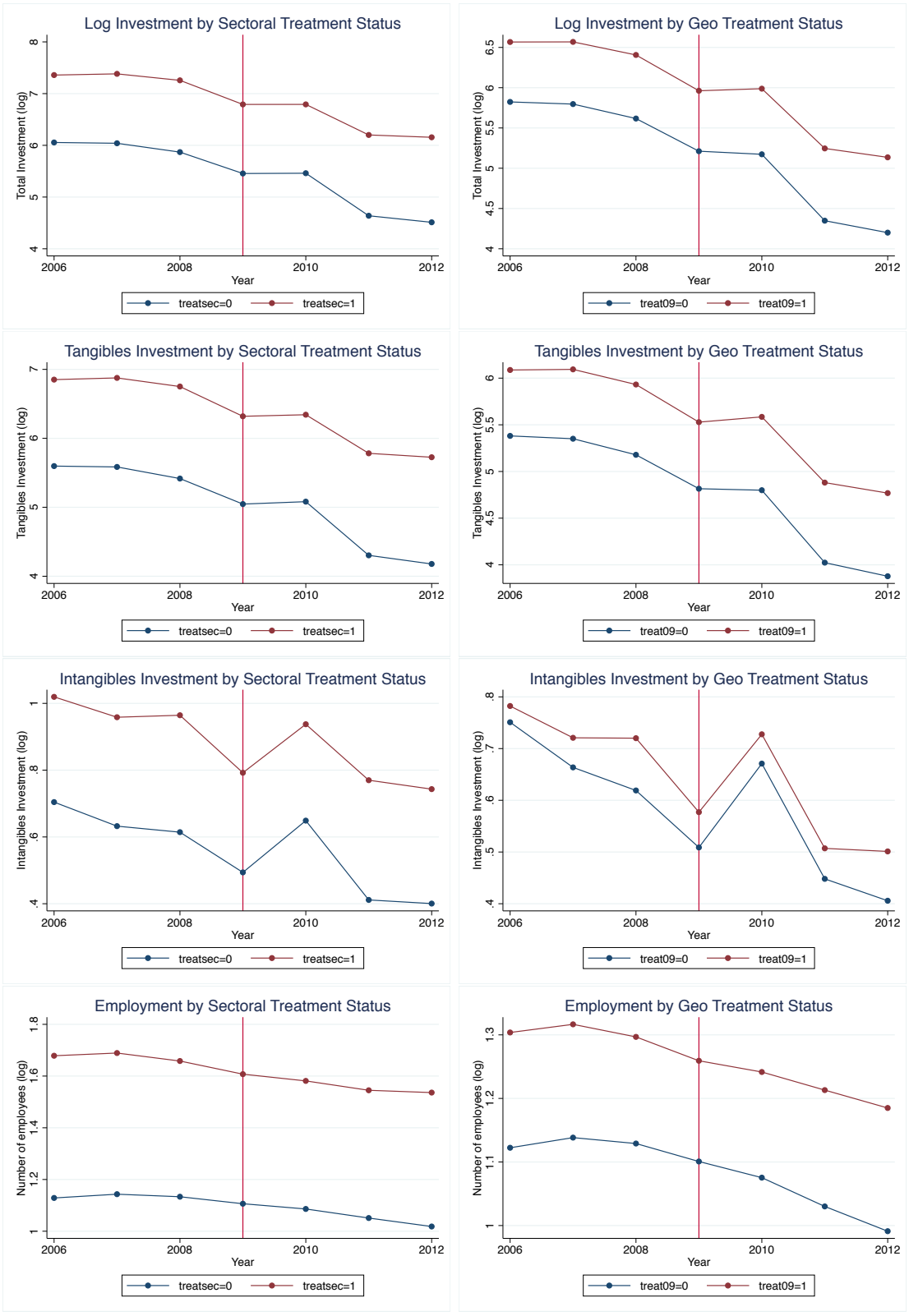
Appendix: Chapter 3

Table C.1: NACE Codes

ITC09 Sector	NACE Codes
Extractive and transformative industry	Divisions 05 - 33
Tourism	Division 55 Subclasses 77210, 90040, 91041, 91042, 93110, 93192, 93210, 93292, 93293, 93294, 96040
IT Services*	Division 62 Group 631
Research and development*	Division 72
Agriculture and forestry	Divisions 01 - 03
Energy, environment and telecommunications	Divisions 37-39, 61 Classes 3511, 3521 Group 353 Subclass 36001
Audio-visual and multimedia *	Divisions 58, 59

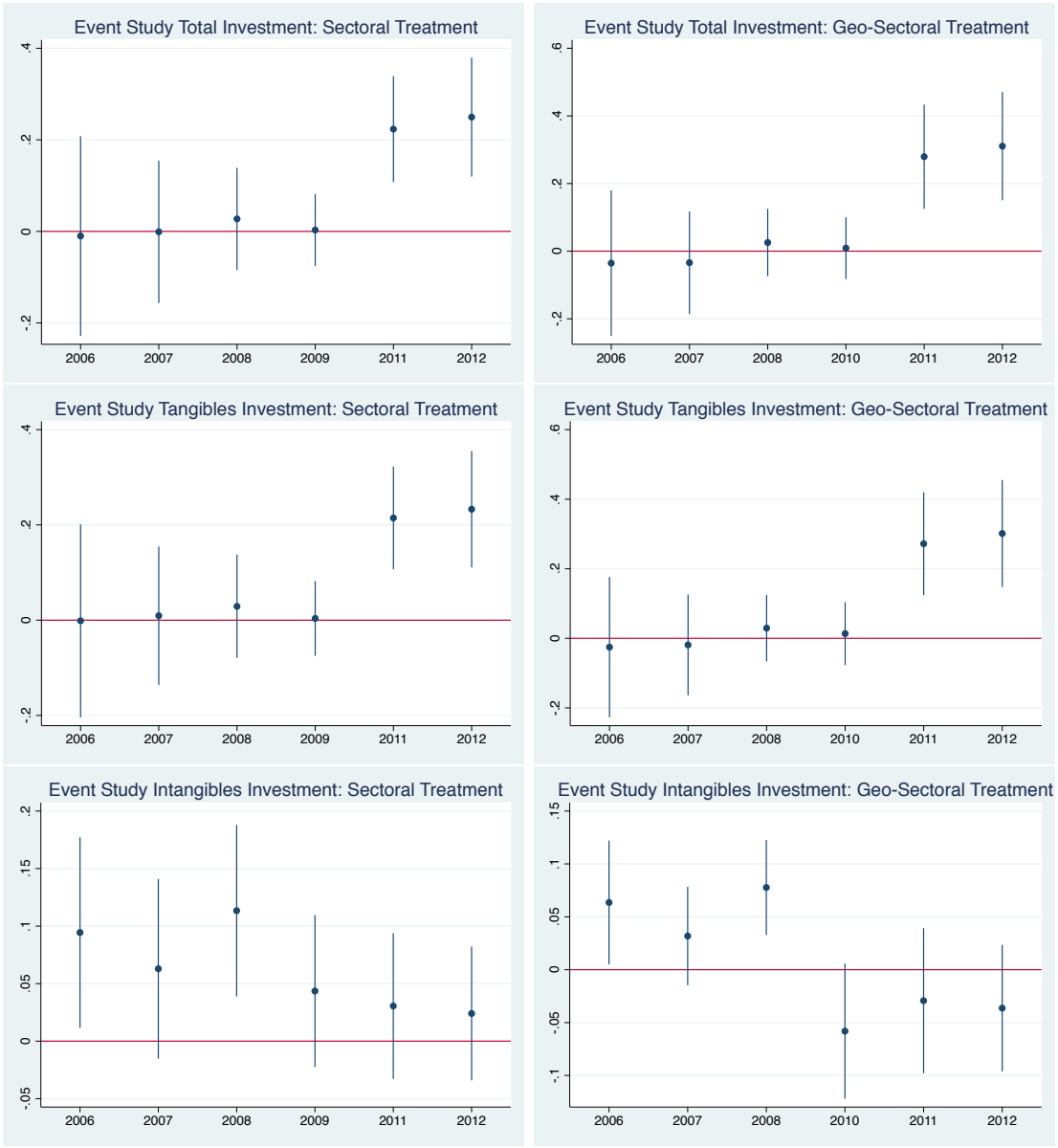
Note: The following sectors are excluded from the extractive and transformative industry and agriculture and forestry, with corresponding NACE subclasses in parentheses: steel industry (24100), shipbuilding (30000), synthetic fabric (20600). NACE code Rev. 2 is used to define the sectors of interest. Sectors marked with a * were only eligible under the CFI, and were included in the sectoral treatment estimations but not the geo-sectoral treatment. (2009)

Figure C.1: Common trends between control and treatment groups: Sectoral and geographical eligibility



Note: Common trends in the dependent variables appear to be parallel between control and treatment groups, for both the sectoral and geographical treatments. Firms in targeted sectors are defined by treatsec=1, and those in treated municipalities by treat09=1. The treatment period is defined as 2010 to 2012.

Figure C.2: Event studies of the treatment effects



Note: While the estimated coefficients hover close to zero in the pre-treatment period, they become positive and significant post-ITC09 for both investment in tangibles and intangibles, although the confidence interval for investment in intangibles crosses zero in the post-treatment period. This provides further support for the hypothesis that the stimulus effect was stronger than the shifting effect for targeted firms.

Table C.2: Effect on Investment: Sectoral Treatment, Firms in Non-Eligible Regions

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.02	0.02	0.01*
	(0.013)	(0.012)	(0.004)
Third-party supplies	0.14***	0.14***	-0.00
	(0.014)	(0.013)	(0.005)
Operating profit	-0.03*	-0.03**	-0.00
	(0.015)	(0.015)	(0.007)
Net earnings	0.12***	0.12***	0.00
	(0.011)	(0.011)	(0.005)
Personnel costs	-0.00	-0.00	0.01***
	(0.007)	(0.007)	(0.002)
Treated sector	0.12	0.14	-0.17
	(0.145)	(0.139)	(0.110)
Post-ITC09	-1.93***	-1.81***	0.03
	(0.149)	(0.140)	(0.020)
Treated sector & Post-ITC09	-0.08	-0.09	0.03
	(0.092)	(0.088)	(0.053)
Constant	3.60***	3.33***	0.36***
	(0.251)	(0.232)	(0.084)
Observations	300,888	300,888	300,888
R^2	0.039	0.039	0.002
Number of firms	91,738	91,738	91,738

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Table C.3: Effect on Investment: Sectoral Treatment - Matched Subset of Firms (Sector)

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.04***	0.03***	0.00
	(0.013)	(0.013)	(0.005)
Third-party supplies	0.16***	0.15***	0.00
	(0.014)	(0.013)	(0.006)
Operating profit	-0.00	-0.01	-0.01*
	(0.012)	(0.011)	(0.007)
Net earnings	0.13***	0.12***	0.01***
	(0.010)	(0.010)	(0.005)
Personnel costs	0.02***	0.01**	0.01*
	(0.006)	(0.006)	(0.003)
Treated sector	-0.09	-0.07	-0.14
	(0.094)	(0.081)	(0.119)
Post-ITC09	-1.98***	-1.87***	0.08***
	(0.087)	(0.079)	(0.022)
Treated sector & Post-ITC09	0.21***	0.20***	-0.12***
	(0.071)	(0.066)	(0.032)
Treatment intensity	1.01	1.15*	0.29
	(0.661)	(0.639)	(0.448)
Constant	4.09***	3.70***	0.60***
	(0.308)	(0.294)	(0.167)
Observations	419,491	419,493	419,491
R^2	0.043	0.043	0.002
Number of firms	110,634	110,636	110,634

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Table C.4: Effect on Investment: Geo-Sector Treatment - Matched Subset of Firms (Sector)

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.04***	0.03***	0.00
	(0.013)	(0.012)	(0.005)
Third-party supplies	0.16***	0.15***	0.00
	(0.014)	(0.013)	(0.006)
Operating profit	-0.00	-0.01	-0.01*
	(0.012)	(0.011)	(0.007)
Net earnings	0.13***	0.12***	0.01***
	(0.010)	(0.010)	(0.005)
Personnel costs	0.02***	0.01**	0.01*
	(0.006)	(0.006)	(0.003)
Treated sector	-0.03	-0.02	-0.22
	(0.163)	(0.145)	(0.170)
Post-ITC09	-1.96***	-1.86***	0.11***
	(0.093)	(0.086)	(0.034)
Treated sector & Post-ITC09	-0.01	-0.01	-0.10*
	(0.085)	(0.080)	(0.056)
Treated region	0.94	0.95*	0.38
	(0.590)	(0.560)	(0.508)
Treated sector & Treated region	-0.07	-0.06	0.09
	(0.181)	(0.167)	(0.124)
Post-ITC09 & Treated region	-0.03	-0.02	-0.05
	(0.056)	(0.052)	(0.036)
Treated sector & region & Post-ITC09	0.27***	0.27***	-0.03
	(0.083)	(0.080)	(0.058)
Treatment intensity	-1.83	-1.74	-0.93
	(1.960)	(1.872)	(1.602)
Constant	4.07***	3.69***	0.61***
	(0.303)	(0.290)	(0.175)
Observations	419,491	419,493	419,491
R^2	0.043	0.043	0.002
Number of firms	110,634	110,636	110,634

Robust standard errors in parentheses

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

Firm and time FE with SE clustered by sector

Table C.5: Effect on number of employees (log) - Matched Subset of Firms (Sector)

	(1)	(2)
VARIABLES	Sectoral Treatment Effect - Matched Firms	Geo-Sectoral Treatment Effect - Matched Firms
Turnover	0.04***	0.04***
	(0.008)	(0.008)
Third-party supplies	0.08***	0.08***
	(0.004)	(0.004)
Operating profit	0.02***	0.02***
	(0.002)	(0.002)
Net earnings	-0.00***	-0.00***
	(0.001)	(0.001)
Treated sector	0.07***	0.06**
		(0.024)
Post-ITC09	-0.00	0.00
	(0.011)	(0.010)
Treated sector & Post-ITC09	-0.00	-0.01
		(0.015)
Treated region		-0.01
		(0.070)
Treated sector & Treated region		0.03
		(0.022)
Treated sector & region & Post-ITC09		0.01
		(0.012)
Treatment intensity	0.26***	0.26
	(0.083)	(0.236)
Constant	0.20*	0.21*
	(0.111)	(0.111)
Observations	419,497	419,497
R^2	0.063	0.063
Number of firms	110,638	110,638

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Table C.6: Effect on Investment: Sectoral Treatment - Matched Subset of Firms (Geo)

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.01	0.01	0.01**
	(0.012)	(0.011)	(0.003)
Third-party supplies	0.13***	0.13***	-0.00
	(0.011)	(0.010)	(0.004)
Operating profit	-0.01	-0.02	-0.00
	(0.010)	(0.010)	(0.005)
Net earnings	0.11***	0.11***	0.01
	(0.008)	(0.007)	(0.004)
Personnel costs	0.00	0.00	0.00**
	(0.006)	(0.006)	(0.002)
Treated sector	0.04	0.06	-0.16
	(0.124)	(0.119)	(0.103)
Post-ITC09	-0.89***	-0.82***	0.15***
	(0.095)	(0.087)	(0.020)
Treated sector & Post-ITC09	0.08	0.07	-0.03
	(0.083)	(0.079)	(0.027)
Treatment intensity	0.30	0.59	0.57*
	(0.628)	(0.587)	(0.345)
Constant	3.94***	3.55***	0.28***
	(0.305)	(0.289)	(0.074)
Observations	555,654	555,656	555,654
R^2	0.040	0.040	0.002
Number of firms	157,105	157,107	157,105

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Table C.7: Effect on Investment: Geo-Sectoral Treatment - Matched Subset of Firms (Geo)

	(1)	(2)	(3)
VARIABLES	Total Investment (log)	Tangibles (log)	Intangibles (log)
Turnover	0.01	0.01	0.01**
	(0.012)	(0.011)	(0.003)
Third-party supplies	0.13***	0.13***	-0.00
	(0.011)	(0.010)	(0.004)
Operating profit	-0.01	-0.02*	-0.00
	(0.010)	(0.010)	(0.005)
Net earnings	0.11***	0.11***	0.01
	(0.008)	(0.007)	(0.004)
Personnel costs	0.00	0.00	0.00**
	(0.006)	(0.006)	(0.002)
Treated sector	0.03	0.04	-0.22
	(0.159)	(0.143)	(0.147)
Post-ITC09	-0.87***	-0.81***	0.17***
	(0.098)	(0.092)	(0.024)
Treated sector & Post-ITC09	-0.07	-0.08	-0.01
	(0.092)	(0.089)	(0.050)
Treated region	-0.53	-0.44	0.05
	(0.540)	(0.513)	(0.303)
Treated sector & Treated region	0.08	0.09	0.04
	(0.192)	(0.176)	(0.103)
Post-ITC09 & Treated region	-0.05	-0.03	-0.04*
	(0.068)	(0.062)	(0.023)
Treated sector& region & Post-ITC09	0.24**	0.24**	-0.04
	(0.100)	(0.096)	(0.054)
Treatment intensity	1.89	1.86	0.48
	(1.759)	(1.677)	(0.907)
Constant	3.95***	3.56***	0.28***
	(0.299)	(0.284)	(0.078)
Observations	555,654	555,656	555,654
R^2	0.040	0.040	0.002
Number of firms	157,105	157,107	157,105

Robust standard errors in parentheses

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

Firm and time FE with SE clustered by sector

Table C.8: Effect on number of employees (log) - Matched Subset of Firms (Geo)

	(1)	(2)
VARIABLES	Sectoral Treatment Effect - Matched Firms	Geo-Sectoral Treatment Effect - Matched Firms
Turnover	0.03***	0.03***
	(0.008)	(0.008)
Third-party supplies	0.06***	0.06***
	(0.004)	(0.004)
Operating profit	0.02***	0.02***
	(0.002)	(0.002)
Net earnings	-0.00***	-0.00***
	(0.001)	(0.001)
Treated sector	0.07***	0.09***
		(0.021)
Post-ITC09	0.01	0.03***
	(0.010)	(0.008)
Treated sector & Post-ITC09	-0.00	-0.01
		(0.014)
Treated region		0.06
		(0.072)
Treated sector & Treated region		0.01
		(0.024)
Post-ITC09 & Treated region		-0.04***
		(0.005)
Treated sector & region & Post-ITC09		0.02
		(0.015)
Treatment intensity	0.21***	0.08
	(0.073)	(0.229)
Constant	0.24**	0.23**
	(0.101)	(0.100)
Observations	555,661	555,661
R^2	0.050	0.051
Number of firms	157,110	157,110

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Table C.9: Log Total Investment: Regressions (Sectoral Treatment)

	Sectoral Treatment Effect: Log of Total Investment								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Baseline	Post-ITC09	Sectoral Treatment	Turnover	Services	Operating profit	Net earnings	Personnel costs	Treatment intensity
Treated sector	0.08	0.08	-0.00	0.03	0.02	-0.03	-0.01	-0.01	-0.01
	(0.102)	(0.102)	(0.116)	(0.115)	(0.116)	(0.104)	(0.107)	(0.107)	(0.107)
Post-ITC09		-1.02***	-1.05***	-1.02***	-1.02***	-0.93***	-0.90***	-0.90***	-0.90***
		(0.079)	(0.091)	(0.095)	(0.094)	(0.088)	(0.090)	(0.090)	(0.090)
Treated sector & Post-ITC09			0.15*	0.12	0.11	0.12	0.14*	0.14*	0.14*
			(0.079)	(0.079)	(0.079)	(0.076)	(0.077)	(0.077)	(0.077)
Turnover				0.02***	0.00	0.02**	0.01	0.01	0.01
				(0.005)	(0.005)	(0.007)	(0.011)	(0.010)	(0.010)
Third-party supplies & services					0.09***	0.13***	0.14***	0.13***	0.13***
					(0.013)	(0.013)	(0.011)	(0.011)	(0.011)
Operating profit						0.10***	-0.01	-0.02*	-0.02*
						(0.007)	(0.009)	(0.009)	(0.009)
Net earnings							0.12***	0.12***	0.12***
							(0.006)	(0.006)	(0.006)
Personnel costs								0.01**	0.01**
								(0.005)	(0.005)
Treatment intensity									0.44
									(0.446)
Constant	6.63***	6.63***	6.65***	6.35***	5.67***	4.28***	4.24***	4.21***	4.11***
	(0.065)	(0.065)	(0.072)	(0.096)	(0.142)	(0.286)	(0.290)	(0.283)	(0.286)
Observations	1,436,997	1,436,997	1,436,997	1,361,237	1,361,237	1,101,137	1,025,630	1,025,624	1,025,624
R^2	0.045	0.045	0.045	0.043	0.043	0.041	0.040	0.040	0.040
Number of npc_fic	386,338	386,338	386,338	365,689	365,689	312,810	302,502	302,499	302,499

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Firm FE with SE clustered by sector

Table C.10: Log Total Investment: Regressions (Geo-Sectoral Treatment)

Geo-Sectoral Treatment Effect: Log Total Investment

VARIABLES	(1) Baseline	(2) Sector	(3) Post-ITC09	(4) Geo-Sectoral Treatment	(5) Turnover	(6) Services	(7) Operating profit	(8) Net earnings	(9) Personnel costs	(10) Treatment intensity
Treated region	0.16	0.16	0.16	0.16	0.09	0.09	0.12	0.11	0.10	-0.13
	(0.107)	(0.107)	(0.107)	(0.105)	(0.108)	(0.108)	(0.129)	(0.141)	(0.141)	(0.392)
Treated sector		0.06	0.06	0.01	0.04	0.02	-0.03	-0.00	-0.00	-0.00
		(0.086)	(0.086)	(0.139)	(0.136)	(0.136)	(0.140)	(0.150)	(0.150)	(0.149)
post-ITC09			-1.02***	-1.02***	-1.00***	-1.01***	-0.92***	-0.88***	-0.88***	-0.88***
			(0.079)	(0.097)	(0.101)	(0.100)	(0.096)	(0.099)	(0.100)	(0.100)
Treated region & Treated sector				-0.04	-0.03	-0.03	0.02	0.02	0.01	0.01
				(0.125)	(0.130)	(0.129)	(0.148)	(0.158)	(0.158)	(0.158)
Treated region & post-ITC09				-0.05	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03
				(0.042)	(0.043)	(0.044)	(0.045)	(0.046)	(0.046)	(0.046)
Treated sector & post-ITC09				-0.09	-0.11	-0.11	-0.08	-0.07	-0.07	-0.07
				(0.089)	(0.090)	(0.090)	(0.090)	(0.093)	(0.093)	(0.093)
Treated region & Treated sector & post-ITC09				0.31***	0.29***	0.29***	0.27***	0.28***	0.28***	0.28***
				(0.070)	(0.071)	(0.071)	(0.075)	(0.076)	(0.076)	(0.076)
Turnover					0.02***	0.00	0.02**	0.01	0.01	0.01
					(0.005)	(0.005)	(0.007)	(0.011)	(0.010)	(0.010)
Third-party supplies & services						0.09***	0.13***	0.14***	0.13***	0.13***
						(0.013)	(0.013)	(0.011)	(0.011)	(0.011)
Operating profit							0.10***	-0.02	-0.02*	-0.02*
							(0.007)	(0.009)	(0.009)	(0.009)
Net earnings								0.12***	0.12***	0.12***
								(0.006)	(0.006)	(0.006)
Personnel costs									0.01**	0.01**
									(0.005)	(0.005)
Treatment intensity										0.80
										(1.326)
Constant	6.54***	6.53***	6.53***	6.54***	6.29***	5.62***	4.20***	4.16***	4.14***	4.12***
	(0.097)	(0.096)	(0.096)	(0.099)	(0.122)	(0.159)	(0.299)	(0.299)	(0.291)	(0.284)
Observations	1,436,997	1,436,997	1,436,997	1,436,997	1,361,237	1,361,237	1,101,137	1,025,630	1,025,624	1,025,624
R^2	0.045	0.045	0.045	0.045	0.043	0.043	0.041	0.040	0.040	0.040
Number of npc_fic	386,338	386,338	386,338	386,338	365,689	365,689	312,810	302,502	302,499	302,499

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Firm and time FE with SE clustered by sector

Table C.11: Number of Employees: Regressions (Sectoral Treatment)

Sectoral Treatment Effect: Number of Employees

VARIABLES	(1) Baseline	(2) Post-ITC09	(3) Sectoral treatment	(4) Treatment intensity	(5) Turnover	(6) Services	(7) Operating profit	(8) Net earnings
Treated sector	0.08***	0.08***	0.08***	0.08***	0.08***	0.07***	0.07***	0.08***
	(0.015)	(0.015)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)
Post-ITC09		0.00	0.00	0.00	-0.02	-0.02	-0.00	0.00
		(0.012)	(0.014)	(0.014)	(0.014)	(0.013)	(0.012)	(0.011)
Treated sector & post-ITC09			-0.00	-0.00	-0.00	-0.01	-0.00	-0.00
			(0.013)	(0.013)	(0.013)	(0.012)	(0.011)	(0.011)
Treatment intensity				0.22***	0.20***	0.19***	0.15***	0.18***
				(0.053)	(0.051)	(0.049)	(0.057)	(0.060)
Turnover					0.03***	0.02***	0.02***	0.03***
					(0.006)	(0.003)	(0.007)	(0.008)
Third-party supplies & services						0.06***	0.07***	0.06***
						(0.003)	(0.004)	(0.004)
Operating profit							0.01***	0.02***
							(0.001)	(0.001)
Net earnings								-0.01***
								(0.001)
Constant	1.18***	1.18***	1.18***	1.13***	0.86***	0.40***	0.15	0.10
	(0.009)	(0.009)	(0.010)	(0.017)	(0.072)	(0.065)	(0.107)	(0.104)
Observations	1,437,000	1,437,000	1,437,000	1,437,000	1,361,240	1,361,240	1,101,139	1,025,632
R^2	0.001	0.001	0.001	0.001	0.024	0.045	0.047	0.049
Number of npc_fic	386,338	386,338	386,338	386,338	365,689	365,689	312,812	302,504

Robust standard errors in parentheses

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

Firm FE with SE clustered by sector

Table C.12: Number of Employees: Regressions (Geo-Sectoral Treatment)

	Geosectoral Treatment Effect: Number of Employees								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Baseline	Treated sector	Post-ITC09	Geo-Sectoral Treatment	Treatment intensity	Turnover	Services	Operating profit	Net earnings
Treated region	0.08***	0.09***	0.09***	0.08***	0.02	-0.00	0.00	0.04	0.02
	(0.017)	(0.017)	(0.017)	(0.019)	(0.049)	(0.048)	(0.047)	(0.052)	(0.058)
Treated sector		0.12***	0.12***	0.11***	0.11***	0.09***	0.08***	0.08***	0.08***
				(0.023)	(0.023)	(0.022)	(0.021)	(0.022)	(0.021)
Post-ITC09			0.04***	0.03***	0.03***	-0.02	-0.02*	-0.00	0.00
			(0.011)	(0.012)	(0.012)	(0.012)	(0.011)	(0.010)	(0.009)
Treated region & Treated sector				0.02	0.02	0.01	0.01	0.03	0.03
				(0.019)	(0.019)	(0.017)	(0.017)	(0.019)	(0.020)
Treated region & Post-ITC09				0.01	0.01	0.00	0.00	0.00	0.00
				(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Treated sector & Post-ITC09				-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
				(0.018)	(0.018)	(0.016)	(0.015)	(0.014)	(0.014)
Treated region & Treated sector & Post-ITC09				-0.00	0.00	0.00	0.00	0.00	0.01
				(0.016)	(0.016)	(0.013)	(0.012)	(0.011)	(0.012)
Treatment intensity					0.21	0.19	0.16	0.02	0.09
					(0.160)	(0.161)	(0.156)	(0.176)	(0.183)
Turnover						0.03***	0.02***	0.02***	0.03***
						(0.006)	(0.003)	(0.007)	(0.008)
Third-party supplies & services							0.06***	0.07***	0.06***
							(0.003)	(0.004)	(0.004)
Operating profit								0.01***	0.02***
								(0.001)	(0.001)
Net earnings									-0.01***
									(0.001)
Constant	1.12***	1.10***	1.10***	1.10***	1.10***	0.86***	0.40***	0.15	0.10
	(0.014)	(0.015)	(0.015)	(0.016)	(0.016)	(0.071)	(0.064)	(0.106)	(0.103)
Observations	1,642,100	1,642,100	1,642,100	1,642,100	1,642,100	1,361,240	1,361,240	1,101,139	1,025,632
R^2	0.002	0.002	0.002	0.002	0.002	0.024	0.045	0.047	0.049
Number of npc_fic	407,525	407,525	407,525	407,525	407,525	365,689	365,689	312,812	302,504

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Firm and time FE with SE clustered by sector

Appendix D

Appendix: Chapter 4

Table D.1: ITC09 – Descriptive statistics

Year	Number of Firms Claiming ITC	Amount of tax credit (€)			
		Mean	Std. Dev.	Minimum	Maximum
2009	175	141 564	812 336	197	10 500 000
2010	229	103 585	609 710	522	8 722 603
2011	299	97 596	537 332	95	8 735 573
2012	694	94 308	669 396	84	14 200 000
2013	1555	65 653	576 170	9	20 900 000
2014	1550	77 434	509 027	17	16 300 000
2015	1790	68 999	250 990	21	6 546 776

Source: Authors' calculations using ITC data for 2009–2015.

Table D.2: ITC09 – Frequency of years of take-up per firm

Years with tax credit	Number of firms
1	1 526
2	715
3	564
4	146
5	88
6	66
7	32
Total	3137

Source: Authors' calculations using ITC data for 2009–2015.

Table D.3: Characteristics of the RFAI: 2009 – 2015

Period in Effect	**2009 – 2012**	**2013 – 2015**
Relevant Laws	Lei N. 10/2009, Article 13 (March) Decreto Lei N. 249/2009 (September)	Lei N. 44/2014, Article 13 (July) Decreto Lei N. 162/2014, Chapter 3, Article 22 (October)
Sector	Agriculture & forestry; energy; tourism; extractive & transformative industry (with the exception of the steel industry, shipbuilding, and synthetic fabric); activities related to broadband equipment	Agriculture & forestry; energy; tourism; extractive & transformative industry (with the exception of the steel industry, shipbuilding, and synthetic fabric); **activities related to high-tech research and development; audiovisual and multimedia; defense; environment; telecommunications; centers for shared services**
Eligible Investment	Acquisition of tangible goods directly related to the firm's activity: all machinery and equipment; land for firms in extractive industries; furniture and decoration for firms in the hotel sector; social equipment which firms are required to have by law. Vehicles excluded. Intangible goods: technological transfer (patents and licenses)	No change
Conditions for the firm	No debts towards the tax authority; use of regular accounting standards (no indirect reporting of taxable income); not officially considered to be firms in financial distress	No change
Conditions for the investment	Must be maintained in the region for at least **five** years; must lead to the creation of at least one job which is maintained until the end of the deduction period	Must be maintained in the region for at least **three** years for micro, small and medium firms; **five** years for all other firms; must lead to the creation of at least one job which is maintained until the end of the deduction period

Source: Assembleia da Republica Portuguesa (2009); Assembleia da Republica Portuguesa (2009).

Table D.4: RFAI Variations in Aid Limits: 2009 – 2015

Period in Effect	**2009 – 2012**	**2013 – 2015**
Maximum deduction	**25%** of total tax bill	**100%** of total tax bill for investments in the first three years of activity for new firms; **50%** for all other firms
Percentage of investment	**20%** up until 5€ million; **10%** above 5€ million	For investment in the North, Center, Alentejo, Madeira, and Azores regions: **25%** up until 5€ million; **10%** above 5€ million For investment in eligible municipalities in Algarve, Grande Lisboa, and Península de Setúbal *(see table D.5)*: **10%**
Deferral period	Up to **five** years	Up to **ten** years
Other deductions	For investment in buildings: **Five** year exemption from municipal property tax; exemption from paying indirect and stamp tax on real estate (subject to approval of regional authorities)	For investment in buildings: **Ten** year exemption from municipal property tax; exemption from paying indirect and stamp tax on real estate (subject to approval of regional authorities)
Intangibles	Maximum 50% of investment for firms not considered micro, small, or medium	No change

Source: Assembleia da Republica Portuguesa (2009); Assembleia da Republica Portuguesa (2009).

Table D.5: Geographical Caps on Aid Limits: 2009 – 2020

Period in Effect	**2009 – 2010**	**2011 – 2013**	**2014 – 2020**
North	30	30	25
Center	30 *Exceptions* Beira Interior Norte, Beira Interior Sul, Cova da Beira, Pinhal Interior Norte, Pinhal Interior Sul, Pinhal Litoral, Serra da Estrela: 40 Dão Lafões: 36.5	30	25
Alentejo	40 *Exceptions* Lezíria do Tejo: 30	30	25
Madeira	52	40	35
Azores	52	50	45
Algarve	30	20	10
Grande Lisboa	0 *Exceptions* Vila Franca de Xira - Alhandra, Alverca do Ribatejo, Castanheira do Ribatejo, Vila Franca de Xira: 15	0 *Exceptions:* Vila Franca de Xira - Alhandra, Alverca do Ribatejo, Castanheira do Ribatejo, Vila Franca de Xira: 15	0 *Exceptions:* Mafra, Loures, Vila Franca de Xira, S. Joào das Lampas e Terrugem: 10
Península de Setubal	0 *Exceptions* Setúbal, Palmela, Montijo, Alcochete: 15	0 *Exceptions:* Setúbal, Palmela, Montijo, Alcochete: 15	10

Note: All caps are increased by 10 percentage points for medium firms and 20 percentage points for small firms, except where eligible investment exceeds 5 €0 million.

Table D.6: Corporate Taxation in Portugal: 2010-2014

		2010-2011		2012	2013	2014	
		< €12,500	> €12,500			< €15,000	> €15,000
BASE RATE	Continent	12.5%	25%	25%	25%	23%/17%*	23%
	Madeira	10%	25%	25%	25%	23%/17%*	23%
	Azores	8.75%	17.5%	17.5%	17.5%	18.4%/13.6%*	18.4%

Note: Tax rates as reported by PWC in their annual summary of corporate taxation in Portugal. SMEs are micro, small, and medium-sized enterprises, defined by the European Commission as firms with less than 250 employees and either less than €50 million in annual turnover or a balance sheet total of less than €43 million. *Second set of numbers in 2014 for firms with less than €15,000 taxable profit applies to firms with SME designation.
Source: PricewaterhouseCoopers (2014)