Austerity Plans and Tax Evasion : Theory and Evidence from Greece

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January 16, 2014

Abstract

The austerity plans implemented in Greece in 2010 have yielded lower than expected increases in tax receipts. We argue that this has been the result of the arbitrage that firms face when choosing to declare their activity. A tax hike has a direct effect on the degree of tax evasion, and an indirect one through credit markets. A tax increase tightens the credit constraints of firms and depresses even further their incentives to be transparent. Using a dataset of about 30'000 Greek firms per year over the period 2002-2011, we provide evidence that firms adjust their declared profitability, and this adjustment depends on the tax burden and their need for credit. We then calibrate our model and show that leakages due to tax evasion are quite high : a 21% increase in tax rates only delivers a 7% increase in tax receipts. The response of transparency generates an additional investment slack which is the result of a contracting demand for credit by small and medium size firms induced by tax evasion.

JEL Classification Codes: E44, O17, H26.

Key words: tax evasion, austerity plans, credit frictions.

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1. Introduction

Following the sovereign crisis in late 2009, Southern European countries (Greece in particular but also Portugal, Italy and Spain) plunged into a deep recession and a severe political crisis. In all those countries, the response to the sovereign debt crisis consisted in large fiscal adjustments in order to reduce immediate deficits and ultimately, get further from the threatening debt ceiling. These adjustments were accompanied by a strong economic contraction and were insufficient to consolidate the primary balance compared to what was expected. Political crises in Greece, Italy or Spain emerged from the discrepancy between the popular sentiment that austerity was dampening the economic slack and the sequence of even more stringent policies adopted by the governments. Since these austerity plans were the key condition for having access to bail-out programs of international financial institutions[1], people had the feeling that austerity was intended as a punishment from outsiders rather than a cure.

We provide in this paper a very simple argument for the failure of austerity plans, particularly when they rely heavily on tax increases rather than cuts in government spendings[2]: in presence of imperfect tax enforcement, the decision to declare activity results from an arbitrage between improved access to credit and a lower tax burden. We provide evidence that Greek firms adjust their declared profitability, and this adjustment depends on the tax burden and their need for credit.

An austerity plan distorts this arbitrage through (i) an increased tax burden and (ii) lower gains from transparency. The behavioral response to higher tax rates is twofold. First, for a given level of transparency, a higher tax burden reduces future pledgeable cash flows and tightens credit constraints (taxes are senior to debt). Second, access to credit markets is less profitable, thus firms have less incentives to be transparent.[3] To understand the decomposition of these behavioral responses, consider the following accounting exercise. Let τ denote the tax rate paid by firms on the reported value added γv, where γ is the reported share of value added v. Suppose that the government wants to generate a fiscal surplus through an increase of value

[1] This was the case for the two financial packages delivered to Greece in 2010 and 2012.

[2] For many reasons (some of them political), over-indebted countries among the GIIPS like Portugal, Greece or Italy implemented fiscal reforms based mainly on tax increases.

[3] In addition, the marginal tax revenue generated by a marginal tax increase is low when the declared tax base is low. This mechanical consequence of tax evasion induces government of such countries to climb even further the Laffer curve to extract a surplus, exposing themselves to large behavioral responses.

added tax rate (VAT) and ultimately tax revenue dTR. The impact of this fiscal policy is :

$$dTR = \underbrace{\gamma v d\tau}_{dM} + \underbrace{\gamma \tau dv}_{dB} + \underbrace{\tau v d\gamma}_{dE}$$

We argue that the behavioral response, composed of the standard dB and our transparency component dE alleviates most of the mechanical response dM. These estimations are in line with the observed discrepancies between the targeted and actual tax revenues on firms collected by the Greek authorities during this period.[4] For instance, Greece planned a fiscal adjustment of 6 points of GDP in 2010 (from 15.4 in 2009 to 9.4), decomposed into expenditure cuts (2.9 points of GDP) and an increase in tax revenue (3.1 points of GDP). Greek authorities increased VAT accordingly (from 9 to 11 percent for the basic rate and from 19 to 23 percent for the high rate) but only collected a surplus of 1.5 points of GDP.

We build a very stylized model with heterogeneous credit-constrained firms and a passive government implementing an exogenous VAT tax shock. In order to account for the entrepreneur's trade-off between credit and tax burden, we assume that the choice of transparency, i.e. the proportion of declared plants, determines both the tax receipts and the cash flows that can be pledged to investors. In our model, a tax increase will have two effects. First, some small firms will not find it profitable anymore to be transparent and get access to credit. The reason is that there is a modern technology that necessitates a fixed investment. When credit constraints tighten, small firms cannot borrow enough and make this fixed investment profitable. Their response is to hide their activity completely. Second, medium-size firms will still find profitable to have access to credit but they show less than before. The aggregate implication of our model is that the transparency of the economy decreases adding to the direct recessionary effect of higher taxes.

We then calibrate the model using a dataset (balance sheets) of 30'000 Greek firms and show how costly it is for the government to levy VAT taxes as a function of institutional parameters, such as the protection of lenders and the tax monitoring. We provide a measure of the performance of austerity plans through their direct and indirect effects : (i) direct losses from poor enforcement (the internal revenue service is unable to collect tax receipts), (ii) indirect

[4]The Greek prime minister Lucas Papademos declared in an interview to *Il Sole 24 Ore* on March 30th 2012 that "the fight against tax evasion has yielded limited results partly because of the greater than previously forecast contraction of the economy". We argue that it was due to the greater than forecast contraction of the *declared* economy.

effects through the distortion induced by taxes and the incentives of informality when financial development is low. We show that the impact of austerity plans can be related to the interaction between fundamentals of the economy – the protection of lenders or tax monitoring – and the distribution of firms' size. To be more precise, the major channel through which a tax hike affects the economy is through small-medium firms becoming more informal. The amplitude of this effect depends on the share of activity generated by those marginal firms. Southern European countries are economies in which those effects are large: rather weak institutions are coupled with a large fraction of small-medium firms at the margin of formality. In the United States, financial development and tax monitoring are more developed and firms ta the margin of informality would be much smaller. In developing countries, tax enforcement is poor but the distribution of firms is bimodal with few very large firms and a multitude of very small businesses. In both cases, we would expect our behavioral response to be lower.

A critical mechanism of our model is the possibility for firms to strategically adjust the extent to which they declare their activity. We find empirical support for this mechanism in our data. We show an empirical regularity for firms subject to high tax pressure: Their profitability (ratio sales/total costs) jumps immediately before having access to credit. We do not observe this excess profitability before credit in sectors with low tax pressure (with the lowest VAT rate, and very exports-oriented). We interpret this observation as indirect evidence that firms strategically modify their transparency, i.e. the size of their declared activity, depending on their needs for external financing.

The stylized facts on the correlation between credit access and tax evasion come from a very different strategy than the literature. We use the fact that access to credit is preceded by exceptional peaks in firm's profitability, particularly in sectors with a high tax pressure. Doing so, we differ from Kleven et al. (2011) and Cai and Liu (2009), who estimate tax evasion using two reporting sources of income and the concordance between them.

While most of the literature focuses on personal income tax,[5] we rather focus on corporate tax evasion. This entails one major difference: corporate tax evasion crucially affects the extent to which firms borrow on financial markets. In that respect, we relate to Artavanis et al. (2012), which offers estimates of tax evasion based on bank's perceptions of true income in Greece. Their idea is that banks anticipate how reported income from borrowers maps to their real

[5]See Andreoni et al. (1998) and Slemrod and Yitzhaki (2002) for a review.

income. Occupations characterised by high tax evasion are those which are offered large loans relatively to their reported income. Our exercise is very different in nature but builds on the intuition that the activity declared to banks is closely tied to reports made to tax authorities. The fact that reported activity also influences access to finance has received some theoretical support from Straub (2005); Desai et al. (2007); Ellul et al. (2012). Firms face a trade-off when choosing their transparency: they can avoid taxes at the expense of access to credit. More generally, the literature has long established that firms can adjust the extent to which they declare their activity. In Cai and Liu (2009), the more competitive is the environment, the more reported profits differ from their imputed counterparts. Our exercise also departs from these studies since we provide a macro-estimate of the response of tax evasion to a change in tax pressure (austerity plans).

Our modeling of a dual technology world with a modern and a traditional technology relates to studies of shadow economies.[6] We depart from Rauch (1991) and Straub (2005) as we allow firms to adjust their degree of informality. In our setup, firms can decide to operate in the traditional sector, in which case access to credit is not needed. Accordingly, they operate as if they were completely informal. However, firms can also operate in the formal economy without being fully transparent. In this paper, we also estimate the degree to which firms switch from the formal to the informal sector following a tax hike. Lemieux et al. (1994) provides such estimates for individual labor supply in the shadow economy.

Finally, to our knowledge, this project is the first one which models the macroeconomic cost of an austerity plan in the presence of tax evasion. Nonetheless, the response of an economy to a tax shock has been extensively studied. Among others, Romer and Romer (2010), Ilzetzki et al. (2010), Favero et al. (2011), Auerbach and Gorodnichenko (2010), Alesina and Ardagna (2009) have tried to estimate a fiscal multiplier, some articles focusing on the identification of differences across countries, some other on how these multipliers might vary depending on the type of fiscal shock considered.

The paper is organized as follows: in section 2, we present the stylized facts on tax evasion that motivate the theoretical framework. In section 3, we introduce a model of transparency choice and credit access, where we detail the arbitrage faced by firms when declaring their activity. In section 4, we calibrate our model using the empirical evidence from Hellastat; we conduct

[6] See Enste and Schneider (2000); La Porta and Shleifer (2008) for a review.

numerical simulations to assess the impact of tax evasion and credit market frictions on the effectiveness of austerity plans. We then discuss some of the predictions of our model for the aggregate economy and for the distribution of credit among Greek firms. Finally, section 5 discusses some extensions and section 6 briefly concludes.

2. Tax evasion and credit access

In this section, we discuss the trade-off that is faced by firms when deciding to evade taxes. This trade-off is the building-block of our theoretical argument.

We first describe corporate tax evasion and extract an indicator of profitability (the ratio of profit to sales) that is related to firm's transparency. Then we provide evidence that access to credit is preceded by abnormally high values for this indicator: just before contacting lenders, firms declare more of their activity, which generates a sudden peak of observed profitability. Since we only observe this empirical regularity for firms subject to heavy tax burden, we take this observation as indirect evidence that firms in sectors with high tax pressure adjust their degree of transparency depending on their financial needs.

A. Corporate tax evasion

In general, media outlets focus on personal tax evasion, revealing for instance the existence of hidden Swiss bank accounts, or corporate tax avoidance, e.g. firms legally avoiding taxes by settling in a fiscal paradise. In this paper, we rather concentrate our focus on corporate tax evasion, which encompasses all illegal methods that reduce the corporate tax burden. Generally, corporate taxes consist in (i) a profit tax, and (ii) a VAT. In Greece, the corporate income tax (*profit* tax) is a flat rate on net operating income (sales net of total costs of production).[7] The VAT is a traditional tax on value added, and exported goods are thus not taxed. The VAT rate depends on the category of the produced good. The benchmark rate is 23% and concern most of the final goods. There exists a reduced rate of 13% that applies to fresh food and medicines.

[7] Over the period 2004-2011, the tax rate has decreased from a 32% in 2004 to 29% in 2006, and then 25% in 2007. From 2010 onward, a decrease of 1% per year is planned to reach 20%. Capital gains are taxed as regular income but there is an additional withholding tax of 10% on corporate dividend that applied starting from 2009.

Cultural goods and hotel accommodation benefit from a discount rate of 6.5%. Insurance, educational, legal and medical services are exempt from VAT.[8]
There are two main frauds that are used by firms to evade taxes:

- firms conceal or under-report sales. Reporting only part of their activity or, in the extreme case, avoiding any formal registration allow firms to escape both the profit tax and the VAT. In Greece, most of the self-employed (lawyers, doctors, plumbers, electricians...) and small businesses (street shops, restaurants...) that would be subject to registration do not comply despite an increasingly aggressive policy from tax authorities. In the same vein, it is possible to report some category 1 goods that are subject to high VAT rates (23%) to discounted categories (2 and 3, respectively 13 and 6.5%).

- firms can also inflate their operating costs, which reduce the income on which the profit tax is deducted. Typically, such outcome is achieved by over-reporting payments of intermediate goods; overstating wages is, for instance, a simple way to artificially increase costs.

In both cases, tax evasion is associated to low ratios sales/total costs. We refer henceforth to this ratio as the firm's *profitability*. How can tax authorities identify anomalies in this observed quantity? Sudden drops in firm's profitability or permanently low ratios sales/costs without bankruptcy point to potential frauds. We build on this observation and ask the question of what would occur if a firm suddenly needs to declare its activity. We would then expect a sudden jump in this firm's indicator of profitability.
Why would firms need to be transparent? Misreporting sales and operating costs of production may induce difficulties in the capacity of firms to raise funds and borrow. Artificially weak firm fundamentals increase the borrowing costs and reduce the availability of external funds. Consequently, reporting a large part of its activity is a requirement for access to credit. In the following subsection, we exploit balance sheet data from Greek firms and investigate how anomalies in corporate profitability immediately precede credit access.

[8]In addition, some areas in Greece, essentially the islands, are subject to a specific tax regime with lower rates for each category.

B. Anomalies in profitability and credit access

We present in this section our empirical strategy. Contrasting with Kleven et al. (2011) and Cai and Liu (2009) for instance, we cannot use the discrepancies between two sources of reporting income in order to identify tax evasion. We only observe accounting reports and cannot rely on any auditing information. Accordingly, we cannot fully ensure that anomalies in such reports are reporting anomalies, including tax evasion, or that they also reflect real changes in firm's activity.

In order to investigate the link between transparency and credit access, we rely on firm-level balance sheets data from Hellastat.[9] This dataset consists in comprehensive balance sheet information of Greek firms over the period 2001-2011. Firms have to publish their balance sheets whenever two of the following three criteria are fulfilled : (i) Turnover: 3 million, (ii) Total Assets: 1.5 million, (iii) Average staff: 50 people. We therefore observe the universe of registered firms above these thresholds in Greece. We also observe smaller firms that publish their accounts on a voluntary basis.

We are aware that the nature of data is such that we miss the tax evasion decision of very small firms and self-employed. However, it is very difficult to collect data on these small businesses because they simply do not appear in business registers. Although we do not observe fully informal firms, our data include firms that are mostly self-financed and operating in sectors plagued by tax evasion. These firms publish their accounts but adjust their transparency depending on their financial needs, the monitoring pressure and the tax environment. After cleaning the data for missing observations, we are left with more than 25'000 firms per year. The dataset is an unbalanced panel and we cannot assess the status of entrant/exiting firms.

Our empirical strategy relies on the following intuition: abnormal variations in firm profitability that precede the access to credit might reveal a transparency choice of the firm. One might argue that it is not very surprising that firms behave differently just before contacting lenders; they could have experienced an idiosyncratic productivity shock for instance. Our findings are a bit more subtle. We show that only firms subject to high tax rates behave differently immediately before the loan. Our methodology can be considered as a difference-in-difference,

[9]We thank the research director of the Foundation for Economic and Industrial Research (IOBE), Aggelos Tsakanikas, and Evaggelia Valavanioti for giving us access to these data.

comparing treated groups (high VAT) to non-treated groups (low VAT) in treatment periods (just before a loan) against non-treatment periods (the other periods).

First, we construct *profitability* $P_{i,t}$ of firm i in period t as the ratio of sales to operating costs. Second, for each firm, we identify the year of the largest growth of loans over the entire period and we define a dummy *credit access* $C_{i,t}$ equal to 1 in this specific year.[10]

We then regress *profitability* in period t on lags and forwards of *credit access*, and control for firm μ_i, industry×year $\eta_{ind,t}$ fixed effects. This specification allows us to extract the evolution of *profitability* around the access to loans, cleaned of firm-specific heterogeneity and cleaned of the industry-specific evolution.

$$P_{i,t} = \sum_{\tau=-2}^{2} \pi_\tau C_{i,t-\tau} + \eta_{ind,t} + \mu_i + \varepsilon_{i,t}$$

Letting T_i denote the period at which firm i gets access to credit, i.e. $C_{i,T_i} = 1$, then the coefficient π_0 is the gap between expected firm profitability in T_i and its profitability over the period. π_τ is the gap between expected firm profitability in $T_i + \tau$ and its profitability over the period.[11]

Figure 1 displays the coefficients π_τ with their 95% confidence interval for the full sample of firms. Two periods before having access to credit, firm profitability is very close to its average level. One period before the loan, profitability jumps .01 above its average, then drops below the average in the period contemporaneous to credit access, and finally reverts to the mean one period after.

Our main point is to argue that this empirical regularity should not be recorded for firms having little reason to conceal activity. How does the previous shape change along the different tax regimes? In figures 2 and 3, we reproduce the exercise for 2 decompositions into subsamples

[10] We also consider alternative definitions of credit access without any difference for our results: the year in which the firm switches its loans from 0 to a positive amount, the year of the largest growth in loans over the entire period, the year of the largest growth in leverage, the year of the largest growth rate of loans over the entire period, the year of the largest growth rate of leverage over the entire period, and the year when loans have increased by at least 25%.

[11] π_τ is the expected profitability conditional on credit being granted in period $t - \tau$, i.e. $C_{i,t-\tau} = 1$.

$$\pi_\tau = E[P_{i,t} | C_{i,t-\tau} = 1] - \mu_i$$

As a conclusion, τ is the difference between t and the loan period.

of firms facing different tax pressure. In figure 2, we divide the sample into non-tradable vs tradable sectors. Non-tradable sectors are defined as sectors where firms do not export.[12] In tradable sectors, firms are less concerned by VAT on their produced goods, because VAT on exported goods is reimbursed. In figure 3, we focus on firms in sectors with a lower rate (category 2 and 3) against firms in category 1. In all subsamples, $\pi_{-2}, \pi_0, \pi_1, \pi_2$ are the same. First, profitability coincides with its average two periods before the loan and after the loan. Second, firm profitability contemporaneous to the loan is always below average. The unique date in which the profitability dynamics differs across subsamples is one period before credit access. For firms subject to high tax pressure (high rate or non-tradable), firm profitability is above its average. For firms subject to low tax pressure (low rate or tradable), firm profitability is close to its average. Consequently, apart from the contemporaneous drop in profitability (common to all firms), firms subject to low VAT do not exhibit any significant deviation from the average. Only firms subject to high tax pressure exhibit excess profitability immediately before being granted credit.

We interpret the previous observation as evidence of a transparency margin. Firms face a trade-off between paying taxes and having access to credit. Declaring a larger fraction of its activity increases observable firm profitability and access to credit at the expense of higher VAT payments. Naturally, when tax pressure is low (low rate or tradable), this trade-off is not relevant and firms declare activity more frequently: they do not need external incentives such as credit.

3. A model of firm transparency and access to credit

We build on the previous empirical regularity and develop a theoretical model that captures the trade-off between paying taxes and being granted access to credit. There are three crucial ingredients in our model. First, we allow firms to choose the extent to which they declare their activity. Second, since access to external financing is conditional to the existence of pledgeable capital, concealing activity reduces the capacity to levy funds. Third, we introduce two technologies, one linear (the traditional technology), and the modern technology that is more productive but requires an operating fixed cost. We do so in order to capture that very

[12] See table in the appendix.

small firms are not able to levy sufficient funds for investment in the modern technology to be profitable. Accordingly, they prefer to operate in the informal sector with the traditional technology and without external financing. Importantly, we model firms' decisions for a given endowment: we ignore the dynamics that explain firm size distribution.

A. Environment

The economy is composed of a mass of homogenous firms producing competitively a unique final good that will be the numeraire. Firms are endowed with ω. Let $G(.)$ denote the cumulative distribution of those endowments.

Each firm is organized in a unit mass of homogeneous plants. The plants or establishments are homogenous in the sense that entrepreneurs cannot use a different technology or a different investment across their plants. We assume however that entrepreneurs can choose the fraction of plants whose value added is concealed. Each plant is either fully declared or informal. Let γ denote the fraction of declared plants (thereafter *transparency*). Firms produce using capital as unique factor, which they borrow from a competitive financial intermediary sector. The entrepreneurs have access to two technologies: a traditional one and a modern one. The access to the modern technology is conditional on paying a fixed innovation cost c. She then produces with a Cobb-Douglas function: $y = Ak^{\alpha}$. The traditional technology is available to all entrepreneurs. We assume that its returns are linear and equal to the international interest rate r. Once production has taken place, firms pay a tax rate τ on the reported value added, i.e. the value added generated in the declared establishments.

Taxes are collected by a tax authority, which has access to an audit technology. The tax authority detects an informal plant with probability $z(\omega)$.[13] In case of auditing, firms pay the tax $\theta\tau$ on the concealed value added. The punishment for being detected consists in the payment of an extra tax $\theta \geq 1$, which is set by the government. In order to get rid of idiosyncratic risk due to the random monitoring process, we assume that each establishment can be monitored with a random probability z by the tax police. The punishment implied by tax enforcement is then deterministic: a proportion of activities $z(\omega)$ is always audited. The total amount of taxes paid by firms is equal to the taxes on declared value added $\tau\gamma v$, and the amount $z(\omega)\theta\tau(1-\gamma)v$

[13] We assume here that endowment is observable: tax authorities may have imperfect signals on the firm's size.

paid to tax authorities after controls.

How do firms finance their investments? We assume that they borrow from international markets at a fixed interest rate r. However, there exists a financial friction arising from the imperfect pledgeability of firms' cash flows: creditors can only seize a fraction of entrepreneur's endowment in transparent plants. Taxes are junior to this recovery process. In the end, entrepreneurs can only pledge a fraction λ of the endowment stocked in their declared establishments. They reimburse as long as the amount that they need to pay is lower than the capital that can be seized by lenders.

$$\lambda\gamma\omega \geq (1+r)(k-\omega)$$

The timing of actions is as follows. Entrepreneurs first decide on their level of transparency, which is going to jointly determine how much value added can be pledged to lenders and how much will be taxed by the government. They borrow capital k at the international interest rate subject to their pledgeability constraint. Then, they decide to use the modern technology or the traditional one, they produce, reimburse their creditors and pay taxes, or fines if any.

We have not specified yet whether firms could become lenders. We assume that credit is fully transparent and taxed at the same rate τ, such that firms always prefer to invest in the traditional technology, rather than lending.

B. Choice of tranparency

We now derive the choice of entrepreneurs. For the sake of clarity, we display the analytical expressions with $z(\omega) = 0$ (no tax auditing from the government). In Appendix B, we derive the expressions for a more general auditing schedule $z(\omega)$. We also propose a simple model with endogenous auditing that generates auditing probabilities increasing with observed firm size.

Few preliminary remarks help us derive the behavior of entrepreneurs. First, there exists a threshold below which endowment is too low for investment in the modern technology to be sufficient and cover the fixed costs. Second, there exists another threshold above which the marginal investment is lower than returns on the traditional technology. Consequently, very rich and the very poor entrepreneurs are not willing to use external finance.

Under which condition do entrepreneurs invest in the modern technology? As long as the marginal returns on the modern technology are higher than the marginal returns on the tradi-

tional one, entrepreneurs would gain in borrowing. However, there is an additional cost: firms need to declare their activity and pay a tax on their declared production. The minimal level of investment $\underline{k}$ upon which entrepreneurs start to use their innovation is the wealth for which entrepreneurs are indifferent between operating in the traditional sector and using their innovation, given that they need to be fully transparent to do so. $\underline{k}$ is the smallest solution to the equation

$$A(1-\tau)\underline{k}^{\alpha} - c = r\underline{k}$$

Let $\underline{\omega}$ denote the minimum wealth that allows to levy $\underline{k}$, i.e. $\lambda\underline{\omega} = (1+r)(\underline{k} - \underline{\omega})$. Any entrepreneur with $\omega \geq \underline{\omega}$ could do better by being fully transparent with the modern technology than operating in the informal sector with the traditional one.

Under which condition do entrepreneurs invest in the modern technology without any recourse to external finance? Absent credit frictions, entrepreneurs that have access to the modern technology would conceal all their establishments and borrow such as to maximize $Ak^{\alpha} - c - Rk$. Let $k^* = (A\alpha/r)^{\frac{1}{1-\alpha}}$ denote the unconstrained solution. Rich entrepreneurs with endowment ω above $\overline{\omega} = k^*$, are unconstrained and thus set transparency equal to 0. They invest $\overline{\omega}$ in the modern technology and the residual $\omega - \overline{\omega}$ in the traditional one.

Those two quantities $(\underline{\omega}, \overline{\omega})$ allow us to isolate two zones in which the entrepreneur decision is simple. For $\omega < \underline{\omega}$, even a full transparency would not allow the entrepreneur to generate any surplus from borrowing. Accordingly, small firms are better off concealing their activity and renege on any loan. For $\omega \geq \overline{\omega}$, entrepreneurs are able to levy the optimal capital without relying on external creditors. Consequently, they conceal all their establishments.[14]

Finally, firms whose endowments are between $\underline{\omega}$ and $\overline{\omega}$ invest in the modern technology and their program can be written as follows:

$$\max_{\gamma,k} \{(1-\tau\gamma)Ak^{\alpha} - c - r(k-\omega)\}$$

subject to

$$\lambda\gamma\omega \geq (1+r)(k-\omega)$$

Define $\hat{k}$ the solution to this program. Investment $\hat{k}$ is the result of a trade-off between benefitting from the high returns in the modern technology, and the cost that it represents in terms of transparency. In order to borrow an additional unit, which generates $A\alpha k^{\alpha-1}$, the firm needs

[14] Naturally, this result hinges on the hypothesis that $z(\omega) = 0$.

to declare part of its activity and pay taxes (second term in the square brackets below). The difference between the gain and the cost should be equal to the price r of borrowing.

$$A\alpha k^{\alpha-1}\left[1-\frac{(1+r)\tau}{\lambda}\left(\frac{1+\alpha}{\alpha}\frac{k}{\omega}-1\right)\right]=r \tag{T}$$

Let $\hat{\gamma}=\frac{(1+r)(\hat{k}-\omega)}{\lambda\omega}$ denote the associated transparency.[15] The production of firms, drawn in the second panel of figure 5, is:

$$y=\begin{cases} r\omega & \text{if } \omega<\underline{\omega} \\ A[\min\{\frac{(\lambda+1+r)\omega}{1+r},\hat{k}\}]^{\alpha}-c & \text{if } \underline{\omega}\leq\omega<\overline{\omega} \\ A\bar{\omega}^{\alpha}+r(\omega-\bar{\omega})-c & \text{if } \omega\geq\overline{\omega} \end{cases}$$

Transparency follows a non-monotonic relationship with endowment. Before threshold $\underline{\omega}$, it is equal to 0. It jumps to 1 on the threshold, with entrepreneurs obliged to show all plants such as to make the investment in the modern technology profitable. Entrepreneurs borrow such as to bridge the gap between their wealth and the optimal investment. Immediately after $\underline{\omega}$, they need to bridge a very large gap, such that they declare everything. As their endowment grows, the gap becomes smaller and smaller, implying a lower transparency. It then reaches 0 for firms that do not require external financing.

Finally, remark that firms are rationed if their net worth is not sufficient to reach k^*: investing up to k^* requires to make an effort in terms of transparency. Accordingly, the marginal returns on the modern technology are lower than r even for an investment equal to k^*. Consequently, entrepreneurs with $\omega<k^*$ will not borrow entirely up to k^*.

We turn now to the properties of this allocation.

C. Predictions

How do aggregate investment and aggregate tranparency depend on the fundamentals of the economy? First, for firms investing in the modern technology, a simple analysis of equation (T) shows us that optimal investment $\hat{k}$ increases in capital pledgeability λ and decreases in taxes

[15] It could be that the solution to this equation implies that transparency is greater than 1. In this case,

$$\begin{cases} k=\min\{\frac{(\lambda+1+r)\omega}{1+r},\hat{k}\} \\ \gamma=\min\{1,\hat{\gamma}\} \end{cases}$$

τ, for any initial endowment. This observation comes from the fact that, if β denotes $\frac{(1+r)\tau}{\lambda}$, then

$$\frac{\partial \hat{k}}{\partial \beta} = -\frac{k + \alpha(k-\omega)}{\alpha(1-\alpha)(1+\beta)\frac{\omega}{k} + (1+\alpha)\alpha\beta} < 0$$

The intuition is that more tightening credit constraints (lower levels of λ) increase the cost of capital, and force firms to declare more in order to borrow a given amount. The leverage of firms is lower, and so is level of transparency. The impact of an increase in tax rates is qualitatively similar to a decrease in λ. In parallel, there is also a change in the threshold $\underline{\omega}$ when financial development decreases (or taxes increase): less firms decide to operate in the formal sector and only invest their endowment in the traditional technology.

Building on this result, following an increase in financial development, some firms find it profitable to get access to the modern technology at the expense of tax evasion (*extensive margin*). Firms that were already transparent can now borrow more (*intensive margin*). The size of the aggregate effect depends on the distribution of firms. To be more precise, it depends on the number of firms around the threshold $\underline{\omega}$ and the number of firms between $\underline{\omega}$ and $\overline{\omega}$. Those quantities determine the weights of the extensive margin effect and the intensive margin.

What happens after an increase of taxes? On the extensive margin, an increase in taxes induces some transparent firms in the modern sector to hide all their activity and operate in the traditional sector. On the intensive margin, firms see the investment in the modern sector less profitable than before, and reduce their investment together with their transparency.

We provide below the decomposition between the different effects. The aggregate production Y in the economy is :

$$Y = \int_0^{\underline{\omega}} r\omega dG(\omega) + \int_{\underline{\omega}}^{\bar{\omega}} \left[A\hat{k}(\omega)^\alpha - c\right] dG(\omega) + \int_{\overline{\omega}}^{\infty} \left[A\bar{\omega}^\alpha + r(\omega - \bar{\omega}) - c\right] dG(\omega)$$

The aggregate production of firms that do not access the credit market is $\int_0^{\overline{\omega}} r\omega dG(\omega) + \int_{\overline{\omega}}^{\infty} r\omega dG(\omega)$. Since these firms choose to conceal all their production (γ=0), the government does not manage to levy any taxes on them. The aggregate tax base is therefore :

$$Y_\tau = \int_{\underline{\omega}}^{\overline{\omega}} \hat{\gamma}(\omega) A\hat{k}(\omega)^\alpha dG(\omega)$$

Following an infinitesimal change in taxes $d\tau$, changes in aggregate tax base dY_τ can be decomposed as follows:

$$dY_\tau = dY_\tau^{ext} + dY_\tau^{int,k} + dY_\tau^{int,\gamma}$$

where dY_τ^{ext} is the extensive margin effect

$$dY_\tau^{ext} = -\frac{\partial \underline{\omega}}{\partial \tau}\hat{\gamma}(\underline{\omega})A\hat{k}(\underline{\omega})^\alpha g(\underline{\omega})d\tau \tag{D ext}$$

and $dY_\tau^{int,k}$ and $dY_\tau^{int,\gamma}$ are both intensive margin effects, $dY_\tau^{int,k}$ being the direct effect (decrease in investment) and $dY_\tau^{int,\gamma}$ the indirect response of transparency to the decrease in the required investment.

$$\begin{cases} dY_\tau^{int,k} = \int_{\underline{\omega}}^{\overline{\omega}} \hat{\gamma}(\omega)A\frac{\partial \hat{k}(\omega)^\alpha}{\partial \tau}dG(\omega)d\tau \\ dY_\tau^{int,\gamma} = \int_{\underline{\omega}}^{\overline{\omega}} \frac{\partial \hat{\gamma}(\omega)}{\partial \tau}A\hat{k}(\omega)^\alpha dG(\omega)d\tau \end{cases} \tag{D int}$$

This decomposition echoes our discussion in the introduction except that the transparency response consists in two components dY_τ^{ext} and $dY_\tau^{int,\gamma}$, while $dY_\tau^{int,k}$ is the traditional behavioral response described in the literature: taxes decrease the marginal returns on investments. The three effects are all negative following an increase in τ. The advantage of our model is to isolate them cleanly and provide a simple accounting framework that can be used for counterfactual experiments.[16]

In the following lines, we calibrate the model to the Greek case and illustrate, in this specific calibration, the quantitative importance of each margin.

4. The impact of austerity plans on Greek economy

We analyze in this section the Greek Austerity Plan implemented in 2010-2011. We first give some figures for the crisis and its aftermath. We then study the crisis through the lens of our model: we calibrate our model using Greek data in 2010 and provide some numerical estimates for the response of the underground economy to the austerity plan. We finally discuss some additional insights on the distributional implication of the austerity plans given by our model and discuss their empirical support.

A. The drastic austerity plan in Greece 2010-2011

In this paper, we analyze one channel through which austerity plans may prove inefficient as a way to reduce government deficits and we think of Greece as the perfect guinea pig. We explain here why this crisis is a good benchmark.

[16] See Appendix A for the details of output decomposition.

During the beginning of the 2000, Greece experienced a credit boom fostered by the integration to the Euro zone. At this time, there were already some concerns about (i) the flexibility of labor markets and (ii) the high indebtedness. Both concerns were attenuated by the globally positive perspectives on output growth. In the aftermath of the global crisis of 2008, those concerns materialized: the spreads peaked and Greece was forced to restructure its debt. A troika (European Commission, European Central Bank and International Monetary Fund) took over and imposed some conditions to the Greek government for them to roll-over the Greek debt[17] under some conditions. The government had to reduce deficits through the adoption of severe austerity plans. Since then, Greece has experienced a series of such plans.

The process has been more difficult than expected because of constant mismatches between the forecasts and the actual outcomes of each reform. In short, expected tax receipts were always over-estimated either by the government or by independent sources (research departments of Greek banks). This over-estimation reflected both optimistic estimations as regards the drop in GDP and inelastic estimates of the tax base (once accounted for the economic slack). In reality, the Greek economy responded to the tax hikes by concealing more of its activity to the government. As an example on the amplitude of the misalignment, between 2009 and 2010 the Bank of Greece (together with the Greek authorities) estimated that the increase in tax revenues should be around 15.5%, of which only 7.4% was realized. This shortfall was compensated by additional last-minute expenditures cuts: -9.5% instead of -5.3%. The same misalignment has been repeated the year later in Greece. Those readjustments point to behavioral responses as being large.

The measures to rebalance the government account had very strong contracting effects. In 2010, Greece has experienced a GDP contraction of 4.5% explained by the fall of private consumption (contributing for -3.3%), the reduction of government consumption (-1.3%), a fall of investment (-3.1%, gross capital formation), partially compensated by a rebalancing of the external account. In our model, this contraction can be related to a reduction of leverage for firms, and a general tightening of credit constraints, both triggered by higher taxes and lower transparency. In the following subsection, we analyze how our model predicts such responses, once calibrated using our database on Greek balance sheets.

[17] Cyprus, Ireland and Portugal also rescheduled their debt under the control of this troika.

B. Calibration

Our model is an accounting tool, which allows us to match quite precise moments of the Greek economy. Naturally, these degrees of freedom are obtained at the expense of some others: we consider the size distribution of firms as exogenous, so do we for the policy of tax authorities. In our view, firm's size is not as responsive as investment or transparency. Similarly, we shut down the possibility for technology or tax monitoring, i.e. fundamentals of the economy, to evolve during the period 2009-2013.

Our calibration strategy is the following. We calibrate our model using the firms' balance sheet information provided by our dataset. We observe a subsample of firms in Greece that represent a very high share of Greek activity (more than 80%).[18] We give in the following lines the predictions of our model on this subsample of firms. In order to clarify how such results can map to aggregate predictions, we need to make assumptions on the rest of the economy that we do not observe. We make such assumptions and interpret our results at the aggregate level in the following section. We choose our underlying parameters such as to match important features of those firms, i.e. the leverage, the output and tax receipts.

First, we set the elasticity sales/assets for range of mid-size Greek firms α equal to 0.8 in line with our estimates (see figure 8). We consider firms with sales above 0.1M Euros and estimate the elasticity of sales with respect to their size. It is well-known that such estimations suffer from endogeneity bias that we cannot fully alleviate. However, both cross-firms and within-firm across-time estimates give similar results – respectively 0.8 and 0.81. Figure 8 shows the fit of the relationship.

Second, we use our dataset to measure the average tax rate paid by firms. We use the sector classification used in the analysis of the profitability of firms to measure the average VAT tax rate paid by firms. In our dataset, about 69.4% of firms produce goods in the high VAT regime (19%), whereas 12.4% of firms are subject to the middle VAT regime (9%) and the remaining 18.2% of firms is either subject to the high regime or exempted (4%).[19] This provides us an

[18] Our notion of "aggregate" variable may be a bit different than the standard ones, as we only aggregate using our sample of firms, excluding de facto very small firms, whose contributions to total tax revenues are quite small and inelastic – they are informal irrespectively of credit conditions.

[19] In our database, over the period, we observe 60'662 firms under the low VAT regime, 41'238 firms under the middle VAT regime and 231'114 firms under the high VAT regime.

aggregate tax rate of 0.167. Finally, we set the interest rate r to 4%.

Third, sanctions $\theta z(\omega)$ are set such that the first firm for which $\theta z(\omega) = 1$, i.e. the smallest firm which finds it more convenient to be fully transparent than partially informal, has a turnover equal to 9M Euros. This is the level of activity above which all Greek firms are subject to have an external certification of their account. We interpret this threshold as the level of activity for which tax authorities may audit firms with ease, inducing firms to be fully transparent. Table 1 reports the benchmark calibration.

Given parameters α, τ, r and the function $\theta z(\omega)$, we are left with parameters A, c, and λ. These three parameters are chosen such to (i) minimize the distance between the theoretical leverage and the empirical leverage for firms with assets between 0 and 50M Euros (cf. figure 6), (ii) minimize the distance between the theoretical and the empirical output for firms with assets between 0 and 50M euro, and (iii) match the observed aggregate output of firms with assets between 0.5 and 100M Euros in our dataset.

We discretize the set of assets w and solve the optimal transparency decision of firms at each level of endowment. We then weight each variable by the observed density and compute aggregate quantities.

At the initial equilibrium, we find a level of aggregate transparency, defined as the ratio between the aggregate tax base and aggregate output, equal to 0.98. This is substantially higher than what is typically estimated in the literature (the shadow economy in Greece would be at least around 20%): it comes from the fact that we underestimate the influence of small firms in our analysis. Those informal firms are not in our sample and they typically do not respond to changes in tax conditions – they form an inelastic informal sector. Accounting for these firms boils down to adding a fixed informal sector, which would mechanically reduce our estimates for aggregate transparency.

In table 2, we show some targets that we want to match despite our calibration not being directly tied to those objectives. A first important feature is for the aggregate theoretical output to match the aggregate empirical output. As shown in the first line, our estimate is slightly lower than in the data, a discrepancy that arises mainly from very small firms: we under-estimate the contribution of firms below 2 Million Euros of endowment. The third and fourth lines give a measure for the discrepancy between our theoretical distributions of leverage and output and the empirical distributions. We compute the sum of squares of differences

Table 1: Benchmark calibration

Parameter	Symbol	Value
Returns to scale	α	0.82
Value added tax rate	τ	0.167
Risk-free interest rate	r	0.04
Credit constraints	λ	0.36
Fixed cost	c	1.91
Productivity factor	A	0.92

Table 2: Targets

Target	**Model**	**Data**
Output firms [0.5, 100] M	71.3B	86.2B
Full transparency threshold	11.5M	9M
Distance distribution theory-data		
Leverage (mean=.3)	0.05	.

between the empirical and theoretical series for output and leverage weighted by the densities of firms for each size (between 0.5 and 50 Millions of endowment). The result can be interpreted as a standard deviation of the theoretical series relatively to the empirical one. Both standard deviations are non-negligible, and are essentially explained by the discontinuous jumps that our model generates between informality and formality. Firms suddenly produce a much higher output at the cost of a larger dependence on external finance. In the data, such jumps are not observed. Nonetheless, as shown in the second line, the size above which firms are completely transparent in our model is very close to the threshold above which firms are audited in the data.

Finally, we cannot match the overall receipts from auditing, but we do not see it as a failure of our model. Both in the data and in our model, sanctions are very low. Consequently, they only act as a threat and whether we capture them well or not is visible on our levels of transparency rather than on the actual receipts due to tax monitoring.

C. Measuring the behavioral response after a tax hike

Using our benchmark calibration, we analyze the effect of changes in the tax rate on our economy. The objective of our numerical simulations is to replicate the Greek austerity plans and analyze how the transparency response could explain the observed misalignments between predicted tax receipts and actual tax receipts. To this purpose, we set the same tax rates as the government and estimate our predicted tax receipts.

We update the VAT rates according to the austerity measures implemented in 2010. The low VAT rate increased to 5.5%, the middle VAT rate to 11% and the high VAT rate to 23%. The repartition is quite invariant with firm size such that the average tax rate increases to 18.2% for our sample. We then measure the increase in aggregate tax receipts, and compute the change in the aggregate transparency. We also decompose the drop in the aggregate tax base in the extensive and intensive margin (with respect to transparency and capital) as suggested by the theoretical decompositions in equations (D ext) and (D int). We finally define a measure of the fiscal multiplier associated to the austerity plan. Contrary to usual measures of fiscal multipliers that are related to government expenditures, our fiscal multiplier reports the change in total output for an increase of 1 unit in tax receipts ($\Delta Y/\Delta TR$). The results are reported in the second column of table 4. Following the increase in the tax rate of 21.4%, the model predicts a drop in the tax base of 11.7% explained by a decrease of transparency (-8.9%) and output (-3.1%). Given the amplitude of both responses (essentially the transparency adjustment), tax receipts only increase marginally ($+7.4\%$). Interestingly, we can see that most of the drop in tax receipts is concentrated in mid-size firms that either drop off the formal economy or adjust their transparency downward (figure 9 shows the theoretical effect).
Overall, this simple exercise points to a large influence of the transparency channel, and this channel is sufficient in itself to explain the failure of tax hikes. The drop in tranparency may explain also the large ndrop in output observed in Greece after the implementation of the austerity plans in 2010.

Table 3: The impact of austerity measures

Variable	Austerity Plans
tax rate	+21.42
tax receipts	+7.41
tax base	-11.72
output	-3.08
transparency	-8.92
Estimate of fiscal multiplier	-0.42

Note : The figures in the top panel refer to the percentage change in each variable after the implementation of the austerity plans. The estimate of fiscal multiplier is defined as the change in total output for an increase of 1 unit in tax receipts.

Table 4: The drop in tax base at the extensive and intensive margin

Extensive margin	Intensive margin k	Intensive margin γ
0.052	0.085	0.863

Note : The extensive margin, intensive margin k and intensive margin γ refer to the shares of each margin in the drop of the tax base after the implementation of the austerity plans.

D. Aggregate predictions

One motivation behind our study is to reconcile the small increase in tax receipts collected by the Greek government with the large increase in taxes.

Our thought experiment in the previous section (a tax hike similar to the real VAT increase in Greece) predicts a very high behavioral response: taxes increases by 21.4%, but the aggregate tax base decreases by 11.7% in response. As a consequence, tax revenues only increases slightly, much less than in reality. The difference between the figures discussed in preamble and our model-based estimates may be explained by the absence of many concurrent factors in our model. For instance, we abstract from changes in other tax regimes, from changes in the functioning of labor markets or from heterogeneous effects across sectors.

The model-based behavioral response is composed of two elements, the standard behavioral response with a decrease in the real activity, and the decrease in the extent to which the

activity is declared. We estimate the second element to be the largest: 3.1% is lost through actual GDP contraction, and 8.9% through evasion. The evasion effect is large; it does more than bridging the gap between the loss in tax receipts and the loss in output. In other words, evasion, in our model, probably over-reacts compared to the data. The aggregate initial level of transparency, however, is in line with estimates of the literature (see Schneider et al. (2010) for instance).

More generally, under which conditions should we expect a large response to tax hikes? Our theoretical analysis shows that the impact of such experiments depends on the number of firms at the margin between informality and formality, i.e. the number of firms that are currently relying on external finance but are close to being indifferent with full informality. The number of such firms is determined by (a) the threshold at which firms are indifferent between informality and access to credit, (b) the density of firms around this threshold.

In Greece, for instance, financial development is not very high, which implies that a large range of small-medium firms are quite indifferent. We find a very large response because there are many of those firms. In contrast, in the United States, financial development is higher, which implies that the indifferent firm would be very small. The impact of an austerity plan would depend on the weight of such firms in the economy, arguably small.

This simple analysis points to the distribution of firm size as a crucial, and so far under-studied, factor behind the success of an austerity plan. The next section, by specifically analyzing the distributional evolution of firm's leverage, provides additional support for this statement.

E. Distributional implications

Our model of tax evasion makes two key predictions that are not visible in aggregate quantities: (i) credit shifts towards larger firms, and (ii) some firms exit the credit markets.

Before discussing the stylized facts, let us describe the behavior of credit over the period. Aggregate data on credit in Greece tell us that there has been a credit boom before the sovereign debt crisis of 2009. As shown in figure 12, our data confirm this pattern: the average amount of loans has increased steadily between 2003 and 2008, whereas in the aftermath of the Greek sovereign debt crisis in 2009, there has been a global decrease of bank loans. However, the analysis of micro-data allows us to go more into details and show a different response between large firms and small firms. In figure 10, we report the coefficients of a panel estimation where

we regress the ratio of bank loans over total assets on year dummies.[20] Figure 10 clearly shows that the drop in the ratio of bank loans over total assets is much more pronounced for small firms (those with total assets below 10M euro) than large firms.[21] This observation leads to the first stylized fact:

Stylized fact 1 (Access to credit and firm size) *:*
There has been a shift of credit from small firms to medium-large firms during the crisis (see figure 13). This shift is qualitatively similar to our theoretical predictions (see figure 4).

The aggregate drop in credit results from differential effects across the distribution of firms. As predicted by the model, the drop in credit comes essentially from small firms renouncing to contract credit. Figure 13 presents more explicit evidence. This figure reports the average leverage as a function of size in 2011 and 2007. In 2011 small firms with total assets ranging from 1 to 10 M Euros had a leverage substantially lower than the one the same firms had in 2007. However, medium firms in 2011 are more leveraged than their counterparts in 2007. We interpret this shift in the distribution of leverage as an indicator that the credit crunch was demand- and "small firms"- driven. Figure 13 is computed on the cross-section of firms, but is sensibly similar when computed excluding firms present only in 2007 or 2011. This shift is very close to the predictions of our theoretical model.
This shift may indicate that the credit drop is explained by the extensive margin, i.e. a fraction of firms renouncing to credit. A simple analysis of access to credit confirms this intuition.

Stylized fact 2 (Access to credit and the extensive margin) *:*
The number of new firms that have access to credit market decreased after the beginning of the crisis.

The first column of table 5 reports for each year in our panel the percent share of firms that shifted their loans from 0 to a positive amount, as suggested by our definition of *loanaccess*.

[20] Figure 10 is computed cleaning for firms fixed effects. As such, the decrease of leverage does not account for any composition effect. Since we control for industry/year fixed effects, we interpret the figure as the evolution of leverage for one firm over the period. The discrepancies between this figure and the aggregate numbers (these differences are small) come from composition effects (entry-exit) over the period.

[21] In contrast, the patterns of net income before taxes for small and large firms are more similar. As shown in figure 11, small firms on average have lower net income before taxes than large firms, and the drop after the beginning of the recession is slightly bigger for large firms.

We interpret this measure as an indicator of credit access at the extensive margin. While being quite stable at 3.5-4 percent over the period 2003-2009, the fraction of new firms having access to credit falls to around 2.5 percent in 2010 and 2011. Our alternative indicators of credit access also show that after the credit boom that reached its peak in 2007-2008, both the share of firms having their larger growth in the level of loans ($loanaccess_1$) and the share of firms having the larger growth in the level of leverage ($loanaccess_2$) fall to their lower levels over the entire period.

Table 5: Loan access by year.

Year	$loanaccess$	$loanaccess_1$	$loanaccess_2$
2003	4.76	8.52	11.49
2004	3.57	7.63	9.08
2005	3.98	7.77	8.91
2006	3.33	9.26	9.49
2007	3.37	10.16	9.30
2008	3.37	10.96	8.87
2009	4.05	9.72	7.94
2010	2.26	4.73	3.97
2011	2.48	3.59	3.08

In conclusion, the predictions of our model on the distributional impact of tax hikes are empirically verified, at least qualitatively.

5. Discussion and extensions

In our model, we focus on the transparency decision of firms, and credit demand. There are additional mechanisms at play that we have not discussed so far. These mechanisms pertain to the role of the financial intermediary sector (credit supply) and the government.

One crucial element that we do not explore is that the austerity plans were a response to a debt overhang, and thus to a high default risk. One such situation has implications on the functioning of credit markets. The domestic banking sector usually owns a large share of sovereign bonds.

A negative shock on the value of those bonds - a debt overhang - lowers the value of bank's assets and limits their capacity to lend. This situation leads to lower transparency because fewer firms are granted access to credit. We ignore this channel because we do not think that it would change our conclusions in the specific Greek case: the injection of capital in undercapitalized banks exactly offset the depreciation of collateral held by domestic banks. The undercapitalization of Greek banks was rapidly tackled with large injections of capital ensured through the Hellenic Financial Stability Fund (HFSF). This policy was successful at saving banks from liquidation but not at revitalizing credit (the purpose was only to stabilize bank's collateral). One could argue, however, that an additional injection of liquidity into the financial sector could counteract the incentives of firms to be less transparent. In our model, one such policy may be insufficient at fostering firms' credit demand, because the decrease in the cost of external finance (the interest rate) needs to be very large to offset the increase in tax burden. One solution could be to target the credit access of small to middle size firms.
Taking the default risk and debt overhang as exogenous does not allow us to model a mechanism frequently evoked in the public debate. If the austerity measures deliver a lower than expected fiscal adjustment, the markets may not believe in the capacity of the country to implement its fiscal adjustment and the risk premia on the sovereign bonds may rise again, fostering the first default shock. Since the financial sector is exposed to sovereign debt default, there could be a further valuation loss for the banking sector leading to a larger credit crunch and more tax evasion from the firms' side.

6. Conclusion

What have we learnt in this paper? When firms adjust the degree to which they declare their activity, an increase in taxes is diluted through the usual contraction of output, but also through a lower aggregate transparency. Since transparency guarantees a better access to credit market, its decrease aggravates the contraction by forcing firms out of credit markets. The amplitude of the transparency response depends upon the number of firms at the margin between formality and informality. The behavior of those firms is very sensitive to changes in the trade-off credit/tax evasion. In Greece, firms at the margin are quite large and very numerous.

Quantitatively, we can explain the gap between the expected tax receipts and the realized ones, only with this transparency channel. Following an increase in VAT of around 3-4 points, the Greek government expected an increase in tax receipts only slightly lower due to output contraction. In our quantitative framework (and in reality), the increase in tax receipts was, at least, twice lower than with a fixed level of tax evasion.

One important contribution of the present paper is to calibrate our model on a subsample of firms that represents the universe of medium and large firms and a large subsample of small-medium firms. In order to clarify why we expect those firms to adjust their transparency, we also provide some evidence that the profitability of the in-sample firms exhibit abnormal profitability levels immediately before getting access to credit. Another indirect support for our analysis is that we replicate closely the evolution of the leverage of firms as a function of their size. In particular, we expect credit to flow from smaller to larger firms and we observe such pattern in the data. Naturally, even if we observe most of the Greek production, we cannot observe very small firms that are expected to constitute most of the informal sector. In order to compensate for this caveat and provide some aggregate predictions, we would need to infer the behaviors of unobserved firms.

The policy implications of our analysis are not obvious. We show that austerity plans in an economy with low tax enforcement and low financial development are very likely to be diluted. Improving these institutions would help but is a difficult task: it is desirable even in the absence of austerity plans, and periods of economic turbulences may not be times in which structural reforms are simple to implement. One immediate implication of our model is that the impact of a tax increase essentially depends on the number of firms (and their size) that are almost indifferent between being formal or informal. This insight could help policy makers choose the timing or the type of tax reforms which reduce this margin as much as possible.

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Figures

Profitability

Figure 1: Firm profitability π_τ around loan access.

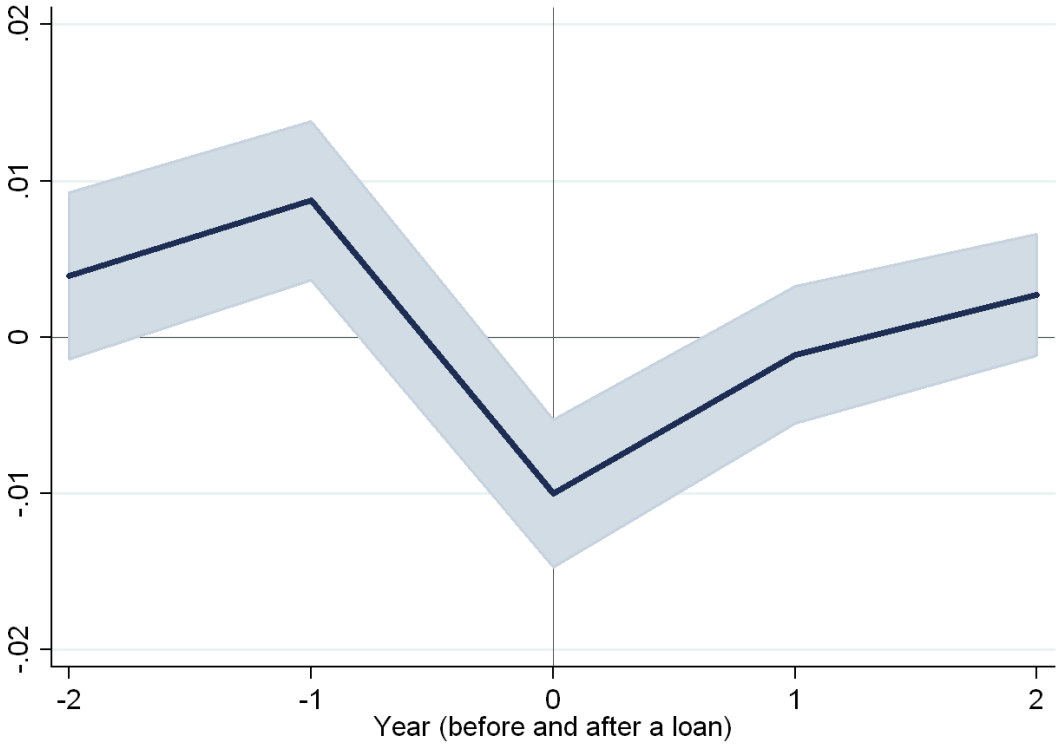
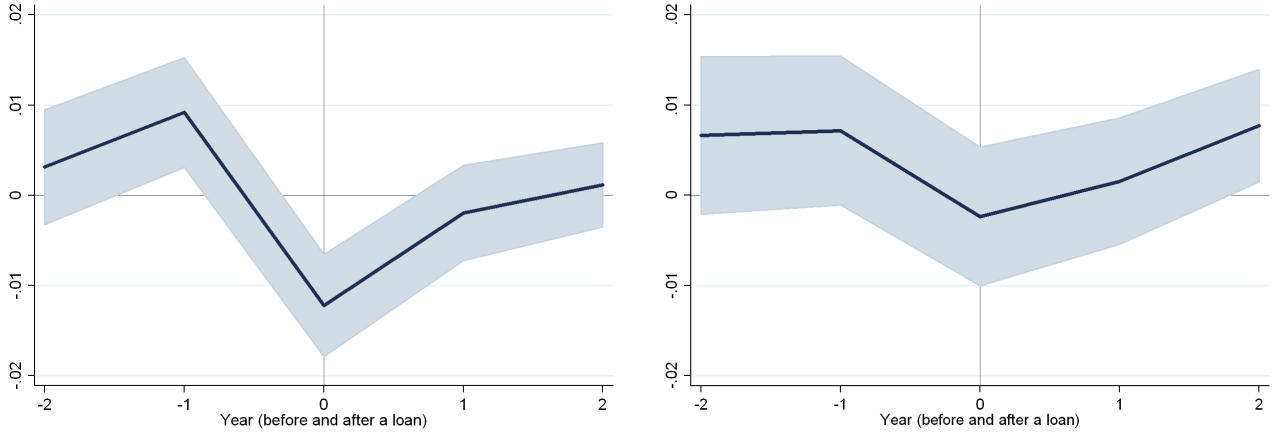


Figure 2: Firm profitability π_τ around loan access, non-tradable vs tradable.

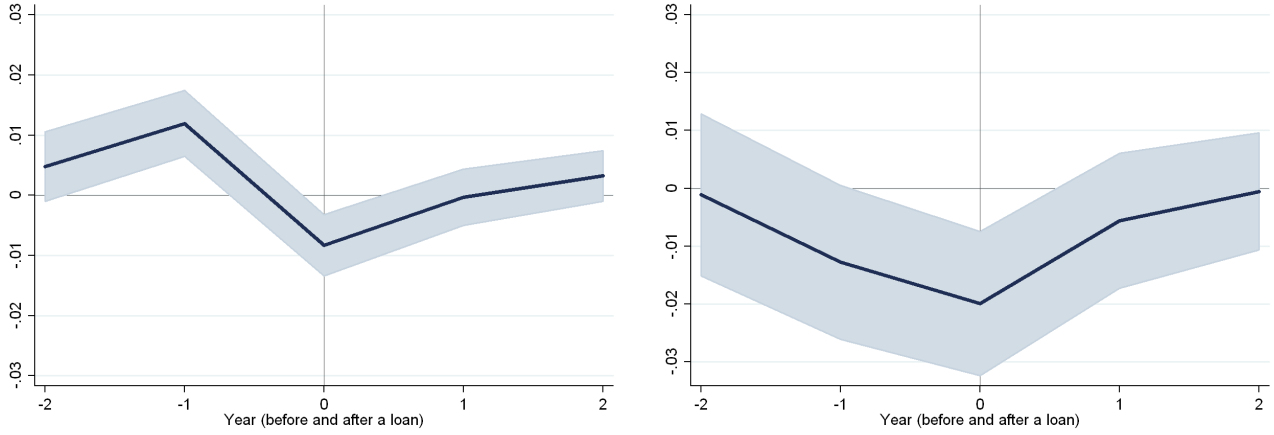


(a) Non-tradable sectors

(b) Tradable sectors

Source: Hellastat, 2001-2011.

Figure 3: Firm profitability π_τ around loan access, high vs low VAT.



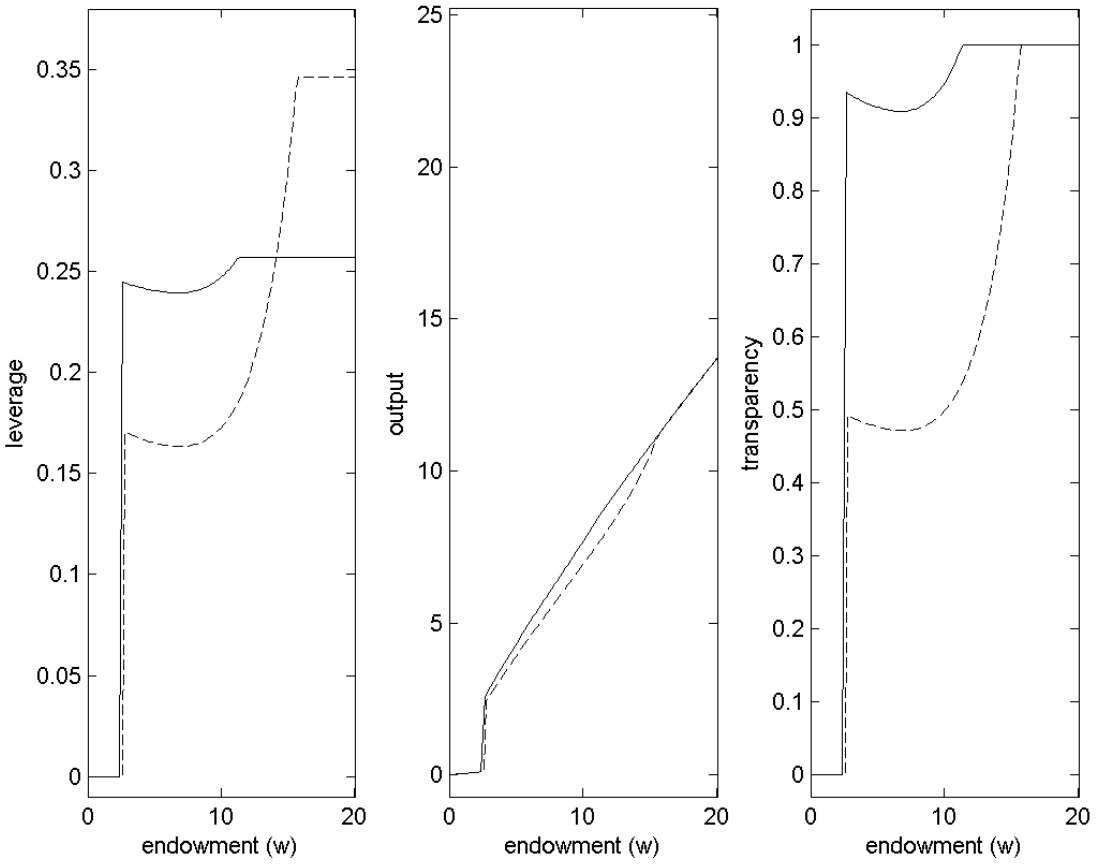
(a) High VAT rate

(b) Low VAT rate

Source: Hellastat, 2001-2011.

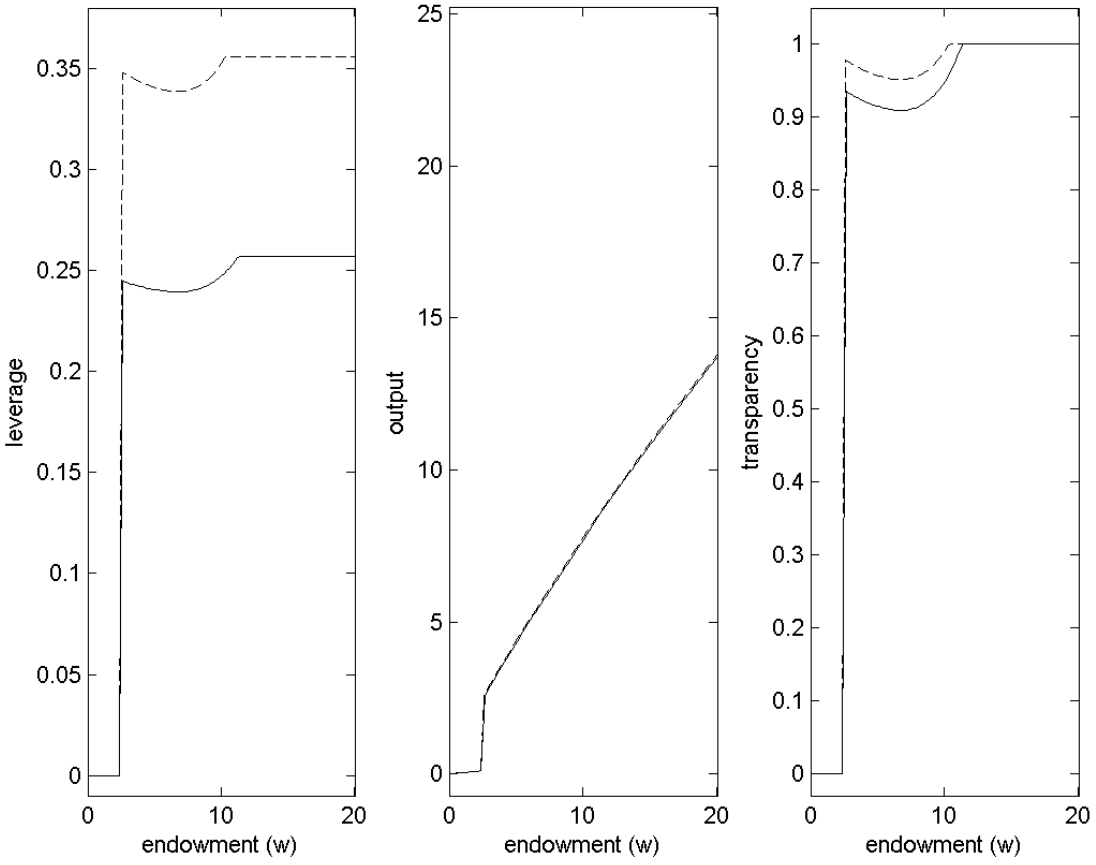
Theoretical predictions

Figure 4: Leverage, output and transparency : increase in τ



Leverage, output and transparency for the benchmark calibration (solid line) and the austerity plans simulation (dashed line).

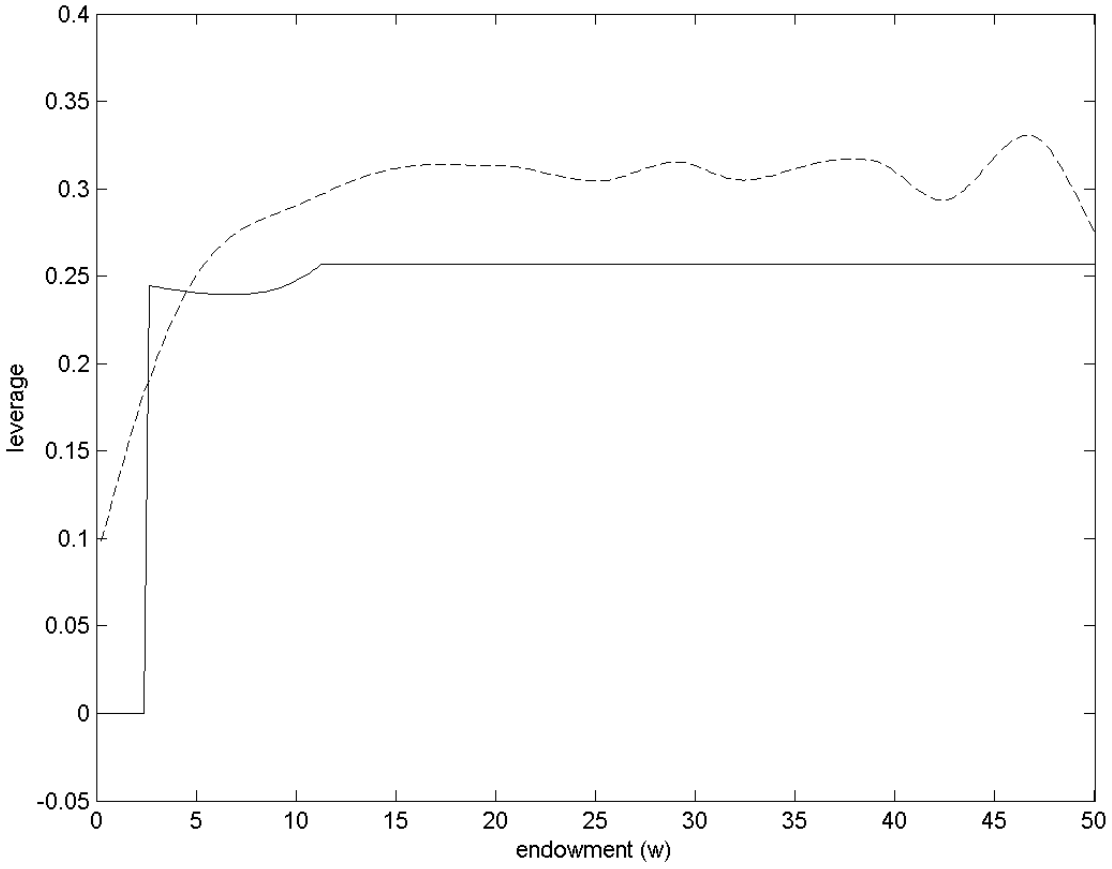
Figure 5: Leverage, output and transparency : increase in λ



Firm transparency for λ equal to 0.36 (solid line, benchmark calibration) and λ equal to 0.37 (dashed line).

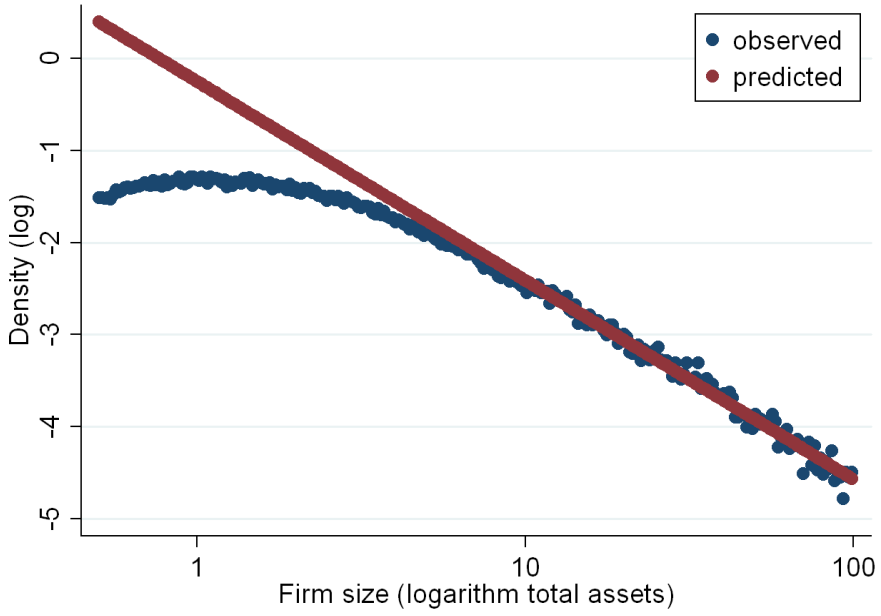
Model calibration

Figure 6: Empirical and theoretical leverage.



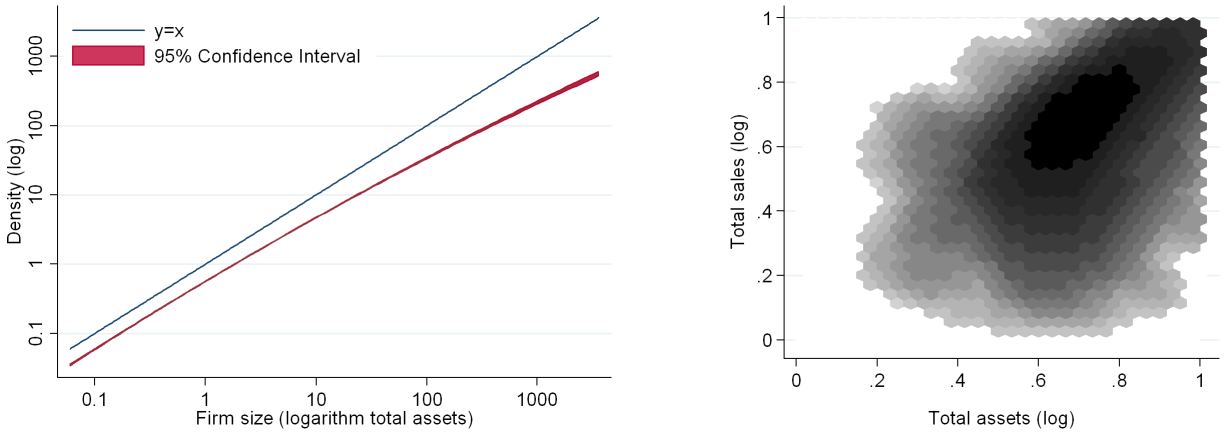
Note : Benchmark calibration. Solid line is the theoretical leverage, the dashed line is the empirical leverage for firms with assets between 0.5 and 50M euro (smoothed using a HP filter).

Figure 7: Size distribution.



Source: Hellastat, 2001-2011.

Figure 8: Empirical production function.



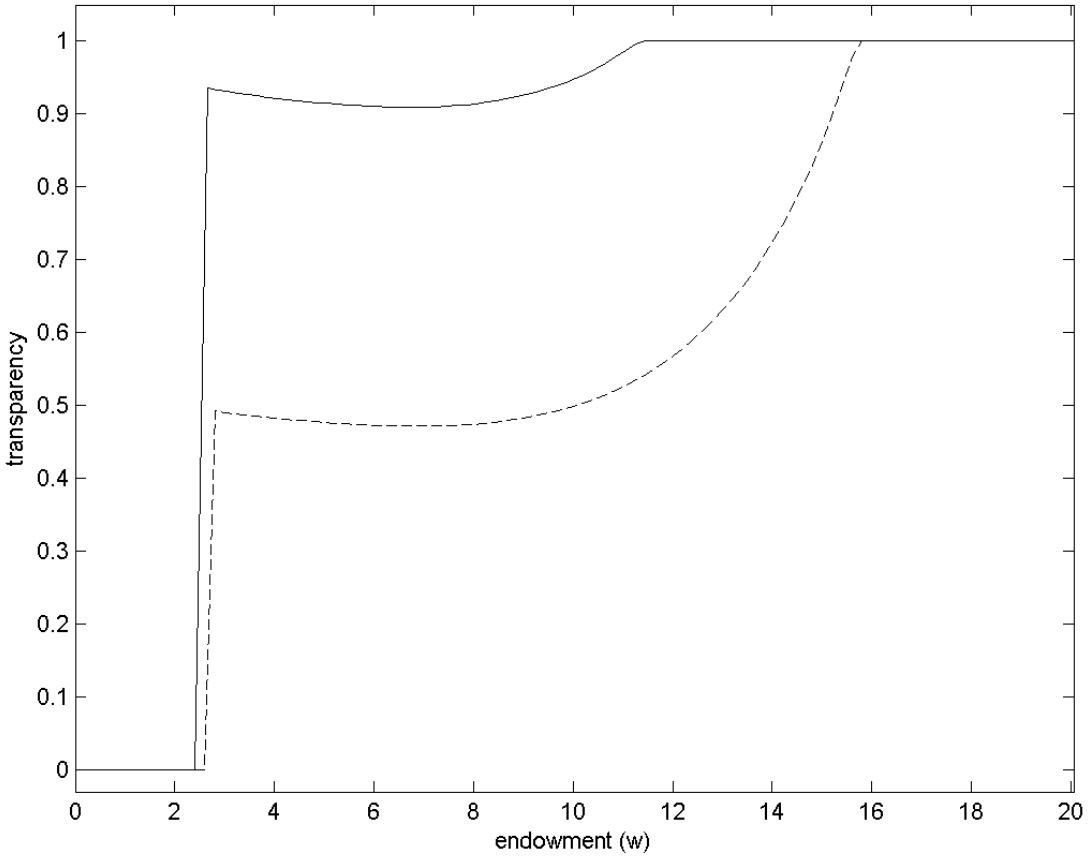
(a) Polynomial estimates

(b) Density

Source: Hellastat, 2002-2012. We use the whole sample of firms (approximately 30'000 firms per year).

Simulations

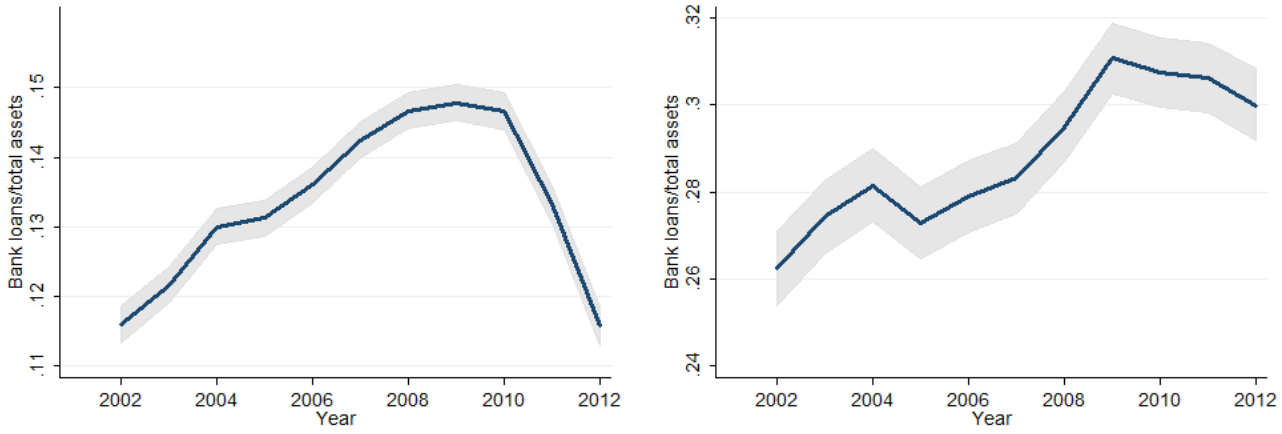
Figure 9: Firm transparency before and after the austerity plans



Firm transparency for the benchmark calibration (solid line) and the austerity plans simulation (dashed line).

Empirical evidence on credit market

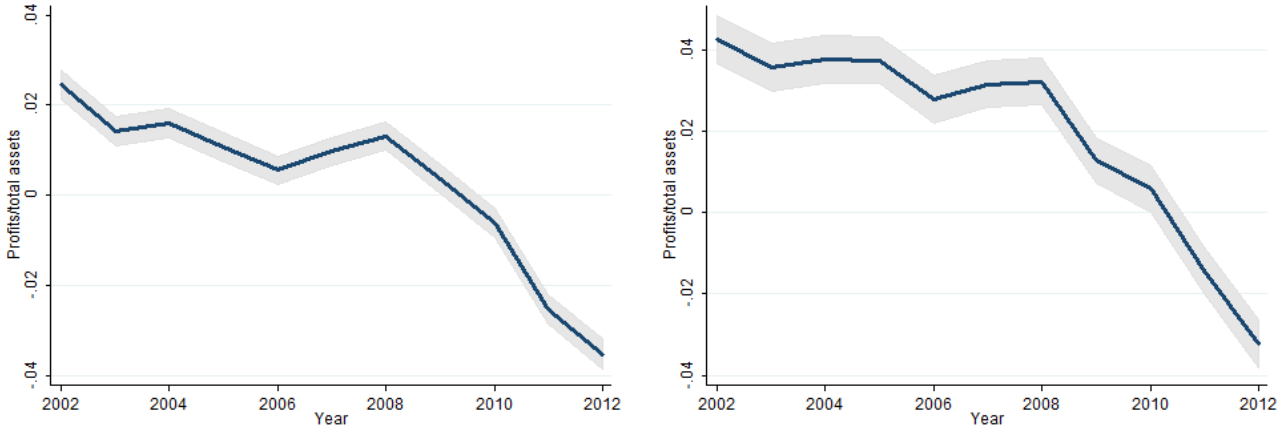
Figure 10: Evolution of bank loans over total assets, 2002-2012.



(a) Small firms, total assets less than 10 M euros (b) Large firms, total assets more than 10 M euros

Source: Hellastat, 2002-2012. We use a panel estimation on the whole sample of firms (approximately 30'000 firms per year). The values reported in the figures above are the coefficients of the year dummies. We weight for the size of firms. Thus the evolution of each variable can be interpreted as its aggregate evolution. Shaded areas are 95% confidence intervals.

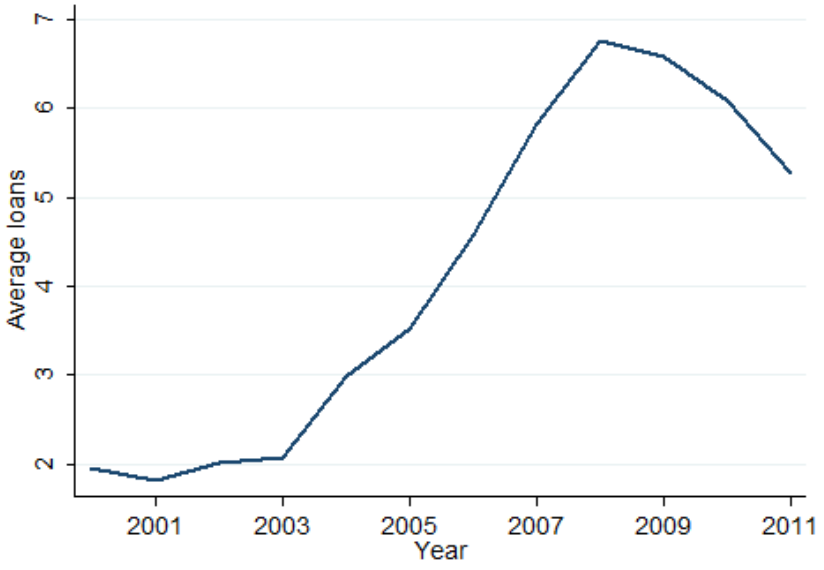
Figure 11: Evolution of net income before taxes over total assets, 2002-2012.



(a) Small firms, total assets less than 10 M euros (b) Large firms, total assets more than 10 M euros

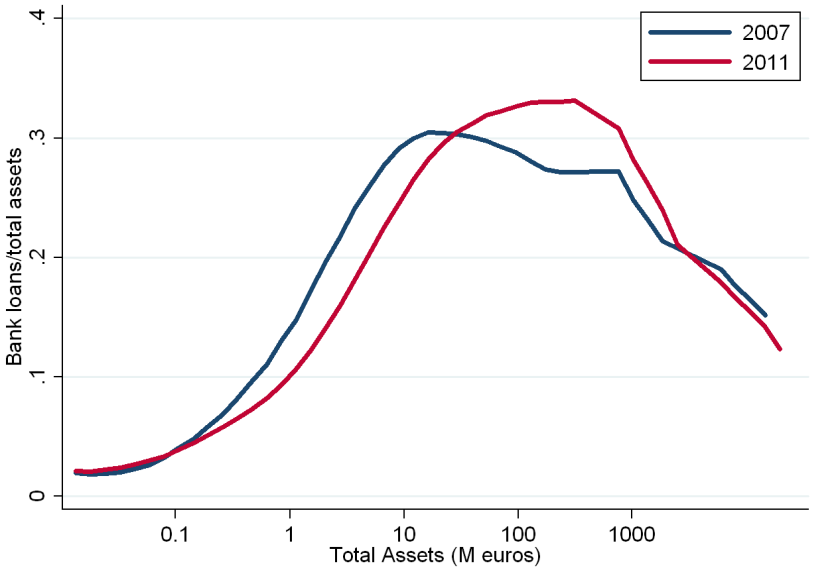
Source: Hellastat, 2002-2012. We use a panel estimation on the whole sample of firms (approximately 30'000 firms per year). The values reported in the figures above are the coefficients of the year dummies. We weight for the size of firms. Thus the evolution of each variable can be interpreted as its aggregate evolution. Shaded areas are 95% confidence intervals.

Figure 12: Average bank loans (M euro), 2000-2011.



Source: Hellastat, 2001-2011. This graph displays the average bank loans per firm over the period 2000-2011

Figure 13: Bank loans/Total assets and Total assets.



Source: Hellastat, 2001-2011. This graph displays the distribution of total bank loans over total assets before (2007) and after (2011) the austerity plan.

Appendix

A Total output and tax base decomposition

We define the total output before the austerity plan as $Y(\underline{\omega},\, \hat{k},\, \hat{\gamma})$, and the total output after the austerity plan as $Y(\underline{\omega}',\, \hat{k}',\, \hat{\gamma}')$. The difference in output after the implementation of the austerity plan may be decomposed as follows :

$$\Delta Y = \underbrace{Y(\underline{\omega}', \hat{k}', \hat{\gamma}') - Y(\underline{\omega}, \hat{k}', \hat{\gamma}')}_{\text{extensive margin}} + \underbrace{Y(\underline{\omega}, \hat{k}', \hat{\gamma}') - Y(\underline{\omega}, \hat{k}, \hat{\gamma}')}_{\text{intensive margin (k)}} + \underbrace{Y(\underline{\omega}, \hat{k}, \hat{\gamma}') - Y(\underline{\omega}, \hat{k}, \hat{\gamma})}_{\text{intensive margin } (\gamma)}$$

A similar decomposition applies for the aggregate tax base.

B Auditing

Exogenous audit schedule

A weakness of the model so far is the prediction that large firms, less dependent on external finance, choose very low levels of transparency. This feature does not map to the real transparency of large firms. Shareholders or the government would not allow part of firm's activity to escape their reach. Likewise, tax authorities cannot allow large firms to hide a big fraction of their plants and renege on these revenues. For instance, according to Greek law, firms with turnover above a given threshold (9 M euro) have to be audited by external accountants.

In this section, we take into account the impact of this auditing regulation on the firms' transparency decision by allowing the tax authority to target firms. Consider now that tax authorities can observe the initial endowment of firms ω at zero cost.[22]

Let $z : \omega \mapsto z(\omega)$ denote the audit schedule as a function of initial firm size. We consider it as exogenously given. Our problem is then very close to our benchmark framework. For simplicity, we assume that small firms (i.e. with $\omega < \bar{\omega}$) are never monitored. Accordingly, the threshold between small informal firms and firms who decide to invest in the modern technology remains

[22]Even if tax authorities only receive a signal on size, our results would go through. The only important feature is that tax audits do not respond to the individual decision of firms (both in terms of investment and transparency).

the same. Second, entrepreneurs that are unwilling to borrow may not be entirely informal: it depends on the cost paid to tax authorities on a unit produced in a concealed firm $\theta z(\omega)\tau$ against the cost τ paid on units produced in transparent plants. As long as $\theta z(\omega) > 1$, the punishment is so high that firms are willing to declare all their plants. For $\theta z(\omega) < 1$, the punishment is too low and firms hide their activity. Only for $\theta z(\omega) = 1$, firms are indifferent between declaring or not the marginal plant.

In the general case, the program can be written as follows:

$$\max_{\gamma,k} \{(1 - \tau\gamma - (1-\gamma)\theta z(\omega)\tau)Ak^{\alpha} - c - r(k-\omega)\}$$

subject to

$$\lambda\gamma\omega \geq (1+r)(k-\omega)$$

Define $\hat{k}$ the solution to this program.

$$A\alpha k^{\alpha-1}\left[1 - \theta z(\omega)\tau - \frac{(1+r)[1-\theta z(\omega)]\tau}{\lambda}\left(\frac{1+\alpha}{\alpha}\frac{k}{\omega} - 1\right)\right] = r \qquad \text{(Tz)}$$

In presence of tax auditing, the aggregate tax receipts include the taxes paid by firms on their transparent activity (τ times the aggregate tax base) and the fees raised by the auditing process. We can therefore define the aggregate tax receipts as :

$$TR = \tau Y_{\tau} + \int_{\underline{\omega}}^{\bar{\omega}} \theta z(\omega)\tau[1 - \hat{\gamma}(\omega)]A\hat{k}(\omega)^{\alpha} dG(\omega)$$

Note that both tax receipts and equation Tz extend the formulas derived in the text for the case $z = 0$. In our calibration, as observed in Greece, z will be an increasing function of size ω. We do not internalize the possible endogenous adjustment of fiscal authorities to changes in the decisions of firms. Our main reason for not incorporating this to our model is that we actually ignore the objective function of tax authorities. However, it is possible to understand why z is increasing in firm's size in a stylized model of tax auditing. We develop such a model below.

Endogenous auditing

We propose here a simple model that determines the extent to which tax authorities inspect firms of a given (observed) size. As before, consider that tax authorities perfectly observe firm size but none of their decisions afterwards.

Monitoring is not perfect in the sense that the tax authority does not discover the total number of hidden plants when they choose to monitor a firm. The effective probability $z(p)$ to discover the number of hidden plants increases in the intensity of monitoring p and decreases in the size of the hidden production.

The tax authority can observe the initial endowment of firms ω at zero cost. Visiting a plant has a cost $c(p)$ which is increasing convex in the monitoring intensity.

The tax authority maximizes tax retrieval from auditing activity, taking as given the hidden production of firms:

$$\max_p z(p)\theta\tau(1-\hat{\gamma})f(\hat{k}) - c(p)$$

The first order condition gives the probability of monitoring chosen by the tax authority :

$$c'(p) = \theta\tau(1-\hat{\gamma})f(\hat{k})z'(p)$$

This equation, coupled with the firm response, describe the equilibrium investment and auditing for a given firm size.

$$\begin{cases} c'(p) = \theta\tau(1-\hat{\gamma})f(\hat{k})z'(p) \\ A\alpha\hat{k}^{\alpha-1}\left[1-\theta z(p)\tau - \frac{(1+r)[1-\theta z(p)]\tau}{\lambda}\left(\frac{1+\alpha}{\alpha}\frac{\hat{k}}{p}-1\right)\right] = r \end{cases}$$

Figure 14 shows the equilibrium in the plan $(\hat{k}(1-\hat{\gamma}), p)$. Any increase in tax potential revenue (an increase in ω represented by the dashed line in graph 14) induces the governmment to monitor with higher intensity, such that firms respond by declaring a larger fraction of their plants.

What happens for larger firms? On the one hand, the relative cost of inspection decreases and tax authorities become more pressing. On the other hand, firms rely less on external finance. Both effects together imply that the effect on resulting hidden investment is ambiguous, but the auditing effort is unambiguously higher.

Figure 14: Equilibrium response of transparency to the monitoring intensity