

AUSTERITY PLANS AND TAX EVASION : THEORY AND EVIDENCE FROM GREECE*

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November 14, 2014

Abstract

Between 2010 and 2013, the Greek government implemented series of drastic fiscal adjustments – austerity plans – which substantially missed their targets. We argue that the failure to meet the expected increase in tax revenues resulted from the response of corporate tax evasion to tax hikes. When facing higher taxes, firms do not only reduce their activity because of lower expected returns, but also increase the share of their non-declared activity. We provide a stylized model of heterogeneous firms, in which the direct effect of taxes on the incentives to declare is amplified through the credit constraints faced by firms. We calibrate the model using a dataset of 30'000 Greek firms over the period 2001-2011 and find that the elasticity of tax receipts to taxes is 0.56, much lower than 1. Three quarters of leakages in tax receipts are explained by small and medium size firms switching to non-declared activity. In turn, the larger share of non-declared activity affects the borrowing capacity of firms, and substantially reduces their investment.

JEL Classification Codes: E44, O17, H26.

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

*We thank Manolis Galenianos, Yuriy Gorodnichenko, Francesco Lippi, Claudio Michelacci and seminar participants at the “Macro and Policy Implications of Underground Economy and Tax Evasion” (Bocconi 2012), 2014 Annual Meeting of the Society for Economic Dynamics (SED) Toronto, University of Lausanne, EIEF and Italian Treasury for helpful comments. We also thank the research director of the Foundation for Economic and Industrial Research (IOBE), Aggelos Tsakanikas, and Evaggelia Valavanioti for giving us access to Hellastat data. The research leading to these results received funding from the European Research Council under the European Union’s Seventh Framework Programme (FP7/2007-2013) / ERC Grant agreement n. 241114.

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1. Introduction

Between 2010 and 2013, the Greek government implemented series of drastic fiscal adjustments imposed by the European Commission, the International Monetary Fund and the European Central Bank – the “Troika” – as a condition for the international bail-out on Greek sovereign debt. The first adjustment program in 2010 was unprecedented in its intensity. The increase in tax revenues targeted by this adjustment program (henceforth *austerity plan*) was based on two pillars : (i) an increase in standard VAT rate from 19 to 23% and (ii) an increase in the excise rates on oil which almost doubled. However, while revenues from excises increased as expected, revenues from VAT only increased marginally. Overall, Greek authorities only collected half of the expected excess tax revenue – 1.5 instead of 3.1 points of GDP – which led to further adjustments in 2011, 2012 and 2013.

The failure to meet the expectations did not come from an unexpected output drop. First, the Greek government and the Troika were aware of the recessionary effects of tax hikes. Second, in order to explain a discrepancy of such magnitude between expected and realized revenues, one would need a fall in output 5 percentage points larger than the one expected. Instead, the failure resulted from a lower capacity of Greek authorities to collect taxes. Figure 1 reports the collection efficiency, i.e. the ratio of realized tax revenues to the expected tax revenues *given the realized output drop*, for VAT and for excises in Greece and in Portugal.¹ Not surprisingly, the collection efficiency for excises is constant over the period for both countries, as the payment of excises on oil is generally well enforced. In contrast, VAT collection efficiency exhibits significant fluctuations reflecting the low VAT enforcement in both countries.² Greece and Portugal display very similar patterns before 2010, but the two trajectories diverge markedly in 2010-2011, precisely when the austerity plan implemented in Greece led to an increase in VAT. Relatively to Portugal where VAT rates remained unchanged, Greece saw its collection efficiency decrease by 5 or 6%, a number sufficient to explain the failure of the first austerity plan. Given that we control for potential changes in composition of the tax base, the movements in collection efficiency directly reflect changes in tax evasion. While fluctuations in output due to tax hikes are known and taken into account by governments willing to implement austerity plans, little is known on the short-term dynamics of tax evasion

¹We consider as given the realized value added in each sector and for each category of good. The expected tax revenue is the sum of each value added weighted by the corresponding VAT rate. As such, we account for composition effects, i.e., changes in the value added generated in sectors subject to low tax rates or exempt from VAT.

²A cross-country analysis of VAT collection efficiencies shows that they are very stable in countries with good tax monitoring like France.

and its implications for the effectiveness of such plans.

In this paper, we study the response of tax evasion to tax hikes in an environment with imperfect tax enforcement, like Greece in 2010. We show that the elasticity of tax evasion to taxes is quantitatively important and contributes to the failure of the austerity plan in raising tax revenues. The theoretical intuition is the following. With imperfect tax enforcement, tax monitoring alone is insufficient to deter businesses from concealing their activity. One important motive for small businesses to declare their activity is access to credit (see Straub (2005); Desai et al. (2007); Ellul et al. (2014)) because reported activity is visible to external investors and can better be pledged. *Transparency*, that is the share of declared activity, simultaneously determines access to external finance and tax pressure. What happens after a VAT increase? First, the cost of being transparent mechanically increases. Second, the lower expected returns to pledgeable cash flows reduce the gains from being granted access to credit. Overall, the trade-off between tax evasion and access to external finance is distorted along these two dimensions. Firms tilt resources toward non-declared activity and the tax base shrinks more than in a fully transparent world.

We build our quantitative analysis on a stylized model in which heterogeneous credit-constrained firms operate in a modern and a traditional sector, and a tax authority implements an exogenous VAT 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 fraction of declared activity, determines both the tax receipts and the extent to which cash flows may be pledged to investors. In our model, a tax increase will have two distinct effects depending on firm size. First, small firms will not find it profitable anymore to be transparent and get access to credit. Their response is to switch their activity from the modern to the less productive traditional sector. Second, medium-size firms will still find profitable to operate mainly in the modern sector and have access to credit but they declare less than before. Interestingly, when small and medium size firms reduce the extent to which they declare their activity, they also tighten their credit constraints and reduce their investment, thereby widening the output drop. Overall, aggregate transparency decreases adding to the direct recessionary effect of higher taxes. At both ends of the firm size distribution, however, the response to tax increase will not pass through a transparency adjustment: large firms remain fully transparent while very small firms remain fully informal.

In our benchmark numerical simulation, we replicate the VAT increase implemented with the first Greek adjustment program in 2010. We calibrate our model

using balance sheets data on 30'000 Greek firms provided by Hellastat. These data allow us to match one crucial component of our analysis, which is the heterogeneity of access to external finance and output along firm size. We study the response of the economy to the austerity plan considering the following decomposition. The government raises indirect taxes τ on the reported share γ of value added v . The elasticity of tax receipts $\tau\gamma v$ to taxes is:

$$\varepsilon_{\tau\gamma v} = (1 + \varepsilon_{\gamma} + \varepsilon_v),$$

where $\varepsilon_{\gamma} < 0$ is the elasticity of transparency to taxes, that is equivalent to the elasticity of collection efficiency to taxes, and $\varepsilon_v < 0$ is the elasticity of output to taxes. These two elasticities constitute the behavioral response of the economy. We find that the total behavioral response alleviates almost half of the mechanical increase in tax revenues, i.e. $\varepsilon_{\tau\gamma v} = 0.56$. Within the behavioral response, three quarters come from the transparency component $\varepsilon_{\gamma} = -0.34$, against one quarter explained by the contraction of the economy $\varepsilon_v = -0.10$. These estimates are in line with (i) the gap between the expected and actual increase in tax revenues and (ii) the drop in collection efficiency observed after the austerity plan. In order to isolate the direct response of output to the change in taxes from the response due to changes in transparency, we use a simple exercise in which firms cannot adjust their transparency in response to the tax increase. We find that the output elasticity would be half lower than in the benchmark case, and would be essentially explained by large firms. To summarize, we find that most of the behavioral response comes from small and medium size firms reducing drastically their transparency, thereby tightening their credit constraints. This shift of credit out of small firms is qualitatively similar to the shift that we observe in our Hellastat panel data.

We run a series of counterfactual experiments in order to understand how the fundamentals of the economy – tax monitoring, financial development, firm size distribution – affect the magnitude of the transparency response. We show that the aggregate transparency response crucially depends on the share of economic activity generated by firms at the margin of informality. As tax monitoring or financial development improves, firms at the margin of informality are smaller, and the aggregate response of both transparency and output to tax changes decrease. The shape of the firm size distribution also plays a key role : the lower is the number of small firms in the economy, the smaller is the share of the activity sustained by firms adjusting their transparency in response to a tax hike.

These results suggest that Southern European countries are economies in which the aggregate effects are large, because marginal firms are medium-size firms and

they constitute a large share of the economy. In a country where financial development and tax monitoring are more developed, e.g. the United States, firms at the margin of informality would be much smaller. In developing countries, tax enforcement is poor but the distribution of firms is bimodal with few large firms and a multitude of very small businesses that are essentially informal. In both cases, we would expect the behavioral response to be lower. In this regard, our results point to Greece as one of the worst country in which an austerity plan based on tax hikes may produce a fiscal adjustment without consistently depressing the economic activity.

One critical point of our analysis is the choice of firms to adjust the extent to which they declare their activity, and the impact of such adjustment on the access to credit. We find empirical support for a strategic adjustment of transparency using our panel data on Greek firms' balance sheets. We analyze the behavior of profitability (ratio sales/total costs) around the time at which firms get access to credit and show an empirical regularity: profitability (ratio sales/total costs) jumps immediately before having access to credit in sectors with high tax pressure, i.e. with the highest VAT rate or not exports-oriented. Profitability is instead flat in sectors with low tax pressure, i.e. with the lowest VAT rate or very exports-oriented. We interpret this observation as indirect evidence that firms strategically modify their transparency, that is the size of their declared activity, depending on their needs for external financing.

This result may seem to contradict the findings in Artavanis et al. (2012), which show that concealed activity may also be partly pledgeable. Artavanis et al. (2012) find that the ratio credit/income granted by bankers depend on banker's perceptions of true income and not only declared income. Banks anticipate how reported income from borrowers maps into their real income and occupations characterized by high tax evasion are therefore those which are offered large loans relatively to their reported income. However, this result does not imply that borrowers can pledge their concealed activity exactly as their reported activity. Conditioning on the banker's beliefs, the individual returns (in terms of credit score, or loans) on the reported activity remain much larger than on the concealed activity. Our paper contributes to the economic literature in one important way. To our knowledge, this project is the first one which estimates the elasticity of transparency to taxes at a macro-level and its implication on the output response. Many papers estimate the elasticity of *output* to taxes, none of them being particularly focused on *tax revenues* per se. Among others, Alesina and Ardagna (2009), Romer and Romer (2010), Ilzetzki et al. (2013), Favero et al. (2011), Auerbach and Gorodnichenko (2012) have tried to es-

timate a fiscal multiplier, focusing on cross-country differences, on the type of fiscal shock considered, or the moment of the cycle when such policies are implemented. None of these papers study the contribution of tax evasion to this multiplier.

There exists a large literature analyzing, at the micro-level, the behavioral response to taxes.³ Micro-estimates are better identified, but may under- or over-estimate the response to tax evasion depending on the sample on which the “local” elasticities are estimated. In contrast, our analysis provides a model-based estimate which allows us to make macro-predictions, and explore how the elasticity should differ along firm size. We also differ from micro-level studies in another dimension. While most of the literature focuses on direct taxation, we rather focus on indirect taxation. This entails one major difference: indirect taxation, and VAT in particular, crucially affects the extent to which firms borrow on financial markets.

Our stylized facts on the correlation between credit access and tax evasion relate to the empirical literature on tax evasion. Among others, Kleven et al. (2011) and Cai and Liu (2009) identify tax evasion using the discrepancies between two reporting sources of income. In this paper, we instead adopt a different strategy and derive a new empirical observation : access to credit is preceded by exceptional peaks in firm’s profitability, particularly in sectors with a high tax pressure.

The fact that reported activity influences access to finance has received support from Straub (2005); Desai et al. (2007); Ellul et al. (2014) and we build our theoretical analysis on their contributions. More generally, the literature has long established that firms can adjust the extent to which they declare their activity. Our modeling of a dual technology world with a modern and a traditional technology relates to studies of shadow economies.⁴ We slightly depart from this literature (Rauch, 1991; Straub, 2005) because we allow firms to adjust their degree of informality rather than being fully informal or fully transparent. In this respect, we believe that such modelling choice is more suitable for the analysis of countries like Greece (or Italy and Spain), which are definitely plagued by tax evasion but can not be classified as developing countries where the transparency choice is often binary.

The paper is organized as follows: in section 2., we present stylized facts on the arbitrage between tax evasion and access to credit based on our dataset of Greek firms. In section 3., we analyze this trade-off in a quantitative model with heterogeneous firms and we discuss how we decompose the elasticity of aggregate tax receipts and aggregate output to taxes. In section 4., we calibrate our model, match important moments of the distribution of firms before the implementation

³See Andreoni et al. (1998) and Slemrod and Yitzhaki (2002) for a review.

⁴See Enste and Schneider (2000); Porta and Shleifer (2008) for a review.

of the austerity plan, and we conduct numerical simulations to assess the reasons behind the failure of the first austerity plan in Greece in 2010. We then perform counterfactual exercises in order to uncover the role of tax evasion, credit market frictions and the firm size distribution in the effectiveness of those plans. Finally, section 5. discusses some policy implications and briefly concludes.

2. The arbitrage tax evasion/credit access

In this section, we discuss one of the building-block of our theoretical argument. Firms affect their access to external finance when evading taxes and we provide a micro-based evidence of this arbitrage.

The section is organized as follows. 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. We then 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. A measure of corporate tax evasion

Policy makers often focus on direct tax evasion or corporate tax avoidance, e.g. firms avoiding taxes by settling in a fiscal paradise. In this paper, we focus on indirect tax evasion. Corporate taxes generally 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).⁵ The VAT is a traditional tax on value added and the rate depends on the category of the produced good (exported goods are exempt). The benchmark rate was 19% in 2009. There exists a reduced rate, 11% in 2009, that applies mainly to fresh food and medicines. Cultural goods and hotel accommodation benefit from a discount rate, 4.5% in 2009. Insurance, educational, legal and medical services are exempt.⁶

There are two main frauds that are used by firms to evade indirect taxes, and VAT in particular:

⁵Over 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 has been 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.

⁶In addition, some areas in Greece, essentially the islands, are subject to a specific tax regime with lower rates for each category.

- firms conceal or under-report sales. Reporting only part of their activity or, in the extreme case, avoiding any formal registration allows 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 to discounted categories.
- firms 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 or overstating wages.

In both cases, tax evasion is associated to low ratios of sales over total costs. We refer henceforth to this ratio as the firm's *profitability*. This measure is used by tax authorities to identify potential frauds. Sudden drops in firm's profitability or permanently low ratios sales/costs without bankruptcy point to such frauds.

We build our empirical strategy on this observation. What would occur if a firm suddenly needs to declare its activity? We would then expect an abnormal jump in this firm's indicator of profitability.

Why would firms need to declare its activity? 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.

Based on those two observations, we investigate how anomalies in corporate profitability immediately precede credit access and, in order to do this, we exploit balance sheet data from Greek firms.

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 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. 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 an increase in transparency. 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, 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).

In this regard, 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.⁷ We then regress *profitability* in period t on lags and forwards of *credit access*, and control for firm μ_i , industry \times 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.

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

⁷We also consider alternative definitions of credit access without any difference for our results: i) the year in which the firm switches its loans from 0 to a positive amount, ii) the year of the largest growth in loans over the entire period, iii) the year of the largest growth in leverage, iv) the year of the largest growth rate of loans over the entire period, v) the year of the largest growth rate of leverage over the entire period, and vi) the year when loans have increased by at least 25%.

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.⁸

Figure 2 displays the coefficients π_τ with their 95% confidence interval for firms subject to high VAT rates (category 1, subfigure 2(a)) and firms subject to low VAT rates (categories 2 and 3, subfigure 2(b)). In the high rate sample, 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. In contrast, in the low rate subsample, there is no evidence of a jump before credit access.

As a robustness check, in figure 3, we divide the sample into non-tradable (subfigure 3(a)) and tradable sectors (subfigure 3(b)). Our rationale is that exporting firms are less concerned by VAT on their produced goods, because VAT on exported goods is reimbursed. Non-tradable sectors are defined as sectors where firms do not export. Our findings are similar to the ones with high versus low VAT samples.

To summarize, in the four 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.

⁸ 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.

How does this transparency margin that can be observed at the micro-level translate to the macro-response following a fiscal policy shock? We turn to this question in the next section.

3. A model of firm transparency and investment

Building on the previous empirical regularity, we develop a simple static theoretical model which allows to derive our macro-elasticities of tax receipts ($\varepsilon_{\tau\gamma v}$), transparency (ε_γ) and output (ε_v) to taxes, accounting for firm heterogeneity. There are three crucial ingredients in our framework. First, we allow firms to choose their *transparency*, that is the extent to which they declare their activity. Second, access to external financing is conditional to the existence of pledgeable capital and concealed activity is less pledgeable than declared activity, such that tax evasion reduces the capacity to levy funds. In order to simplify the analysis, we consider that the activity that can be taxed coincides with what can be pledged. The decision of entrepreneurs can be therefore summarized by one sufficient variable : their level of transparency. Third, in order to replicate the very low transparency of small firms, we introduce two technologies, one linear (the traditional technology), and a more productive modern technology which requires an innovation. This innovation cost implies that very small firms, which are not able to levy sufficient funds for investment in the modern technology to be profitable, invest much less in order to be granted access to the modern technology. They mainly operate in the informal sector with the traditional technology and without external financing.

Note that, in our model, it is not crucial that there exists information asymmetry between the entrepreneurs and the creditors or the tax authorities. The key feature of our model is that tax evasion triggers a higher cost to the latter when they need to retrieve their loans or taxes. Naturally, information asymmetry is one likely factor which explains why recovery costs are higher when dealing with non-transparent firms.

Finally, in our exercise, we consider as given the firm size distribution: we do not try to relate the firm size distribution to fundamentals such as tax monitoring or financial development.

A. Environment

The economy lasts for one period and is populated by a continuum of risk-neutral entrepreneurs of measure one. Each entrepreneur is endowed with a certain quantity ω . Let $G(\cdot)$ denote the cumulative distribution of those endowments.

Firms produce a unique consumption good using capital as the unique factor. The market for the consumption good is perfectly competitive and there is an infinitely elastic demand at price $p = 1$.

There are two technologies available to entrepreneurs in order to produce the consumption good: a traditional one and a modern one. With the modern technology, the economy's capital stock can be used to produce the consumption good according to the following production function :

$$f(k) = Ak^\alpha.$$

We assume that the returns on the traditional technology are linear and equal to ρ . The access to the modern technology is conditional on an innovation. We assume that the innovation requires to pay an innovation investment c and is subject to an idiosyncratic draw whose success depends on the innovation investment. With probability $p(c)$, the entrepreneur is successful and can use the modern technology.

We turn now to the firm organization. Each entrepreneur owns a unique firm that 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 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 fully informal. Let γ denote the fraction of declared plants (thereafter transparency).

There is a tax authority which mechanically raises taxes τ on the reported value added, i.e. the value added generated in the declared establishments. As regards the the value added generated in the concealed establishments, we assume that the tax authority has access to an audit technology and can monitor firms. For simplicity, we posit that the tax authority perfectly observes each firm's endowment and firm's technology.⁹ However, even though the tax authority may infer a firm's transparency from these fundamentals, there exist auditing costs which prevent the tax authority from fully auditing non-transparent firms. Moreover, the monitoring technology does not allow recovering funds from concealed plants. The monitoring costs are introduced as follows : the tax authority can set for each firm the probability z of detecting a concealed plant and retrieve the unpaid taxes, but this effort incurs a cost $m(z)$. In case of an audit, firms pay the tax $\theta\tau$ on the concealed value added that is retrieved. $\theta \geq 1$ is the punishment for being detected and it is set exogenously. In conclusion, for a firm subject to monitoring effort z , the total amount of taxes paid

⁹Our results would go through if tax authorities have imperfect signals on the firm's size.

is equal to the taxes on declared value added $\tau\gamma v$, and the punishment $z\theta\tau(1 - \gamma)v$ paid to tax authorities after controls.

We turn now to the financial markets. In our small economy, the international risk neutral interest rate is $r > 0$. Among entrepreneurs, those with small endowments might want to borrow in order to expand their investment in the modern technology. They can do so by issuing bonds, which are subject to a financial friction. Entrepreneurs can only pledge to their creditors a share λ of declared endowment. As a result, entrepreneurs face the following credit constraint, which crucially depends on transparency:¹⁰

$$(1 + r)(k - \omega) \leq \lambda \cdot \gamma \cdot \omega. \quad (1)$$

The timing of actions is as follows. Entrepreneurs first invest in innovation, receive the innovation draw and decide whether to adopt the modern technology or not upon innovation success. Further, entrepreneurs decide on their level of transparency, which is going to jointly determine how many plants can be pledged to lenders and how many taxes on value added are paid to the government. They borrow capital $(k - \omega)$ at the international interest rate subject to their pledgeability constraint. Finally, they produce and reimburse their creditors. In parallel, the tax authority chooses, for each individual firm, an audit effort z and firms pay taxes or fines following the audit.

We have not specified yet whether firms could become lenders. We assume (i) that the return to the traditional technology is equal to the international interest rate $\rho = r$ and (ii) that credit is fully transparent and taxed at the same rate τ . This implies that (i) firms prefer to invest in the traditional technology rather than lending, except if they are fully transparent, and (ii) never borrow to produce in the traditional technology.

In the following lines, we describe the equilibrium allocation characterizing our economy. In order to clarify the entrepreneurs' trade-off between tax evasion and access to credit, we start with the entrepreneur's program once innovations have been made, taking the tax authority behavior as given. We then show how the tax authority determines the equilibrium monitoring decision, for each type of firms.

¹⁰Note that creditors can only seize a fraction of entrepreneur's endowment in transparent plants, and taxes are junior to this recovery process. Similarly to the tax authority, creditors observe firm's endowment and technology but the recovery technology is fully inefficient at recovering funds from concealed plants. Alternatively, we can relax this assumption and assume that there exists two technologies $\lambda_t > \lambda_c$ for transparent and concealed firms.

B. The entrepreneur

We consider first an entrepreneur endowed with ω and the traditional technology, subject to an audit effort z . The traditional entrepreneur maximizes

$$\pi_{\omega}^{tr} = \max_{\gamma} \{[1 - \tau\gamma - (1 - \gamma)\theta z\tau]r\omega\}$$

The entrepreneur never borrows nor lends, and invests exactly her endowment. Her transparency choice, however, depends on how θz compares to 1. Strictly above 1, she becomes fully transparent ($\gamma = 1$). Strictly below 1, she remains fully informal ($\gamma = 0$). Otherwise, she is indifferent.

We consider now an entrepreneur endowed with ω and the modern technology, and subject to an audit effort z . This modern entrepreneur maximizes her profits net of taxes subject to the credit constraint of equation (1):

$$\pi_{\omega}^{md} = \max_{\gamma, k} \{[1 - \tau\gamma - (1 - \gamma)\theta z\tau]Ak^{\alpha} - r(k - \omega)\}$$

subject to

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

Generally, as long as $\theta z \leq 1$ and $\omega \leq (A(1 - \tau)\alpha/r)^{\frac{1}{1-\alpha}}$, the credit constraint is binding.¹¹ In this case, the solution \hat{k} verifies:

$$A\alpha k^{\alpha-1} \left[1 - \theta z\tau - \frac{(1 + r)[1 - \theta z]\tau}{\lambda} \left(\frac{1 + \alpha}{\alpha} \frac{k}{\omega} - 1 \right) \right] = r \quad (2)$$

and the transparency choice $\hat{\gamma}$ is obtained by substituting the solution \hat{k} into the credit constraint. Equation (2) is very intuitive.¹² There is a trade-off between reaping the high returns in the modern technology, and the cost that it represents in terms of transparency. In order to borrow an additional unit, the firm needs 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.

When the credit constraint is not binding, the solution to the program is close to

¹¹ $(A(1 - \tau)\alpha/r)^{\frac{1}{1-\alpha}}$ is the frictionless optimal level of capital, so firms with an endowment higher than this level are not financially constrained.

¹²It could be that the solution to this equation implies that transparency is greater than 1. In this case,

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

the solution for the traditional technology case. The entrepreneur invests up to her optimal level $(A(1 - \tau\gamma - (1 - \gamma)\theta z\tau)\alpha/r)^{\frac{1}{1-\alpha}}$ and lends the rest of her endowment. The transparency choice depends on how θz compares to 1. Strictly above 1, she becomes fully transparent. Strictly below 1, she remains fully informal. Otherwise, she is indifferent.

One unknown so far is the choice of audit effort z as a function of firm endowment and technology. As will be evident in the following lines, the audit effort will be a function of concealed production $y_c = (1 - \gamma)f(k)$. We now turn to this problem.

C. The tax authority

Facing a firm characterized by an (observable) endowment ω and an (observable) modern md or traditional tr technology, the tax authority maximizes tax retrieval from audit activity net of the verification costs, taking as given the concealed production $y_c = (1 - \gamma)f(k)$:

$$\max_z z\theta\tau y_c - m(z)$$

The solution z of this program verifies:

$$m'(z) = \theta\tau y_c. \quad (3)$$

Any increase in concealed production induces the tax authority to monitor with higher effort.

The previous equation, coupled with the entrepreneur response (her capital and transparency decision given z), describes the equilibrium investment and audit schedule z for a given firm size ω and technology. We can distinguish two cases. When the entrepreneur is not credit-constrained, either her production is too low for inducing any audit from the tax authority, i.e. $y_c < m'(0)$ and she conceals everything, or the tax authority sets z such that $z\theta = 1$. In this case, the entrepreneur is indifferent and chooses γ such that $(1 - \gamma)f(k)\theta\tau = c'(1/\theta)$ (see left panel, figure 4).

When the entrepreneur is credit-constrained, her response is smoothly monotone (see right panel, figure 4). Does audit effort (always) increase with firm size? On the one hand, for a given transparency, the relative gain of verification increases because concealed production becomes larger as firm size increases. On the other hand, firms may rely more on external finance and thus be more transparent. Both effects together imply that the effect of size on resulting hidden investment and the audit effort is theoretically ambiguous.

We still need to determine what is the initial entrepreneur's choice, i.e. the

investment in innovation c . We describe this choice and define the equilibrium of our economy next.

D. Equilibrium

Given the audit schedule $z(\omega)$, the entrepreneur solves:

$$\max_c \{p(c)\pi_\omega^{md}(z(\omega)) + [1 - p(c)]\pi_\omega^{tr}(z(\omega)) - c\}$$

which brings:

$$p'(c) [\pi_\omega^{md}(z(\omega)) - \pi_\omega^{tr}(z(\omega))] = 1. \quad (4)$$

As firm size increases, the innovation cost gets relatively smaller compared to the gains, i.e., the differences between operating with the traditional or modern technologies, and firms invest more in innovation. As a result, the share of firms that innovate and use the modern technology increases with firm size.

Naturally, since the incentives to innovate are crucially related to the differential gains between the two technologies, any downward shift in the returns to the modern technology, e.g., more stringent credit constraint or higher taxes, will reduce the investment in innovation from all firms.

Equation 4 completes our set of equations characterizing the equilibrium

Definition 1. *Equilibrium.*

Each entrepreneur of each type ω chooses the investment in innovation c (equation 4), observes the realization of the investment and produces with the modern or traditional technology, maximizes profits subject to the credit constraint (equation 1), and determines the level of capital and transparency (equation 2), taking into account the audit effort chosen by tax authority (equation 3).

In order to represent our equilibrium allocation – depending on firm size, we plot two crucial quantities in our analysis, i.e. the average transparency and the average leverage for each firm size in figure 8. These figures implicitly internalize that, for a given firm size, only a fraction $p(c)$ of entrepreneurs get access to the modern technology. These figures may therefore be interpreted as an average of the behavior in the modern sector versus the traditional sector, with weights $p(c)$. In the appendix, we also show separately the transparency and leverage in the modern sector uniquely.

We can remark that there exist two areas for firm endowment. When firms are sufficiently small, transparency and leverage depend on firm endowment through two channels. First, the probability to operate with the modern technology increases

with size. Second, firms borrow such as to bridge the gap between their wealth and the optimal investment (which should imply that transparency decreases with size), but the difference between paying and evading taxes depend on the response of tax authorities (which is more intense with size).

When firms are large enough, they do not borrow anymore, even in the modern sector, and transparency increases with size such as to leave the absolute value of concealed production constant.

In our framework, we can distinguish two effects related to transparency fluctuations due to taxes. In the modern sector, transparency choices, and equivalently leverage and production, depend on the level of taxes. After an increase in taxes, declaring more plants in order to relax the credit constraints is more costly and entrepreneurs conceal more. This effect can be interpreted as the *intensive margin* effect, i.e. modern firms adjusting their transparency. In contrast, taxes also depress investment in innovation such that higher taxes induce a lower share of firms operating in the modern sector. This effect can be interpreted as the *extensive margin* effect.

In general, both the intensive and extensive margins work in the same direction and their intensity is mostly concentrated in small and medium size firms relying on external finance. This observation proves useful in order to understand what drives the aggregate response of our economy to tax hikes.

E. The behavioral response of the aggregate economy to a tax increase

So far, we have analyzed some comparative statics for each individual firm, depending on their size. We turn now to the aggregate response. Given that the economy is a small open economy, prices are fixed such that the aggregate quantities are easy to derive from each entrepreneur's decisions.

In order to derive the aggregate elasticities ($\varepsilon_{\tau\gamma v}, \varepsilon_\gamma, \varepsilon_v$) to taxes, we need to account for the size distribution of firms, because this determines the relative weights of the medium-size firms, which, as we have seen earlier, drive most of the response.

We first need to introduce some notation. Let $\varepsilon_{\tau\gamma v}^\omega, \varepsilon_\gamma^\omega, \varepsilon_v^\omega$ denote, respectively, the elasticity of tax receipts, transparency and output with respect to taxes for any given endowment ω .

$$\varepsilon_x^\omega = \frac{dx}{d\tau} \frac{\tau}{x}$$

Those quantities can easily be constructed from our previous analysis. For a given

wealth ω , they are indeed related through our decomposition, i.e.

$$\varepsilon_{\tau\gamma v}^\omega = 1 + \varepsilon_\gamma^\omega + \varepsilon_v^\omega.$$

This relationship does not directly apply at the aggregate level. However, we can define equivalent aggregate elasticities as follows:

$$\underbrace{\int \varepsilon_{\tau\gamma v}^\omega dG(\omega)}_{\varepsilon_{\tau\gamma v}} = 1 + \underbrace{\int \varepsilon_\gamma^\omega dG(\omega)}_{\varepsilon_\gamma < 0} + \underbrace{\int \varepsilon_v^\omega dG(\omega)}_{\varepsilon_v < 0}$$

Notice that our elasticities are not the elasticities of aggregate quantities with respect to taxes, but rather the individual elasticities with respect to taxes weighted by their prevalence over the population of firms. In practice, our weighted elasticities will be very close to the elasticities of aggregate quantities.

Before turning to the quantitative analysis, we also need to define what is the role of transparency in the output drop captured by ε_v . We decompose the response of output to taxes as follows :

$$\varepsilon_v = \nu_v + \nu_\gamma.$$

The response of output to taxes measured by the elasticity ε_v has two components: the direct component ν_v and the indirect component ν_γ . The direct component is defined as $\nu_v = \varepsilon_v|_{\gamma=\bar{\gamma}}$, and is the response of output to taxes maintaining transparency fixed. The elasticity ν_v therefore measures the standard output drop in response to a tax hike, which is due to the lower expected returns in investment. The second component ν_γ measures the indirect impact of transparency on the output drop. As transparency falls in response to the tax hikes, the firm leverage decreases, which leads to a drop in output.

In the following section, we calibrate the model to the Greek economy in 2009 and illustrate, in this specific calibration, the quantitative importance of each elasticities, as well as the importance of transparency within the output response.

4. Quantitative analysis

We provide in this section a quantitative analysis of the aggregate transparency response to tax hikes following the austerity plan in 2010. We build on our previous theoretical framework and calibrate it on our benchmark situation, i.e., Greece just before the adjustment program of 2010.

The organization of this section is as follows. We study the crisis episode through

the lens of our model: we provide some numerical estimates for our behavioral responses $(\varepsilon_\gamma, \varepsilon_v)$, as well as our decomposition of the output drop ν_v . We then discuss some additional insights on the distributional implication of the austerity plans given by our model and discuss their empirical support. Finally, in order to understand which fundamentals may drive our behavioral response, we provide counterfactual experiments in which we analyze the policy implications of a similar adjustment program in a country with different lender’s protection, tax monitoring or distribution of firm size.

A. The benchmark 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. In our view, firm’s size is not as responsive as investment or transparency. Similarly, we shut down the possibility for technology and other fundamentals of the economy to evolve during the period 2009-2011.

We observe a subsample of firms in Greece that represent a very high share of Greek economic activity (more than 80%). Firms with assets above 9 Million Euros are observed with certainty and very small firms (with assets below 100,000 Euros) are mostly unobserved. Between those two thresholds, we observe only a subsample of firms, which, in practice, may also be biased. Figure 5 shows that the firm size distribution is Pareto above the threshold of 9 Million Euros, as the logarithm of density is a straight line when firm size is Pareto distributed. The distance between the Pareto benchmark and our data can be interpreted as the “missing firms” in the sample.

In order to account for the universe of firms between 100,000 Euros and 100 Million Euros, we assume that the real distribution of firms $g(\omega)$ is the Pareto distribution estimated in figure 5, and suppose that unobserved firms are fully informal in 2009 and remain fully informal after the tax increase. This assumption is a compromise between two extreme assumptions : 1. that we observe all firms, and 2. that the missing firms are similar (in terms of transparency and leverage) to the observed ones. As a robustness check, we compute our main quantities of interest in both cases, and use the results as reasonable bounds for the true elasticity.

Another question that arises is whether we observe the actual endowment of firms or whether this variable already suffers from under-reporting. In the model, taxes are not directly based on firm endowment, and we suppose that firm endowment is fully observed by tax authorities. In order to be consistent with the model, we

consider that the assets reported in Hellastat reflect total firm size including assets that could be related to undeclared activity. In contrast, one can think that reported assets are assets in declared plants in which case we would need to consider that the observed firm size distribution is an endogenous object that is (slightly) different from reported firm size distribution because of misreporting.

We use the distribution of firm endowments coming from our balance sheet data to calibrate the model. We start by estimating the parameters that are directly observed. We estimate the elasticity of sales with respect to their size for firms with sales above 0.1M Euros using a specification which controls for firm-specific characteristics. 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 0.82 – as the fit of the relationship is shown in figure 6. We therefore set α equal to 0.82. In the same vein, we estimate the Pareto parameter ψ which matches the asymptotic distribution of endowments in our sample, and find that $\psi = 1.9$.

Then, we use our dataset to measure the average tax pressure on firms. We use the sector classification used in the analysis of the profitability of firms to measure the average VAT rate in the economy. 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 low regime or exempted (4.5%).¹³ We then compute the aggregate elasticity of tax receipts in the economy as the weighted sum of the elasticities for each tax regime. The interest rate is set to $r = 0.08$ such as to match the average short-term interest rate to non-financial corporations as of May 2010.

For the parameters of our model that relate to the credit market frictions and the productivity of firms, we use the firms' balance sheet information provided by our dataset, and choose our underlying parameters such as to match the resulting leverage and the total output of firms. The parameters which determine the distribution of leverage are the collateral pledgeability λ , and the probability to require such access, which is tied with the probability to operate with the modern technology $p(c) = (\frac{c}{c_0})^{\beta_p}$. Intuitively, λ determines the leverage for large firms which operate only with the modern technology. c_0 and β_p help characterize the slope and curvature for the leverage of small and medium-size firms as a function of firm size. The best way to understand the role of each parameter is to look at figure 9 : the level of the plateau is essentially pinned down by the collateral pledgeabil-

¹³In our database, over the period, we observe 60'662 firm/year observations under the low VAT regime, 41'238 firm/year observations under the middle VAT regime and 231'114 firm/year observations under the high VAT regime.

ity parameter λ , whereas the slope and concavity of the first part of the curve is determined by c_0 and β_p . We therefore set these parameters such to minimize the distance between the theoretical and the empirical leverage shown in the left panel of figure 9. Similarly, we set the productivity factor A such as that our theoretical output reproduces closely the empirical output as shown in the right panel of figure 9.

Concerning the monitoring intensity, it is hard to collect evidence on the underlying monitoring strategy of Greek tax authorities. We therefore choose to calibrate the model with an exogenous monitoring intensity, which is a linear function of the firm endowment. With respect to the sanctions, we parametrize them as to match the minimum administrative sanctions for VAT tax evaders in Greece.¹⁴ We therefore set $\theta = 1.5$. In our numerical exercise, we do not aim at matching the overall receipts from auditing because we do not observe them in Greece. However, both in the data and in our model, sanctions are quite low. They only act as a threat and whether we capture them well or not would be visible on our levels of transparency rather than on the actual receipts due to tax monitoring.

At the initial equilibrium, the level of aggregate transparency in the economy, defined as the ratio between the aggregate tax base and aggregate output, is equal to 0.82. This is slightly higher than what is typically estimated in the literature.¹⁵ This is due to the fact that we may underestimate the influence of small firms in our analysis. However, those informal firms 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. Table 1 reports the benchmark calibration. We later shows the sensitivity of our results to these parameters.

B. The drastic austerity plan of 2010

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 misalignment 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, and the elasticities $(\varepsilon_\gamma, \varepsilon_v)$.

We update the VAT rates according to the austerity measures implemented in 2010. The low VAT rate increased from 4.5 to 5.5%, the middle VAT rate from 9 to

¹⁴See the Tax Procedure Code. Legal penalties are huge but in practice rarely implemented.

¹⁵The shadow economy in Greece is typically estimated around 25%. See Schneider et al. (2010).

Table 1. Benchmark calibration

	Interpretation	Value	Rationale
α	Returns to scale	0.82	Sales - Hellastat (2009)
r	Interest rate	0.08	Bank of Greece (2009)
A	Productivity factor	0.92	Distribution output - Hellastat (2009)
λ	Collateral pledgeability	0.50	Distribution leverage - Hellastat (2009)
β_p	Innovation (scale)	0.30	Distribution leverage - Hellastat (2009)
c_0	Innovation (factor)	2.10	Distribution leverage - Hellastat (2009)
ψ	Shape (size dist.)	1.9	Distribution size - Hellastat (2009)
θ	Punishment	1.5	Tax Procedure Code (2010)
τ	VAT - low rate	.045 (18%)	VAT - Greece (2009)
	VAT - medium rate	.09 (12%)	VAT - Greece (2009)
	VAT - high rate	.019 (70%)	VAT - Greece (2009)

11% and the high VAT rate from 19 to 23%. The repartition along VAT categories is invariant with firm size. In practice, we run three experiments for firms subject to the low, medium and high tax rates and we aggregate our results - using as weights the shares of firms in each VAT regime - in order to deduce the aggregate response of the economy.

The results are reported in the second column of table 2. Following the increase in the tax rates, the model predicts a drop in the tax base of 9.22% explained by a decrease of transparency (-7.34%) and output (-2.07%). Given the amplitude of both responses (essentially the transparency adjustment), half of the increase in taxes is diluted and does not translate in higher tax receipts.

Table 2. The impact of the first adjustment program

	Austerity Plans	Fixed transparency
<i>Percentage changes</i>		
Tax rate	+21.41	+21.41
Tax base	-9.22	-1.50
Output	-2.07	-1.15
Transparency	-7.34	-0.33
<i>Elasticities</i>		
$\varepsilon_{\tau\gamma v}$	0.56	0.95
ε_{γ}	-0.34	0
ε_v	-0.10	-0.05

We find that the elasticity of tax receipts to the change in VAT rate introduced by the austerity plans is $\varepsilon_{\tau\gamma v} = 0.56$. 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 : the transparency response ε_γ accounts for a bit more than three quarters of the fall in the tax base (-0.34 out of -0.44), whereas the output response ε_v accounts for the remaining quarter (-0.10 out of -0.44).

Let us recall our main assumption about the firm distribution in our sample. Since we acknowledge that there may be “missing firms” in our sample, we assume that we do not observe informal small firms in 2009 which remain fully informal after the tax increase. We now modify this assumption and rather consider that in our sample we observe all firms. Under this assumption, the elasticity of transparency and output are very similar to our benchmark case (respectively -0.32 and -0.11). In contrast, when we assume that there exist unobserved small firms that behave exactly like the observed ones, the absolute elasticity of transparency increases significantly ($\varepsilon_\gamma = -0.48$), because there are more firms responding by adjusting their transparency. One can therefore think that the elasticity of transparency should lie between these two extremes $-0.48 < \varepsilon_\gamma < -0.32$. As regards the elasticity of output, it remains almost unchanged in both cases.

We have shown that most of the drop in expected tax receipts come from a drop in transparency. This transparency adjustment has also an impact on the extent to which output decreases. Indeed, when small and medium-size firms reduce their transparency, they tighten even further their credit limits and reduce accordingly their credit demand. A simple experiment which highlights the quantitative impact of such channel is to replicate the austerity plans maintaining constant the transparency decision of firms. Under the assumption of a fixed transparency choice by firms, the contribution of transparency to output changes is nil, i.e., $\nu_\gamma = 0$. It allows us to identify $\nu_v = \varepsilon_v$, i.e., the standard fall in output purged of the transparency effect. The last column of table 2 reports the results of the simulation where the transparency response is shut down, that is when $\varepsilon_\gamma = 0$ and $\nu_\gamma = 0$, and the only effect that is captured is the standard fall in output $\nu_v = -0.05$. This result shows that the indirect impact of transparency on the output response accounts for more than half of the total output response. In other words, if the transparency had been insensitive to changes in taxes, the output drop would be 50% lower. This simple exercise points to the large influence of the transparency channel both in the relatively small increase in tax receipts and in the subsequent output drop.

In addition to the aggregate estimates, it is interesting to study the distributional

implications of such tax hike. Figure 10 shows the elasticities of transparency and output to tax hike along firm size. Most of the drop in tax receipts is due to mid-size firms that either drop off the formal economy or adjust their transparency downward. In order to understand why the response of middle-size firms is important, we can represent our economy as follows. Basically, there are three types of firms in the economy : small informal ones, large transparent ones and middle-size firms. Following the tax hike, small firms remain informal and large firms remain transparent. If there were only such firms in the economy, there would not be a transparency response to tax increase but only an output response driven by lower expected returns, and the overall elasticity of tax receipts to tax revenues would be close to 1. In contrast, middle-size firms react by changing their level of transparency, i.e. either by becoming fully informal or by reducing the extent to which they declare their activity. Accordingly, the tax base decreases for these firms. If there were only such firms in the economy, the increase in taxes would actually *reduce* tax revenues, i.e. the elasticity $\varepsilon_{\tau\gamma v}$ is negative in this range of endowments.¹⁶

We also find direct evidence of this size-specific credit crunch in our panel of firms: there has been a shift of credit out of small firms during the crisis (see figure 7). This figure reports the average leverage as a function of size in 2011 and 2009 restricting the sample to firms present at both dates. In 2011, small firms with total assets ranging from 1 to 30 M Euros had a leverage substantially lower than in 2009. The figure is very comparable to our theoretical predictions (see figure 8), both quantitatively and qualitatively.

C. Counterfactual experiments and sensitivity to fundamentals

In this part, we explore under which conditions we should expect a large transparency response to tax hikes as we observed in the first adjustment program. 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, and both quantities are pinned down by fundamentals of the economy, i.e. the lender's protection, tax monitoring and firm size distribution.¹⁷

¹⁶Note that $|\varepsilon_\gamma|$ of small and middle-size firms is greater than 1. This is equivalent to say that these firms are on the right hand side of the Laffer curve.

¹⁷A caveat of our analysis is that we consider the firm size distribution as given. One may think that firm size distribution is the outcome of real fundamentals, like financial development, the structure of product and labor markets, and barriers to entry.

When we modify such fundamentals, we modify both the steady state of the economy, and notably the steady-state aggregate transparency, and the elasticities of tax receipts, transparency and output to taxes. We take advantage of this observation in order to represent elasticities, not as a function of each underlying parameter but rather as a function of steady-state quantities. We define $\lambda \mapsto \Gamma(\lambda)$, where the aggregate transparency $\Gamma(\lambda)$ is a function of the share of observed investment that can be pledged λ . We then compute the elasticities of tax receipts, transparency and output to taxes when the variations in steady-state aggregate transparency $\Gamma(\lambda)$ are only driven by different credit market conditions. Similarly, we define the same mapping $\theta \mapsto \Gamma(\theta)$ and $\psi \mapsto \Gamma(\psi)$ for the aggregate transparency as function of the punishment when tax evasion is detected θ , and the shape of the firm size distribution ψ respectively.

Figures 11, 12 and 13 display those elasticities when we consider variations in λ , θ and ψ .¹⁸ In the horizontal axis we report the aggregate transparency which moves with the change in the underlying fundamental. Aggregate transparency is increasing in the pledgeability λ and the punishment θ , whereas it is decreasing in the shape parameter ψ . A high level of ψ corresponds to lower tail for the firm size distribution, and the density of firms at the margin of informality is higher.

As shown in figure 11, as the extent to which collateral can be pledged (λ) increases, the elasticity of tax receipts to tax rate increases but quite slowly. When financial development increases, the pressure of the credit constraint is lower for larger firm but higher for smaller firms, which are now investing more in the modern technology. Both effects together imply a higher elasticity for more financially developed economy. In contrast, the output response to taxes seems to be barely affected by an improvement in financial development as the gap between the blue line ($\varepsilon_{\gamma\tau v}$) and the dotted red line ($1 + \varepsilon_\gamma$) in figure 11 remains constant.

As regards the elasticity of tax receipts to tax rate, figure 12 shows that, as the sanctions applied by tax authorities increase, $\varepsilon_{\gamma\tau v}$ increases because transparency becomes then less and less responsive to taxes. Indeed, when tax monitoring improves, only very small firms can really conceal their activity and those firms are generally informal independently of the exact level of taxes. As it was the case for the counterfactual on credit market conditions, the increase in $\varepsilon_{\gamma\tau v}$ is almost completely determined by the reduction in the transparency response.

We also study what happens when we modify the relative weight of large firms versus small firms in the economy. First, an economy with a fat-tail firm size distri-

¹⁸Figure 14 shows the sensitivity of the aggregate elasticity of tax receipts to the fundamentals of the economy : λ , θ and ψ . We plot the aggregate elasticity as a function of two parameters while keeping the third one at its benchmark level.

bution (low ψ) would be less responsive to taxes since most of the effect comes from the weight of small-medium size firms. In contrast, the output response increases, as the number of unconstrained and large firms increases (these large firms are the ones for which the standard behavioral response to taxes is the largest). This is the reason why the gap between the dotted red line ($1 + \varepsilon_\gamma$) and the blue line ($\varepsilon_{\gamma\tau v}$) in figure 13 widens and the overall elasticity of tax receipts to taxes slightly decreases with aggregate transparency.

To conclude, in a country like Greece where (i) tax enforcement is low, (ii) credit markets are not fully developed, and (iii) the firm size distribution is shifted towards small and medium size firms, austerity plans are expected to be very inefficient. In comparison, in the United States, financial development and tax monitoring are of better quality, which implies that firms on the verge of becoming informal 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.

5. Concluding remarks

This paper shows that the failure of the Greek austerity plan in raising the expected tax revenues is mostly due to the behavioral response of firms increasing their tax evasion. When firms adjust the degree to which they declare their activity – their transparency – in response to tax changes, the standard erosion of the tax base is augmented by the lower transparency. Three quarters of the overall behavioral response to the increase in taxes come from the transparency response of firms. 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 between credit access and tax evasion. In Greece, low tax monitoring and intermediate financial development contribute to having quite large and numerous small-medium firms for which the transparency response to taxes is important.

Quantitatively, we can explain part of the gap between the expected tax receipts and the realized ones, and mostly through 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 almost twice lower than with a fixed level of tax evasion. However, we cannot exactly match the total tax receipts levied by the austerity plan in our exercise because we focus on VAT, while

the austerity plans in Greece included several tax changes (e.g. excises on oil).

One important contribution of the present paper is that we calibrate a model of heterogeneous firms and transparency/credit trade-off using a balance-sheet dataset of Greek firms. We provide some evidence for the ability of firms to adjust their transparency as we show 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 before and after the implementation of the austerity plans. In particular, we expect credit to flow from smaller to larger firms, and we observe such pattern in the data. Naturally, although 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 need to infer the behaviors of unobserved firms, and we provide a range of estimates corresponding to different scenarios.

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 turbulence may not be times in which structural reforms are simple to implement. One direct implication of our model is that the efficiency of a tax increase essentially depends on the number of firms (and their size) that are almost indifferent between declaring their activity or being fully informal. This insight could help policy makers choose the timing or the type of tax reforms which reduce this margin as much as possible. One plausible policy would consist in designing exceptional tax exemptions or targeted tax deductions when firms rely on external finance. It would encourage them to declare more of their activity.

Finally, there are many macroeconomic mechanisms that we ignore in our quantitative exercise. Among them, one crucial element that we do not explore is credit supply. 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 and 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. 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.¹⁹ The further valuation loss for the banking

¹⁹The under-capitalization of Greek banks was rapidly tackled with large injections of capital

sector could lead to a larger credit crunch and more tax evasion from the firms' side. We leave this feedback channel coming through credit supply for further research.

ensured through the Hellenic Financial Stability Fund (HFSF). This policy was successful at saving banks from liquidation, as it helped stabilize bank's collateral but not at revitalizing credit.

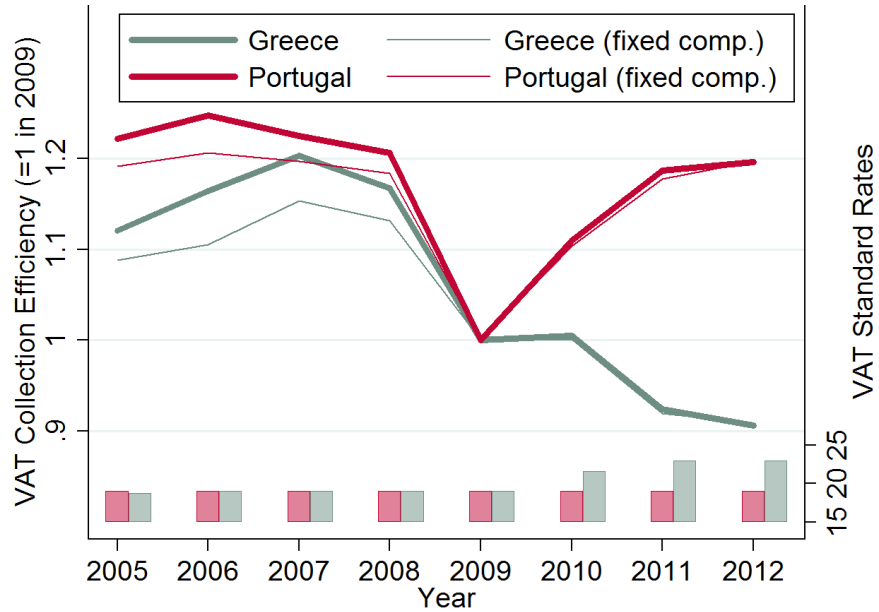
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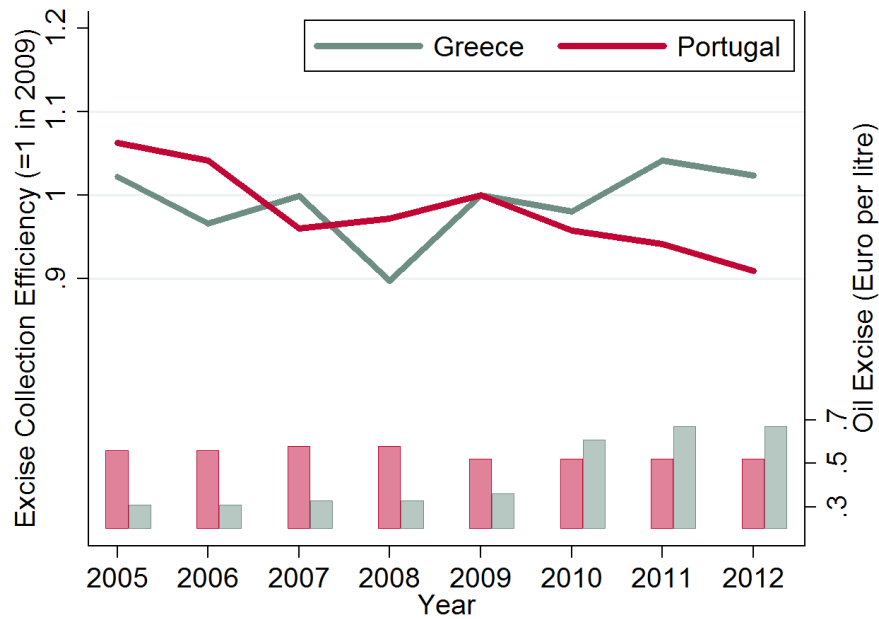
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Figures

Figure 1. VAT and excise collection efficiency.



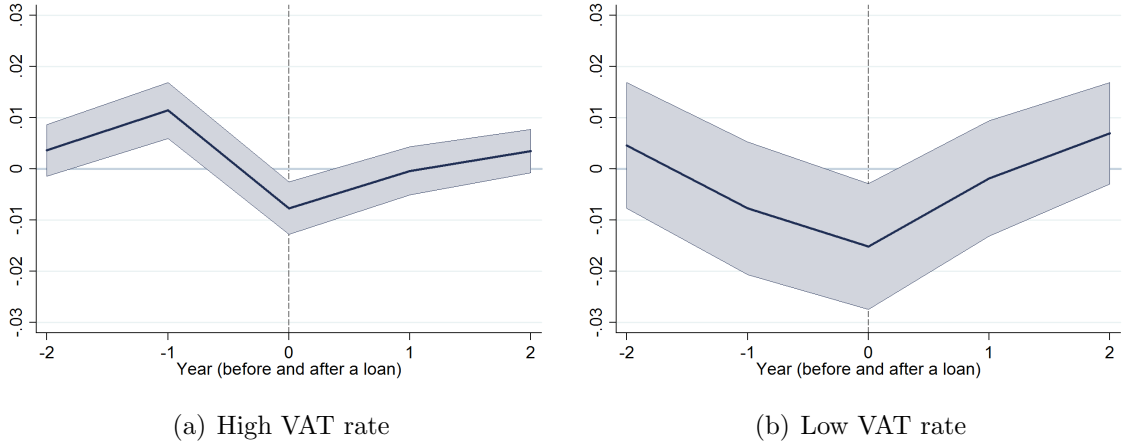
(a) VAT



(b) Excise

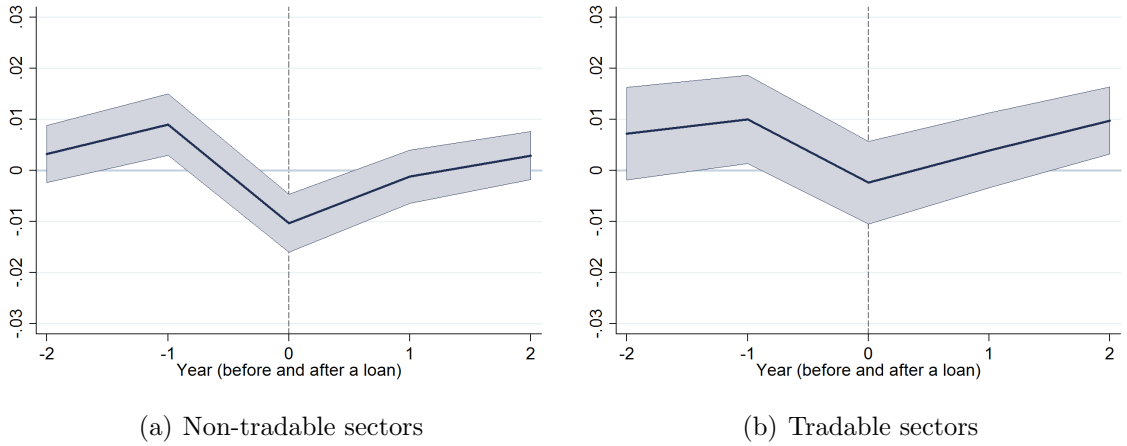
Note: These figures represent the ratio of realized tax revenues to expected tax revenues, given the value added generated in sectors subject to the different excises or VAT rates. On the right axis, we report the VAT standard rate (top panel) and oil excise (bottom panel) over the period 2005-2012 in Portugal (red bars) and Greece (green bars).

Figure 2. Firm profitability π_τ around loan access, high vs low VAT.



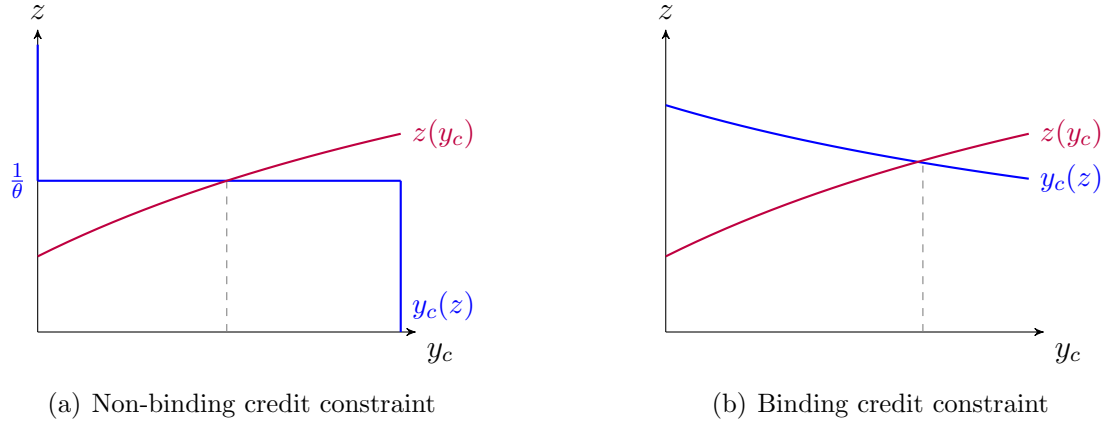
Note: These figures represent the firm profitability $\pi_{i,t}$, i.e., the ratio of sales to operating costs around the year of the largest growth of loans over the entire period for the subsamples of firms in the high-VAT category and the others. Firm profitability $\pi_{i,t}$ is cleaned of firm μ_i , industry \times year $\eta_{ind,t}$ fixed effects. Dataset: Hellastat, panel 2001-2011.

Figure 3. Firm profitability π_τ around loan access, non-tradable vs tradable.



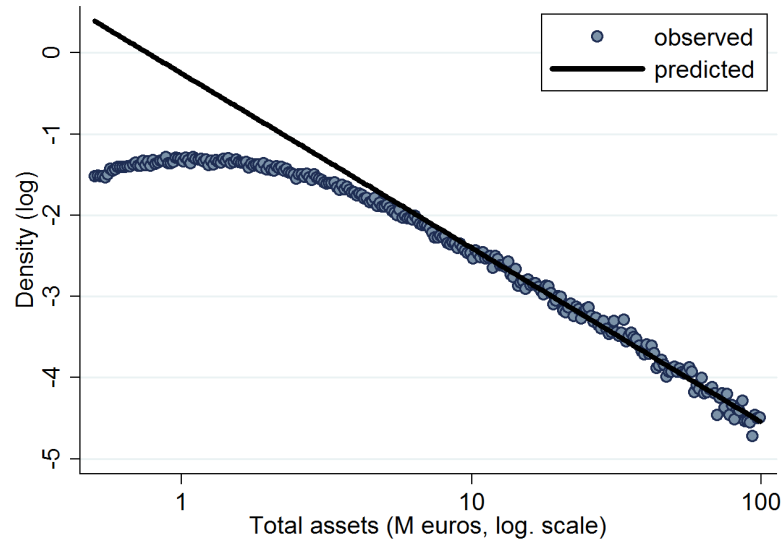
Note: These figures represent the firm profitability $\pi_{i,t}$, i.e., the ratio of sales to operating costs around the year of the largest growth of loans over the entire period for the subsamples of exporting sectors and the others. Firm profitability $\pi_{i,t}$ is cleaned of firm μ_i , industry \times year $\eta_{ind,t}$ fixed effects. Dataset: Hellastat, panel 2001-2011.

Figure 4. Audit and concealed production.



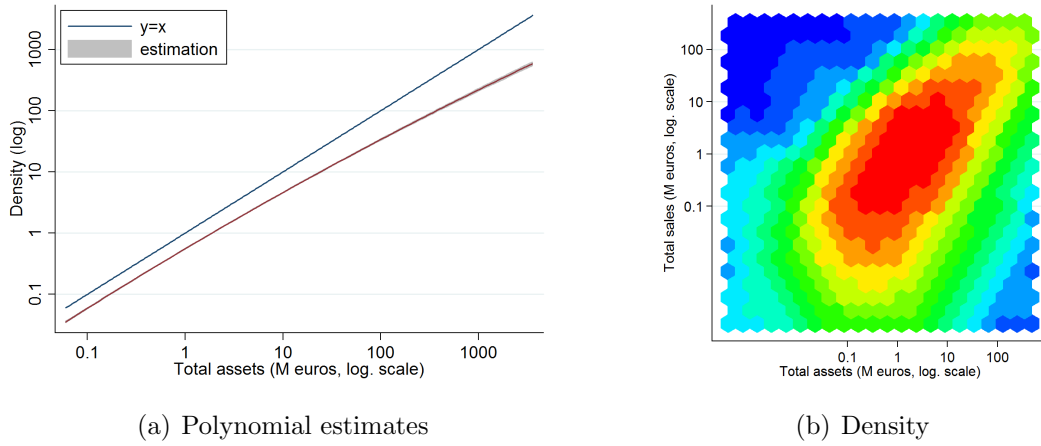
Note: These figures represent the optimal response of tax authorities to a certain level of concealed production $z(y_c)$, and the optimal concealed production as a function of audit intensity $y_c(z)$.

Figure 5. Size distribution.



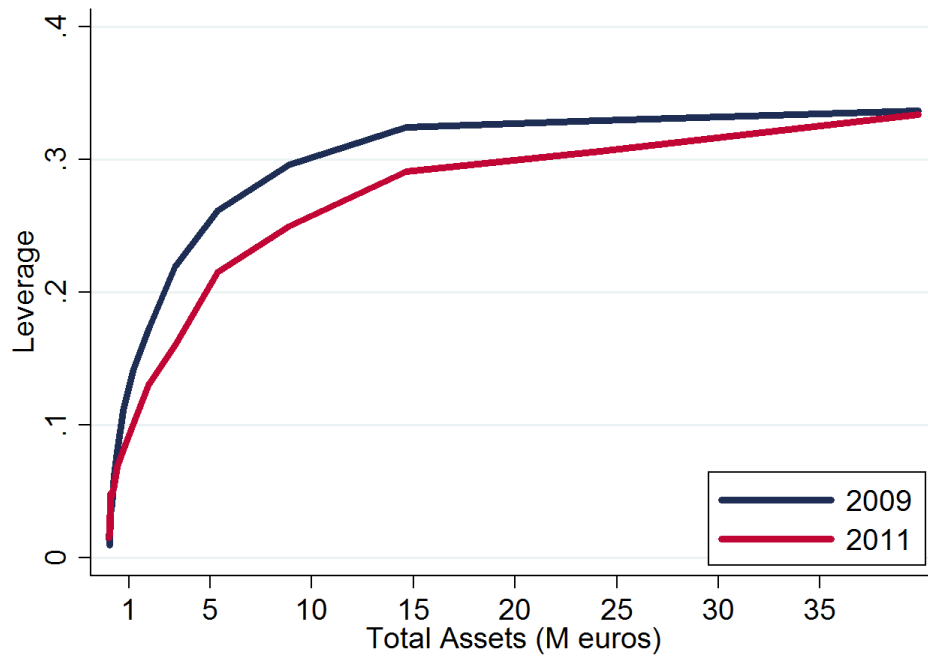
Note: This figure represents the observed firm size distribution in Hellastat (2009) and the predicted density computed using only firms with endowment above 10M euros. The x-axis is on a logarithmic scale.

Figure 6. Empirical production function.



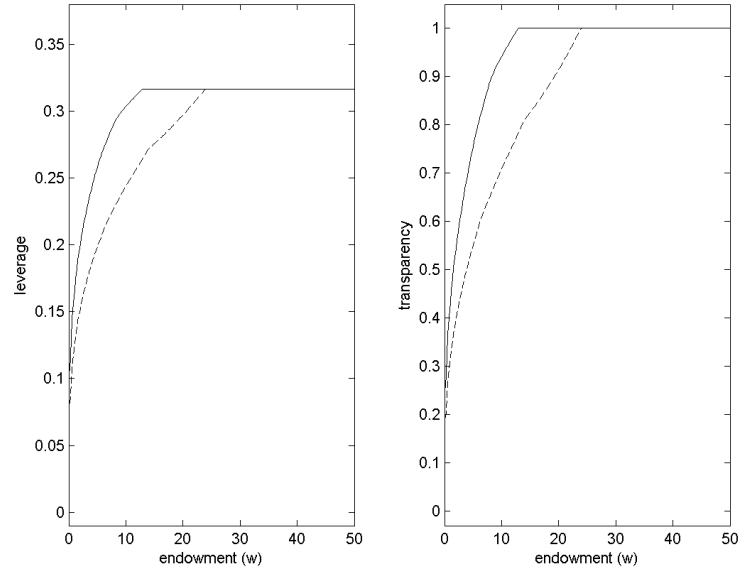
Note: These figures represent the polynomial estimates for the elasticity of sales to firm endowment using the whole sample of firms (approximately 30'000 firms per year) and controlling for firm and industry×year fixed effects. For both figures, the axes are on a logarithmic scale.

Figure 7. Leverage.



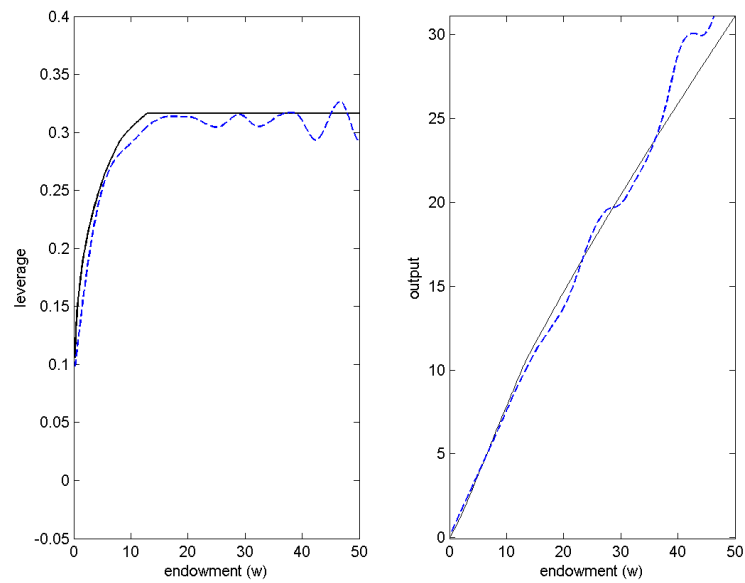
Note: Source Hellastat, 2009, 2011. This graph displays the leverage by firm size (total assets) before (2009) and after (2011) the austerity plan.

Figure 8. Leverage and transparency : the impact of the austerity plans.



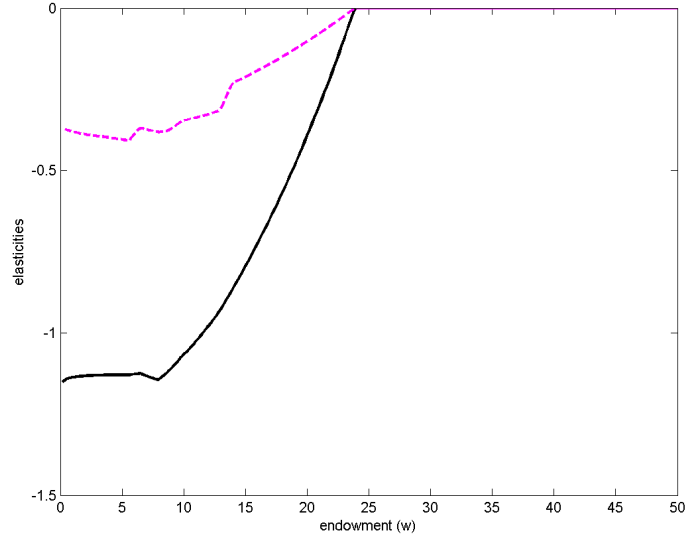
Note: Leverage and transparency along firm size for the benchmark calibration (solid line) and the austerity plans simulation (dashed line).

Figure 9. Empirical vs. theoretical leverage and output.



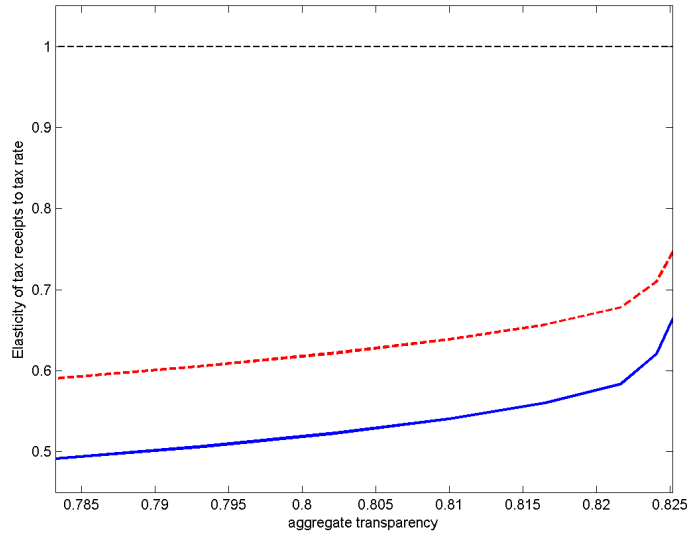
Note : Benchmark calibration. The solid black lines are the calibrated leverage and output, the dashed blue lines are the empirical leverage and output for firms with assets between 0.5 and 50M euro (smoothed using a HP filter).

Figure 10. Transparency and output elasticity by firm size.



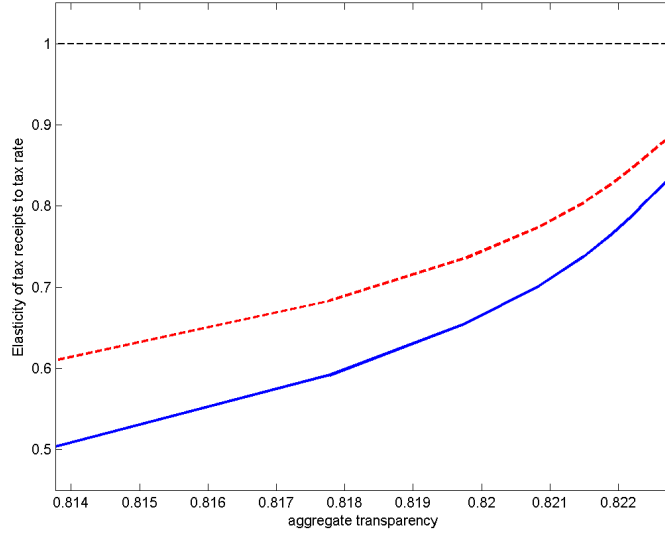
Note: The solid line is the elasticity of transparency ε_γ , the dashed line is the elasticity of output ε_v as a function of firm size. Both are computed using the 2010 austerity plan.

Figure 11. Credit frictions and the elasticity of tax receipts.



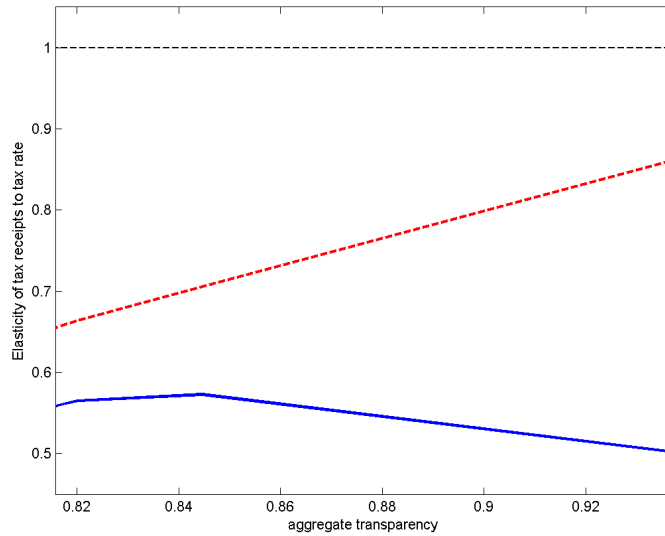
Note : Response to the 2010 austerity plan. The solid blue line is the elasticity of tax receipts ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_\gamma + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax receipts ($1 + \varepsilon_\gamma$). In the horizontal axis we report the aggregate transparency $\Gamma(\lambda)$ which is associated with values of $\lambda \in [0.42, 0.58]$.

Figure 12. Tax enforcement and the elasticity of tax receipts.



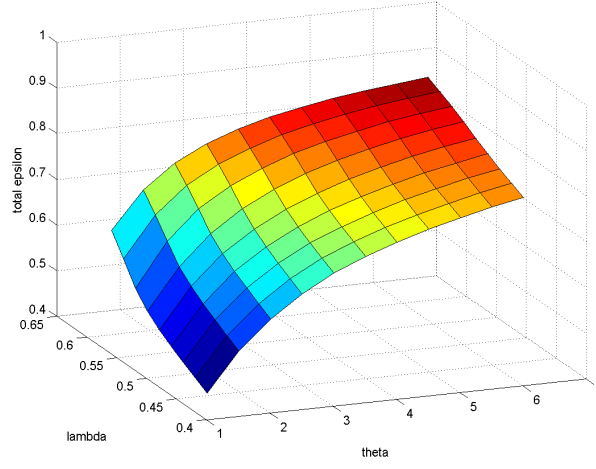
Note : Response to the 2010 austerity plan. The solid blue line is the elasticity of tax receipts ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_{\gamma} + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax receipts ($1 + \varepsilon_{\gamma}$). In the horizontal axis we report the aggregate transparency $\Gamma(\theta)$ which is associated with values of $\theta \in [1.2, 6.2]$.

Figure 13. Firm size distribution and the elasticity of tax receipts.

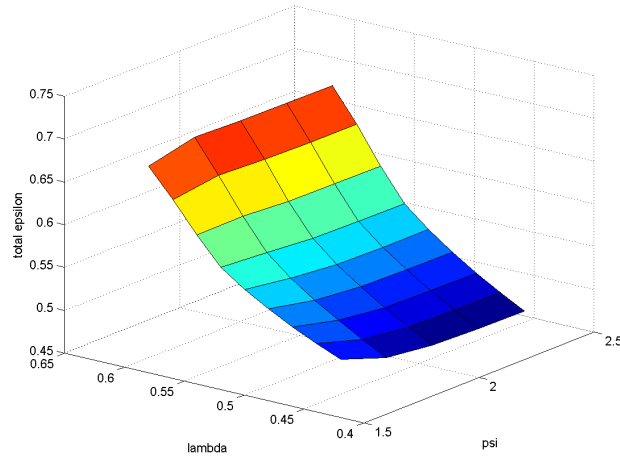


Note : Response to the 2010 austerity plan. The solid blue line is the elasticity of tax receipts ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_{\gamma} + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax receipts ($1 + \varepsilon_{\gamma}$). In the horizontal axis we report the aggregate transparency $\Gamma(\psi)$ which is associated with values of $\psi \in [1.3, 2.3]$. Aggregate transparency is decreasing with the shape of firm size distribution ψ .

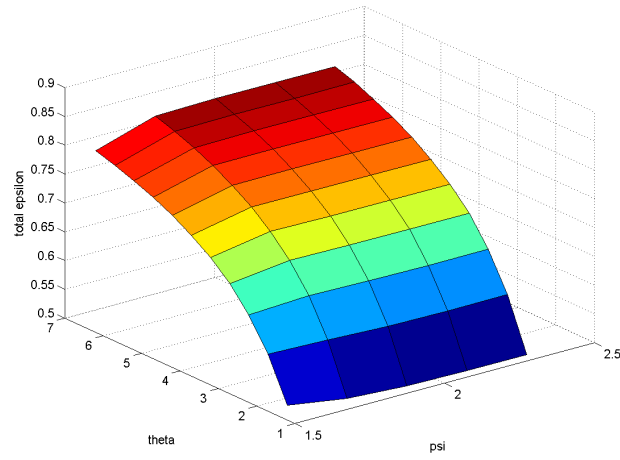
Figure 14. Aggregate elasticity of tax receipts. Sensitivity to fundamentals.



(a) Sensitivity to credit frictions λ and tax enforcement θ



(b) Sensitivity to credit frictions λ and firm size shape ψ



(c) Sensitivity to tax enforcement θ and firm size shape ψ