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Austerity Plans and Tax Evasion : Theory and Evidence from Greece*

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Résumé francais

Les hausses d'impôts sans précédent mises en oeuvre en Grèce en 2010 ont généré une augmentation beaucoup plus faible que prévu des recettes fiscales. Dans cet article, nous présentons un nouveau fait stylisé pour expliquer cet écart: la forte augmentation de l'évasion fiscale. Nous analysons ensuite la réponse de l'économie à des hausses d'impôts dans un modèle stylisé où les entreprises ajustent la part de leur activité déclarée. Nous calibrons le modèle en utilisant des données de bilan au niveau des entreprises pour la Grèce et quantifions la réaction de l'évasion fiscale à l'ajustement budgétaire de 2010. Un tiers de l'augmentation des impôts est dilué à cause des petites et moyennes entreprises qui élargissent la part de leur activité non-déclarée. Par conséquent, cela diminue leur capacité d'emprunt et contribue à des pertes de production non négligeables.

Codes JEL: E02, E62, H26.
Mots-clés: évasion fiscale, plans d'austérité, frictions du marché du crédit.

Abstract

The unprecedented tax hikes implemented in Greece in 2010 generated a much lower than expected increase in tax revenues. In this paper, we document a new stylized fact explaining this gap: the strong increase of tax evasion. We then analyze the response of the economy to tax hikes in a stylized model where firms adjust the share of their declared activity. We calibrate the model to firm-level balance sheet data for Greece and quantify the response of tax evasion to the 2010 fiscal adjustment. One third of the tax increase is lost because small and medium size firms expand their share of non-declared activity. In turn, this lowers their borrowing capacity and contributes to non-negligible output losses.

JEL Classification Codes: E02, E62, H26.
Key words: tax evasion, austerity plans, credit frictions.

Non-technical summary

The fiscal adjustment program implemented in Greece in 2010 was unprecedented in its intensity, and targeted an increase in tax revenues mainly based on VAT hikes. Overall, Greek authorities only collected half of the expected additional tax revenue – 1.5 instead of 3.1 points of GDP – which led to further fiscal adjustments.

The failure to meet the targeted tax revenues came from an unexpected decrease of the declared tax base. An unexpected output drop cannot explain the discrepancy between expected and realized revenues. The realized fall in output was 2 percentage points larger than the one forecasted by Greek authorities, but only an unexpected fall in output of about 10 percentage points would fully explain the gap between expected and realized revenues. Instead, tax evasion strongly responded to the tax hikes – a response that was mostly unanticipated.

In this paper, we measure tax evasion by computing the collection efficiency, i.e. the ratio of realized tax revenues to the expected tax revenues *given the realized output drop*. We find that, after the 2010 VAT hike, the VAT collection efficiency decreased by about 10% in Greece, a number sufficient to explain the failure of the austerity plan. This change represents a loss in VAT revenues of about 1.4 billion euros or 0.8% of GDP. When facing high taxes, firms do not only reduce their activity because of lower expected returns, but they also conceal more of it (the transparency response). Concealing production is costly for the government; it implies that a part of the tax increase will not translate into additional tax revenues. In addition, the firms that become more informal are less able to attract external finance, and need to downsize their activity even further. Using Hellastat firm-level balance sheet data, we indeed show that the response of tax evasion was larger among medium-size firms that in turn experienced a larger fall in the access to credit.

In our benchmark numerical simulation, we replicate the VAT increase implemented as part of the first Greek adjustment program in 2010. We calibrate our model using firm-level balance sheets data on 30'000 Greek firms. These data allow us to match one crucial component of our analysis, which is the heterogeneity of access to external finance along firm size. The elasticity of transparency and output to taxes constitute the behavioral response of the economy. We find that the total behavioral response alleviates almost half of the mechanical increase in tax revenues. Within the behavioral response, three quarters come from the transparency component, i.e. the drop in declared activity in response to the tax hikes, against one quarter explained by the contraction in output. These estimates are consistent with (i) the gap between the expected and actual increase in tax revenues and (ii) the drop in VAT collection efficiency observed after the austerity plan.

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, e.g., the excise on unleaded petrol rose from 36 cents per liter to 67 cents. However, while revenues from excises increased as expected, revenues from VAT increased marginally. Overall, Greek authorities only collected half of the expected additional 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 targeted tax revenues came from an unexpected decrease of the declared tax base. An unexpected output drop cannot explain the discrepancy between expected and realized revenues. The realized fall in output was 2 percentage points larger than the one forecasted by Greek authorities, but only an unexpected fall in output of about 10 percentage points would fully explain the gap between expected and realized revenues.[1] Instead, tax evasion strongly responded to the tax hikes – a response that was mostly unanticipated. We measure tax evasion by computing the collection efficiency, i.e. the ratio of realized tax revenues to the expected tax revenues *given the realized output drop*. We find that, after the 2010 VAT hike, the VAT collection efficiency decreased by about 10% in Greece, a number sufficient to explain the failure of the austerity plan. This change represents a loss in VAT revenues of about 1.4 billion euros or 0.8% of GDP.

While fluctuations in output due to tax hikes are known and taken into account by governments willing to implement tax reforms, little is known on the short-term dynamics of tax evasion and its implications for the effectiveness of such reforms. In this paper, we show that there exist large movements in tax evasion. Based on this observation, we build a theoretical model and 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 missing increase in tax revenues. The intuition is the following. With imperfect tax enforcement, tax monitoring alone is insufficient to

[1] "In March, GDP was forecast to fall by around 2% over 2010 as a whole. This forecast is surrounded by high uncertainty, while there is a strong possibility of an even sharper drop". Source : Annual report of Bank of Greece, April 2010 (BoG, 2010).

deter businesses from concealing their activity. The main motive for small businesses to declare their activity is then access to credit 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, for a constant access to external finance, 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. Using Hellastat firm-level balance sheet data, we indeed show that the response of tax evasion to the austerity plan was larger among medium-size firms, that in turn experienced a larger fall in the 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 much 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 profitable anymore to be transparent and get access to credit. Their response is to switch their activity from the modern (and transparent) sector to the traditional sector. Second, medium-size firms 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, firm leverage decreases adding to the direct recessionary effect of higher taxes. At both ends of the firm size distribution, however, the response to tax increase does 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 as part of the first Greek adjustment program in 2010. We calibrate our model using firm-level 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 along firm size. In order to illustrate our results on the response of the economy to the austerity plan, we consider the

following decomposition. If 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 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 in output $\varepsilon_v = -0.10$. These estimates are consistent with (i) the gap between the expected and actual increase in tax revenues and (ii) the drop in VAT collection efficiency observed after the austerity plan.

We then analyze the impact of changes in transparency on output. In our framework, output responds to taxes through a direct effect and an indirect effect passing through changes in transparency. 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 loss would be one percentage point lower than in the benchmark case, and would then be essentially explained by large firms reducing their investment.

When we investigate the distributional impacts of our tax reform, we find that most of the behavioral response comes from small and medium size firms reducing drastically their transparency, thereby tightening their credit constraints. We find empirical support for the shift of credit out of small and medium size firms when we compare firm leverage before and after the austerity plan in our panel data, a pattern that is particularly pronounced in region with the strongest tax evasion response. The responses of the theoretical and the empirical distributions of credit along firm size are qualitatively and quantitatively similar.

Finally, 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 response of tax evasion to tax hikes is large, because marginal firms are medium-size firms and they constitute a large share of the economy. In a country with more developed financial development and tax monitoring, 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 candidate for austerity plans based on tax hikes.

Our paper contributes to the economic literature in one important way. To our knowledge, this is the first project which uses firm-level data to estimate the aggregate elasticity of tax evasion to taxes and its implications 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), Favero et al. (2011), Auerbach and Gorodnichenko (2012), Ilzetzki et al. (2013), Alesina et al. (2015) have tried to estimate 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. Pappa et al. (2014) studies the contribution of tax evasion and corruption to the size of the fiscal multiplier during the recent consolidation plans in Greece, Italy, Portugal and Spain. In line with our main findings, they show that tax hikes increase the incentives to conceal part of the activity and produce in the less productive informal sector, thus increasing output and welfare losses.[2]

In our paper, we assume that transparency affects access to credit, which seems to contradict the findings in Artavanis et al. (2012). They find that the ratio of credit over income granted by bankers depends on the income declared by the borrower and the bankers' beliefs on undeclared activity. Bankers anticipate how reported income from borrowers maps into their real income based on their occupation. 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.

[2]Using a survey of managers and firm level data, Athanasouli et al. (2012) find that small and medium firms display a higher engagement in corrupt practices. In a country with relatively low tax enforcement like Greece, fiscal corruption is very likely, and such corruption may also respond to changes in taxes. In this paper, we do not explicitly disentangle corruption from tax evasion. We therefore mostly ignore the quantitative impact of corruption on tax evasion, namely how the unpaid taxes are shared between the taxpayer and the corrupt tax officials.

Instead, the amount of credit is a function of their reported income multiplied by a factor which is increasing with tax evasion and specific to their occupation. In line with our interpretation, we find a strong correlation between the regional fluctuations in tax evasion and the regional fluctuations in leverage, independently of the regional economic indicators.

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 which sample 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.

We establish important stylized facts on fluctuations in VAT collection efficiency that 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. Fisman and Wei (2004) look at the discrepancies between the declared exports of Hong Kong to China and the imports of China from Hong Kong to measure empirically tax evasion. They show that these discrepancies are not due to measurement errors as they are systematically higher for those goods subject to higher taxation. We intuitively adopt the same strategy : while constructing our measure of collection efficiency, we use the discrepancies between reports on aggregate tax revenues and reports on aggregate consumption to build a measure of tax evasion.

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. We believe that such modeling choice is more suitable for the analysis of countries like Greece (or Italy and Spain), which are definitely plagued by tax evasion but in which many firms are

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

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

only partly informal.

The paper is organized as follows: in section 2, we present three important stylized facts on the response of tax evasion to the fiscal adjustment implemented in Greece in 2010. Based on these observations, in section 3, we introduce a quantitative model where firms are heterogeneous in terms of size and decide the share of their declared activity. We then compute the theoretical elasticity of aggregate tax receipts and aggregate output to taxes. In section 4, we calibrate our model using firm-level balance sheet data for Greece. We match important moments of the distribution of firms before the implementation of the austerity plan in Greece, and we assess the reasons behind the failure of this fiscal adjustment program. We then generalize our analysis and perform counterfactual exercises in order to uncover the role of tax evasion, credit market frictions and the firm size distribution on the effectiveness of those tax reforms. Finally, section 5 discusses some policy implications and briefly concludes.

2 The response of tax evasion to the Greek austerity plan

In this section, we show that tax evasion is an important factor that should not be overlooked when evaluating the behavioral response of an economy to tax reforms. In this regard, we compute the tax collection efficiency to measure tax evasion, and we present three unexplored stylized facts about the dynamics of tax evasion and its consequences following the 2010 tax reforms in Greece.

First, aggregate tax evasion strongly responds to the tax hikes implemented in the Greek austerity plan in 2010. We compute the collection efficiency for the main tax at the core of the first adjustment program, i.e. VAT. We show, by using a comparison with similar countries (GIIPS), that tax evasion strongly responds to the increase in VAT rates. Tax evasion is not only a factor that affects tax revenues in the long run but it also fluctuates markedly.

Second, we exploit the large regional disparities in the tax hikes due to exemptions and initial sectoral composition, and show that the response of tax evasion is much stronger in regions with larger tax hikes, controlling for the regional output growth in a large set of sectors. In this exercise, we isolate the elasticity of tax evasion to the tax hikes, and we disentangle this response from the changes in tax evasion related to output fluctuations.

Third, we uncover one potential consequence of tax evasion on firm investment. There is a drop in the access to credit of medium-size firms, and this is markedly larger in regions having experienced a larger drop in collection efficiency. In contrast, very small and large firms have their access to external finance unchanged after the

tax reform.

2.1 A measure of aggregate tax evasion and the response to tax hikes

The 2010 tax reform in Greece essentially consisted into a VAT increase from a standard rate of 19% to 21% and finally 23% after a revision in July 2010, and an increase in the excise on unleaded petrol from 36 cents per liter to 61 and finally 67 cents after a similar revision.

For these two taxes, VAT and excise on unleaded petrol, we construct a measure of *collection efficiency* in Greece, Italy, Ireland, Portugal and Spain - the GIIPS countries - over 2005-2013 using three different components. First, we observe tax revenues as declared by the government in national accounts. In particular, we construct annual tax revenues from VAT and excises on petrol. Second, we retrieve the VAT rates for the different categories of goods, defined at the 2-digit industry level, and the excise rates on unleaded petrol. Third, we collect reports on the tax bases : the valued added (as captured by consumption) for each different categories of goods, and the unleaded petrol consumption. We then construct the ratio of tax revenues to expected tax revenues, i.e., the tax revenues as predicted by tax rates and the tax base induced by reports on consumption. Letting TR_t denote tax revenues in year t, $\tau_{i,t}$ the tax rate for good i and $C_{i,t}$ the reported consumption of good i in year t, our measure of collection efficiency is written as:

$$CE_t = \frac{TR_t}{\sum_i \tau_{i,t} C_{i,t}}.$$

Intuitively, our measure CE_t uses two different sources, taxes as received by the government and the reported consumption of goods (weighted by the tax rate), and capture any discrepancies between the two sources. We argue that such discrepancies capture a large share of tax evasion. It is true, however, that they may capture loose enforcement from tax authorities. In general, tax authorities may tolerate informal exemptions for some sectors, regions, or newly-taxed activities. In this specific reform, only the tax rates were changed and we are quite confident that fluctuations in collection efficiency essentially reflect fluctuations in tax evasion.[5]

[5]While we are interested in the fluctuations of collection efficiency over time, Aizenmann and Jinjarak (2005) use a similar measure of collection efficiency for cross-sectional comparisons. They compare the collection efficiency of VAT revenues in a large cross-section of countries, and relate it to some fundamentals of the economy, e.g., financial development or corruption. Our findings are in line with Tagkalakis (2014), who finds that the VAT collection efficiency has been more responsive since the start of the big recession in Greece in 2009, and that tax evasion is a relevant channel for the explanation of such drop in collection efficiency.

The left panel of figure 1 plots the VAT collection efficiency for Greece (green line) and the average VAT collection efficiency in Italy, Ireland, Portugal and Spain (red line) over the period 2007-2012.[6] On the right vertical axis, we report the effective VAT rate in Greece (green bars), and the average VAT rates in Italy, Ireland, Portugal and Spain (red bars) weighted by the share of activity to which they should be applied. Two important facts stand out. First, in 2010, the tax rate markedly increases in Greece relatively to the other countries and there are no other reforms of the same magnitude over the period. Second, while the VAT collection efficiencies display very similar fluctuations in 2007-2009 and 2010-2012, the Greek collection efficiency in 2010 is markedly lower than in other GIIPS countries. To highlight this fact, we report in the right panel of figure 1 the gaps (in percentage points) between the VAT collection efficiency and the VAT rate in Greece to their counterpart averages in Italy, Spain, Portugal and Ireland.[7] Apart from the year 2010, the gaps in tax rates and collection efficiencies are constant over time. In 2010, the strong decrease in the relative collection efficiency mirrors the substantial increase in relative VAT rates following the 2010 reform in Greece. We interpret this discrepancy in 2010 as the response of aggregate tax evasion to the tax reforms implemented in Greece.

These large fluctuations in VAT collection efficiency are not observed everywhere. In countries with strong tax monitoring, the VAT collection efficiency is very stable and less sensitive to tax hikes. In figure 3, we provide the same analysis for the German 2007 VAT reform, and we compare the German VAT collection efficiency relatively to some of its "neighbors", i.e., France, the Netherlands, Denmark and the United Kingdom. In general, the VAT collection efficiencies fluctuate much less. There is however a decrease in VAT collection efficiency for Germany in 2007, but (i) much lower than in the Greek case, and (ii) quite temporary: VAT collection efficiency decreases by 5% in 2007 but is back to the same level in 2009.

The marked divergence in terms of VAT collection efficiency between Greece and the other GIIPS countries does not show up in the excise collection efficiency. In figure 2, we replicate the same exercise as in figure 1, but for the excise on

[6] We construct this measure without accounting for fluctuations in the activity for each category of goods. In other words, we use the 2009 shares to compute the collection efficiencies over the whole period (see figure A1 in the appendix for a robustness check using the contemporaneous shares). We normalize all measures such that they are equal to 1 in 2009. We also provide in the appendix the same figure in which we account for fluctuations in the activity of each categories of goods separately (see figure A1), and the conclusion is similar.

[7] We compute the difference between the (logarithm of) VAT collection efficiency in Greece and the average (logarithm of) VAT collection efficiencies in the GIIPS countries excluding Greece. We then compute the same difference for the (logarithm of) VAT effective rates, and we plot the results in the bottom panel of figure 1.

unleaded petrol. There is a decrease of about 10% in the excise collection efficiency in response to the 85% increase in the excise rate. In absolute terms, this number is comparable with the decrease in VAT collection efficiency over the same time period, but the elasticity to the tax increase is much smaller. To summarize, in the Greek adjustment program of 2010, following the increase of about 20% in the VAT rate, VAT revenues increases only by 10%. Instead, the increase of about 85% in the excise rate on unloaded petrol generates an increase in excise tax revenues of about 70%. The fact that the tax base shrinks by 10% for VAT whereas it remains almost unchanged for the excise points to a different behavior of tax evasion in response to these tax hikes. The payment of excises is indeed generally better enforced, and it is much more difficult to conceal or under-report than the VAT payment.

To conclude, given that we control for potential changes in the composition of the tax base, the movements in the collection efficiency shown in figure 1 and 2 directly reflect changes in tax evasion. This response of tax evasion to tax hikes is sufficiently large to have relevant implications for the effectiveness of fiscal adjustments. Before getting to the quantitative analysis of the response of tax evasion to tax hikes based on our theoretical framework, we analyze the response of tax evasion at a more disaggregated level.

2.2 The heterogeneous response of tax evasion

We have shown that, in 2010-2011, the aggregate tax evasion strongly increases in response to the VAT hikes. We now show that there exist large variations in this response across regions, and these variations can be related to the region-specific tax shock.

We use Elstat data to observe (i) the annual VAT revenues (total and subtotals for legal entities and individuals), and (ii) the annual value added in each 1-digit industry between 2006 and 2011 for 51 regional units. This allows us to compute the regional collection efficiency $CE_{j,t}$, for each region j. We also compute ΔCE_j, that is the gap (in percentage points) of the regional collection efficiency between the pre-reform period (2006-2009) and the post-reform period (2010-2011).

We observe a large cross-regional variation in the evolution of collection efficiency before and after the austerity plan. The standard deviation of ΔCE_j across regions is around 0.1 implying a difference of 0.15 points between the first and last quartile of regions. Some regions experience a marked decrease in their collection efficiency, namely Thessaloniki and Attiki, which are home to the two largest cities, whereas some others experience a large increase, e.g., the islands Chios, Kyklades, Samos

or Zakynthos.[8] The large fall in collection efficiency in Attiki and Thessaloniki, the two regions where about 65% of Greek GDP is generated, explains the aggregate fall in the economy. Below we provide two robust pieces of evidence that are common to the overall Greek economy and help understand (i) these regional disparities and (ii) which factors drive fluctuations in tax evasion.

First, we show that the fluctuations in collection efficiency are strongly related to the fluctuations in effective VAT rate, independently of fluctuations in output. We define the effective VAT rate as the average tax rate on a unit of output produced in the region. This tax rate would be 19% for a region whose industry is entirely dedicated to the production of category 1 goods. There exist large variations in the fluctuations in effective VAT rates due to the regional sectoral composition but also to the tax exemptions implemented in some regions (mainly islands). In the left panel of figure 4, we plot ΔCE_j as a function of fluctuations in effective VAT rate controlling for fluctuations in output. The regions where the VAT hike is larger are those with the larger drop in collection efficiency on average. The relationship is extremely strong and robust to the addition of sector-specific output growth.

Second, the other main predictor for the fluctuations in collection efficiency before and after the tax hike is the average regional firm size (measured by total assets). The regions where the average firm size (measured by total assets) is larger are also those with larger drop in collection efficiencies on average, as shown in the right panel of figure 4.[9] These results are obtained cleaning for the variations induced by regional GDP growth and the regional growth rate in effective VAT.

We summarize these two results in table 1. In this table, we first show the unconditional correlation between firm size and changes in collection efficiency weighted by the regional value added (first column). The correlation is very large: a region with average firm size of 0.2 M euros experience a 10 percentage point decrease in collection efficiency relatively to a region with average firm size of 0.1 M euros. We then add the change in the effective VAT rates. Both the firm size and the change in VAT rates are strong predictors for fluctuations in collection efficiencies (they explain almost 70% of the total variation in this measure ΔCE_j). We also condition this correlation by other important regional characteristics. We include the regional growth rate (third column) and the sector-specific growth rates (fourth column). All

[8]There exists a long-standing lower tax regime that applies on the Aegean islands in order to foster tourism. Besides, tax enforcement is notably lower. In 2010, the Greek authorities decided to increase enforcement without revising the exemptions and we see that VAT revenues strongly responded in these islands.

[9]We exclude the Attic region from this picture because it has a much larger average firm size and collection efficiency than the other regions. Including the Attic region would make the relationship even stronger. Source : Annual business registers, Elstat statistical yearbook 2010.

set of additional controls capture only a small part of total variations in ΔCE_j.[10] Firm structure and variations in effective VAT rates are the only relevant regional characteristics which predict leakages following the 2010 reform.

2.3 The impact of tax evasion on credit access

Having established the link between tax hikes and subsequent tax evasion, we now explore the impact of such tax evasion on credit access. As long as hidden activity is not as pledgeable as declared activity, the response of tax evasion to the VAT hikes should imply a credit flow out of medium-size firms in 2010-2011. In turn, the stronger response of tax evasion in those regions where the share of medium-size firms is larger should also be associated to a stronger credit crunch.

We investigate the impact of the response of tax evasion to the austerity plan on credit access using a panel of firm-level balance sheet data on a quasi-exhaustive sample of Greek firms[11]. The panel dimension of our data allows us to follow the credit history of these firms and, in particular, assess the degree to which they rely on external finance.

First, the fiscal adjustment in 2010 is associated with an overall decrease in leverage in Greece : for all given firm size, there is at least a small decrease in their access to credit. In figure 5, we plot the leverage – the ratio of external funds to total assets – in 2009 (blue line) and 2011 (red line) by firm size for the whole country. We keep in this figure all firms, including new entrants and exiters. Notice, however, that there is more exit during the recession (the exit rate in our dataset is 5% in 2009, 10% in 2010 and 15% in 2011) and the exiters have generally a slightly higher leverage. In contrast, the share and leverage of new entrants remain quite stable during the whole period.[12]

Second, figure 5 also shows the heterogeneous response of credit across firm size. The leverage is close to 0 in 2009 for firms with less than 1 million euros in total assets, and it remains negligible in 2011. Large firms with assets above 25 million euros have a leverage of about 0.33 in 2009 and it slightly decreases in 2011.[13] In contrast, medium-size firms experience a substantial fall in their access to external

[10] Our results are also robust to the addition of a dummy for Aegean islands, the addition of the Attic region and they are robust when we do not use any weights. We also control for regional sector-specific incidence captured by the employment shares, and GDP per capita.

[11] Hellastat 2001-2013, see section 4 for a detailed description of the dataset.

[12] Compositional effects add to the shift that would be already observed with the balanced panel of firms (they represent about one fourth of the shift).

[13] We do not expect very large firms to respond because they are subject to a much tighter monitoring from tax authorities and investors. We do not expect the leverage of very small firms to decrease because it is already very close to zero.

finance. For instance, a firm with 10 million euros in total assets exhibit a leverage of 0.3 in 2009 and 0.25 in 2011. These results are robust to a large set of controls: e.g. even within the same industry, medium-size firms are the only ones whose leverage drops. Finally, the shift in leverage would be slighty less pronounced in the balanced panel but the results would be qualitatively similar.

Third, we show that the decrease in leverage is larger in regions where tax evasion is large. In figure 6, we show the evolution of leverage in 2011 relatively to 2009 in regions with high versus low response to tax evasion. The downward shift in leverage is substantially larger in regions where the response of tax evasion to tax hikes is larger. We further explore this correlation in figure 7. We plot the regional change in collection efficiency ΔCE_j against its counterpart change in leverage for medium-size firms (with assets between 1 Million euros and 50 Millions euros) around the austerity plan. The correlation is positive and significant (the elasticity is 0.83 with a standard error of 0.28). Interestingly, the elasticity is close to 1, thereby supporting the idea that credit is proportional to declared activity for credit-constrained firms. While there may be some differential compositional effects across regions, they do not have an impact on this correlation.

In the next section, on the basis of the three stylized facts presented above, we argue that the aggregate response of tax evasion to tax hikes is relevant in a country with weak tax enforcement, because medium-size firms substantially reduce their declared activity. In turn, these firms lose part of their access to external finance, which reduces aggregate investment. For our last effect to exist, we need access to credit to be affected by the degree to which a firm activity is concealed to tax authorities.

3 A model of firm transparency and investment

This section presents a simple static model of firm transparency and investment which allows to derive our macro-elasticities of tax revenues ($\varepsilon_{\tau\gamma v}$), transparency ($\varepsilon_{\gamma}$) and output ($\varepsilon_{v}$) to taxes, accounting for firm size heterogeneity. There are three crucial ingredients in our framework. In line with our stylized facts, we allow firms to adjust their *transparency*, that is the extent to which they declare their activity. Access to external financing is conditioned by the existence of pledgeable capital and concealed activity is less pledgeable than declared activity, such that tax evasion reduces the capacity to levy funds. Finally, 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 entrepreneurs and creditors or tax authorities. We only need that tax evasion triggers a higher cost to the latter when they need to retrieve their loans or taxes. Information asymmetry could be one likely factor which explains why recovery costs are higher when dealing with non-transparent firms. In the model, we disregard fiscal corruption, that is potentially important in a country with relatively low tax enforcement like Greece. While corruption does not modify the tax revenues for the government for a given transparency, it does modify the entrepreneur's behaviour ex-ante through the share that is captured by corrupted officials. In our framework, fiscal corruption would change our conclusions if the surplus share that is captured by fiscal officials responds to taxes. 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.

3.1 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 invest and is subject to an idiosyncratic draw whose success depends on the innovation efforts. When the entrepreneur invests c, with probability $p(c)$, the entrepreneur is successful and can use the modern technology.

Because the access to the modern technology is stochastic, for a given firm size, there may exist (informal) firms using the traditional technology and (transparent) firms using 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 homogeneous 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). By assumption, γ is also the share of declared collateral and declared output.

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. We assume that the tax authority has also access to an audit technology and can monitor firms in order to retrieve the concealed value added. For simplicity, we posit that the tax authority perfectly observes each firm's endowment and firm's technology, and can choose a firm-specific level of monitoring.[14] The tax authority can set for each firm a probability z of detecting a concealed plant and retrieve the unpaid taxes, but this effort incurs a cost $m(z)$. When a concealed plant is detected by the tax authority, 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 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.[15]

We turn now to the financial markets. We assume that the economy is small relative to the international financial market, and that the international financial market is willing and able to supply an unbounded amount of risk-less bonds that yield the international interest rate $r > 0$. 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

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

[15] In our framework, even though the tax authority may perfectly infer the firm's transparency from fundamentals, e.g., size and technology, there exist auditing costs which prevent the tax authority from fully auditing non-transparent firms.

on transparency:[16]

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

The timing of actions is as follows. Entrepreneurs 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 taxes to be paid to the government. They borrow capital $(k-\omega)$ at the international interest rate subject to the pledgeability constraint. Finally, they produce and reimburse their creditors. In parallel, once a technology has beed adopted, the tax authority chooses, for each individual firm, an audit effort z and firms pay taxes or fines following the audit outcome.

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.

3.2 The entrepreneur

The traditional entrepreneur. We first consider an entrepreneur endowed with ω and the traditional technology, subject to an audit effort z from tax authorities. This traditional entrepreneur solves the following program:

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

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,

[16]Note that creditors can only seize a fraction of entrepreneur's endowment in transparent plants, and taxes are junior to this recovery process. This assumption rules away a potential gambling-for-resurrection behavior from entrepreneurs where they would evade taxes and leave creditors with the tax arrears in case of monitoring. As for the tax authority, we assume that 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 $\lambda_t > \lambda_c$ to recover funds from transparent and concealed firms.

she becomes fully transparent ($\gamma = 1$). Strictly below 1, she remains fully informal ($\gamma = 0$). Otherwise, she is indifferent and any γ solves the optimization program.

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

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

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.[17] In this case, the solution $\hat{k}$ verifies:

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

and the transparency choice $\hat{\gamma}$ is obtained by substituting the solution $\hat{k}$ into the credit constraint. Equation (2) is very intuitive.[18] There is a trade-off between borrowing and 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 from lenders, the firm needs to declare part of its activity and pay taxes (second term in the square brackets below). At the optimum, 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 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 and any γ solves the optimization program.

One unknown so far is the choice of audit effort z as a function of firm endowment and technology. As will be clear in the following lines, the audit effort will be a

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

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

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

function of concealed production $y_c = (1-\gamma)f(k)$.

3.3 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:

$$m'(z) = \theta\tau y_c. \tag{3}$$

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 8). When the entrepreneur is credit-constrained, her response is smoothly monotone (see right panel, figure 8) and decreasing with the audit probability z.

At the equilibrium, audit effort may not always increase with firm size. At both ends of the firm size distribution, audit efforts and transparency clearly increase with firm size because the credit constraint does not matter much in the entrepreneur's program. However, when the credit constraint becomes relevant, larger firms may rely more on external finance and be more transparent thereby reducing the incentives for the tax authority to audit. In turn, for a given transparency, the relative gain of verification increases because concealed production becomes larger as firm size increases. Both effects together imply that the effect of size on (i) resulting hidden investment and (ii) the audit effort is theoretically ambiguous.

We now 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.

3.4 Equilibrium

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

$$\max_{c} \left\{ p(c)\pi_{\omega}^{md}(z(\omega)) + [1 - p(c)]\pi_{\omega}^{tr}(z(\omega)) - c \right\},$$

which brings:

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

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 increase, 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).

The equilibrium allocation may be described by looking at two distinct firm endowment regions. When firms are small and need to get access to credit, 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 depends on the response of tax authorities. When firms are large enough, they do not borrow anymore and transparency increases with size such as to leave the absolute value of concealed production constant.

3.5 The behavioral response of the economy to a tax increase

We now illustrate some implications of the model that reproduce our stylized facts on transparency and credit access. Consider the comparative statics exercise in which an adverse tax shock affects our economy, i.e., an increase in τ.

In our framework, we can distinguish two effects related to such tax increase. In the modern sector, transparency choices, 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 parallel, 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.

So far, we have analyzed the comparative statics exercise for each individual firm. We turn now to the aggregate response. Given that the economy is a small open economy, prices (including bond prices) are fixed such that there are no general equilibrium effects and the aggregate quantities are easy to derive from each entrepreneur's decisions.[19]

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 medium-size firms, which, as we have seen earlier, drive most of the response.

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

$$\varepsilon^\omega_x = \frac{dx}{d\tau}\frac{\tau}{x}$$

Those quantities can easily be constructed from our previous analysis. For a given wealth ω, they are indeed related through our decomposition, i.e.

$$\varepsilon^\omega_{\tau\gamma v} = 1 + \varepsilon^\omega_\gamma + \varepsilon^\omega_v.$$

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

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

[19] In our analysis, we ignore credit supply based on the following observation: In 2010, 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, and it helped stabilize bank's collateral.

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 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 the quantitative importance of each elasticities, as well as the impact of the change in 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 economy, i.e., Greece just before the 2010 adjustment program.

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 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.

4.1 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 calibrate the model using firm-level balance sheets data from Hellastat.[20] This dataset consists in comprehensive balance sheet information of Greek firms over the period 2001-2013. 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 and smaller firms that publish their accounts on a voluntary basis. After cleaning the data for missing observations, we are left with more than 25'000 firms per year. The dataset is an unbalanced panel.[21]

Our sample of firms 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 only observe a subsample of firms, which, in practice, may be biased. Figure 9 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 these missing firms, we assume that the real distribution of firms $g(\omega)$ is the Pareto distribution estimated in figure 9, 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 elasticities.

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

[20]We 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.

[21]There is non-negligible exit in the recession, mainly driven by small firms with a higher-than-average leverage. We can also perform the same exercise on the balanced panel without significant differences in the results.

are not directly based on firm endowment but on value added, 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 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 (see the fit of the relationship in figure 10). We 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%).[22] 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 $p(c) = (\frac{c}{c_0})^{\beta_p}$.[23] Intuitively, λ determines the leverage for large firms which operate only with the modern technology. c_0 and β_p help characterize the slope

[22] In 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.

[23] We do not observe the investment in R&D, and we cannot calibrate our innovation costs parameters such as to match real investment.

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 12 : the level of the plateau is essentially pinned down by the collateral pledgeability parameter λ, whereas the slope and concavity of the first part of the curve are 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 12. 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 12.

Concerning the monitoring intensity, it is hard to collect evidence on the strategy of Greek tax authorities. The statistics on the monitoring activity by Greek tax authorities are available since January 2011, and as such they do not allow to observe potential changes in the strategy around the implementation of the tax reforms.[24] On the one hand, the endogenous auditing described in section 3.3 predicts an increase in the effort of tax authorities at detecting undeclared activity, and a strenghtening of tax enforcement has also been part of the reforms asked by the Troika, as suggested by the data availability starting in 2011.[25] On the other hand, the tax authorities may suffer a significant reduction in the resources available for their auditing activity during a recession. In the end, 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 evaders in Greece.[26] 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.[27] 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

[24] See http://www.gsis.gr/gsis/info/gsis_site/PublicIssue/Statistics.html.

[25] A tighter monitoring can also be observed in Italy during the same period with a marked increase in tax controls.

[26] See the Tax Procedure Code. Legal penalties are huge but in practice rarely implemented.

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

boils down to adding a fixed informal sector, which would mechanically reduce our estimates for aggregate transparency. Table 2 reports the benchmark calibration. We later shows the sensitivity of our results to these parameters.

4.2 The drastic austerity plan of 2010

Using our benchmark calibration, we analyze the effect of changes in the VAT rate on our economy. The objective of our numerical simulations is to replicate the 2010 Greek tax reform and analyze how the transparency response could explain the observed misalignment between predicted tax revenues and actual tax revenues. To this purpose, we set the same tax rates as the government and estimate our predicted tax revenues, 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 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 3. 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 revenues. Those results are in line with our aggregate estimates from section 2.

We can interpret these results in terms of elasticities to taxes. 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).

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 constraints 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 of firms. Under the assumption of fixed transparency, 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 3 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 1 percentage point 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 the tax hike. Figure 13 shows the elasticities of transparency and output to tax hike along firm size. Most of the drop in tax receipts is due to middle-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. There are three types of firms: 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.[28]

We also find direct evidence of this size-specific credit crunch in our panel of firms (see section 2 and figure 5): there has been a shift of credit out of small and medium-size firms during the crisis. The empirical evolution of credit along firm size is comparable to our theoretical predictions (see figure 11), both quantitatively and qualitatively. Overall, our model does not only match well the aggregate evolution in credit and transparency, but also its distributional features.

4.3 Counterfactual experiments and sensitivity to fundamentals

We now 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 tax reforms depends on the number of firms at the margin between informality and formality, i.e. the number of firms that are relying on external finance but are not fully transparent. The number of such firms is determined by (a) the range in which firms are almost indifferent between informality and access to credit, (b) the density of firms in this range, and both quantities are pinned down by fundamentals of the economy, i.e. the lender's protection, tax monitoring and firm size distribution.[29]

When we modify these fundamentals, we modify both the "steady state" of the economy, and notably the "steady-state" aggregate transparency, and the elasticities of tax revenues, transparency and output to taxes. We take advantage of this observation in order to represent our elasticities, not as a function of each underlying parameter but rather as a function of steady-state quantities. For the share of observed investment that can be pledged λ, we define $\lambda \mapsto \Gamma(\lambda)$, where $\Gamma(\lambda)$ is the aggregate transparency. We compute the elasticities of tax revenues $\epsilon_{\gamma\tau v}(\lambda)$, transparency $\epsilon_{\gamma}(\lambda)$ and output $\epsilon_{v}(\lambda)$ to taxes as functions of λ. Our objective is to study how the response to taxes depends on steady-state aggregate transparency when the variations in steady-state aggregate transparency $\Gamma(\lambda)$ are only driven by different credit market conditions. Similarly, we compute the same elasticities as functions of θ and ψ, and define the same mappings $\theta \mapsto \Gamma(\theta)$ 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.

[28] Note 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.

[29] A 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.

Figures 14, 15 and 16 display those elasticities when we consider variations in λ, θ and ψ.[30] In the horizontal axis we report the aggregate transparency which moves with 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 14, as we increase the extent to which collateral can be pledged (λ), the elasticity of tax receipts to tax rate slightly increases. 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 aggregate elasticity $\epsilon_{\gamma\tau v}$ for more financially developed economy (medium-size firms represent a low share of the 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 14 remains constant.

As regards the elasticity of tax receipts to tax rate, figure 15 shows that, as we increase the sanctions applied by tax authorities, $\varepsilon_{\gamma\tau v}$ 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. An economy with a fat-tail firm size distribution (low ψ) is less responsive to taxes since most of the effect comes from the weight of 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 the blue line ($\varepsilon_{\gamma\tau v}$) in figure 16 widens and the overall elasticity of tax receipts to taxes slightly decreases with aggregate transparency. If we only increase instead the number of medium-size firms, we would find a much lower aggregate elasticity $\varepsilon_{\gamma\tau v}$, consistent with our empirical findings across Greek regional units.

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

[30] In figure 17, we plot the aggregate elasticity as a function of two parameters while keeping the third one at its benchmark level.

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-explored, factor behind the success of an austerity plan in raising tax revenues.

5 Concluding remarks

This paper shows that the failure of the Greek 2010 tax reforms in raising the expected tax revenues is mostly due to the response of 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 erosion of transparency. Three quarters of the overall behavioral response to the increase in taxes come from the transparency response of firms. As transparency guarantees a better access to credit market, firms switching to the informal sector are excluded from credit markets thereby depressing aggregate investment.

We show that 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 explain the gap between the expected tax revenues and the realized ones mostly through this transparency channel. Following an increase in VAT of around 3-4 points, the Greek government expected an increase in tax revenues 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 revenues levied by the tax reforms in our quantitative exercise because we focus on VAT, while the austerity plans in Greece included at least one other significant tax change, that is excise on petrol.

One important contribution of the present paper is the calibration of our heterogeneous firms model using a balance-sheet dataset of Greek firms. We provide some evidence that our aggregate predictions are in line with the aggregate evolution of collection efficiency, a measure that captures fluctuations in tax evasion. 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 out of mid-size 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 drastic VAT reforms 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.[31] The further valuation loss for the banking 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.

[31] In contrast, in two recent papers (Gibert (2014) and Metelli (2014)), austerity measures act as a signalling device. Well-behaved governments would then implement fiscal austerity to reduce their borrowing costs.

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Tables

Table 1. The correlation between the change in VAT collection efficiency and the firm size across regions.

$\Delta CE_{j,t}$	(1)	(2)	(3)	(4)
Firm size (assets, M euros)	-1.341**	-1.256**	-1.388**	-1.204**
[.174]	(.332)	(.211)	(.211)	(.188)
Effective VAT change		-1.484**	-1.425**	-1.733**
[.149]		(.174)	(.169)	(.174)
Controls (GDP and VAT growth)			Yes	Yes
Controls (sector-specific growth)				Yes
Observations	50	50	50	50

Significantly different than zero at † 90% confidence, * 95% confidence, ** 99% confidence. Standard errors between parentheses are robust. The averages over the sample are shown between brackets.

Table 2. Benchmark calibration

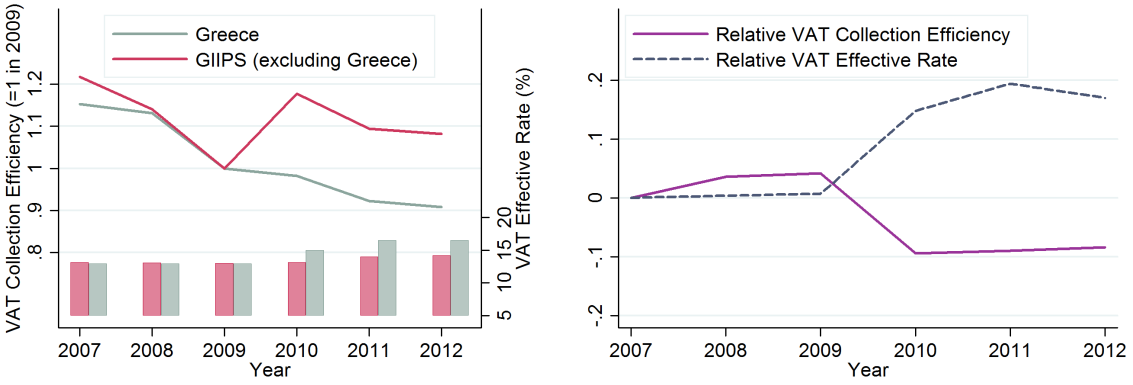
	Interpretation	Value	Rationale
α	Returns to scale	0.82	Sales - Hellastat (2009)
r	Interest rate	0.08	Bank of Greece (2009)
A	Productivity factor	0.92	Distribution output - Hellastat (2009)
λ	Collateral pledgeability	0.50	Distribution leverage - Hellastat (2009)
β_p	Innovation (scale)	0.30	Distribution 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)

Table 3. The impact of the first adjustment program

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

Figures

Figure 1. VAT collection efficiency.

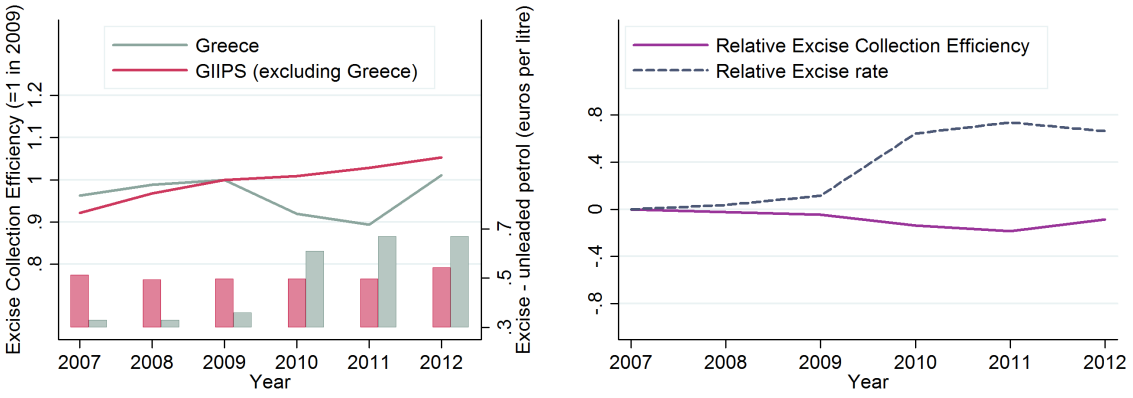


(a) VAT collection efficiencies and VAT rates

(b) Relative VAT collection efficiencies and relative VAT rates

Note: These figures represent the ratio of realized tax revenues to expected tax revenues, given the value added generated in the different sectors subject to different VAT rates. In the top panel, we report the VAT standard rate (on the right axis) and the associated VAT collection efficiency (normalized to 1 in 2009) over the period 2007-2012 in Italy, Spain, Portugal and Ireland (red bars and red line) and Greece (green bars and green line). In the bottom panel, we report the gap (in percentage points) between the Greek VAT collection efficiency and VAT rate to the averages in Italy, Spain, Portugal and Ireland.

Figure 2. Excise (on unleaded petrol) collection efficiency.

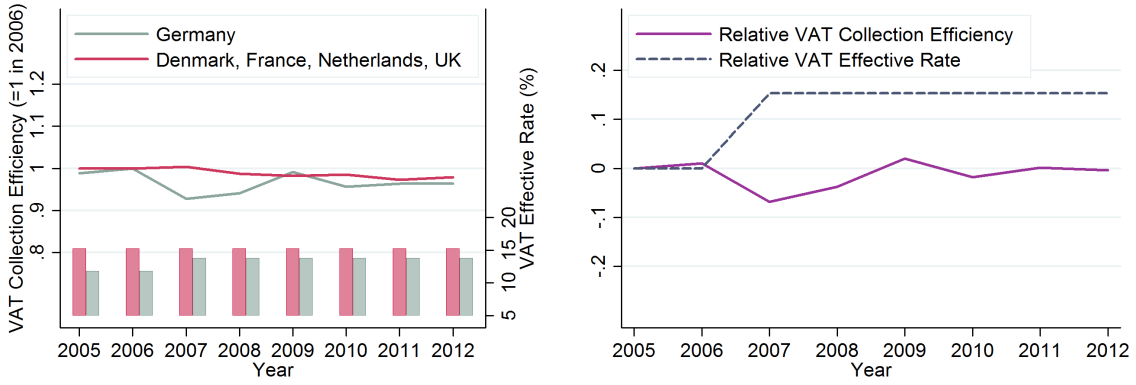


(a) Excise collection efficiencies and excise rates

(b) Relative excise collection efficiency and relative excise rates on unleaded petrol

Note: These figures represent the ratio of realized excise revenues to expected excise revenues, given the consumption of unleaded petrol. In the top panel, we report the excise on unleaded petrol (on the right axis) and the associated excise collection efficiency (normalized to 1 in 2009) over the period 2007-2012 in Italy, Spain, Portugal and Ireland (red bars and red line) and Greece (green bars and green line). In the bottom panel, we report the gap (in percentage points) between the Greek excise on oil collection efficiency and the excise on oil rate to the average of Italy, Spain, Portugal and Ireland.

Figure 3. VAT collection efficiency – the 2007 German reform.

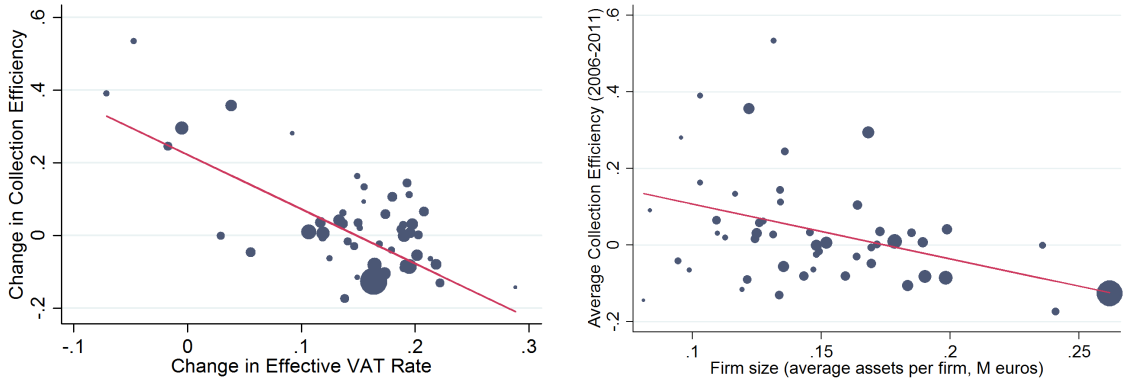


(a) VAT collection efficiencies and VAT rates

(b) Relative VAT collection efficiencies and relative VAT rates

Note: These figures represent the ratio of realized tax revenues to expected tax revenues, given the value added generated in the different sectors subject to different VAT rates. In the top panel, we report the VAT standard rate (on the right axis) and the associated VAT collection efficiency (normalized to 1 in 2006) over the period 2005-2012 in Denmark, France, the Netherlands and the United Kingdom (red bars and red line) and Germany (green bars and green line). In the bottom panel, we report the gap (in percentage points) between the German VAT collection efficiency and VAT rate to the averages in Denmark, France, the Netherlands and the United Kingdom.

Figure 4. Response of VAT collection efficiency to the 2010 VAT reform and the role of tax pressure and firm size.

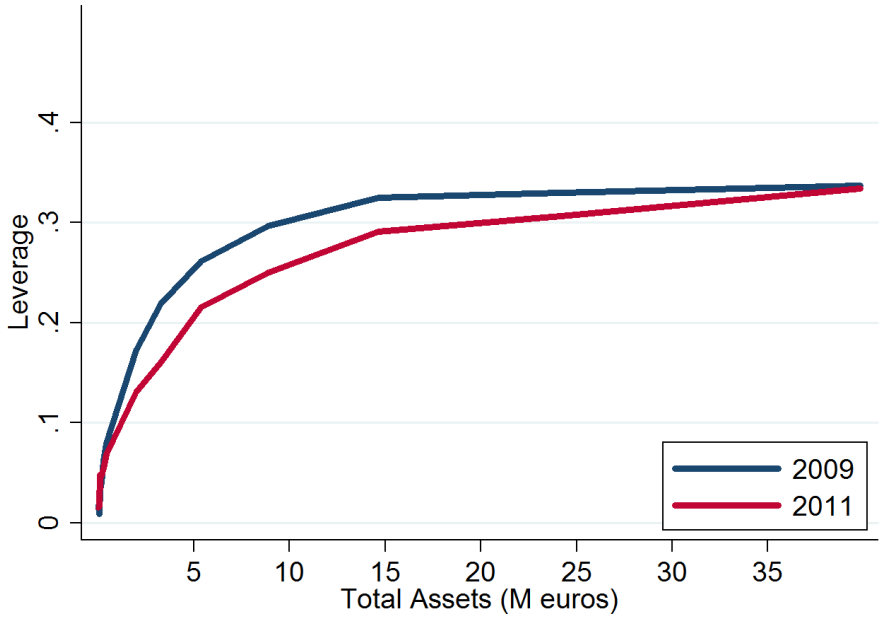


(a) Change in effective VAT rate

(b) Firm size

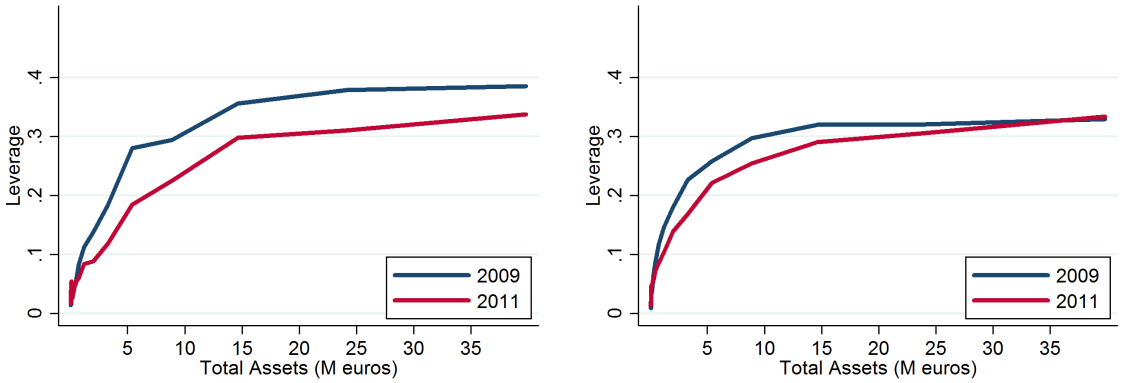
Note: In the left panel (resp. right panel), we report the correlation between the evolution of VAT collection efficiency, i.e., the (log) difference of regional VAT collection efficiencies after and before the 2010 tax reform, and the percentage change in effective VAT rates (resp. the average regional firm size). In both figures, the circle size illustrate the share of national activity for each region. For readibility purposes, we omit the Attic region (very high share of total activity, very high collection efficiency and large negative response to the 2010 reform).

Figure 5. Leverage as a function of firm size before and after the 2010 tax reform.



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

Figure 6. Leverage as a function of firm size before and after the 2010 tax reform for the subsamples of regions with high/low tax evasion response.

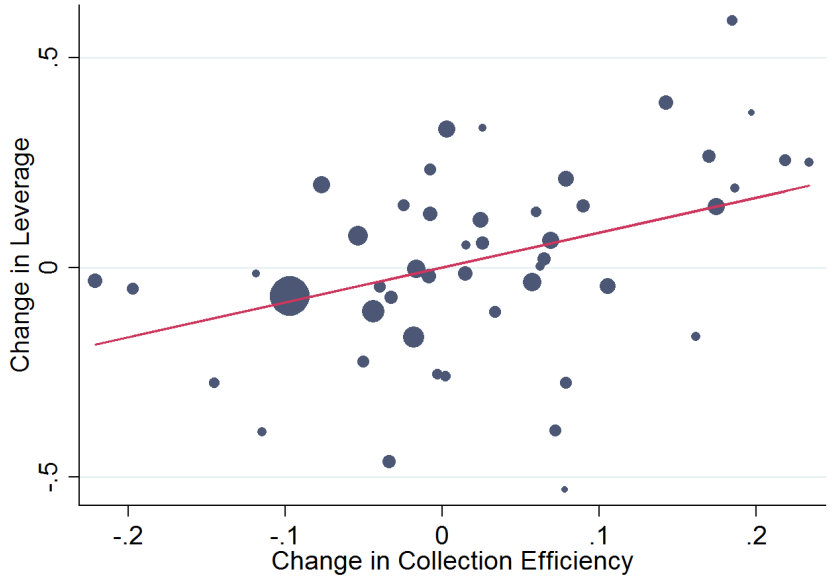


(a) High evasion response

(b) Low evasion response

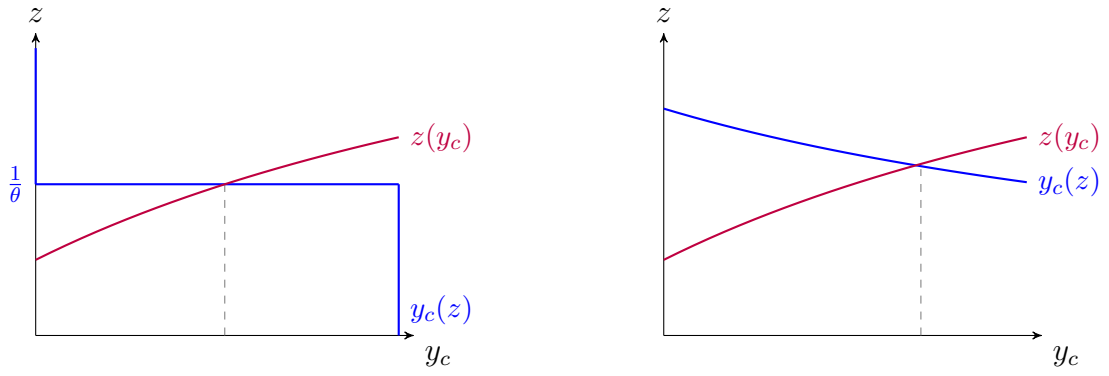
Note: Source Hellastat, 2009, 2011. This graph displays the leverage by firm size (total assets) before (2009) and after (2011) the austerity plan in regions with above-median response in collection efficiency (left panel) and below-median response in collection efficiency (right panel).

Figure 7. VAT collection efficiency and leverage.



Note: We report the correlation between the evolution of VAT collection efficiency, i.e., the (log) difference of regional VAT collection efficiencies after and before the 2010 tax reform, and the evolution of leverage, i.e., the (log) difference of leverage after and before the 2010 tax reform. In both figure, the circle size illustrate the share of national activity for each region. For readibility purposes, we omit the Attic region.

Figure 8. Audit and concealed production.

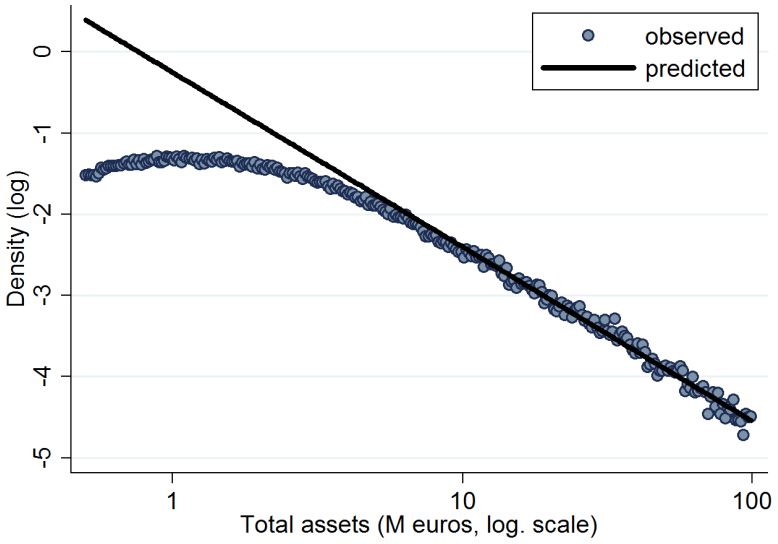


(a) Non-binding credit constraint

(b) Binding credit constraint

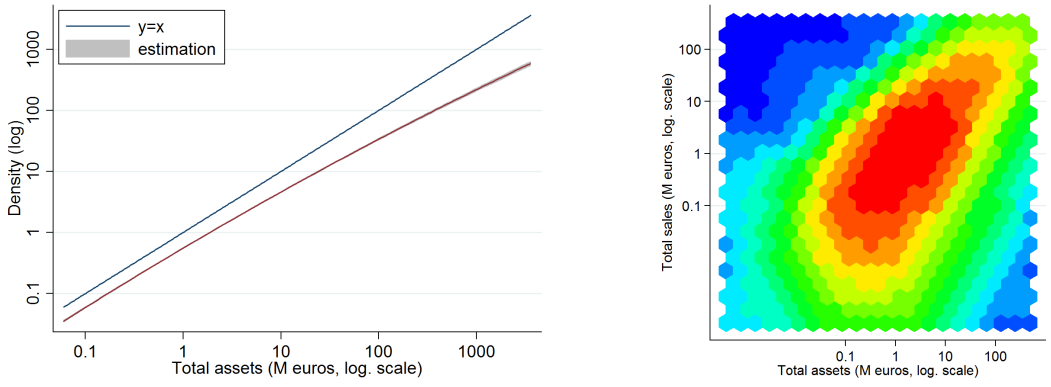
Note: These figures represent the optimal response of tax authorities to a certain level of concealed production $z(y_c)$, and the optimal concealed production as a function of audit intensity $y_c(z)$.

Figure 9. 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 10. Empirical production function.

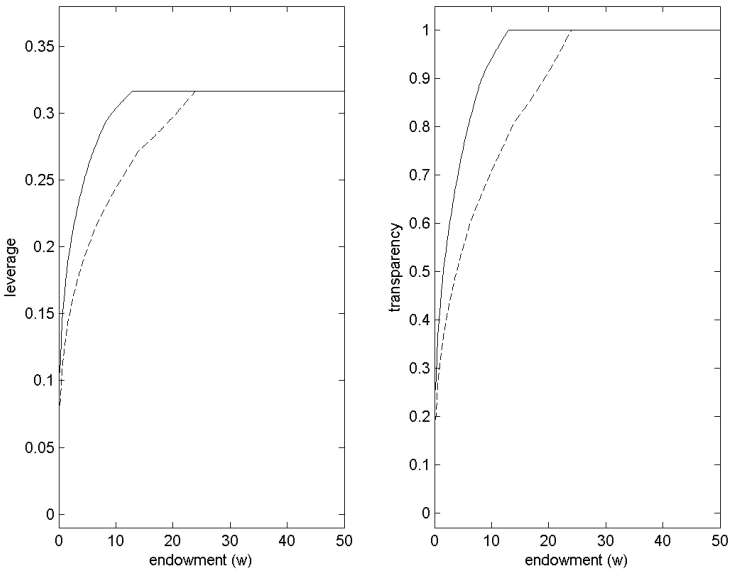


(a) Polynomial estimates

(b) Density

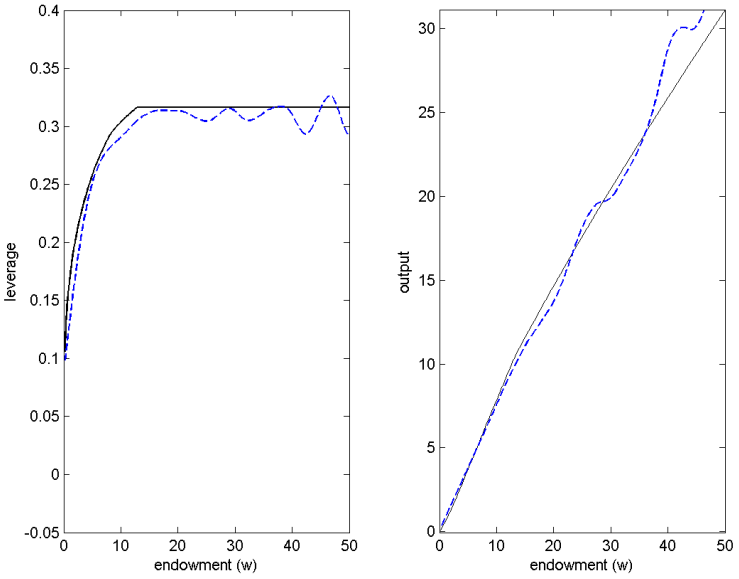
Note: These figures represent the polynomial estimates for the elasticity of sales to firm endowment using the whole sample of firms (approximately 30'000 firms per year) and controlling for firm and industry×year fixed effects. For both figures, the axes are on a logarithmic scale.

Figure 11. Leverage and transparency : the impact of the 2010 tax reform.



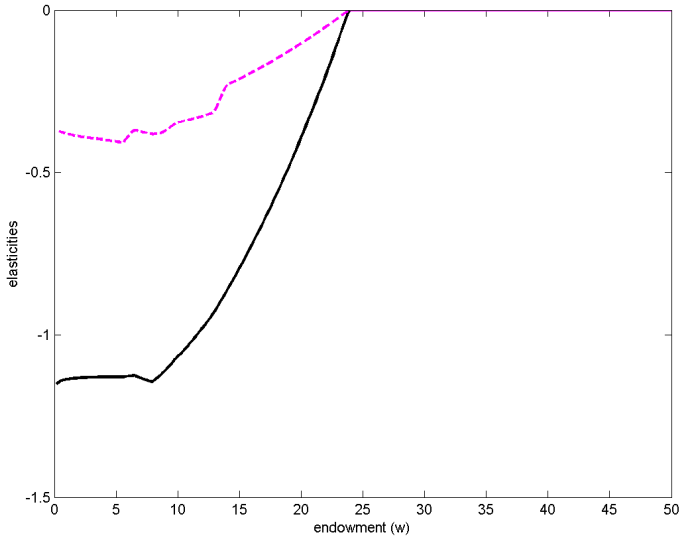
Note: Leverage and transparency along firm size for the benchmark calibration (solid line) and the 2010 austerity plan simulation (dashed line).

Figure 12. Empirical vs. theoretical leverage and output.



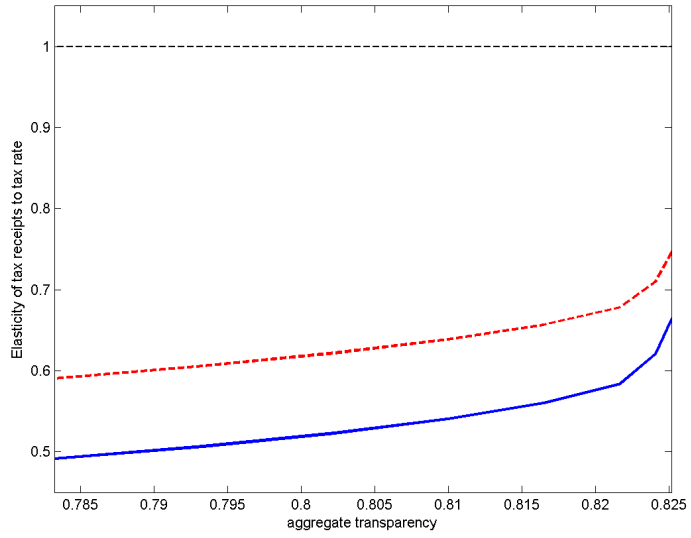
Note : Benchmark calibration. The solid black lines are the calibrated leverage and output, the dashed blue lines are the empirical leverage and output for firms with assets between 0.5 and 50M euro (smoothed using a HP filter).

Figure 13. Transparency and output elasticity by firm size.



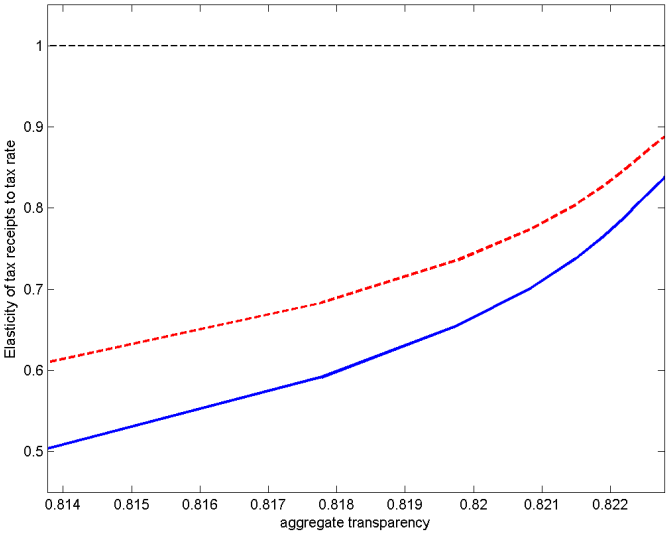
Note: The solid line is the elasticity of transparency ε_γ, the dashed line is the elasticity of output ε_v as a function of firm size. Both are computed using the 2010 austerity plan simulation.

Figure 14. Credit frictions and the elasticity of tax receipts.



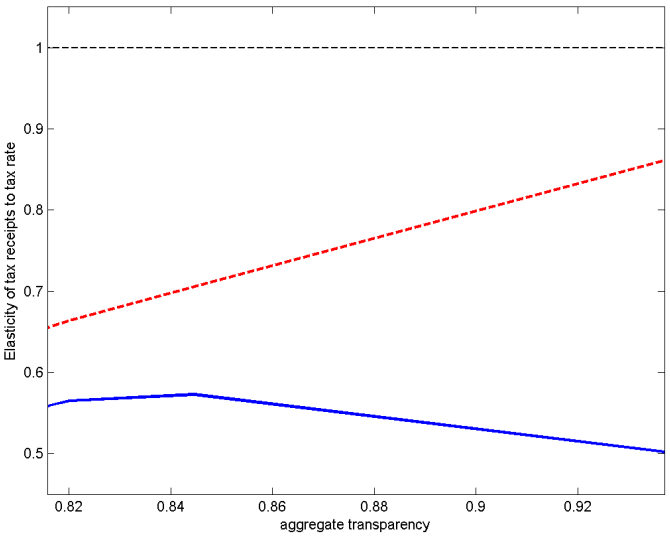
Note : Response to the 2010 tax reform. The solid blue line is the elasticity of tax receipts ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_\gamma + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax receipts ($1 + \varepsilon_\gamma$). In the horizontal axis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

Figure 15. Tax enforcement and the elasticity of tax receipts.



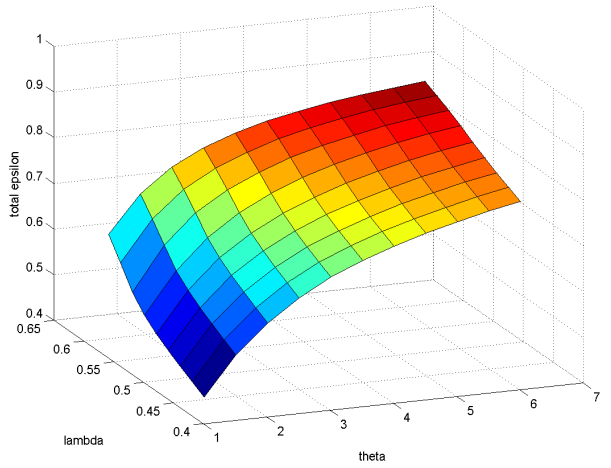
Note : Response to the 2010 tax reform. The solid blue line is the elasticity of tax receipts ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_\gamma + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax receipts ($1 + \varepsilon_\gamma$). In the horizontal axis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

Figure 16. Firm size distribution and the elasticity of tax receipts.

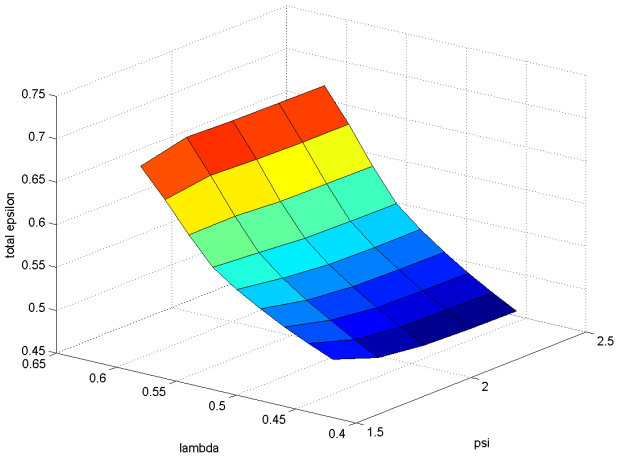


Note : Response to the 2010 tax reform. The solid blue line is the elasticity of tax receipts ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_\gamma + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax receipts ($1 + \varepsilon_\gamma$). In the horizontal axis 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.

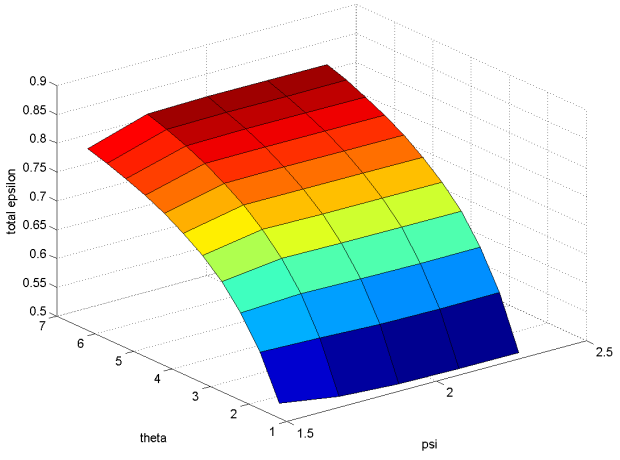
Figure 17. Aggregate elasticity of tax receipts. Sensitivity to fundamentals.



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



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



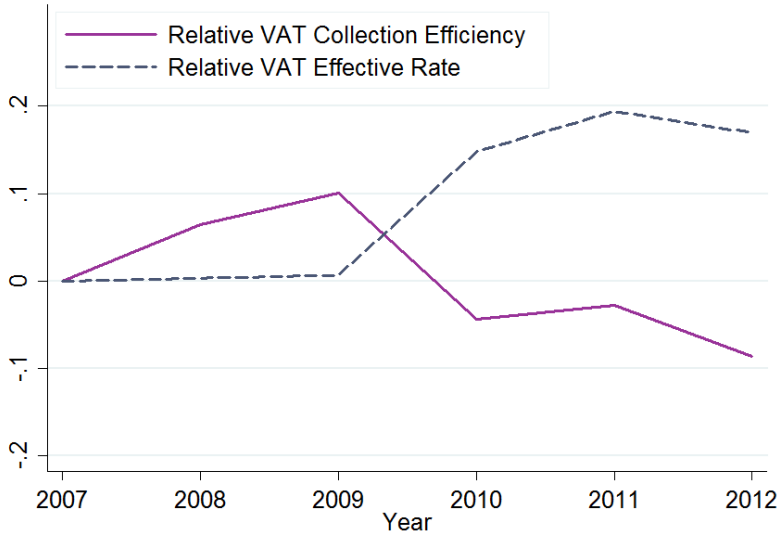
(c) Sensitivity to tax enforcement θ and firm size shape ψ

Appendix

Additional figures.

Figure A1. VAT collection efficiency – accounting for compositional effects.

(a) VAT collection efficiencies and VAT rates



(b) Relative VAT collection efficiencies and relative VAT rates

Note: These figures represent the ratio of realized tax revenues to expected tax revenues, given the value added generated in the different sectors subject to different VAT rates. Compared to figure 1, we account for fluctuations in the activity generated in each sector. In the top panel, we report the VAT standard rate (on the right axis) and the associated VAT collection efficiency (normalized to 1 in 2009) over the period 2007-2012 in Italy, Spain, Portugal and Ireland (red bars and red line) and Greece (green bars and green line). In the bottom panel, we report the gap (in percentage points) between the Greek VAT collection efficiency and VAT rate to the averages in Italy, Spain, Portugal and Ireland.

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