Fiscal consolidation and tax compliance*

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Abstract

Relying on a novel measure of VAT compliance in a panel of 35 countries, we document a robust negative association between changes in tax compliance and tax rates. In order to rationalize this finding, we develop a theoretical framework where heterogeneous firms adjust the share of declared activity. We calibrate the model using firm-level data in Greece, and find large leakages following the recent fiscal consolidation. We then show how differences in financial development and the size of economic activity at the margin of informality are able to explain the heterogeneous response of tax compliance to tax rates across countries.

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1 Introduction

Some recent episodes of fiscal consolidation, e.g., peripheral European countries in the recent crisis, have shown that the increase in tax revenues after a tax hike may be undermined by the strong response of tax compliance. 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 compliance and its implications for the effectiveness of such reforms.[1] A decrease in tax compliance may not only reduce the impact of a fiscal adjustment, but also have collateral effect on firm behaviors, e.g., their access to external finance and investment.

In this paper, we provide evidence of a large tax compliance response to fiscal consolidation episodes. We introduce a new measure of Value-Added-Taxes (VAT) compliance based on the comparison between two distinct sources: reported household consumption collected in household surveys and tax revenues reflecting taxpayers' declarations. In parallel, we compile a catalogue of indirect tax reforms in 35 countries between 1990 and 2012.[2] In order to capture fluctuations in VAT compliance and clean for potential confounders, e.g., compositional effects, we associate tax rates to reported household consumption for each 2-digit category of goods over the same period, and we construct the ratio of *actual* annual tax revenues to the *expected* VAT revenues.[3]

One stylized fact stands out from the empirical analysis: there is a robust and large negative association between changes in VAT compliance and changes in VAT rates. A VAT increase of 10% is associated with a decrease in VAT compliance of about 4.5%, and these estimates are robust to controlling for the business cycle and changes in the trade balance or government expenditures. Importantly, the response of VAT compliance to VAT reforms is highly heterogeneous across countries. We show that the elasticity of tax revenues to tax reforms is much smaller within the sample of countries with high legal enforcement.

In order to explain the quantitative relationship between tax compliance and tax

[1] The impact of tax reforms on the economic activity has been widely explored in the literature, and the debate on the size of fiscal multiplier has flourished over the past few years. 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 estimated fiscal multipliers, focusing on cross-country differences, on the type of fiscal shock considered, or the moment of the cycle when such policies are implemented. The objective of these papers is to estimate the elasticity of *output* to taxes, none of them being particularly focused on *tax revenues* per se.

[2] In our sample of countries, VAT revenues represent a large share of total tax revenues (about 35%) and a large share of the transitory fluctuations in tax pressure comes from VAT reforms.

[3] This measure of VAT compliance is cleaned for the realized output fluctuations in each good category: in an economy where taxpayers declare entirely their transactions, this ratio would be equal to 1 and orthogonal to fluctuations in output.

reforms as well as its heterogeneity across institutional environments, we build a theoretical model with heterogeneous credit-constrained firms operating in a modern or a traditional sector. In the model, there is imperfect tax enforcement such that the main motive for small businesses to declare their activity is 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. 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 with lower returns to capital. 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. Overall, firm leverage decreases thereby 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.

We explore two quantitative implications of our model that can be compared with our initial stylized fact. First, we calibrate the model to replicate a recent and relevant fiscal consolidation, i.e., the fiscal adjustment program imposed on the Greek government by the "Troika" as a condition for the international bail-out on Greek sovereign debt in 2010.[4] Second, we perform some comparative statics and analyze how the transparency response depends on two factors: the degree of legal enforcement (governing access to credit) and the share of economic activity at the margin of informality.

We calibrate our model using firm-level balance sheets data on 30'000 Greek firms provided by Hellastat. These data allow us to match the heterogeneity of access to external finance along firm size, which proves to be a crucial component of our quantitative analysis. We illustrate our results on the response of the calibrated economy with the following decomposition. When the government raises indirect taxes τ on the reported share γ of value added v, the elasticity of tax revenues $\tau\gamma v$

[4]The first adjustment program in 2010 included unprecedented hikes in tax rates with the standard VAT rate increasing from 19 to 23%, and Greek authorities only collected about half of the expected additional tax revenues – 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 in the declared tax base. Instead, tax compliance strongly responded to the tax hikes – a response that was mostly unanticipated.

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 compliance observed after the fiscal consolidation.[5] They are also consistent with the range of estimates provided by our systematic empirical analysis (between -0.2 and -0.5). We also analyze the impact of this change in transparency on output. In order to isolate the direct output response from the response due to changes in transparency, we use a simple counterfactual with constant transparency: the output loss would be much lower than in the benchmark case, and would then be essentially driven by large firms instead of small and medium firms.

When we investigate the distributional impacts of the tax reform in our calibrated economy, 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 a strong 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. The evolution of the theoretical and empirical distributions of credit along firm size are qualitatively and quantitatively similar.

We then analyze how the fundamentals of the economy – legal enforcement, financial development and firm size distribution – affect the magnitude of the transparency response. We run a series of counterfactual experiments and show, by performing comparative statics on the fundamentals of the economy, that the aggregate transparency response crucially depends on the share of economic activity generated by firms at the margin of informality. As 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

[5]Following the 2010 tax reforms in Greece, VAT compliance decreased by about 7% while the VAT rate increased by about 20%, which implies an elasticity of VAT compliance to VAT rates equal to -0.35.

in response to a tax hike. These results help explain the quantitative difference in VAT compliance response to fiscal consolidation observed in the data. For instance, Southern European countries are economies in which the aggregate response of tax compliance 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 legal enforcement, e.g., Germany, firms at the margin of informality would be much smaller. In developing countries, legal 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.

Our paper contributes to the economic literature in one important way. We build a measure of VAT compliance and study its interaction with the business cycle and, more importantly here, VAT reforms. In order to do so, our measure of tax compliance identifies tax evasion using the discrepancies between two reporting sources of income, a strategy similar to Kleven et al. (2011) and Cai and Liu (2009) for instance. Closer to our empirical measure, 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, and they show that these discrepancies are not due to measurement errors as they are systematically higher for those goods subject to higher taxation. Our empirical strategy requires to observe actual consumption and tax rates at a much disaggregated level in order to clean for compositional effects: our contribution is to compile a catalogue of VAT reforms for 35 countries between 1990 and 2012 and consistently associate indirect tax rates to reported consumption at the 2-digit good category level.

Our finding of a tax compliance effect beyond the traditional behavioral response is related to recent work by Pappa et al. (2014) or Gordon and Li (2009). Pappa et al. (2014) study 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, Pappa et al. (2014) 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.[6] Gordon and Li (2009) explain how access to external finance–through the relevance of informal activity– may explain differences in tax structure between developing and developed countries.

[6]Using a survey of managers and firm level data, Athanasouli et al. (2012) find that small and medium firms engage more 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.

Since the value from external finance is low in developing countries, firms prefer to use cash and switch to informal activity, and the government takes this imperfect tax enforcement channel into account when choosing optimal tax policy.

One important assumption behind our theoretical findings is that firm transparency affects access to credit, which seems to contradict recent findings in Artavanis et al. (2015). Artavanis et al. (2015) 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 much as their reported activity. Instead, the amount of credit is a function of their reported income multiplied by an occupation-specific factor, and a higher reported income would still be associated with looser credit constraints. By analyzing the behavioral response to taxes, we relate to a larger body of literature focusing on micro-level evidence.[7] In contrast with this literature, our analysis provides a model-based estimate which allows us to derive aggregate elasticities, and explore how micro-elasticities differ along firm size.

Finally, our study is related to a large theoretical literature examining the relationship between tax evasion or informal activity and financial development. The fact that reported activity influences access to finance has received support from Straub (2005); Desai et al. (2007); Ellul et al. (2015) 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. One feature of our theoretical framework–the dual technology world (modern and traditional)–relates to studies of shadow economies.[8] 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.

The paper is organized as follows: in Section 2, we introduce a measure of tax compliance and present a novel stylized fact on the response of tax compliance to fiscal consolidation episodes. Motivated by this empirical analysis, we describe our quantitative framework in Section 3. We make explicit the theoretical elasticity of aggregate tax revenues and aggregate output to taxes. In Section 4, we calibrate our model using quasi-exhaustive firm-level balance sheet data in Greece. We match

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

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

important moments of the distribution of firms, and we study the evolution of the calibrated economy under the 2010 fiscal consolidation program. In Section 5, we then generalize our analysis and show the role of the fundamentals of our economy, i.e. legal enforcement and the number of firms at the margin of informality, for the aggregate response of tax compliance to tax rates. Finally, Section 6 discusses some policy implications and briefly concludes.

2 The elasticity of tax compliance to fiscal consolidation

In this section, we show that fluctuations in tax compliance should not be overlooked when evaluating the behavioral response of an economy to fiscal consolidation. In this regard, we compile a catalogue of tax reforms, associate indirect tax rates and reported consumption for 2-digit categories of goods, and construct an annual measure of VAT compliance for about 35 countries.

We then present an unexplored stylized fact about the dynamics of tax compliance: there exists a strong and robust negative association between changes in tax compliance and tax rates in our sample of 35 countries, even when controlling for fluctuations in output. Tax compliance is not only a factor that affects tax revenues in the long run but it also fluctuates markedly. Importantly, the elasticity of tax compliance to tax rates is larger among countries of our sample with lower legal enforcement.

2.1 Data sources

To construct a measure of VAT compliance, we use three different data sources. First, we collect a decomposition of tax revenues by tax instruments, as declared by each national tax authority. Second, we collect household consumption measures as reported by national statistical offices based on large household expenditure surveys and we use these 2-digit good category consumption measures as a proxy for the potential tax base. Third, we create a dataset of VAT reforms in which we document changes in tax rates, but also and more crucially changes in the tax base.

Tax revenues. For European Union countries, data on tax revenues are collected centrally by Eurostat under the European system of national and regional accounts (ESA 2010) transmission programme. European Union member states are legally obliged to transmit this information for each individual tax.[9] VAT revenues are

[9]The format is a list of National taxes (the National Tax List) that are subsequently aggregated in common categories. As regards VAT, we focus on category *D.211: Value added type taxes (VAT)*.

generally recorded on an accrual basis, which may introduce some noise in reports. For instance, revenues are calculated based on the transaction time but there could be a time difference between transaction and cash receipt. Along the same lines, a transaction can be declared but may not be collected. For non-EU/OECD members, we take advantage of the OECD Model Tax Convention to collect revenues from the category *Value added type taxes (VAT)*. Finally, we complete our data on tax revenues by directly collecting detailed national accounts from national statistical offices.

Household consumption. In countries complying with the ICLS Resolution on household income and expenditure statistics (2003), household expenditure is collected by statistical office in integrated surveys including Income, Expenditure and Wealth questionnaires. One purpose of such data collection is to estimate baskets of goods and services and compute consumer price indices. There are two differences with tax reporting that are worth mentioning. First, *Households Final Consumption Expenditure* is not a proper accounting variable: it is not based on transaction reports but on household surveys. While tax revenues are based on taxpayers' declarations, consumption is reported by agents who are not legally accountable for tax evasion, i.e., (final good) buyers. Second, household surveys are less standardized across countries than accounting reports and there may exist significant variation in the survey design.

There are several measurement issues arising with these surveys, and the extent to which they affect the final consumption measure may differ across countries. We list several of them below. First, there may exist a difference between the time of acquisition and the time of use. Our ideal measure should be computed using the time of acquisition for a better comparison with VAT revenues. Second, expenditure may be computed as an accounting variable, i.e., a purchase value or a payment approach, or a consumption costs approach estimating the service flow from the good acquisition. Third, goods may be consumed gradually and be durable or semi-durable. The choice between a payment approach and a consumption costs approach is then particularly relevant. In most cases, statistical offices use the payment approach which fits our purposes. Apart from definitions, there are other differences between household surveys that could affect our analysis. Some statistical offices use a fixed reference period and then interview all households during a short period of time, some others define a moving reference period usually corresponding to the 12 previous months. Data collection may also vary: the process could be guided through an interview or the questionnaire can be completed by a household

member. The scope of the survey and the sampling design are less problematic. Sample size and questions are designed such as to provide precise estimates for the baskets of goods and services, which is also our variable of interest. One difference with statistical offices is that we do not sum the different consumption categories to determine a cost of living, but we also weight them by their supposed VAT rate to determine the *VAT content* of the consumption basket.

Valued-Added Tax rates. We finally collect VAT rates and we reference the types of goods (at the 2 digit level) that are subject to these rates for each country/year. This data collection is the novelty that supports our empirical approach and allows us to estimate fluctuations in VAT compliance with sufficient precision. For example, in a large number of countries, categories like medical services, international public transport, basic food products or cultural services are subject to reduced rates or exemptions and–very importantly–these categories are frequently updated.

For European Union members, we use two administrative sources, i.e., the European Commission and Eurostat, to construct the monthly VAT rates for about 80 expenditure categories since 2005. We complete this dataset for European Union members before 2005 and all countries by using national sources. This exercise requires some harmonization across expenditure categories in different accounting systems. It also requires some cleaning that we describe in the online Appendix. Finally, we collect other taxes such as to control for simultaneous changes in income tax or corporate tax.

Among the sample of 35 countries, we can identify 65 major VAT reforms implying changes in VAT rates larger than 5%. About 45 of these reforms are associated with an increase in the effective VAT rate and can be labelled as episodes of "fiscal consolidation". In contrast, about 20 reforms imply lower effective rates. These large fiscal episodes are quite equally spread across countries.

2.2 A measure of VAT compliance

In order to construct a measure of VAT compliance, we need *declared* transactions and a counterfactual measure that would capture the *actual* transactions. We use VAT revenues as a proxy for declared transactions. The difference between declared transactions and VAT-charged transactions is minimal and comes from arrears from defaulting legal entities. We use household-based consumption measures as a proxy for actual transactions based on the fact that households are not liable for reporting

consumption of undeclared transactions.[10]

Aggregate tax compliance is the ratio between tax revenues from total declared transactions and the counterfactual tax revenues from actual transactions. Letting $DT_{t,c,j}$ (resp. $AT_{t,c,j}$) denote the declared (resp. actual) transactions and $\tau_{t,c,j}$ denote the good-specific VAT rates for each good j in country c and year t, our measure $TC_{t,c,j}$ of VAT compliance is defined as:

$$TC_{t,c} = \frac{\sum_j \tau_{t,c,j} DT_{t,c,j}}{\sum_j \tau_{t,c,j} AT_{t,c,j}}.$$

Letting $T_{t,c}$ denote VAT revenues in year t for country c, and $C_{t,c,j}$ the reported consumption of good j in year t and country c, we have that:

$$TC_{t,c} = \frac{T_{t,c}}{\sum_j \tau_{t,c,j} C_{t,c,j}}.$$

Intuitively, our measure TC_t uses two different sources and capture the discrepancies between the two sources. We argue that such discrepancies capture, for a large share, tax evasion decisions. It is true, however, that they also may capture loose enforcement from tax authorities. For instance, tax authorities may tolerate informal exemptions for some sectors, regions, or newly-taxed activities.

Given the availability (time coverage and data quality) of our main data sources across countries, our final datasets covers an unbalanced panel of 35 (mostly European) countries between 1990 and 2012.[11]

There exist several adjustments that we need to implement for our empirical measure to be as close as possible from this theoretical benchmark. First, we are interested in the short-term fluctuations of this measure, and we need to smooth the "high-frequency" measurement error. Tax reforms are often implemented during the year, while national accounts are closed at the end of each period, i.e., year or quarter. For this reason, we need to generate the effective tax rate for a unit of consumption in a given period. When tax rates were changed during the course of the year, we construct the annual effective tax rate by weighting each tax rate

[10] In few countries, however, there may exist an interaction between the type of transactions and household reports. Indeed, in China, consumers are incentivized to ask for VAT revenues as they serve for national lottery and households may better keep track of registered transactions than undeclared transactions. In this case, we would underestimate fluctuations in tax compliance.

[11] The list of countries in the sample is: Australia, Austria, Belgium, Bulgaria, Canada, Chile, Colombia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Luxemburg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Roumania, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland and the United Kingdom.

by the consumption observed during its spell. When consumption could not be observed at a higher frequency than the period, we construct the annual effective tax rate by weighting each tax rate by the duration within the period during which it was enforced. Second, some tax reforms did not modify rates but also modify the category of goods that are subject to the different tax regimes. In such instances, we redefine our tax base. Third, some reforms modify the tax environment without modifying the tax rates per se. For instance, a reform may considerably simplify the registration process. We collect this information and control for any such reforms in our regression analyses. We describe some of these challenges in greater details in the online Appendix.

2.3 Tax compliance and tax reforms

To uncover the correlation between VAT compliance and VAT reforms, we estimate the following specification in first difference:

$$\Delta TC_{t,c} = \alpha a_{t,c} + \beta \Delta \tau_{t,c} + \gamma \cdot \mathbf{X}_{t,c} + \mu_c + \nu_t + \varepsilon_{t,c}, \tag{1}$$

where t stands for years and c stands for the country. Δ is the log-difference operator, i.e., $\Delta x_t = \ln(x_t) - \ln(x_{t-1})$, a_{tc} is the HP-filtered GDP per capita, and τ_{tc} is the effective VAT tax rate. The vector $\mathbf{X}$ will include time-varying controls, such as the existence of concomitant tax reforms, growth in trade balance, sectoral output and government expenditures. μ_c captures the country-specific trends in tax compliance, and ν_t captures year-Fixed Effects. $\varepsilon_{t,c}$ is the error term. The coefficient of interest β can be interpreted as the elasticity of tax compliance to tax rates conditional on output fluctuations.

We report in Table 1 the results of specification (1) estimated on our sample of countries. We find an elasticity of VAT compliance to standard VAT rate of about $-.40$ (see panel A) and $-.45$ with respect to effective VAT rates (see panel B), i.e., when weighting standard, reduced and super-reduced rates by their incidence.

In the benchmark regression (column 1), we control for country-specific trends, year-Fixed effects and the country economic cycle. The estimates are extremely robust to the addition of controls for government expenditures (column 2), sectoral composition (column 3) and trade (column 4).[12]

This estimated elasticity is an average measure across potentially very different countries – with strong or weak institutions. To uncover the differences across

[12]The estimates are also robust when we control for simultaneous income or corporate tax reforms.

countries, we use a simple dichotomy exercise and separate our sample between above- and below-median countries for the time of debt enforcement proceedings.[13] We then estimate the elasticities β_h (below-median) and β_l (above-median) in a similar specification as (1) with interactions.

We report the separate estimates in Table 2. While the elasticity of tax compliance to tax rates is around $\beta_l = -.50$ for low-enforcement countries, it falls around $\beta_l = -.20$ for high-enforcement countries (see columns 3 and 4).

In the remainder of the paper, we develop an analytical framework which helps to understand (i) the magnitude of the empirical elasticity, and (ii) the possible sources of difference across countries. Our theoretical elasticities will depend on legal enforcement and the size of the economic activity at the margin of informality.

3 A model of firm transparency and investment

This section presents a simple static model of firm transparency and investment which allows to derive 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 two crucial ingredients in our framework. We allow firms to adjust their *transparency*, that is the extent to which they declare their activity. As we want to highlight the potential role of financial frictions, we assume that access to external financing is conditioned by the existence of pledgeable capital and concealed activity is less pledgeable than declared activity, such that lower tax compliance reduces the capacity to levy funds. In addition, we introduce two technologies, a traditional technology, and a more productive modern technology which requires an innovation in order to replicate the very low transparency of small firms. The fixed cost to operate in the modern sector implies that very small firms, which are not able to levy sufficient funds for investment in the modern technology to be profitable, mostly operate in the informal sector with the traditional technology and without external financing.

In our model, lower tax compliance triggers a higher cost to tax authorities when they need to retrieve their loans or taxes. Information asymmetry between entrepreneurs and creditors/tax authorities is not key for our results. It is one factor which could explain why recovery costs are higher when dealing with non-transparent firms.

Finally, we disregard fiscal corruption, which is potentially important in countries with relatively low tax enforcement. While corruption does not modify the tax rev-

[13]The measure is described in Djankov et al. (2008). Our below-median countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Japan, Luxembourg, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom.

enues 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 ω. Let $G(\cdot)$ denote the cumulative distribution of endowments.[14]

Firms produce a unique consumption good and use capital as the unique production 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:

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

In contrast, the returns on the traditional technology are linear and equal to ρ.

The access to the modern technology is conditional on a fixed cost (an "innovation"). We assume that the access to the modern technology 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. Since 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

[14]We use heterogeneity in endowments in order to generate differential response to tax hikes across firms. However, one can think that such heterogeneity can also be indirectly generated by differences in fundamentals, e.g., heterogeneity in productivity, or in industry (and their reliance on external financing).

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.[15] Tax authorities have access to an audit technology and can monitor firms in order to retrieve the concealed value added. Let $z(\omega)$ denote the probability to be monitored for a firm with initial endowment ω. 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 is also set exogenously.[16]

We turn to the financial markets. We assume that the economy is small 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.[17] As a result, entrepreneurs face the following credit constraint, which crucially depends on transparency:[18]

$$(1 + r)(k - \omega) \leq \lambda\gamma\omega. \tag{2}$$

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 interna-

[15] We assume that there is only one unique tax rate on a unique final good. Accordingly, our model will not be able to generate the compositional effects justifying our careful empirical construction of tax compliance.

[16] Even though the tax authority can perfectly infer the firm's transparency from fundamentals, e.g., size and technology, we can imagine that there exist auditing costs which prevent the tax authority from fully auditing non-transparent firms.

[17] We assume here that only endowment can be pledged and not future earnings. The reason is essentially that, when entrepreneurs can freely adjust the extent to which they declare activity, they may not have any commitment to report future earnings once they have received funds from the investors. In contrast, endowment can be pledged at the moment at which debt is contracted.

[18] 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.

tional interest rate subject to the pledgeability constraint. Finally, they produce and reimburse their creditors. In parallel, once a technology has been adopted, the tax authority monitors with 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 low tax compliance 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 $p(\omega)$ from tax authorities. This traditional entrepreneur solves the following program:

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

The entrepreneur never borrows nor lends, and invests exactly her endowment. Her transparency choice, however, depends on how $\theta z(\omega)$ compares to 1. Strictly above 1, she becomes fully transparent ($\gamma = 1$). Strictly below 1, she remains fully informal ($\gamma = 0$). Otherwise, she is indifferent 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 $z(\omega)$ from tax authorities. This modern entrepreneur maximizes her profits net of taxes subject to the credit constraint of equation (2):

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

subject to

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

Generally, as long as $\theta p(\omega) \leq 1$ and $\omega \leq (A(1-\tau)\alpha/r)^{\frac{1}{1-\alpha}}$, the credit constraint is binding.[19] In this case, the solution $\hat{k}$ verifies:

$$A\alpha k^{\alpha-1}\left[1-\theta z(\omega)\tau-\frac{(1+r)[1-\theta z(\omega)]\tau}{\lambda}\left(\frac{1+\alpha}{\alpha}\frac{k}{\omega}-1\right)\right]=r, \tag{3}$$

and the transparency choice $\hat{\gamma}$ is obtained by substituting the solution $\hat{k}$ into the credit constraint. Equation (3) is very intuitive.[20] 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 $(A(1-\tau\gamma-(1-\gamma)\theta z(\omega)\tau)\alpha/r)^{\frac{1}{1-\alpha}}$ and lends the rest of her endowment. The transparency choice depends on how $\theta z(\omega)$ 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.

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.

3.3 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 tech-

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

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

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

nologies 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 2), and determines the level of capital and transparency (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.

3.4 The behavioral response of the economy to a tax increase

We now illustrate some implications of the model. 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.

We turn now to the aggregate response. Let $\varepsilon^{\omega}_{\tau\gamma v}$, $\varepsilon^{\omega}_{\gamma}$, ε^{ω}_{v} denote, respectively, the elasticity of tax revenues, transparency and output with respect to taxes for any given endowment ω.

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

We can define equivalent aggregate elasticities as follows:

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

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.

This is a small open economy: prices (including bond prices) are fixed such that there are no general equilibrium effects. The aggregate elasticities are thus easy to derive from each entrepreneur's decisions.

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 illustrate the quantitative importance of each elasticity, as we calibrate our model to the Greek economy in order to reproduce the recent large fiscal consolidation.

4 Fiscal consolidation in Greece

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

program.

The organization of this section is as follows. We first study the crisis episode through the lens of our model: we provide some numerical estimates for behavioral responses $(\varepsilon_\gamma, \varepsilon_v)$. We then provide additional insights on the distributional implication of tax hikes in our framework and discuss their empirical support.

4.1 The benchmark calibration

Our model is an accounting tool, which allows us to match quite precise moments of firm heterogeneity. Naturally, these degrees of freedom are obtained at the expense of some others: we consider the size distribution of firms as exogenous based on the fact that firm endowment is not as responsive as investment or transparency. Similarly, we shut down the possibility for technology and other fundamentals of the economy to evolve.

We calibrate the model using firm-level balance sheet data from Hellastat.[21] 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.[22]

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 2 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 2, 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 :

[21]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.

[22]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.

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 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 describe in the online Appendix how we calibrate the model, and match the most important empirical moment–the distribution of leverage across firms. Table 3 reports the benchmark calibration. We later shows the sensitivity of our results to these parameters.

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.[23] This is due to the fact that we may underestimate the influence of small firms in our analysis. However, those informal firms typically do not respond to changes in tax conditions – they form an inelastic informal sector. Accounting for these firms boils down to adding a fixed informal sector, which would mechanically reduce our estimates for aggregate transparency.

4.2 Quantitative results

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 fiscal consolidation 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 minimum VAT rate increased from 4.5 to 5.5%, the reduced VAT rate from 9 to 11% and the standard VAT rate from 19 to 23%. The repartition along

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

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 producing goods subject to each VAT regime - in order to deduce the aggregate response of the economy.

The results are reported in the second column of Table 4. 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.

We can interpret these results in terms of elasticities to taxes. We find that the elasticity of tax revenues 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). The elasticity of transparency to tax rates ε_γ is consistent with (i) the systematic empirical analysis conducted in Section 2 which gave a range between -0.2 (high legal enfocement) and -0.5 (low legal enfocement), and (ii) the empirical evidence on the elasticity of tax compliance to the Greek tax reform in 2010 (see online Appendix). We interpret this finding as an external validation of our calibration strategy, since we did not use this moment (the observed fall in VAT compliance) to calibrate the model.

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 revenues 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 fiscal consolidation 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 4 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 revenues 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 6 shows the elasticities of transparency and output to tax hike along firm size. Most of the drop in tax revenues 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 revenues 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.[24]

We also find direct evidence of this size-specific credit crunch in our panel of firms (see Figure 1): 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 4), both quantitatively and qualitatively.[25]

[24] In Figure 6, 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.

[25] In the online Appendix, we provide some evidence on the relationship between firm size and tax compliance elasticities. We focus on the 2010 Greek austerity plan, estimate regional tax

Overall, our model does not only match well the aggregate evolution in credit and transparency, but also its distributional features.

In the next section, we perform some comparative statics in order to estimate how variations in the fundamentals of our economy may explain wide variations in elasticities across countries, as illustrated by our empirical analysis.

5 The elasticity of tax revenues to tax reforms : the role of fundamentals

We now investigate which fundamentals of our economy may explain the large observed differences in the tax compliance response to tax hikes. Our theoretical analysis shows that the elasticity of tax revenues to tax reforms depends on the number of firms at the margin between informality and formality, i.e., the number of firms relying on external finance but 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 legal enforcement (represented here by lender protection) and firm size distribution.[26] In the following lines, we describe our comparative statics exercise to understand the quantitative role of these two fundamentals.

In our framework, changes to the two fundamentals 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 are only driven by different credit market conditions. Similarly, we compute the same elasticities as functions of ψ, and define the same mapping $\psi \mapsto \Gamma(\psi)$ for the aggregate transparency as function of the shape of the firm size distribution ψ.

Figures 7 and 8 display these elasticities. 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

compliance elasticities and show the importance of firm size differences across regions to predict the response of tax compliance.

[26] 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.

of the elasticity of tax receipts $(1+\varepsilon_\gamma)$. On the horizontal axis, we report aggregate transparency which moves with the underlying fundamental: it increases with the pledgeability parameter λ, whereas it decreases with 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 7, as we increase the extent to which collateral can be pledged (λ), the elasticity of tax revenues 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). The variation in transparency response across the different institutional environments is quantitatively relevant: an increase from 78% to 82% in aggregate transparency due to a change in credit constraints reduces the transparency elasticity from -.40 to -.25 (a variation that is of the same order of magnitude as our observed empirical estimates).

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 7 remains constant.

We then study how the relative weight of large versus small firms in the economy modify the elasticity of tax revenues to tax reforms. 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 blue line $(\varepsilon_{\gamma\tau v})$ in figure 8 widens and the overall elasticity of tax revenues 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 $\varepsilon_{\gamma\tau v}$. To summarize, while the elasticity of tax revenues to tax reforms is not sensitive to changes in firm size distribution, the transparency response is quite responsive: an increase from 82% to 86% in aggregate transparency due to a change in firm size distribution (lower number of small firms) reduces the transparency elasticity from -.35 to -.28.

Finally, in figure 9, we plot the aggregate elasticity for different combinations of λ and ψ while keeping the sanctions at its benchmark level. The quantitative results suggest that the elasticity of tax revenues to tax reforms is in the range [0.45, 0.65]. These results are consistent with the empirical estimation of the changes in VAT

compliance associated with VAT reforms shown in Table 2. The lower bound of the range of elasticity corresponds to an economy where financial development is low and the firm size distribution is shifted towards small and medium size firms. The upper bound refers instead to countries where legal enforcement is of better quality and firms on the verge of becoming informal are very small.[27] This simple analysis points to the distribution of firm size as a crucial, and so far under-explored, factor behind the success of a fiscal consolidation in raising tax revenues.

6 Conclusion

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. We document this effect using a novel measure of VAT compliance across 35 countries. We then develop a model in which firms decide on their declared activity. We calibrate the model to the recent fiscal consolidation episode in Greece and show that there is a large behavioral response from the economy and three quarters of the overall behavioral response to the tax increase come from this transparency channel. As transparency guarantees a better access to credit market, firms switching to the informal sector are excluded from credit markets thereby depressing aggregate investment.

One direct implication of our analysis is 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 compliance. 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. Our quantitative analysis shows that variations in the fundamentals of the economy, i.e. the legal enforcement, the financial development and the firm size distribution are able to explain the large differences across countries in the response of tax compliance to tax hikes shown in our empirical results. Quantitatively, we find leakages consistent with our empirical estimates. In our quantitative framework, the increase in tax revenues is almost twice lower than if tax compliance had been constant.

The policy implications of our analysis are not obvious. We show that a drastic fiscal consolidation in an economy with low tax enforcement and low financial development is very likely to be diluted. Improving these institutions would help

[27]Many developed countries have a firm size distribution which may be represented as a Pareto with a shape parameter close to 1, as shown by Axtell (2001) for the US, Levchenko et al. (2010) for France and ECB-Compnet data for Germany.

but is a difficult task: 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 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. Recent episodes of fiscal consolidation – e.g. Greece in 2010 – 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 fiscal consolidation delivers 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.[28] The further valuation loss for the banking sector could lead to a larger credit crunch and lower tax compliance from the firms' side. We leave this feedback channel coming through credit supply for further research.

[28]In contrast, in 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. Elasticity of tax compliance to tax rates.

Panel A: Standard VAT rate				
VAT Compliance	(1)	(2)	(3)	(4)
Elasticity β	-.403***	-.355***	-.407***	-.403***
	(.053)	(.072)	(.078)	(.078)
	[605]	[468]	[421]	[421]
Panel B: Effective VAT rate				
VAT Compliance	(1)	(2)	(3)	(4)
Elasticity β	-.465***	-.403***	-.457***	-.455***
	(.045)	(.061)	(.066)	(.066)
	[605]	[468]	[421]	[421]
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Economic cycle	Yes	Yes	Yes	Yes
Government expenditures	No	Yes	Yes	Yes
Sectoral composition	No	No	Yes	Yes
Trade	No	No	No	Yes

Significantly different than zero at * 90% confidence, ** 95% confidence, *** 99% confidence. Robust standard errors are reported between parentheses. The number of observations for each specification is reported between brackets. Each cell displays the estimate of a separate regression (see equation 1).

Table 2. Elasticity of tax compliance to tax rates – high versus low legal enforcement.

Panel A: Standard VAT rate				
VAT Compliance	(1)	(2)	(3)	(4)
Elasticity β_l	-.412***	-.468***	-.585***	-.583***
	(.076)	(.092)	(.097)	(.097)
Difference $\beta_h - \beta_l$	.018	.282**	.470***	.479***
	(.105)	(.143)	(.157)	(.156)
	[605]	[468]	[421]	[421]
Panel B: Effective VAT rate				
VAT Compliance	(1)	(2)	(3)	(4)
Elasticity β_l	-.458***	-.461***	-.556***	-.556***
	(.060)	(.073)	(.078)	(.079)
Difference $\beta_h - \beta_l$	-.014	.185	.324**	.331***
	(.085)	(.127)	(.139)	(.139)
	[605]	[468]	[421]	[421]
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Economic cycle	Yes	Yes	Yes	Yes
Government expenditures	No	Yes	Yes	Yes
Sectoral composition	No	No	Yes	Yes
Trade	No	No	No	Yes

Significantly different than zero at * 90% confidence, ** 95% confidence, *** 99% confidence. Robust standard errors are reported between parentheses. The number of observations for each specification is reported between brackets. Each column in each panel displays the estimate of a separate regression (equation 1 augmented by the interaction with a dummy *high-enforcement country*).

Table 3. Fiscal consolidation in Greece – 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 4. Fiscal consolidation in Greece – results

	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

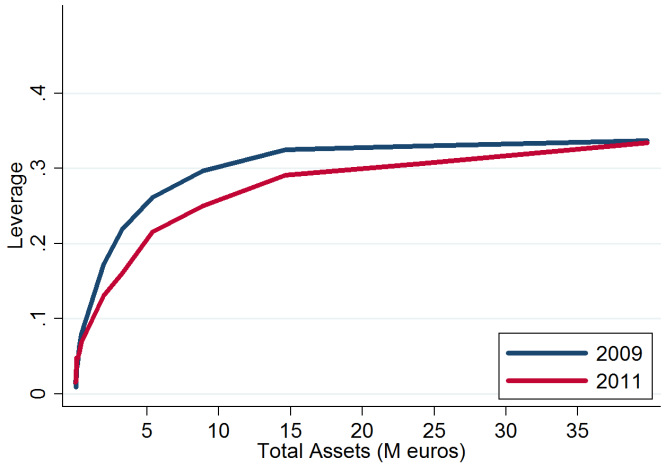
Table 5. Fiscal consolidation in Greece – evolution of leverage by firm size (panel).

Leverage	(1)	(2)
Post-Recession (assets less than 2M)	-.0218***	-.0150***
	(.0011)	(.0018)
Post-Recession (assets between 2M and 20M)	-.0494***	-.0371***
	(.0018)	(.0018)
Post-Recession (assets between 20M and 50M)	-.0005	.0004
	(.0038)	(.0038)
Observations	187,705	187,705
Firms	37,540	37,540
Fixed effects	Yes	Yes
Sectoral trend	No	Yes

Significantly different than zero at * 90% confidence, ** 95% confidence, *** 99% confidence. Robust standard errors are reported between parentheses.

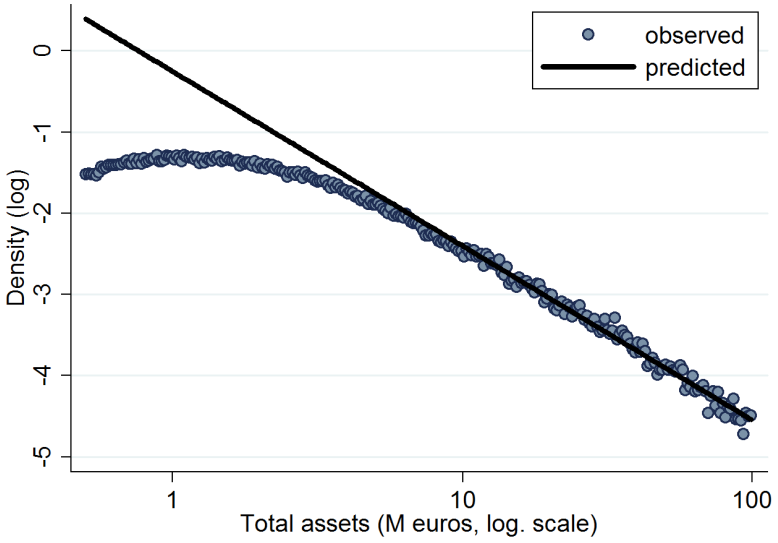
Figures

Figure 1. Leverage as a function of firm size before and after the 2010 tax reform.



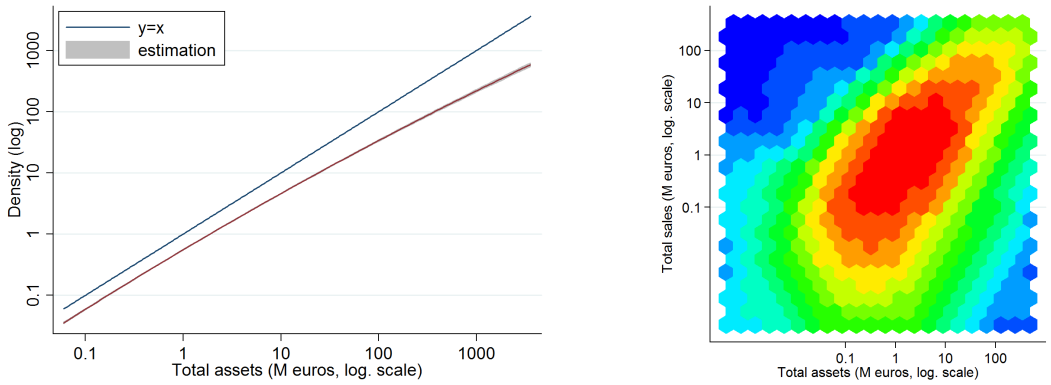
Note: Source Hellastat, 2009, 2011. This graph displays the leverage by firm size (total assets) before (2009) and after (2011) the austerity plan.

Figure 2. Firm size distribution Greece.



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.

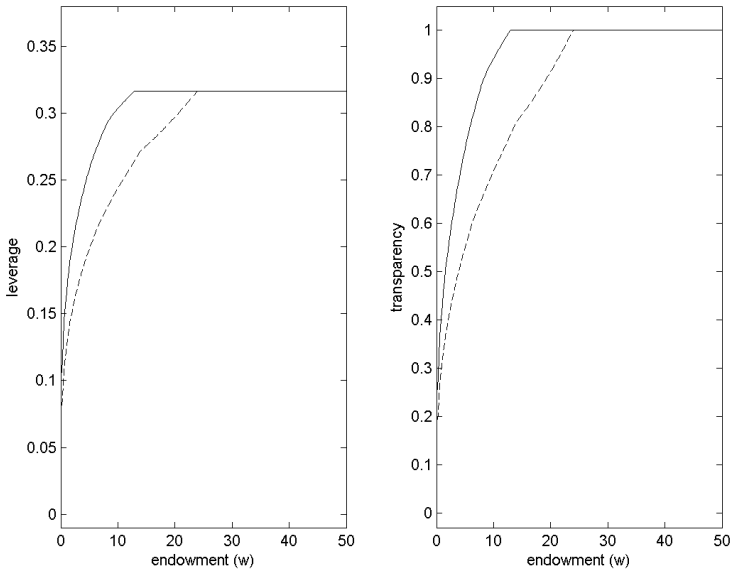
Figure 3. Empirical production function.



(a) Polynomial estimates (b) Density

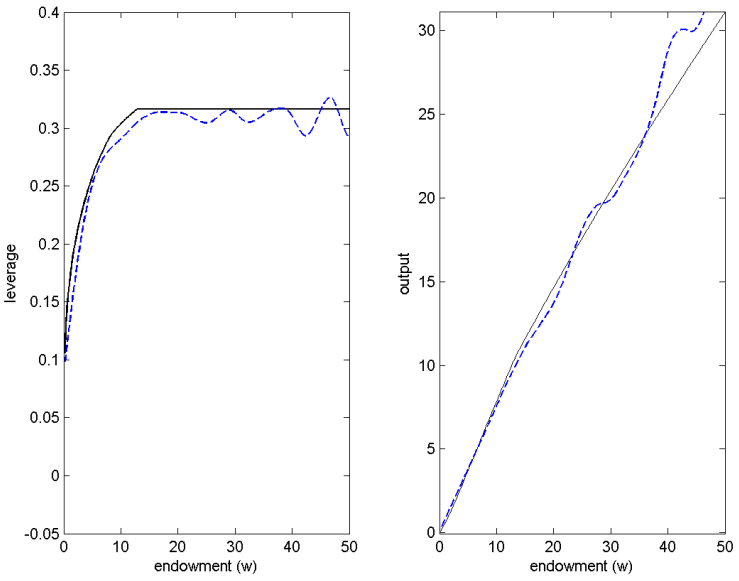
Note: These figures represent the polynomial estimates for the elasticity of sales to firm endowment using the whole sample of firms (approximately 30'000 firms per year) and controlling for firm and industry×year fixed effects. For both figures, the axes are on a logarithmic scale.

Figure 4. Leverage and transparency : the impact of the 2010 tax reform.



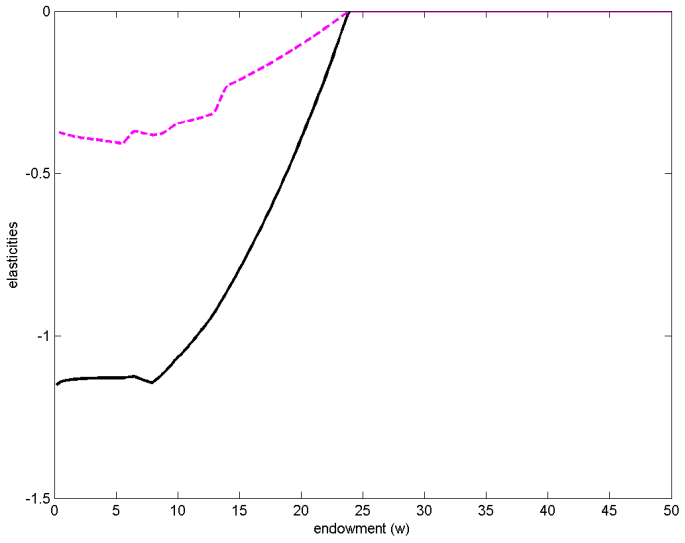
Note: Leverage and transparency along firm size for the benchmark calibration (solid line) and the 2010 austerity plan simulation (dashed line).

Figure 5. Empirical vs. theoretical leverage and output.



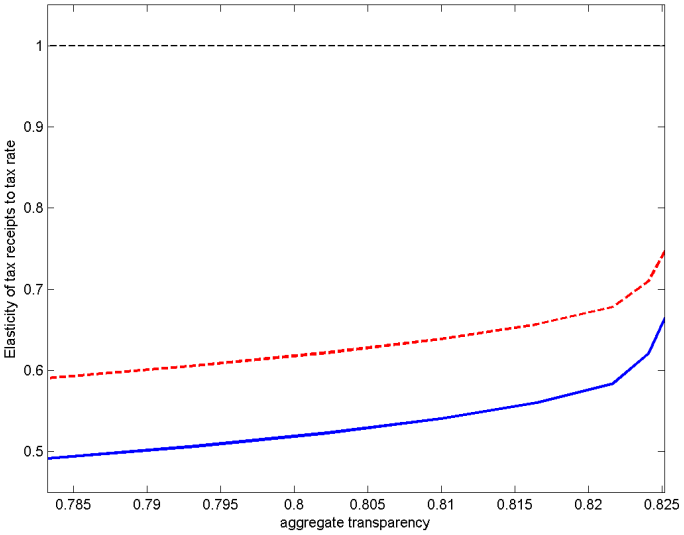
Note : Benchmark calibration. The solid black lines are the calibrated leverage and output, the dashed blue lines are the empirical leverage and output for firms with assets between 0.5 and 50M euro (smoothed using a HP filter).

Figure 6. Transparency and output elasticity by firm size.



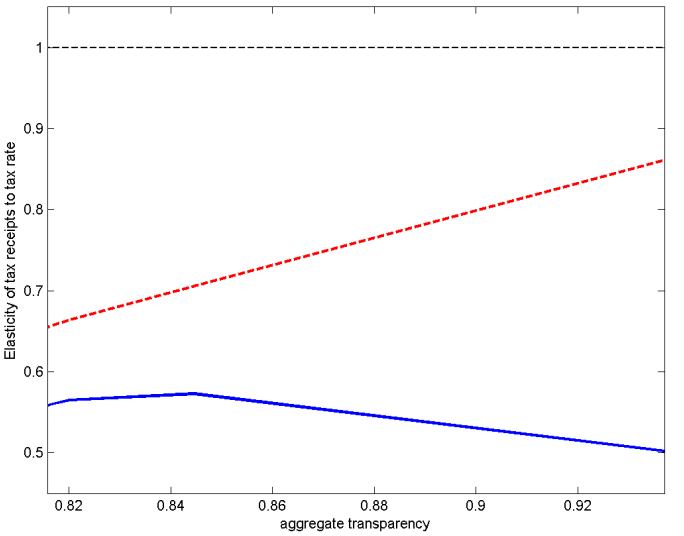
Note: The solid line is the elasticity of transparency ε_γ, the dashed line is the elasticity of output ε_v as a function of firm size. Both are computed using the 2010 austerity plan simulation.

Figure 7. Elasticity of tax revenues to tax reforms : the role of credit frictions.



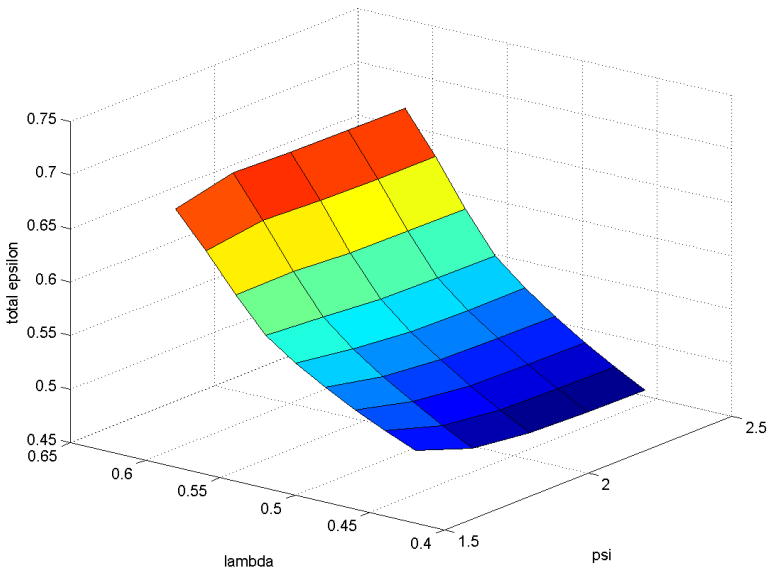
Note : Response to the 2010 tax reform. The solid blue line is the elasticity of tax revenues ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_\gamma + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax revenues ($1 + \varepsilon_\gamma$). In the horizontal axis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

Figure 8. Elasticity of tax revenues to tax reforms : the role of firm size distribution.



Note : Response to the 2010 tax reform. The solid blue line is the elasticity of tax revenues ($\varepsilon_{\tau\gamma v} = 1 + \varepsilon_\gamma + \varepsilon_v$), the dashed red line is the transparency component of the elasticity of tax revenues ($1 + \varepsilon_\gamma$). 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 9. Aggregate elasticity of tax revenues – credit frictions λ and firm size shape ψ.



Online Appendix

A Measuring tax compliance

In this section, we describe a series of challenges and cleaning procedures that we implement to get closer to the ideal measure for the largest set of countries/years.

A.1 Time aggregation

First, we are interested in the short-term fluctuations of the measure $TC_{t,c}$, and we need to smooth the "high-frequency" measurement error. Tax reforms are often implemented during the year, while national accounts are closed at the end of each period, i.e., year or quarter. For this reason, we collect the effective tax rate for a unit of consumption in any given month. When tax rates were changed during the course of the year, we use these monthly measures and construct the annual effective tax rate by weighting each tax rate by the consumption observed during its spell. When consumption could not be observed at a higher frequency than the period, we construct the annual effective tax rate by weighting each tax rate by the duration within the period during which it was enforced. Given that we rely on monthly VAT data, about 1/12 of total consumption could be allocated to the wrong VAT rate in the worse case scenario. This time aggregation issue thus generates little residual noise in our estimates.

A.2 Measurement error in tax base

Second, some tax reforms do not modify rates but also modify the category of goods that are subject to the different tax regimes. For instance, for countries entering in the European Union, art galleries would pass from category 1 to category 3. In such instances, we redefine our tax base correctly when our decomposition in the different categories allows us to observe exactly the category that has been modified. When, instead, we do not observe consumption in art galleries but we observe consumption for a larger category ("cultural goods"), we reconstruct a synthetic tax base for art galleries and the other cultural goods by considering the share of art galleries among cultural goods in specific years or in some benchmark country when more detailed consumption categories are never documented. Along the same lines, VAT can be collected for all registered firms or there may exist a minimum threshold. In the case of a reform, we would recreate the new tax base by subtracting the average share of value added created by firms below the threshold. Remark that it is likely that the

actual share of value added reacts to the changes in tax coverage, a response that we mostly ignore.

These adjustments for changes in categories and exemptions may remain subject to measurement errors. With our correction on tax categories, we may still attribute a share of a certain expenditure category to the wrong tax rate. This share would be the residual consumption of a specific good compared to its benchmark consumption as computed either in a specific year, or for the United States, and may not be negligible. However, within this measurement error, only a small fraction should correlated with changes in the tax reforms: in our example, we would attribute to art galleries their share under another tax regime than the one induced by the tax reform and actual consumption may be lower than imputed consumption due to the behavioral response. To give orders of magnitude, if the consumption of an exempted good that represents half of a category increases by 10% following a tax reform while the imputed consumption is fixed, we would misclassify 5% of the expenditure to exempted VAT at the category level.

A.3 Accounting for structural reforms

Third, some reforms modify the tax environment without modifying the tax rates per se. For instance, online registration considerably simplifies the registration process. We collect this information and clean for the jumps associated with such reforms.

This correction implies that our measure is a relevant measure to study the cyclical behavior of VAT compliance, but it may not account for some structural reforms which affect the long-term levels.

B Fiscal consolidation in Greece

B.1 Empirical evidence on the response of tax compliance to tax reforms

In this section, we study the average response of tax compliance following the Greek austerity plan of 2010 and we examine the heterogeneity of such response across the intensity of the tax shock.[29]

The 2010 tax reform in Greece essentially consisted of 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 plot the measure of tax compliance over the period 2007-2012 in Figure B1. One important fact stands out. In 2010, while the VAT and excise rates markedly increase in Greece (by respectively 20% and 85%), VAT and excise compliance drop by approximately 6.4% and 10%, which corresponds to elasticities of VAT and excise compliance of $-.32$ and $-.12$. The fact that the tax base shrinks by 6% for VAT whereas it remains almost unchanged for the excise points to a different behavior of tax compliance 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.

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. We can then proceed as described in the previous subsection, and compute the regional VAT compliance $TC_{j,t}$, for each region j. There is a difference with the previous exercise that is worth noting: we now observe consumption for industries and not goods, and only at the 1-digit level. Accordingly, our matching between the observed units for consumption and the defined categories for VAT rates is imperfect and relies on some assumptions: we construct the incidence of each 2-digit good category in the different 1-digit industry category at the national level, and we associate to each 1-digit industry an "effective" VAT rate at the regional level. Doing so, we ignore all intra-industry reallocation across goods subject to different tax rates, which may bias our measure of tax compliance. However, we can bound the bias generated by such composition effect: within an industry category taxed on average at 16%, a substitution of 5 percentage points between good A taxed at 13% and good B taxed at 23% would

[29] For a detailed description of the VAT hikes see Table B1.

generate a fluctuation of $0.05 \times 10/16 \approx 0.03$ in the tax compliance measure, which is an order of magnitude lower than the standard deviation of fluctuations in regional VAT compliance.[30]

In order to illustrate the differential response across regions, we compute ΔTC_j, i.e., the gap (in percentage points) of the regional VAT compliance 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 VAT compliance before and after the austerity plan. The standard deviation of ΔTC_j across regions is around 0.12 implying a difference of 0.15 points between the first and last quartile of regions. Some regions experience a marked decrease in their compliance, 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.[31] The large fall in compliance 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 compliance.

First, and similarly to our cross-country analysis (see table 1), the fluctuations in compliance 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 B2, we plot ΔTC_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 compliance 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 compliance 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

[30] At the national level, an increased incidence of 5 percentage points for a 2-digit good in the 1-digit industry is about twice as large as the standard deviation in the incidence.

[31] 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.

panel of figure B2.[32] 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 B2. In this table, we first show the unconditional correlation between firm size and changes in VAT compliance 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 tax compliance 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 VAT compliance (they explain almost 70% of the total variation in this measure ΔTC_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 set of additional controls capture only a small part of total variations in ΔTC_j.[33] Firm structure and variations in effective VAT rates are the only relevant regional characteristics which predict leakages following the 2010 reform.

B.2 Tax compliance and credit access

Having established the link between tax hikes and subsequent tax compliance, we now explore the impact of such tax compliance on credit access. As long as hidden activity is not as pledgeable as declared activity, the response of tax compliance to the VAT hikes should imply a credit flow out of medium-size firms in 2010-2011. In turn, the stronger response of tax compliance 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 to the austerity plan on credit access using a panel of firm-level balance sheet data on a quasi-exhaustive sample of Greek firms[34]. 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 1, 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.

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

[33] 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.

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

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. We thus later use the panel dimension to capture the leverage response cleaned of compositional effects.

Second, Figure 1 shows the heterogeneous response of credit across firm size. The leverage is close to 0 in 2009 for firms with less than 2 million euros in total assets, and it remains negligible in 2011. Large firms with assets above 20 million euros have a leverage of about 0.33 in 2009 and it slightly decreases in 2011.[35] In contrast, medium-size firms experience a substantial fall in their access to external 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.

The shift in leverage is slighty less pronounced in the balanced panel but the results are qualitatively similar. We report in Table 5 the panel estimation of the drop in leverage between 2007-2009 and 2010-2012, and we distinguish three bins of firms: small firms with asset below 2M euros over the period, small-medium firms with assets between 2 and 20 M euros and medium firms with assets between 20 and 50 M euros. The U-shape of the drop in leverage with firm size is confirmed in this panel specification. Small firms see their leverage decrease by 0.02, small-medium by about 0.04 and medium firms do not experience any decrease in leverage.

Third, we show that the decrease in leverage is larger in regions where tax compliance is low. In Figure B3, we show the evolution of leverage in 2011 relatively to 2009 in regions with high versus low response of tax compliance. The downward shift in leverage is substantially larger in regions where the response of tax compliance to tax hikes is larger. We further explore this correlation in Figure B4. We plot the regional change in tax compliance ΔTC_j against its counterpart change in leverage for medium-size firms (with assets between 2 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 compliance to tax hikes is relevant in a

[35] 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.

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.

B.3 Calibration of the model to the fiscal consolidation in Greece

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 3). 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%).[36] 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 $p(c) = (\frac{c}{c_0})^{\beta_p}$.[37] Intuitively, λ determines the leverage for large firms which operate only with the modern technology. c_0 and β_p help characterize the slope

[36] 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.

[37] 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 5 : 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 5. 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 5.

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.[38] 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.[39] 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.[40] 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.

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

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

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

Table B1. VAT reforms in Greece (2010-2011).

Goods and services affected by VAT	Tax regime				
Reform period	Jan. 2010	Mar. 2010	Jul. 2010	Jan. 2011	Sep. 2011
Subject to Standard rate in 2010	19	21	23	23	23
CP020: Alcoholic beverages, tobacco and narcotics	19	21	23	23	23
CP030: Clothing and footwear	19	21	23	23	23
CP040: Housing, water, electricity, gas and other fuels	19	21	23	23	23
CP050: Furnishings, households equipment	19	21	23	23	23
CP060: Health	19	21	23	23	23
CP070: Transport	19	21	23	23	23
CP080: Communications	19	21	23	23	23
CP090: Recreation and culture	19	21	23	23	23
CP120: Miscellaneous goods and services	19	21	23	23	23
Subject to Reduced rate in 2010	9	10	11	13	13
CP010: Food and non-alcoholic beverages					
CP011: Food	9	10	11	13	13
CP012: Non-alcoholic beverages	9	10	11	13	23
CP040: Housing, water, electricity, gas and other fuels					
CP044: Water supply and miscellaneous (50%)	9	10	11	13	13
CP045: Electricity, gas and other fuels	9	10	11	13	13
CP060: Health					
CP061: Medical products, appliances and equipment (50%)	9	10	11	13	6,5
CP062: Out-patient services (50%)	9	10	11	13	23
CP063: Hospital services (50%)	9	10	11	13	23
CP073: Transport services	9	10	11	13	13
CP094: Recreational and cultural services (50%)	9	10	11	13	13
CP110: Restaurants and hotels					
CP111: Catering services	9	10	11	13	23
CP112: Accommodation services	9	10	11	13	6,5
Subject to Super-reduced rate in 2010	4,5	5	5,5	6,5	6,5
CP090: Recreation and culture					
CP094: Recreational and cultural services (50%)	4,5	5	5,5	6,5	6,5
CP095: Newspapers, books and stationery	4,5	5	5,5	6,5	6,5
Excluded from the scope of VAT in 2010					
CP040: Housing, water, electricity, gas and other fuels					
CP044: Water supply and miscellaneous(50%)	excl.	excl.	excl.	excl.	13
CP060: Health					
CP062: Out-patient services (50%)	excl.	excl.	excl.	excl.	13
CP063: Hospital services (50%)	excl.	excl.	excl.	excl.	13
CP100: Education					
CP101: Pre-primary and primary education	excl.	excl.	excl.	excl.	excl.
CP102: Secondary education	excl.	excl.	excl.	excl.	excl.
CP103: Post-secondary non-tertiary education	excl.	excl.	excl.	excl.	excl.
CP105: Education not defined by level	excl.	excl.	excl.	excl.	excl.
CP120: Miscellaneous goods and services					
CP125: Insurance	excl.	excl.	excl.	excl.	excl.
CP126: Financial services n. e. c.	excl.	excl.	excl.	excl.	excl.

For exposition purposes, we only report the evolution of the 1-digit categories, e.g., CP020, for goods and services subject to the standard rate in 2010. All 2-digit categories that do not appear in the other sections, e.g., CP041, are subject to the default tax rates of the associated 1-digit category.

Figure B1. VAT compliance and excise compliance in Greece (2007-2012).

(a) VAT compliance.

(b) Excise compliance.

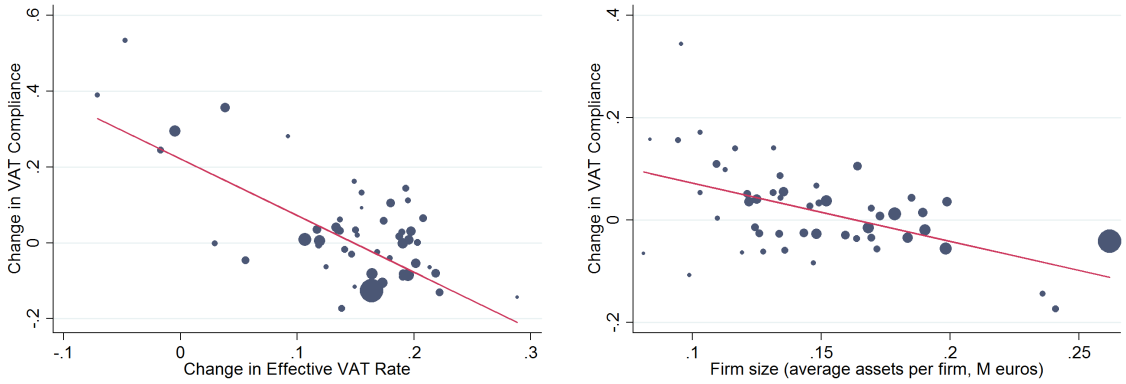
Note: Source Hellastat, 2009, 2011. The left (resp. right) panel represents the ratio of realized tax revenues to expected tax revenues, given the consumption of goods subject to different VAT rates. We report the VAT effective rate (resp. the excise rate) on the right axis and the associated VAT (resp. excise) compliance over the period 2007-2012 in Greece.

Table B2. Tax compliance fluctuations across regions.

VAT Compliance	(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
Adjusted R-squared	0.237	0.692	0.716	0.856

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.

Figure B2. Response of VAT compliance to the 2010 VAT reform and the role of tax pressure and firm size.

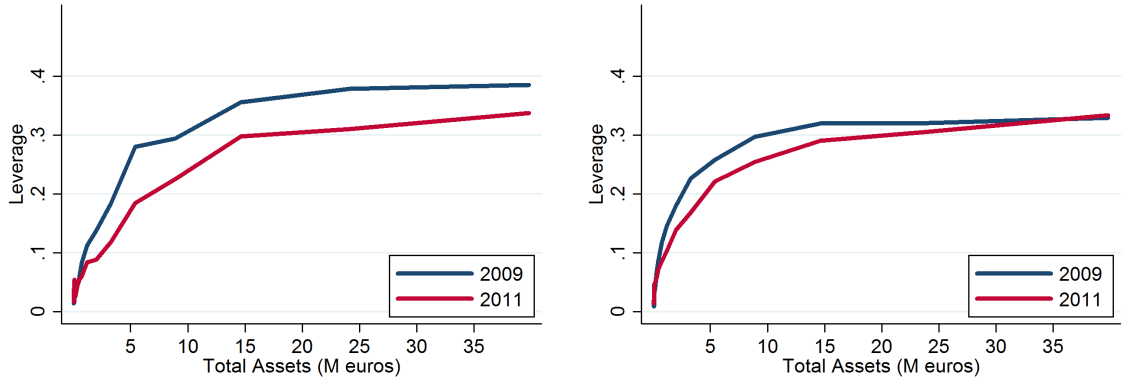


(a) Change in effective VAT rate

(b) Firm size

Note: In the left panel (resp. right panel), we report the correlation between the evolution of VAT compliance, i.e., the (log) difference of regional VAT compliances 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 tax compliance and large negative response to the 2010 reform).

Figure B3. Leverage as a function of firm size before and after the 2010 tax reform for the subsamples of regions with high/low tax compliance response.

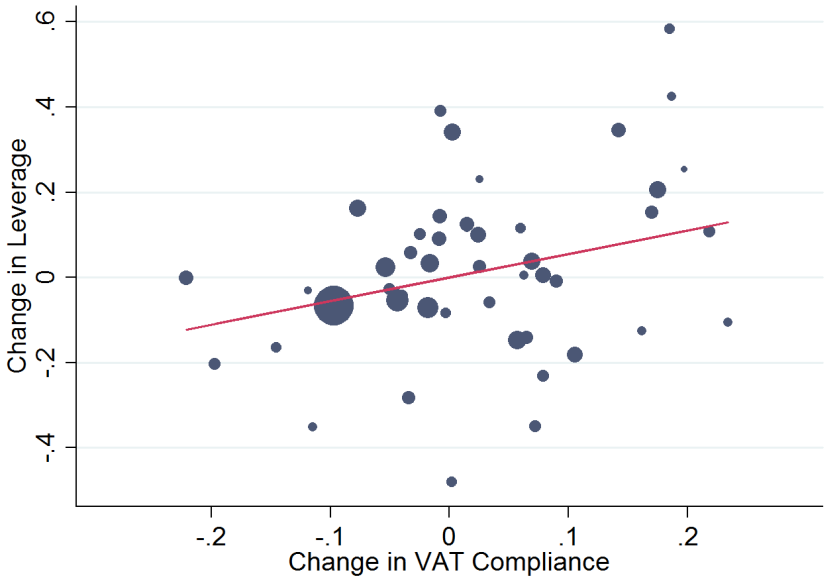


(a) High response of tax compliance

(b) Low response of tax compliance

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 tax compliance (left panel) and below-median response in tax compliance (right panel).

Figure B4. VAT compliance and leverage.



Note: We report the correlation between the evolution of VAT compliance, i.e., the (log) difference of regional VAT compliances 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.