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Informality and macroeconomic volatility: do credit constraints matter?

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Abstract

Purpose – The purpose of this paper is to study the implications of borrowing constraints characterizing the informal sector for macroeconomic volatility.

Design/methodology/approach – To this end, the author develops a simple dynamic stochastic general equilibrium model wherein registered activity not only is the basis to determine tax liabilities, but also serves as collateral for securing debts. Such a framework allows for computational experiments to analyze the effect of informality on aggregate fluctuations.

Findings – The experiments show that the credit-constrained informal sector does exert a significant influence on the cyclical volatility of consumption and investment.

Originality/value – There are not many studies addressing the implications of informal economic activities for macroeconomic fluctuations. This paper contributes to the literature by developing a theoretical model showing that credit constraints characterizing these activities might play a non-negligible role in explaining the cyclical volatility of some important aggregates.

Keywords Tax evasion, Informal economy, Credit constraints, Macroeconomic volatility

Paper type Research paper

1. Introduction

This paper addresses the implications for macroeconomic volatility of credit constraints characterizing the informal economy. It has been well documented that firms in such an economy typically under-report their operations and do not resort to formal capital markets (Straub, 2005). While this modus operandi enables them to hide their activities from tax collectors, it also reflects information asymmetries between borrowers and lenders that reduce incentives for financiers to loan. This argument is formalized here through a simple dynamic stochastic general equilibrium model featuring several attributes observed in corporate income tax structures and debt enforcement procedures around the world. In such a framework, the extent of unrecorded production is endogenized allowing for computational experiments to analyze how the extent of undeclared activity and its determinants affect the cyclical volatility of macroeconomic aggregates like consumption and investment.

Firms engaged in the informal sector must trade-off the potentially larger profits from lack of transparency with the higher risk of detection and the lower access to credit that the concealment decision entails. While their incentives to operate informally are shaped by the possibility of reducing or eliminating tax liabilities and avoiding presumably burdensome regulations, being outside the government's purview also means they may not have access to markets for external finance and formal contract enforcement mechanisms. Banks and other financial institutions are generally unwilling to grant credit to enterprises that lack proper documentation. Moreover,

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if to evade taxes companies do not officially declare all assets, their ability to use them as collateral for loans is limited. Their financial statements, further, may not provide an accurate representation of their financial soundness and economic prospects, thereby reducing their attractiveness to potential lenders[1].

These observations have recently found support in a number of theoretical and empirical studies focussing on the relation between access to credit and the extent of the shadow economy. Ellul *et al.* (2012) argue that the trade-off between the funding benefits and the tax costs of accounting transparency varies considerably across firms and countries depending on the corporate tax rate, the degree of tax enforcement and on a company's need for external finance. Furthermore, Gatti and Honorati (2008) and Dabla-Norris and Koeda (2008) find evidence that higher tax evasion is significantly and robustly associated with lower access to formal credit, with a higher reliance on informal sources of financing (e.g. family, friends and money lenders), and with firms' propensity to report availability of finance as an obstacle to their operations. Such findings are certainly in line with Capasso and Jappelli (2013) and Bose *et al.* (2012), who show that financial and banking development play an important role in reducing the size of shadow economic activities.

One criticism that can be raised on these studies is that they tend to ignore the possibility of self-financing. In contrast to this view, the literature dealing with general equilibrium models of heterogeneous agents that are subject to borrowing constraints and idiosyncratic productivity shocks posits that credit-constrained firms can accumulate internal funds to substitute for the lack of external finance. Moll (2014), in this regard, underscores productive entrepreneurs that cannot acquire capital in the market may still self-finance investment in the sense of paying it out of their own savings. Furthermore, Covas (2006) shows that the interaction of uninsurable production risks and financial frictions induces in poorly diversified entrepreneurs a strong precautionary savings motive that in turn leads to capital over-accumulation.

While the existing literature on the macroeconomic implications of financial restrictions characterizing the unofficial economy focusses on growth and development (see, e.g. La Porta and Shleifer, 2008; Dabla-Norris and Feltenstein, 2005), very few studies have addressed the consequences on short-run aggregate fluctuations. Restrepo-Echavarria (2014) documents a systematically high correlation between the relative volatility of cyclical consumption to output and the extent of the unrecorded sector. Furthermore, Ferreira-Tiryaki (2008) and Granda-Carvajal (2010) present evidence suggesting that countries with a sizeable shadow economy tend to undergo increased volatility of output, investment and consumption over the business cycle. This evidence is partially challenged by Finkelstein Shapiro (2015), who finds no significant relationship between informality and output volatility once it is controlled for other determinants of the variability of output.

To explain these patterns of aggregate volatility, Finkelstein Shapiro (2015) shows that the root cause of changes in informal sector size matters for the relationship between informality and both long- and short-run macroeconomic performance. In addition, Restrepo-Echavarria (2014) argues that poor measurement of the informal sector complements other mechanisms proposed in the literature on emerging market economies to account for high consumption volatility. Mitra (2013) resorts to one of such mechanisms, a working capital constraint, to claim in favor of the seemingly counterfactual idea that informality lowers consumption volatility by offsetting the effect of financial development. Finally, Ferreira-Tiryaki (2008) conjectures

that a large informal sector leads to higher volatility because firms therein are credit constrained and thus cannot smooth fluctuations in cash flows. Despite their focus on financial issues, none of the latter studies takes the role of firms' potential self-financing into account.

This paper addresses the implications for macroeconomic volatility of informal firms' borrowing constraints using a simple dynamic stochastic general equilibrium model featuring tax evasion opportunities. The proposed approach has some similarity to Jermann and Quadrini (2012), in that firms prefer debt over equity due to its tax advantage. In the model, registered activity not only is subject to taxation, but also can be used to signal creditworthiness to potential lenders. Hence tax evasion has two countervailing effects on firms' access to finance: on the one hand, it worsens the terms and conditions of loan contracts by reducing the collateral that can be offered for securing debts. On the other hand, the concealed liabilities enable investment financing by raising internal sources of funds. While the former effect lowers the amount of credit provided and causes aggregate volatility to rise, the latter one leads to a fall in the relative variability of consumption and investment.

The paper is organized as follows. Section 2 describes the model in detail. Then, the model is calibrated in the third section. Section 4 displays the results of computational experiments allowing for variations in the determinants of the extent of undeclared production, among other relevant parameters. These experiments support the prevalence of a self-financing channel, so that credit constraints in the informal sector exert a volatility-lowering influence on aggregate fluctuations. The last section concludes by highlighting some possible extensions and qualifications.

2. The model

This section develops a simple dynamic stochastic general equilibrium model with credit constraints and tax evasion opportunities. The model is similar to the one of Jermann and Quadrini (2012) in that the tax structure matters for the relevance of the borrowing constraint. Such a feature is aimed to bring the financially constrained informal sector into the picture while conveying a likely representation of tax policy as observed in both developed and developing countries (see Gordon and Li, 2009).

The economy is populated by the government, a large number of identical firms, and a large number of identical households, all of whom are infinitely lived. The government enforces a monitoring system for tax evasion and uses revenue to finance a stream of non-productive services. Firms maximize discounted profits contingent on the possibility of being discovered operating informally. Furthermore, they are allowed to claim the interest paid on borrowed funds as deductible from their taxable income. They finance capital investment through borrowing, but the value of their debt cannot exceed the amount of official earnings. Hence registered cash flows not only are subject to taxation, but also ensure lenders that debts will be fully secured. These features overall induce a variety of trade-offs in the choice of tax evasion that are at the heart of the model's predictions.

2.1 Households

Households derive utility from consumption c_t. They rent labor l_t and lend b_t^H to firms at a wage w_t and the agreed net interest rate r_t. Furthermore, they earn real dividend income d_t and receive a lump-sum transfer T_t from the government.

Assuming logarithmic utility and inelastic labor supply (i.e. $l_t = 1$), the representative household's problem is given by:

$$\max_{c_t, b_{t+1}^H} E_0 \sum_{t=0}^{\infty} \beta^t log(c_t)$$

subject to $c_t + b_{t+1}^H = d_t + w_t l_t + (1+r_t) b_t^H + T_t$. The Euler equation for loans is:

$$\frac{1}{c_t} = \beta E_t \left(\frac{1}{c_{t+1}} \right) (1+r_{t+1}). \tag{1}$$

2.2 Firms

Competitive firms in this economy purchase labor services and borrow from households to produce a homogeneous good y_t. Technology is specified as follows:

$$y_t = A_t k_t^{\alpha} l_t^{1-\alpha}, \tag{2}$$

where A_t is a total factor productivity shock (expressed in logarithms) following the autoregressive process:

$$A_t = \rho A_{t-1} + e_t, \quad e_t \sim NIID(0, \sigma^2). \tag{3}$$

Consistent with the typical timing convention, capital is chosen at time $t-1$ and predetermined at time t. It evolves according to the law of motion $k_{t+1} = i_t + (1-\delta) k_t$, where i_t is investment and δ is the depreciation rate.

Firms are assessed a tax on their corporate income at a fixed rate τ. However, they are allowed to deduct the interest paid on borrowed funds from calculation of their tax base as given by the expression $y_t - w_t l_t - r_t b_t^F$. Such a tax advantage, as shown below, generates a preference for debt financing that induces entrepreneurs to leverage up.

In addition to tax avoidance opportunities, the representative firm chooses to hide a fraction $\eta_t \in [0, 1]$ of its activities in order to escape the tax and regulatory burden. Yet it faces the prospect of getting caught and forced to pay the entirety of its tax obligations with an endogenous probability $\phi(\iota, \eta_t) = \varphi(\iota)\eta_t$, where ι represents the monitoring effort of the revenue collection agency such that $\partial\phi/\partial\iota = d\varphi/d\iota > 0$. This detection probability is linear in η_t to convey the idea that having murky accounts, given a firm's scale, induces the authorities to classify the concerned activities as suspicious.

Upon finishing production, the representative firm pays its wage bill $w_t l_t$ and last period loan payment $(1+r_t) b_t^F$. Then it signs a new loan contract. It is assumed that, in case of default, a bankruptcy procedure liquidating the firm takes place such that a fraction $\theta \in (0, 1)$ of the expected value of next period registered production can be repossessed by lenders. Tax is senior to this recovery process. Thus, the firm faces the following collateral constraint:

$$b_{t+1}^F \leqslant \theta E_t \left[(1-\tau)(1-\eta_t) y_{t+1} \right]. \tag{4}$$

Of the other part, creditors must incur the remaining proportion of the liquidation value $(1-\theta) E_t (1-\tau)(1-\eta_t) y_{t+1}$ as a transaction cost. The collateral constraint aims to convey the idea that lenders can only seize those assets that have been officially declared by the firm in the face of default. Note that the collateral share serves as a proxy for the

quality of the financial system and of institutions. This is in line with Djankov *et al.* (2008), who find that the efficiency of debt enforcement procedures is strongly correlated with legal origins and credit market development.

Furthermore, the amount firms are allowed to borrow is decreasing in their degree of tax non-compliance, η_t. This is consistent with the assumption of "book-tax conformity", which in the present setting means that the representative firm cannot report different earnings to both tax authorities and lenders. This assumption suggests that increasing tax evasion has two countervailing implications for firms' access to finance: on the one hand, it reduces the collateral that can be offered for securing debts, and thus worsens the terms and conditions of loan contracts. On the other hand, the successfully concealed income $(1-\phi_t)\tau\eta_t y_t$ enables them to raise internal sources of funds.

Given these circumstances, the representative firm's cash flow is given by:

$$\pi_t = (1-\tau)\left(y_t - w_t - r_t b_t^F\right) - i_t + b_{t+1}^F - b_t^F + (1-\phi)\tau\eta_t y_t, \tag{5}$$

which can be decomposed into after-tax dividends:

$$d_t = (1-\tau)\left[(1-\eta_t)y_t - w_t - r_t b_t^F\right] - i_t + b_{t+1}^F - b_t^F \tag{6}$$

and unreported profits $(1-\phi_t\tau)\eta_t y_t$. Such profits are not redistributed to households but plowed back into the firm as inside funding. Along with Equation (4), Equation (5) implies that the tax gains obtained via greater evasion reduce the cash flow earnings that the firm can pledge to external investors.

The representative firm maximizes discounted profits with the stochastic discount factor of the household, $\gamma_t \equiv \beta E_t\left(c_t/c_{t+1}\right)$. Thus, the firm's problem is:

$$\max_{l_t, k_{t+1}, b_{t+1}^F} E_0 \sum_{t=0}^{\infty} \gamma_t \pi_t,$$

subject to (5) and (4).

Letting μ_t denote the time t Lagrange multiplier associated to the borrowing constraint, firms' behavior is characterized by the Euler equations:

$$\frac{\tau}{1-\tau}\left[1-\phi_t-\varphi(\iota)\eta_t\right]y_t = \theta E_t \mu_t y_{t+1} \tag{7}$$

$$\gamma_t = E_t \gamma_{t+1}\left\{1+(1-\tau)\, r_{t+1}\right\} + \gamma_t \mu_t \tag{8}$$

$$\gamma_t = E_t\left\{\gamma_{t+1}\left[1-\tau+\left(1-\phi_t\right)\tau\eta_t\right] + \gamma_t\mu_t\theta(1-\tau)\left(1-\eta_t\right)\right\}\alpha A_{t+1}k_{t+1}^{\alpha-1} + \gamma_{t+1}(1-\delta), \tag{9}$$

and by the first-order condition determining labor demand:

$$w_t = \left\{1+\frac{\tau}{1-\tau}\eta_t\left(1-\phi_t\right)\right\}(1-\alpha)A_t k_t^{\alpha}. \tag{10}$$

Equation (7) states that the firm evades to the point where the marginal tax savings equal the expected value of foregone borrowing opportunities. In other words, firms choose their degree of non-compliance to lower their burden of taxation; but, in doing so, they expose themselves to a higher cost of credit, and thereby to a reduction in

the volume of loans and subsequent investment. This equation thus underlines the trade-off involved in a firm's decision to conceal (or disclose) the proceeds from its activities as well as its countervailing implications for access to finance.

Furthermore, Equation (8) relates the marginal benefit of borrowing to its marginal cost. Also, Equation (9) shows that the opportunity cost of withholding one unit of capital equals the expected discounted marginal product of capital. Note that borrowers internalize the effects of their capital stock in their financial constraints, so that the marginal benefit of withholding one capital unit is given not only by its marginal product but by the marginal benefit of being able to borrow more.

Finally, note that firms internalize the corporate income tax structure and their compliance behavior in their loan and factor demands. The latter can be clearly seen in Equations (9) and (10), which show that tax evasion supplements the marginal products of capital and labor. As for the former, deductibility of interest payments proves to be the main incentive for borrowing.

2.3 Government

The government produces unproductive services and makes transfer payments each period by collecting taxes on corporate income. Government consumption is assumed to follow a stochastic process given by:

$$g_t = G_t y_t, \tag{11}$$

where G_t is a random variable. As the government does not issue any debt, the flow budget constraint is:

$$g_t + T_t = \tau\left[(1-\eta_t)y_t - w_t - r_t b_t^F\right] + \theta E_t(1-\eta_t)\tau y_{t+1} + \phi_t \tau \eta_t y_t \tag{12}$$

every period. Note that the tax avoidance opportunities associated to firms deducting interest payments on their debts lead to a government revenue loss that in the public finance literature is known as tax expenditures.

Equation (11) can be alternatively expressed as:

$$g_t + T_t = \tau\left(y_t - w_t - r_t b_t^F\right) + \theta E_t(1-\eta_t)\tau y_{t+1} - (1-\phi_t)\tau \eta_t y_t, \tag{13}$$

where the third term on the right hand side reflects the amount of taxes on informal activities that go undetected. Since firms manage to dodge these liabilities, they are subtracted from what otherwise would be total tax revenue. In this regard, this term accounts for the so-called tax gap, that is, the difference between the amount of tax legally owed and the amount actually collected by the government.

2.4 Equilibrium

A competitive equilibrium for this economy consists of a sequence of prices $\{w_t, r_t\}_{t=0}^{\infty}$; a list of consumption plans and debt positions for households $\{c_t, b_{t+1}^H\}_{t=0}^{\infty}$; a list of production and evasion plans and debt positions for firms $\{\eta_t, l_t^d, k_{t+1}, b_{t+1}^F\}_{t=0}^{\infty}$ and the policy function g_t such that:

- households maximize utility;
- firms maximize profits;

- the government balances its budget;
- individual and aggregate decisions are consistent, i.e. $k_t = K_t$; and
- markets for goods, labor and loans clear.

Note that the market clearing conditions imply that each agent's decision rules satisfy the resource constraint:

$$c_t + i_t + g_t = \left[1 - \left(1 - \phi_t\right)\tau\eta_t\right]y_t. \tag{14}$$

Also, equilibrium in the loans market means that borrowing must equal savings every period, that is:

$$b_t^H = b_t^F. \tag{15}$$

Lastly, demand for labor by firms is equal to labor supply by households:

$$l_t^d = 1. \tag{16}$$

In addition to the above, the equilibrium share of output that firms leave "off the books" is characterized in the following:

P1. The fraction of output that the representative firm keeps unrecorded at the steady state is given by:

$$\eta_{ss} = \frac{1 - \theta(1-\beta)(1-\tau)}{2\varphi(\iota)},$$

where it follows that $\partial\eta_{ss}/\partial\theta < 0$, $\partial\eta_{ss}/\partial\tau > 0$ and $\partial\eta_{ss}/\partial\iota < 0$.

Proof. See Appendix 2.

P1 implies that the extent of unreported activities depends positively on the tax burden, and is negatively related to the level of enforcement and financial development. These connections have been extensively confirmed in the literature on informality and the shadow economy. While the former two relations have been claimed to be among the main features of the informal sector (see Ihrig and Moe, 2004), recent studies have shed light on the different channels involved in the link between financial depth and tax evasion (see, among others, Capasso and Jappelli, 2013; Ellul *et al.*, 2012; Dabla-Norris and Koeda, 2008).

To complete the characterization of the equilibrium, the following proposition states the conditions for a binding borrowing constraint.

P2. At steady state, the borrowing constraint holds with equality if $\tau > 0$.

Proof. See Appendix 1.

Note that *P2* can be formally proven only for the steady state. Therefore, the collateral constraint is binding as long as interest payments are deductible from corporate earnings, a feature of the tax structure that induces entrepreneurs to raise funds through debt financing. This feature indeed conveys a likely representation of tax policy, and thus is consistent with plausible parameterizations of the model.

3. Calibration

The system of equations used to compute the dynamic equilibria of the model depends on a set of 12 parameters. Of these, 11 can be obtained by resorting to related studies:

the subjective discount factor (β), the capital income share (α), the depreciation rate (δ), the degree of financial development (θ), the corporate income tax rate (τ), the steady-state share of activity left "off the books" (η_{ss}) and the parameters pertaining to the properties of shocks (the autocorrelation coefficients and the standard deviations).

To begin, the values for the technology and preference parameters are common in the business cycle literature. Since the time period is set to one year, the values of the discount factor and the depreciation rate are 0.95 and 0.1. The capital income share also is set at 0.36. As for the borrowing constraint, the World Bank's Doing Business project reports that the liquidation cost for an average firm in the USA has been about 7 percent of estate since 2006. Subtracting this value from the unity leads to the collateral share used here.

The parameter value pertaining to taxation, $\tau = 0.4136$, is obtained from the OECD Center for Tax Policy and Administration (2012). Specifically, it averages out a series of the combined federal and state statutory corporate income tax rate covering the period 1981-2012. The steady-state share of activity hidden from the revenue authority is taken from Schneider *et al.* (2010), who use the dynamic multiple input multiple indicator approach to provide an estimate of the size of the shadow economy of about 8.6 percent of GDP during 1999-2007.

Moving on to the enforcement parameter, the endogenous detection probability is assumed to take the form $\varphi(\iota)\eta_t = \iota\eta_t$, so that φ is linear in ι. This functional form facilitates computing the steady-state probability of detection by making use of the relation stated in *P1* and the parameter values above. Thus, the probability $\phi_{ss} = 0.4864$ is obtained such that ι approximates 5.6554. This probability is a bit higher than the one backed out by Prado (2011) for the USA, but it still lies within the same author's estimates for OECD countries.

Finally, the value of the autocorrelation coefficient for the productivity shock is $\rho = 0.95^4$. This value comes from adjusting the common coefficient used to match quarterly fluctuations to take account of annual frequencies. A similar criterion is followed to choose the standard deviation of the innovation, as it is set to the conventional 0.007. Likewise, the steady-state share of government expenditures in total output is estimated by averaging out the ratio of government consumption expenditures to GDP during 1970-2011. Further, the values characterizing the distributional properties of government expenditure shocks are taken from Braun (1994). All the parameter values mentioned above are summarized in Tables I and II.

Table I.
Model parameters

β	α	δ	τ	θ	ϕ_{ss}	η_{ss}
0.95	0.36	0.10	0.414	0.93	0.486	0.086

Table II.
Parameter values for structure of shocks

Parameter	Description	Value	Source
G_{ss}	Steady-state share of government expenditure in output	0.190	BEA, 1960-2006
ρ	Persistence of productivity shocks	0.814	DSGE literature
ρ_g	Persistence of government expenditure shocks	0.702	Braun (1994)
σ	SD of productivity shocks	0.007	DSGE literature
σ_g	SD of government expenditure shocks	0.036	Braun (1994)

4. Results

The following experiments consider the implications for macroeconomic volatility of variations in key parameters of the model. It is worth noting that the main purpose of these experiments is not to determine whether the model can capture particular stylized facts about the US economy, but to make a specific point through a series of numerical simulations. Overall, the results confirm the underlying intuition explained in previous sections and reveal some suggestive connections.

Note that the time series generated in the simulations are logged and detrended using the Hodrick-Prescott filter with a smoothing parameter of 100. Throughout the policy experiments and sensitivity exercises, the relative standard deviation – that is, the ratio of the standard deviation of the variable in question to the standard deviation of output – quantifies the volatility of investment and consumption.

4.1 Policy experiments

In this section, the results of experiments pertaining to policy variables such as the tax structure and its enforcement are analyzed. Also, the effects of changes in the degree of financial development are considered.

4.1.1 Corporate tax rate. The first experiment considers changes in the tax structure. In this respect, Figure 1 shows a substantial increase in the relative standard deviations of consumption and investment as the corporate income tax rate is raised, thus suggesting that higher taxes lead to greater aggregate volatility.

Intuitively, a higher burden of taxation reduces the expected return on investment and consumption while increasing their variance. This intuition is certainly reflected in the patterns of macroeconomic volatility seen above, even if the variability of output exhibits a tenuous rise. This latter pattern, nevertheless, seems to contradict the findings of Posch (2011), who claims taxes ultimately affect output volatility.

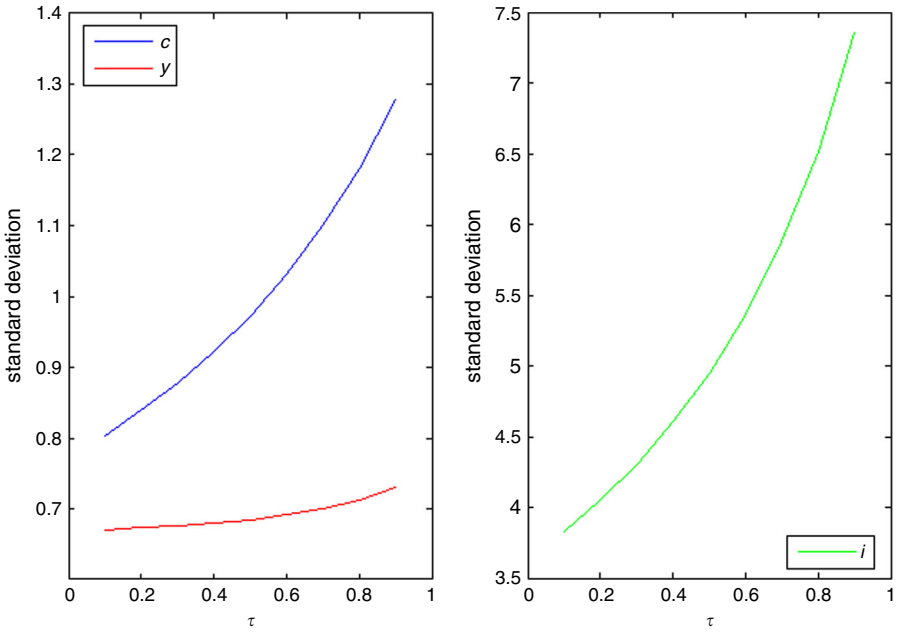

Figure 1.
Corporate tax rate and macroeconomic volatility

Furthermore, a higher burden of taxation induces firms to hide a larger share of their revenues from both tax authorities and lenders, thereby restricting investment financing through borrowing. Tax seniority upon default compounds to this financial friction, making firms even more credit constrained as taxes are raised. All these responses, as a result, support lower and more volatile investment and consumption.

4.1.2 Tax enforcement. As with increments in the corporate tax rate, macroeconomic volatility may increase when the exogenous enforcement parameter rises. Indeed, Figure 2 shows that investment exhibits slightly more fluctuations over the business cycle as ι is allowed to vary between 1 and 10, and thus the monitoring effort is strengthened. These patterns of aggregate behavior take place while the steady-state fraction of unrecorded production decreases considerably.

The rationale for these patterns of both aggregate volatility and tax evasion lies in the deterrent effect of greater enforcement, which induces firms to report a larger share of their activities and increase their expected tax payments[2]. Due to the endogenous character of the detection probability, such patterns stand in accordance with the previously described taxation results to various degrees.

4.1.3 Financial development. Credit constraints arise endogenously in the model because lenders cannot force borrowers to repay their debts unless these are secured by collateral. In such a context, the fraction of the pledgeable asset that is lost in debt enforcement is given by the extent and quality of the financial system. Thus, a high value of θ indicates a lower liquidation cost, and hence a more developed financial sector, compared to a low θ, which points to inefficient enforcement procedures inherent to underdeveloped credit markets. Furthermore, higher financial development exerts a detrimental influence on the degree of tax non-compliance as stated in *P1*.

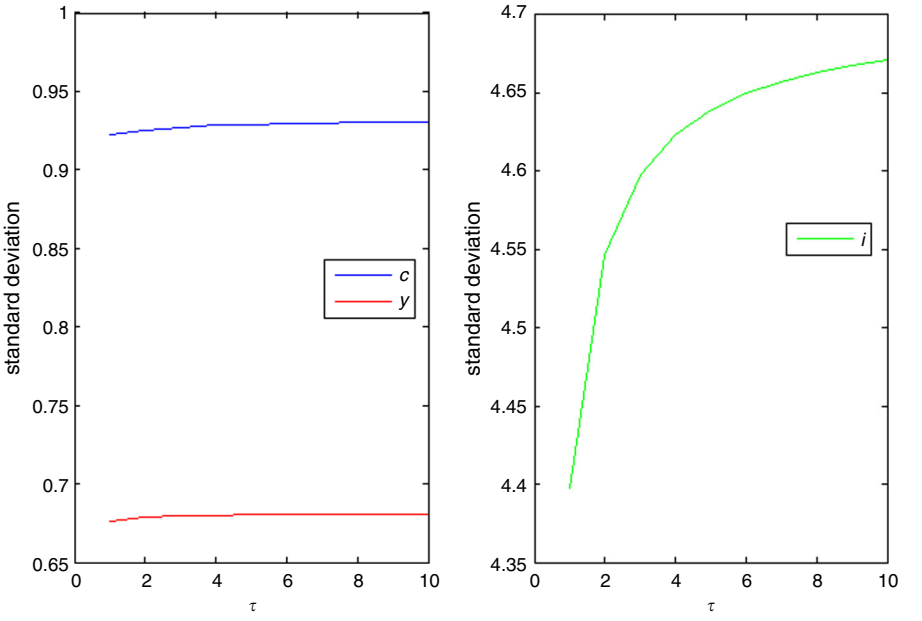

Figure 2.
Tax enforcement and macroeconomic volatility

The existing literature dealing with financial markets has shown that credit frictions may be a powerful transmission mechanism that propagates and amplifies shocks. However, the patterns of aggregate volatility displayed in Figure 3 convey a mixed picture. On the one hand, consumption remains roughly as volatile. On the other hand, the relative standard deviation of investment slightly decreases as financial development rises and thus inefficiencies in the liquidation of the collateralized asset become smaller. In this case, as Mendicino (2012) claims, credit frictions limiting the amount of borrowing to a small fraction of the liquidation value of capital makes the amplification generated by the collateral constraint significant, even under standard assumptions about the utility function and the production process.

Complementary experiments (not shown here) suggest that these patterns of aggregate volatility hold at both high and low degrees of tax non-compliance. These results certainly contrast those found by Mitra (2013), who claims the informal sector weakens the working capital channel of financial development and thereby exerts a downward pressure on the variability of consumption. As can be inferred from the present study, distinct mechanisms are at the core of our discrepancies on the effect of credit market depth on macroeconomic volatility for different levels of informality.

4.2 Further experiments: an exogenous share of undeclared activity

The experiments below allow one to examine a particular case of the model economy in which both the share of unreported production and the detection probability are taken as exogenous. Admittedly, the aim of these experiments is not to explain the emergence of an informal sector, but rather to analyze the consequences of such a sector's inherent financial constraints for aggregate fluctuations assuming its existence as given. The resulting patterns also can be compared with those of related studies.

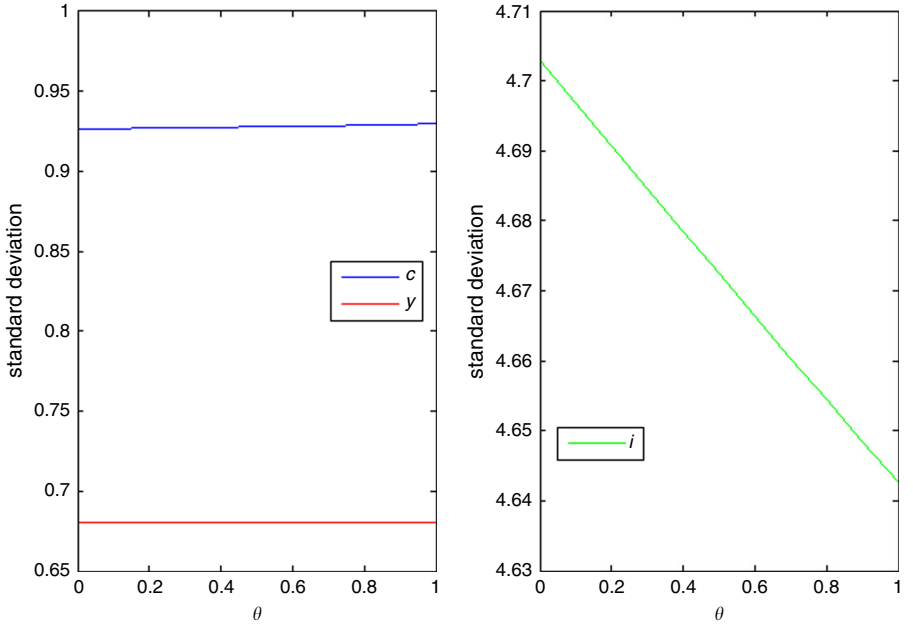

Figure 3.
Financial development and macroeconomic volatility

Figure 4 shows how macroeconomic volatility behaves as the share of production that firms leave off the books is allowed to vary. Note that $\eta = 0$ implies full compliance with the existing taxes and regulations, whereas $\eta = 1$ denotes complete tax evasion. It can be seen that the relative standard deviation of investment declines in a small but non-negligible manner, while output and consumption variability remain approximately constant despite increases in the extent of unreported activity.

While at odds with the literature, these patterns of macroeconomic volatility can be explained in terms of the mechanisms at work in the model. Specifically, tax evasion plays two conflicting roles in the economic environment: on the one hand, it tightens the borrowing constraint by rendering a fraction of output non-collateralizable, thus hindering investment and consumption smoothing (via dividends). On the other hand, the tax liabilities firms manage to conceal from the revenue collection authority constitute a form of savings that supports investment and thereby consumption smoothing. Though the former role causes aggregate variability to rise, tax savings counteract limited access to finance and lead to a fall in the relative volatility of consumption and investment.

The effect of evasion-induced savings can be best seen by comparing both the benchmark economy and the setting above with one in which diverted cash flow earnings are not plowed back into the firm as internal funding, thus comprising a private benefit to the entrepreneur. Since the amount firms are allowed to borrow is decreasing in their degree of informality, economies wherein less activity is reported to the tax authorities presumably exhibit tighter financial conditions. As limited access to external finance further magnifies the propagation of productivity shocks, consumption and investment are expected to be more volatile.

In line with this conjecture, the relative volatility of consumption and investment increase monotonically with the extent of unrecorded activity[3]. These patterns of cyclical behavior are illustrated in Figure 5, which also shows that the standard deviation of output remains approximately constant despite variations in the extent of tax non-compliance. Thus, even though these results do not seem to fully confirm

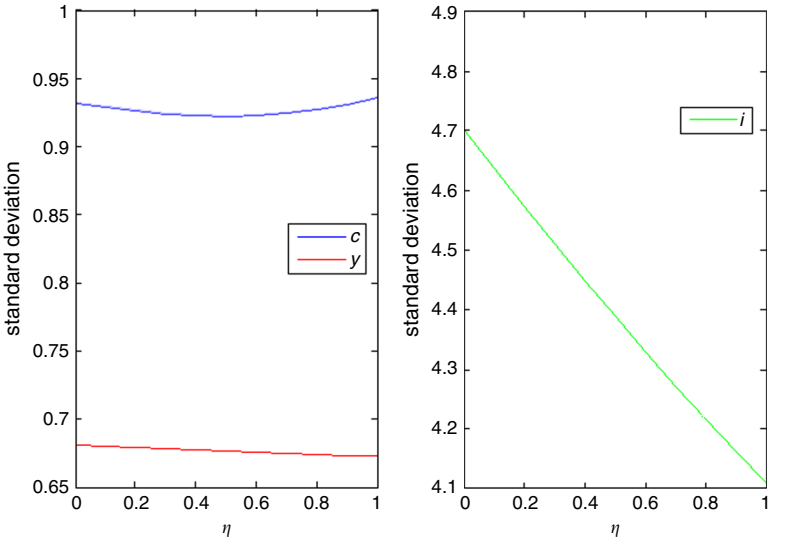

Figure 4.
Extent of informality and macroeconomic volatility

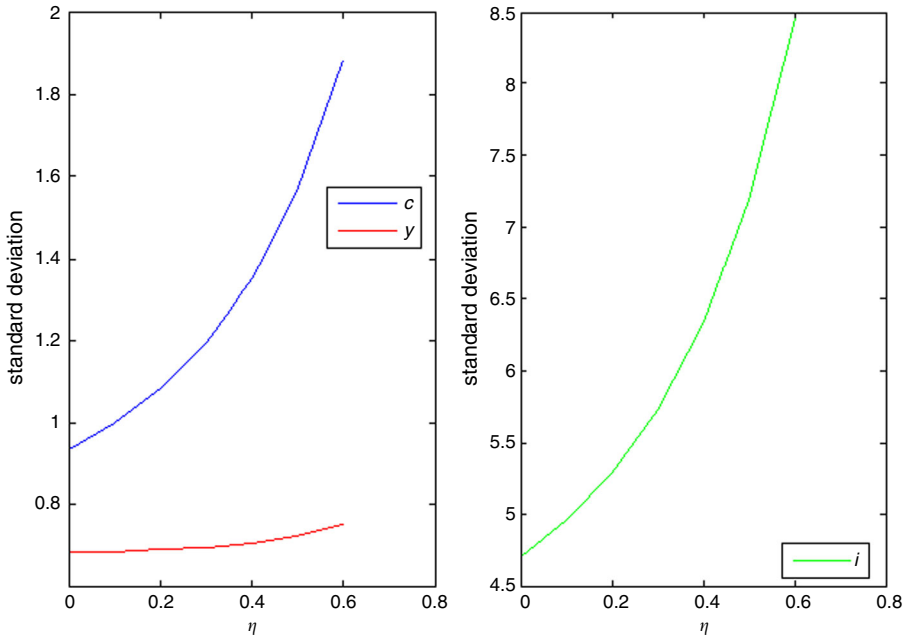

Figure 5.
Macroeconomic volatility when undeclared output is private gain

Ferreira-Tiryaki's (2008) empirical analysis, they certainly support Finkelstein Shapiro's (2015) and Restrepo-Echavarria's (2014) findings regarding the relationship between informality and macroeconomic volatility.

Finally, it is worth noting that higher tax evasion contributes to increase internal sources of funds not only at the present time, but also in future periods. This effect is due to the constraints evasion impose on borrowing possibilities, as these prevent firms from incurring financial costs. Note, further, that such an effect of tax non-compliance offsets the cash flow effects attributable to tax avoidance by reducing after-tax profits, hence limiting the potential for additional savings via tax-deductible interest payments.

5. Concluding remarks

The present paper addresses the implications for macroeconomic volatility of borrowing constraints characterizing the informal sector. To this end, it develops a simple dynamic stochastic general equilibrium model featuring financial frictions and tax evasion opportunities. In the model, firms operating unofficially are subject to credit rationing, which reduces loans in relation to their non-payment of taxes. This assumption is consistent with the observation that it may be more difficult for tax evaders to access external finance because doing so entails official documentation, especially if lenders require collateral and if the process of hiding economic activity involves concealing the true ownership of assets. After identifying the determinants of the extent of the unrecorded sector, some computational experiments allow one to examine how informality and its determinants affect aggregate volatility.

This paper contributes to better understand the trade-offs involved in the choice of tax evasion, as well as the implications of policies addressing this phenomenon for

aggregate fluctuations. The proposed model, in particular, highlights two countervailing consequences of tax non-compliance for firms' access to finance: on the one hand, it worsens the terms and conditions of loan contracts by reducing the collateral that can be offered for securing debts. On the other hand, the successfully dodged liabilities amount to a form of savings that raises internal funds. While the former lowers the amount of credit provided and thus causes macroeconomic volatility to rise, the latter counteracts lack of access to outside financing and leads to a fall in the relative variability of consumption and investment.

As it stands, firms in the model face a binding borrowing constraint in equilibrium. This feature relies on the assumption that interest payments are deductible from taxable income, thereby incentivizing entrepreneurs to raise funds through debt financing. Two other important assumptions underlying the proposed mechanism are book-tax conformity and tax seniority in the event of default. A high degree of alignment between tax and financial reporting implies that the extent of transparency chosen by the representative firm affects not only its tax liabilities, but its debt capacity as well. Tax seniority, in turn, further toughens the financial friction. All these assumptions are aimed to convey a realistic characterization of tax policy and are at the heart of the results.

Provided that the firm reinvests the proceeds of undeclared activity, the findings in this paper do not support the stylized facts reported by Finkelstein Shapiro (2015), which state that countries with a sizeable shadow economy exhibit higher volatilities of consumption and investment. Moreover, these findings contrast a variety of mechanisms suggested in business cycle studies dealing with labor informality (Restrepo-Echavarria, 2014; Mitra, 2013). To the extent that the model presented here addresses informality only at the firm level, comprehensive consideration of the characteristics and dimensions associated to the unofficial sector emerges as a potential improvement. In this regard, accounting for self-financing as a substitute to lack of external funds through models with heterogeneous agents stands as a worthy path to pursue.

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Notes

1. Conversely, it is likely that the same information that is used to signal creditworthiness to financial institutions make firms operations easier to monitor for tax purposes (see Gordon and Li, 2009).
2. Given that its determinants are not being altered, the probability of detection remains constant at steady state. To see this, confront *P1* and φ's functional form.
3. Numerical simulations using Dynare yield convergence problems after $\eta = 0.6$.

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Appendix 1. Proof of *P2*

The first-order condition of the household with respect to savings b_t^H is summarized by:

$$\frac{1}{c_t} = \beta E_t\left(\frac{1}{c_{t+1}}\right)(1+r_{t+1}).$$

At steady state, this condition reduces to:

$$1+r_{ss} = \frac{1}{\beta}. \tag{A1}$$

Now, the first-order condition of the firm with respect to borrowings b_t^F can be summarized by:

$$1-\mu_t = \gamma\{(1-\tau)r_{t+1}+1\}.$$

At steady state, this condition reduces to:

$$\frac{1-\mu_{ss}}{\gamma_{ss}} = (1-\tau)r_{ss}+1. \tag{A2}$$

Substituting (A1) into (A2), and taking into account that $\gamma_{ss}=\beta$, one gets that:

$$1+r_{ss}-\frac{\mu_{ss}}{\beta} = (1-\tau)r_{ss}+1;$$

which, after some simplification, becomes:

$$(1-\beta)\tau = \mu_{ss}. \tag{A3}$$

Hence, a necessary condition for $\mu_{ss}>0$ is that $\tau>0$.

Appendix 2. Proof of *P1*

The first-order condition of the firm with respect to the fraction of output hidden from the tax authority η_t is given by:

$$\frac{\tau}{1-\tau}[1-\phi_t-\varphi(\iota)\eta_t]y_t = \theta E_t\mu_t y_{t+1}.$$

At steady state, this condition reduces to:

$$\frac{\tau}{1-\tau}[1-\phi_{ss}-\varphi(\iota)\eta_{ss}] = \theta\mu_{ss}. \tag{A4}$$

Substituting condition (A1) into (A4), one gets that:

$$\frac{1-2\varphi(\iota)\eta_{ss}}{1-\tau} = \theta(1-\beta);$$

which, after some algebraic manipulations, becomes:

$$\eta_{ss} = \frac{1-\theta(1-\beta)(1-\tau)}{2\varphi(\iota)}. \tag{A5}$$

From Equation (A5), it can be ascertained that:

$$\frac{\partial \eta_{ss}}{\partial \theta} = -\frac{(1-\beta)(1-\tau)}{2\varphi(\iota)} < 0 \tag{A6}$$

$$\frac{\partial \eta_{ss}}{\partial \tau} = \frac{\theta}{2}\frac{(1-\beta)}{\varphi(\iota)} > 0 \tag{A7}$$

$$\frac{\partial \eta_{ss}}{\partial \iota} = \frac{[1-\theta(1-\beta)(1-\tau)]}{2[\varphi(\iota)]^2}\frac{d\varphi}{d\iota} < 0, \tag{A8}$$

where property (A8) comes from the detection probability characteristic that $d\varphi/d\iota > 0$.

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