# To Tax or Not to Tax? When Does it Matter for Informality?

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**Abstract**

Theoretical models generally always predict or assume that higher taxes lead to larger informal sectors. Empirically, however, there is considerable debate on the effect of taxes on informality. In this paper I show that whether a positive, negative or non-relation arises between tax rates and informality depends on the degree of tax enforcement and the level of credit market development in an economy. Higher enforcement implies a higher probability of detection and punishment while more credit implies better formal sector access to finance. Both are incentives to become formal. In a two-sector dynamic general equilibrium model with borrowing constraints, I show that informality rises with the tax rate up to a threshold level of

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tax enforcement beyond which it falls as tax increases. This enforcement threshold depends negatively on the level of credit in the economy.

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# 1. Introduction

The purpose of this paper is to explore theoretically the effect of institutional differences on the relationship between tax and informality in a dynamic general equilibrium framework. I specifically show that the different levels of tax enforcement and financial development observed in developing versus developed economies play a crucial role in the nature of the relationship that emerges between taxation and informality. I also find that productive government expenditures do not matter in this context.

Taxation of output is viewed as a cost to operating in the formal sector. Therefore higher tax rate(s) increase the incentive to underreport income and the prevalance of informal or underground activity. Given this reasoning, theoretical models of the informal sector almost automatically assume or find a positive relationship between taxation and tax evasion (Ihrig and Moe, 2001; Busato and Chiarini, 2004; Amaral and Quintin, 2006; Prado, 2011; D'Erasmo and Boedo, 2012; Mitra, 2013 and Charlot et al, 2015).

Empirically, however, there is less of a consensus on how taxes relate to informality. Several empirical studies associate higher tax rates with a smaller informal sector while others report a positive effect of taxes on informality. Schneider (2005) and La Porta and Shleifer (2008), using different estimates of the informal sector and measures of taxation,

find the latter to be an important driver of the informal sector size. Dabla-Norris et al (2008) focus mainly on developing economies and report that taxes and informality are significantly positively correlated but stronger legal and enforcement institutions reduce the significance of taxes. In a panel analysis, similarly focusing on developing economies, Liu-Evans and Mitra (2015), find informality to be significantly positively correlated with taxes and significantly negatively correlated with different proxies for enforcement. Djankov et al (2010) report a positive correlation between corporate tax rates and informal sector size for 85 countries, a large majority of which are developing economies. Gorodnichenko et al. (2009), study a major tax reform in Russia and find a large positive elasticity of evasion with respect to the tax rate.

Unlike the above studies, authors who look at transition and OECD economies find contrasting results. Johnson et al. (1997) and Johnson et al. (1998) conclude that tax rates are negatively correlated with the size of the informal sector. However, the simple model provided by Johnson et al. (1997), contrary to their empirical findings, implies a positive relationship between tax rates and the size of the informal sector. When Johnson et al. (1998) take into account composite indices of both tax rates and quality of tax administrations, they find that these indices are positively correlated with the size of the informal sector, thus supporting their claim that both administration of taxes and regulatory discretion play key roles in the tax-informality relationship. Friedman et al. (2000) suggest that the positive correlation between tax and informality are the result of poor institutional factors such as corruption and bureaucratic quality. They find some evidence that a higher direct tax rate reduces informal sector size but the result loses significance when they control for per capita income in order to account for the fact that richer countries have better institutions. More bureaucracy, greater corruption, and a

weaker legal environment, on the other hand, are all associated with a larger unofficial economy even after controlling for per capita income in their sample. Similarly, Aruoba (2010) finds, using a much larger group of countries, that institutions play a key role in determining the effect of taxes on informality.

Thus empirical studies remain largely divided on the effect of tax on informality, although, there appears to be greater agreement in the literature on the important role of institutions. There especially seems to be a contrast in the way taxes affect informality in developed and developing economies. Goel and Nelson (2016), for instance, find that determinants of the shadow economy differ across developing and developed economies with the differences mainly arising from the disparate nature of institutional quality in these economies. They also find an increase in their measure of the tax rate promotes informal sector growth in developing economies while stemming it in developed economies.

In this paper I argue that tax enforcement and the level of financial market development play key roles in the nature of the tax-informality relationship that emerges in an economy. I do so in a two sector dynamic general equilibrium model with borrowing constrained formal and informal entrepreneurs. I do not, however, study how the informal sector comes into being, but given that such a sector exists, I investigate the role played by institutional differences in the tax-informality relationship.

Lower tax enforcement implies a lower probability of being caught and punished while less developed domestic credit markets imply formal businesses have less or no access to formal sources of financing, thus lowering the incentive to be formal. Thus both lower tax enforcement and lower FD give rise to larger informal sectors and the degree and importance of these effects with respect to the informal sector's size have been addressed in the literature (see among others Amaral and Quintin, 2006; Quintin 2007; Antunes and

Cavalcanti, 2007, Liu-Evans and Mitra, 2015 and Berdiev and Saunoris, 2016). In this paper, I extend the line of argument to the relationship between taxes and informality. Specifically, I show that higher taxes reduce (raise) informality when enforcement and credit market institutions are well (less) developed. I identify a critical value of tax enforcement below which taxes and informality are positively related and above which the relationship is a negative one. Taxes exert no effects on informality when enforcement is at or around its threshold value.

The reasoning behind the contrasting effects of tax on informality is as follows: As taxes are raised the cost of formal production rises with probability 1, while the informal sector's cost of production rises with the probability of being detected (and the stringency of the punishment associated with detection). Higher enforcement which is associated with better enforcement institutions give rise to a higher probability of detection and associated penalty hence a larger increase in the expected cost of informal production with taxes. This latter implies the informal sector expands less with taxes at higher enforcement. In other words, as enforcement increases the positive relationship between tax and informality becomes weaker until at a high enough probability of detection, taxes do not affect informality at all and beyond this level of enforcement, informality falls with taxes since the cost of hiding is too high.

Of course if formal businesses enjoy high quality access to official sources of financing then there is greater incentive for informal producers to become formal and enforcement needs to rise less to convince informal producers to switch to paying taxes. In my model, as financial development progresses formal businesses are able to borrow more against their income or output which increases the size of this sector relative to the informal sector. Additionally, the expansion of the formal sector brings about an increase in the

demand for and hence the price of resources used in formal production. In our simple model economy labor is the only factor of production implying the competitive wage rate rises due to the higher formal labor demand at higher FD. At this higher cost of labor, the same increase in the tax rate causes a smaller expansion in the size of the informal sector and enforcement needs to rise less in order to clear the bar beyond which informality becomes decreasing in the tax rate.

This paper contributes to the literature in two main ways. Firstly, unlike the large literature studying the determinants of informality this paper focuses on the determinants of the tax-informality relationship. Understanding this latter has become especially important in light of the varied empirical results in the literature. Secondly, this paper provides a simple theoretical construct which allows tax rates and informality to be related either positively, negatively or not at all depending on the level and quality of enforcement and credit market institutions. This provides a departure from the existing models of informal sector that generally predict or assume a positive relationship between tax and informality in contrast to existing empirical findings.

Elgin (2015) is the only exception to my knowledge - he builds a dynamic political economy model and shows that greater political stability may be associated with a negative relationship between tax and informality while less politically stable countries may exhibit a positive relationship between the two. Specifically, in his model, public capital is mainly utilized by the formal sector which implies that countries in which incumbent parties are more likely to stay in power have a higher tax burden but a smaller informal sector. The current paper provides a complementary explanation for the varied relationship observed between taxes and informality across countries by sketching out channels through which tax enforcement and financial development may play important roles. I

calibrate my model to a typical emerging market economy, Brazil, and conduct numerical simulations which sketches the changing relationship between tax rate and informality for different levels of enforcement and FD while all other parameters remain constant. I extend the application of my model to other countries in the sensitivity analysis section.

The rest of the paper is structured as follows: Section 2 presents an analysis of the data and some simple correlations to motivate the contrasting effects of tax on informality in developing versus developed economies before delving into the model in Section 3 which presents a novel theory of interaction between (credit market and enforcement) institutions and their effects on the tax-informality relationship, Section 4 discusses the results and conducts quantitative analyses, Section 5 considers an extension of the model and Section 6 concludes.

# 2. Data and Motivation

This section documents the link between taxation and informality in developing and developed country groups and presents some other indicative statistics to motivate the theoretical work. I compile two separate data sets for the two country groups using data from different sources. My starting point is the informal sector's share in GDP estimated by Schneider et al (2007) for developing, developed and (formerly) transition economies. I use this influential study to create my groups of developing and developed economies and their respective informal sector sizes. For the purposes of this paper I class transition economies in the developed country group for two reasons. Firstly, OECD and transition economies by themselves constitute too few data points in comparison to the developing economies group in Schneider et al (2010), who report results for 25 OECD, 21 formerly

transition and 88 developing economies. Secondly, due to a lack of data availability, my data source for the proxy for financial development differs across developing and developed economies, with the data for transition economies derived from the same source as the developed group of countries as discussed below. Lastly, earlier influential studies (Friedman et al 2000 and Johnson et al, 1997, 1998) have similarly grouped these countries together. That said, the main results do not change when calculated for developed and transition countries separately with the latter generally mimicking the results of the OECD economies. The average informal sector size in Scneider et al (2010) covers the years 1999-2007. So for the rest of my variables, after compiling the data, I calculate the averages over the same years, or less if data for all years are not available.

As is common in the literature I use the Rule of Law index from the Worlwide Governance Indicators (WGI) dataset, see Kaufmann, Kraay and Mastruzzi (2010), as institutional proxy for level of tax enforcement (Aruoba, 2010; Dabla-Norris et al, 2008; Liu-Evans and Mitra, 2016). For financial development, I use the private credit to GDP ratio from the World Development Indicators (WDI) database provided by the World Bank. However, most developed and transition economies are absent from this data set so for these economies I use private sector debt as a fraction of GDP from the Financial Indicators Series of the OECD database.

I use three different measures of tax rates. Income tax is the composite of taxes on income, profits and capital gains as a % of total taxes, obtained from the WDI database of the World Bank. Tax revenue as a % of GDP is also obtained from the WDI and is commonly used in the literature as a measure of the tax burden. Both these tax measures are averaged over the period 1999-2007 for every country in each group. My corporate income tax rate is from Paying Taxes 2007, compiled by the World Bank and

Pricewaterhouse Coopers for the *Doing Business* project. It is based on the findings of a survey which looked at the corporate tax position of a standard modest-sized company in 175 countries 2006.

| | Developing | | | Developed | | |
|---|---|---|---|---|---|---|
| | N | Mean | SD | N | Mean | SD |
| $rl$ | 83 | -0.32 | 0.68 | 44 | 0.81 | 0.98 |
| $fd$ | 50 | 0.34 | 28.9 | 28 | 1.86 | 58.5 |
| $inf$ | 85 | 0.35 | 11.34 | 44 | 0.24 | 12.3 |
| Corporate tax | 80 | 0.195 | 10.8 | 43 | 0.17 | 10.33 |
| Income tax | 71 | 0.22 | 10.83 | 43 | 0.25 | 14.6 |
| Rev. as % of GDP | 68 | 0.16 | 9.88 | 43 | 0.18 | 5.88 |

Table 1: Description of data by developing and developed country groups. $N$ = number of observations, $SD$ = standard deviation, $rl$ =Rule of Law index, $fd$ =financial development, $inf$ =informal output to GDP ratio.

A summary of the data is presented in Table 1. The Rule of Law index is very low (negative in fact) for the developing country group as is the proxy for FD, compared to developed economies. The informal sector is much larger in developing economies, however, the different measures of tax used are not very different across the two country groups. While corporate tax is a shade higher in developing economies, both the income tax rate and tax revenue as a fraction of GDP are higher in case of developed economies.

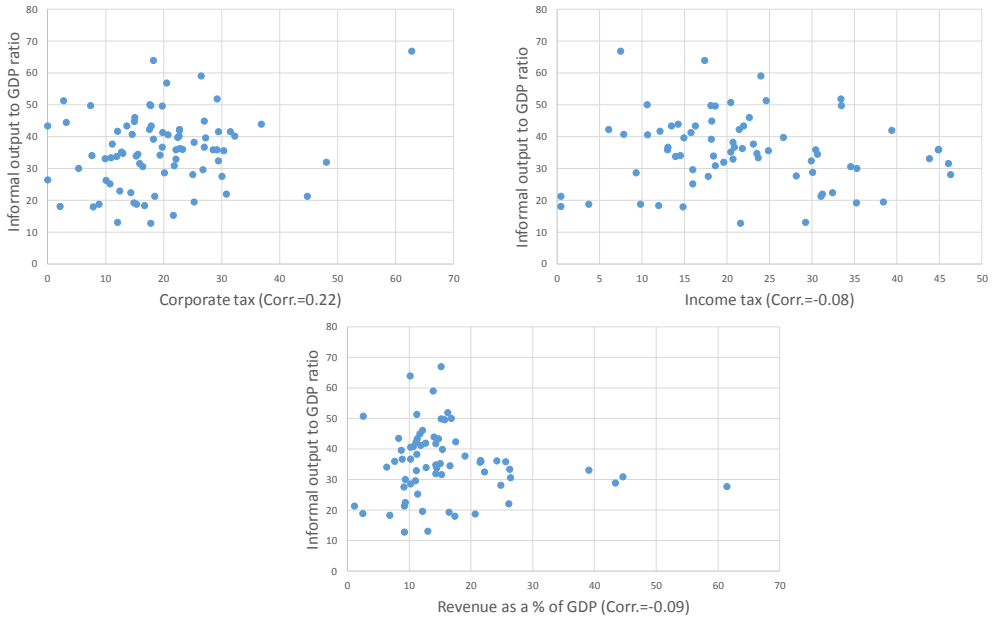


Figure 1: Different tax measures and informality for developing economies.

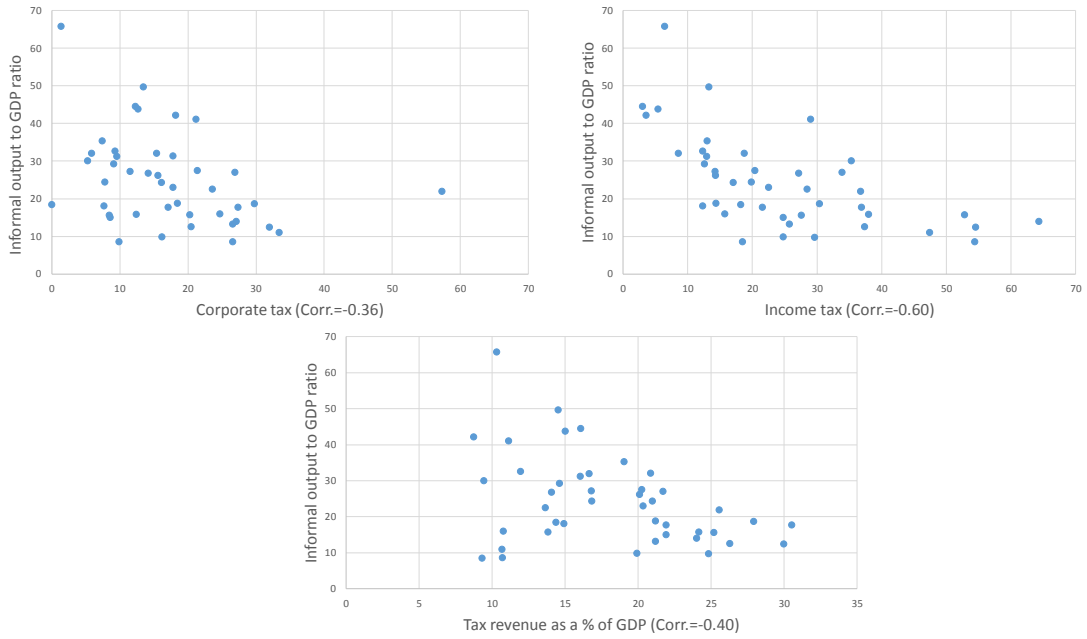


Figure 2: Different tax measures and informality for developed economies.

Figures 1 and 2 plot the 3 different measures of tax rates against the informal sector size estimated in Scneider et al (2010) for the group of developing and developed economies respectively. A positive relationship emerges between the corporate tax rate and the

informal sector size in developing economies in Figure 1, while the income tax rate and tax revenue as a fraction of GDP display no clear link with informality for the same group of countries. Figure 2 reveals, contrastingly, a strong negative association between informality and the tax rate for developed economies irrespective of the measure of tax rate used. Thus two clear features are revealed by this comparison: the informal sector is related either positively or not at all to taxes in developing economies while it is related negatively to taxes in developed economies.

| Correlations | Developing | Developed |
|---|---|---|
| $\rho(rl, inf)$ | -0.37 | -0.86 |
| $\rho(fd, inf)$ | -0.11 | -0.53 |
| $\rho(rl, fd)$ | 0.62 | 0.66 |

Table 2: $rl$ =Rule of Law index, $fd$ =financial development, $inf$ =informal output to GDP ratio.

Table 2 further highlights that both Rule of Law and FD are strongly negatively correlated with informality in developed economies while Rule of Law seems to matter more for informality in developing economies with FD displaying a very weak negative correlation with the informal sector size. Finally, Rule of Law and FD are strongly positively correlated in both country groups. Thus, economies with better enforcement and well developed financial markets tend to have smaller informal sectors but financial markets matter more for informality in developed economies. These findings are also confirmed by Liu-Evans and Mitra (2015) who find that informality is significantly positively related to the tax rate and significantly negatively related to the Rule of Law in developing economies while FD did not exert any significant direct effect on informality. Dabla-Norris et al (2008) also find, using firm level survey data for 40 developed and developing economies that the quality of the legal framework is crucially important in determining the size of the informal sector and the significance of financial constraints is reduced in

the context of a well functioning legal system. The focus of these studies, however, is on the determinants of informality rather than the tax informality relationship which is the main focus of this paper.

In sum, the following observations emerge from this section: Firstly, informality is related non-negatively to taxes in developing economies while it is strongly negatively related to taxes in developed economies. Secondly, tax enforcement proxied by the Rule of Law index is very low in developing economies as is the level of FD compared to developed economies. Finally, enforcement or Rule of Law is an important determinant of informality in both developing and developed economies whereas better financial markets seem to matter more for informality in developed economies.

# 3. Model Environment

I consider a model economy where formal and informal entrepreneurs co-exist and produce the same homogenous output. Formal entrepreneurs are defined as those that pay tax on their output with probability 1 while informal agents are those that pay no taxes unless they are caught by inspectors and made to pay the tax they owe. I also assume (in line with Allingham and Sandmo, 1972; Ihrig and Moe, 2001 and Busato and Chiarini, 2004) that being detected implies paying a penalty, which, if large enough, could make the expected tax payment of the informal sector larger than the tax paid by the formal sector. The combination of the probability of audit and the penalty for evasion determines the stringency of tax enforcement in the economy. How large enforcement is, in turn determines how much a tax-increase raises the cost of operating in the formal sector relative to the informal sector. Entrepreneurs can borrow but only against declared

income, implying only formal entrepreneurs can participate and borrow in credit markets.

Both entrepreneurs and households maximize consumption. The main difference between them is that the former own production technologies using which they convert labor input to output. They use this output and any additional borrowing to pay their wage bill and consume. Households own no such production technology but supply labor to the two sectors and lend to the formal sector. They consume out of their wage and interest income each period.

*Entrepreneurs*

Representative formal and informal entrepreneurs maximize consumption,

$$\text{Max}\, E_t \sum_{t=0}^{\infty} \gamma^t \ln c_{i,t},$$

where $i = 1, 2$ stands for formal and informal entrepreneurs respectively, $c_i$ is their consumption in period $t$ and $\gamma$ is the discount factor.

As in Koreshkova (2006) and Prado (2011), production occurs using labor and technology,

$$y_{i,t+1} = A_{i,t}(l_{i,t})^{\alpha},$$

where the $i$th firm hires labor ($l$) in period $t$ to produce output ($y$) in period $t+1$. I assume that tax evading firms have lower productivity than the formal sector in keeping with the findings of La Porta and Shleifer (2008). $A_{i,t}$ are the sectoral productivities at date $t$. The formal sector's productivity is at the frontier and given by $A_{1,t} = A_t$ where

$A_t$ is common knowledge and follows a first order autoregressive process,

$$\log A_t = \rho_A \log A_{t-1} + e_t^A,$$

where $e_t^A$ are zero-mean, i.i.d. innovations. Following Koreshkova (2006), we assume the inferior informal-sector technology is given by $A_{2,t} = \phi A_{1,t}$ such that $0 < \phi \leq 1$, where $\phi$ reflects the difference in sectoral productivities.

The production function implies that entrepreneurs need to hire labor and pay the wage bill before production occurs thus creating a role for borrowing. This is similar to Aoki, Benigno and Kiyotaki (2010) and Aoki and Kalin (2015) who use the same production function and motivate their borrowing constraints similarly. I assume, as in these papers, that borrowing occurs against expected future income of the entrepreneurs which implies that informal entrepreneurs, since they hide their production, cannot participate in financial markets and financial development only affects the formal sector's labor demand. More specifically, the formal sector borrows according to,

$$R_t b_{1,t} \quad \leq \quad E_t \theta y_{1,t+1},$$

while the informal sector's borrowing constraint is given by,

$$R_t b_{2,t} \quad \leq \quad 0.$$

$R_t$ is the gross interest rate, $b_i$ is the amount of borrowing/lending and $\theta$ is the fraction of output up to which formal entrepreneurs can borrow - it is an efficiency parameter and measures the level of FD in the model[1]

The formal and informal sector's budget constraints are respectively given by,

$$c_{1,t} + R_t b_{1,t-1} + w_t l_{1,t} = (1-\tau)y_{1,t} + b_{1,t}, \quad (1)$$

$$c_{2,t} + R_t b_{2,t-1} + w_t l_{2,t} = (1-p\tau)y_{2,t} + b_{2,t}. \quad (2)$$

Consumption and wage bill on the left is financed by output and net borrowing on the right. Labor is perfectly mobile between sectors and $w_t$ is the competitive wage rate. In equation (2), with a probability $(1-p)$ informal entrepreneurs retain their entire income $y_{2,t}$, but with probability $p$ they are caught and made to pay the tax evaded along with a fine. $p$ is a measure of the level of tax enforcement in the model and can be interpreted in one of two ways as in Ihrig and Moe (2004). If the informal agent faces a probability $p$ of being caught, and when caught, the agent only pays tax on output at the rate of $\tau$, then the value of $p\tau$ ranges from 0 to $\tau$. However, as in Allingham and Sandmo (1972), the taxpayer may have to pay tax on the undeclared amount, at a penalty rate which is higher than $\tau$. In this case $p$ is the product of the probability of audit ($< 1$) and the penalty which is a proportion ($> 1$) of $\tau$. In the latter interpretation, the upper bound on the value of $p\tau$ is greater than the tax rate in the formal sector.

[1]Note that it does not matter for the paper's qualitative results if entrepreneurs were borrowing against assets (capital) instead of output, as is often used in the literature. In this case, informal agents would hide their assets (not output) from the authorities which would allow them to escape paying taxes on the income generated by these assets. This would preclude them from borrowing in financial markets implying, as in the current version, FD only benefits formal firms by allowing them to borrow and invest more.

The first order conditions of the entrepreneurs are,

$$w_t \frac{1}{c_{1,t}} = (\gamma \frac{1}{c_{1,t+1}}(1-\tau) + \lambda_1 \theta)\alpha A_t l_{1,t}^{\alpha-1} \quad (3)$$

$$w_t \frac{1}{c_{2,t}} = (\gamma \frac{1}{c_{2,t+1}}(1-p\tau))\alpha \phi A_t l_{2,t}^{\alpha-1} \quad (4)$$

$$\frac{1}{c_{i,t}} = E_t[\gamma R_{t+1} \frac{1}{c_{i,t+1}} + \lambda_i R_t]. \quad (5)$$

$\lambda_i$ are the Lagrange multipliers for the borrowing constraints faced by the entrepreneurs. Equations (3) and (4) are the first order conditions with respect to labor for the formal and informal entrepreneurs respectively. Both sectors equate the marginal productivity of hiring an additional unit of labor, on the right hand side, to its marginal cost on the left to arrive at their respective labor demands. Note that the marginal productivity of labor in the formal sector, internalizes the additional benefit an extra unit of labor brings, in the form of greater borrowing, while labor productivity in the informal sector is not affected by the level of borrowing in the economy. Thus the amount of borrowing taking place in the economy impacts the sectoral labor productivities differently which is crucial for the effect FD has in the model. Equation (5) relates the marginal benefit of borrowing by the sectors to its marginal cost.

*Households*

Households supply labor to both sectors and also lend to the formal sector. They maximize consumption as follows,

$$\text{Max} \qquad E_t \sum_{t=0}^{\infty} \beta^t (c_{3,t} - \frac{l_{s,t}^{1+\frac{1}{\eta}}}{(1+\frac{1}{\eta})})$$

subject to

$$c_{3,t} + Rb_{3,t-1} = w_t l_{s,t} + b_{3,t},$$

where $c_3$ is household consumption and $l_s$ is total labor supplied. $\beta$ is the household discount factor such that $\beta > \gamma$ in order to allow credit flows and ensure that the borrowing constraints bind. This is a common assumption in the literature and is discussed further below.

The household's first order conditions are,

$$l_{s,t}^{\eta} = w_t \tag{6}$$

$$\frac{1}{c_3} = \beta R_t E_t \frac{1}{c_{3,t+1}}. \tag{7}$$

*Government*

A government collects $\tau y_{1,t}$ from the formal sector with certainty and $p\tau y_{2,t}$ from the informal sector given enforcement level $p$, in tax revenue, which is used to finance government consumption, $g_t = \tau y_{1,t} + p\tau y_{2,t}$. I assume here that government expenditures are wasteful. In Section 5, I relax this assumption to include productive government expenditures.

*Timing*

The timing of the model economy is as follows: Entrepreneurs enter period $t$ with output $y_{i,t}$ (produced by labor hired in $t-1$), where $i = 1, 2$ stands for formal and informal firms respectively. They observe their productivity ($A_{i,t}$) in period $t$, decide on their labor demand and the investment on wage bill. They then borrow, hire workers, pay the wage bill and consume. The payment of wages and consumption in period $t$ therefore occurs out of the beginning of period output ($y_{i,t}$) and net borrowing ($b_{i,t} - R_t b_{i,t}$). At the start of next period they obtain output $y_{i,t+1}$ and the process starts all over again.

Thus when (formal) entrepreneurs borrow in period $t$ they have already observed the period $t$ productivity and know with certainty what their next period's output is going to be. The borrowing constraint stipulates entrepreneurs can borrow up to a fraction ($\theta$ for formal and 0 for informal entrepreneurs) of this fully known future income thus precluding default in the model.

# 4. Equilibrium and steady state

*Definition of Equilibrium*

For a list of policies $[\tau,\ p,\ \theta]$, and technology, $A_t$, a competitive equilibrium is given by a list of consumption plans, production plans and debt positions $[c_{i,t}, y_{i,t}, l_{i,t}, b_{i,t}]$, for entrepreneurs $i = [1, 2]$; a list of consumption plans and debt positions $[c_{3,t}, b_{3,t}]$ for the household; and prices, $[w_t, R_t]$ such that (i)$[c_{i,t}, l_{i,t}, b_{i,t}]$ maximize entrepreneur i's expected utility subject to their respective production functions, budget constraints and borrowing constraints, (ii) $[c_{3,t}, b_{3,t}]$ maximize household's expected utility subject to their budget constraint, and (iii) Labor, goods and bond markets clear such that, $\sum_{i=1}^{2} l_{i,t} = l_{s,t}$,

$\sum_{i=1}^{3} c_{i,t} + g_t = \sum_{i=1}^{2} y_{i,t}$, and $\sum_{i=1}^{3} b_{i,t} = 0$, given $[A_{i,t-1}, l_{i,t-1}]$.

In a steady-state equilibrium all variables are constant. Such an equilibrium can be characterized using the following system of eight equations in the eight unknowns, $R, \lambda, y_1, y_2, l_1, l_2, l_s, w$ thus proving that the steady state exists.

$$
\begin{aligned}
1 &= \beta R && (8)\\
\frac{1}{c_i} &= \gamma R \frac{1}{c_i} + \lambda_i R && (9)\\
w\frac{1}{c_1} &= (\gamma \frac{1}{c_1}(1-\tau) + \lambda_1 \theta)\alpha \frac{y_1}{l_1} && (10)\\
w\frac{1}{c_2} &= (\gamma \frac{1}{c_2}(1-p\tau))\alpha \frac{y_2}{l_2} && (11)\\
l_s &= w^{1/\eta} && (12)\\
y_1 &= A_1 l_1^{\alpha} && (13)\\
y_2 &= \phi A_1 l_2^{\alpha} && (14)\\
l_s &= l_1 + l_2 && (15)
\end{aligned}
$$

Equation (8) is the euler equation of households and equation (9) gives the first order conditions with respect to borrowing for the entrepreneurs where i=$\{1,2\}$. Equations (10) and (11) are the first order conditions with respect to labor for the formal and informal entrepreneurs respectively. Equation (12) is the first order condition for the household's labor supply. Equations (13) and (14) are the formal and informal sector's production functions respectively and equation (15) is the labor market clearing condition.

Equation (8) gives the steady state interest rate which is $R = 1/\beta$. Once we know the

interest rate $R$, we can determine $\lambda_i$ from equation (9) such that $\lambda_i = (\beta - \gamma)1/c_i$. Thus for any $\beta > \gamma$, $\lambda_i$ is positive implying the borrowing constraints are binding for both the entrepreneurs. In other words, entrepreneurs always borrow the maximum possible amount, which at steady state implies $b_1 = \frac{\theta y_1}{R}$ and $b_2 = 0$ (from the respective borrowing constraints in Section 3).

Substituting $\lambda_1$ into equations (10) and (11) gives the steady state labor input in each sector, $l_1$ and $l_2$. Assuming, $s = l_2/l_1$, we get,

$$s = \left( \frac{(1 - p\tau)\phi}{(1 - \tau) + \frac{(\beta - \gamma)\theta}{\gamma}} \right)^{\frac{1}{1-\alpha}}. \tag{16}$$

Equation (16) gives the steady-state inter-sectoral allocation of labor. This is a key equation of the model as it determines the steady state allocation of labor across formal and informal sectors in the economy. It states the informal sector's size relative to the formal sector is a function of the tax rate ($\tau$), the enforcement parameter ($p$), the level of FD ($\theta$) and the discount rates of the two types of entrepreneurs ($\beta$ and $\gamma$). The first three are policy variables in my model while the last two are parameters. These variables and parameters vary by country which determine in turn the relative informal sector size that arises in any given country.

We assume the economy is at this steady state at the start of our analysis, that is, before taxes and other policy variables change. It is helpful therefore to first pin down this steady state allocation of labor and hence the informal sector size relative to the formal sector. We do this in the next section in the context of Brazil, a typical developing economy with a large informal sector, such that the steady state relative size of the informal sector

predicted by equation (16) reflects the average informal sector size for Brazil in the data over the relevant period. We also apply the model to other countries in Section 4.3 and conduct robustness analyses.

It is straightforward to see from equation (16) that, $\delta s/\delta p < 0$ and $\delta s/\delta \theta < 0$. These relations are well established in the literature and discussed in Section 1. In addition, here we show that the following proposition holds.

**Proposition 1.** *There exists a threshold value of enforcement, $\bar{p}$, such that when $p < \bar{p}$, $\frac{\delta s}{\delta \tau} > 0$ and when $p > \bar{p}$, $\frac{\delta s}{\delta \tau} < 0$ and $\bar{p}$ is given by,*

$$\bar{p} = \frac{\gamma}{\theta\beta + (1-\theta)\gamma}. \tag{17}$$

*Proof.* Differentiating Eq. (16) with respect to $\tau$, gives

$$\frac{\delta s}{\delta \tau} = \frac{1}{1-\alpha}\left(\frac{(1-p\tau)\phi\gamma}{\gamma(1-\tau)+(\beta-\gamma)\theta}\right)^{\frac{\alpha}{1-\alpha}}\left(\frac{-p\phi\gamma(\gamma(1-\tau)+(\beta-\gamma)\theta)-(1-p\tau)\phi\gamma(-\gamma)}{(\gamma(1-\tau)+(\beta-\gamma)\theta)^2}\right)$$

For $\frac{\delta s}{\delta \tau} > 0$, the term within the second set of brackets on the right hand side must be positive, or, $1 - p\tau > p((\gamma(1-\tau)+(\beta-\gamma)\theta)$ which implies $p < \frac{\gamma}{\theta\beta+(1-\theta)\gamma}$. □

From equation (17), $\bar{p}$ depends negatively on FD implying when FD is low (high) the threshold level of enforcement beyond which the relationship between tax and informality becomes negative is high (low). The intuition is as follows; When enforcement is low, an increase in the tax rate raises the cost of operating formally relative to the informal sector given that the former's actual tax payment rises relative to the expected tax payment of the latter. Thus informal employment and output grow relative to the formal sector.

At a higher $p$, however, responsiveness of informal production to a tax rate increase is dampened since the expected tax rate of this sector, $p\tau$ increases more with taxes. When $p$ is at or close to $\bar{p}$, tax rates have no effect on informality and beyond $\bar{p}$, the increase in the expected tax payment of the informal sector is large enough that the same increase in the tax rate causes informal employment and output to fall relative to the formal sector.

When FD is higher, the marginal product of labor of formal firms is higher (see equation 3) and this sector increases their borrowing in order to invest in the wage bill, so their demand for labor rises. This effect of FD implies the formal sector's labor demand and output falls less with a tax rate increase when FD is higher. As formal employment and output falls less with taxes, the wage rate falls less as well causing hiring by the informal sector and their output to increase less in turn. Thus when FD is higher, the informal sector's incentive to expand is lower so there is less reallocation of labor from formal to informal sectors with a tax rate hike. In other words, FD weakens the positive relationship between tax and informality. As explained above an increase in $p$ also works by dampening the positive tax-informality relationship. At higher FD, the existing (positive) tax-informality relationship is weaker to begin with, implying, a smaller increase in enforcement is required to clear the threshold, $\bar{p}$, beyond which informality falls with the tax rate.

# 5. Quantitative Analysis

In this section we calibrate the model to Brazil and quantitatively analyze the results of the model.

## 5.1. Calibration

The time period is a quarter. I set the discount factor of the households to $\beta = 0.975$ corresponding to a quarterly interest rate of 2.5% or an average annual interest rate of 10% between 2000-2005 (Segura-Ubiergo, 2012). The entrepreneurs' discount factor, $\gamma = 0.70$, is set lower than values commonly used in the literature on collateral constraints (for example Iacoviello (2008) and Iacoviello and Neri (2010)). A lower $\gamma$ ensures that $\bar{p}$ varies over a wider range with changes in FD, however, the results go through with higher $\gamma$'s as well.

Following Aoki et al (2009), I set the Frisch elasticity of labor to $\eta = 3$. Labor's income share is set to $\alpha = 0.68$. The productivity ratio, $\phi = A_2/A_1 = 0.70$, lies within the range calculated by La Porta and Shleifer (2008). The benchmark FD, $\theta = 0.48$, is the average of the World Bank's measure of domestic credit to the private sector as a % of GDP, for Brazil between 1990-2013. It is described as a measure of "financial resources provided to the private sector by financial corporations". The tax rate, $\tau = 0.33$, is the average revenue to GDP ratio for Brazil between 1990-2012 obtained from the OECD database for Latin America.

The volatility of the aggregate productivity shock, $\sigma$ is set to 0.016 to account for the higher volatility of emerging market business cycles (Aguiar and Gopinath (2007), Neumeyer and Perri (2005)). The persistence of the shock is set to the standard value of $\rho = 0.95$.

## 5.2. Quantitative Analysis

| $\theta$ | $\bar{p}$ |
|---|---|
| 0 | 1 |
| 0.25 | 0.93 |
| 0.45 | 0.88 |
| 0.75 | 0.81 |
| 1.1 | 0.75 |
| 2.0 | 0.625 |

Table 3: Values of $\bar{p}$ for different FD ($\theta$).

Table 3 displays the values of $\bar{p}$ for different levels of FD as implied by equation (17). As FD goes from 0, implying entrepreneurs cannot borrow at all, to a high of 2, consistent with a credit limit of 200% of the entrepreneurs' income (observed in the developed country group), $\bar{p}$ falls from 1 to 0.625.

Figure 3 plots the tax-informality relationships for different levels of enforcement across a range of FD. At lower levels of enforcement, the model generates a positive relationship between tax and informality (the ratio of informal to formal output). The positive relationship is especially strong when FD is low as well. However at higher levels of FD considered, the levels of enforcement at which the tax-informality curves become negatively sloped is lower.

A visual comparison of panels (a) through (d) of Figure 3 shows that FD lowers both the mean and the spread of the tax-informality curves across the different levels of $p$. Specifically, FD not only shrinks the size of informal output but also causes informality

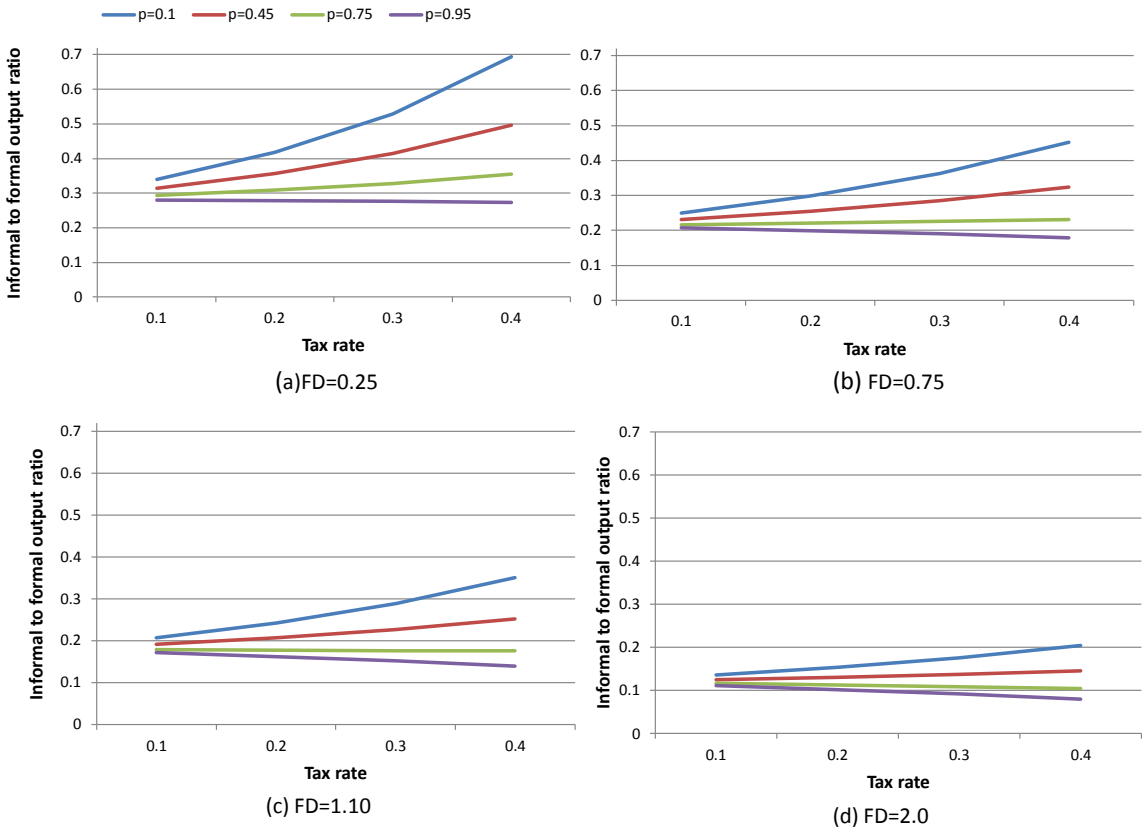


Figure 3: Changes in informal to formal output ratio with tax rates for different levels of enforcement and FD.

to rise less with the tax rate for any given level of enforcement. When $FD = 0.25$, in panel (a) of Figure 3, at the lowest enforcement of 10% (the blue line), a tax rate of 20% corresponds to a relative informal sector size of 42%. As the tax rate is increased to 30%, informality rises to 53%, an increase of 27%. The same increase in the tax rate, for the same enforcement level causes a much lower increase in informality in panel (b), where $FD = 0.75$. Now informality goes from 30% to 36%, an increase of 21%. Thus FD reduces both the level of informality and its response to a tax rate hike.

When enforcement is high enough, in Figure 3, the tax-informality relationship switches sign and turns negative. In order to see the change in slopes more clearly, Figure 4 plots the percentage changes in informality brought about by a tax rate change for the same

levels of enforcement and FD considered in Figure 3. Specifically, in Figure 4, all the tax-informality curves of Figure 1 are normalized to begin at 100 in order to facilitate a comparison of their slopes.

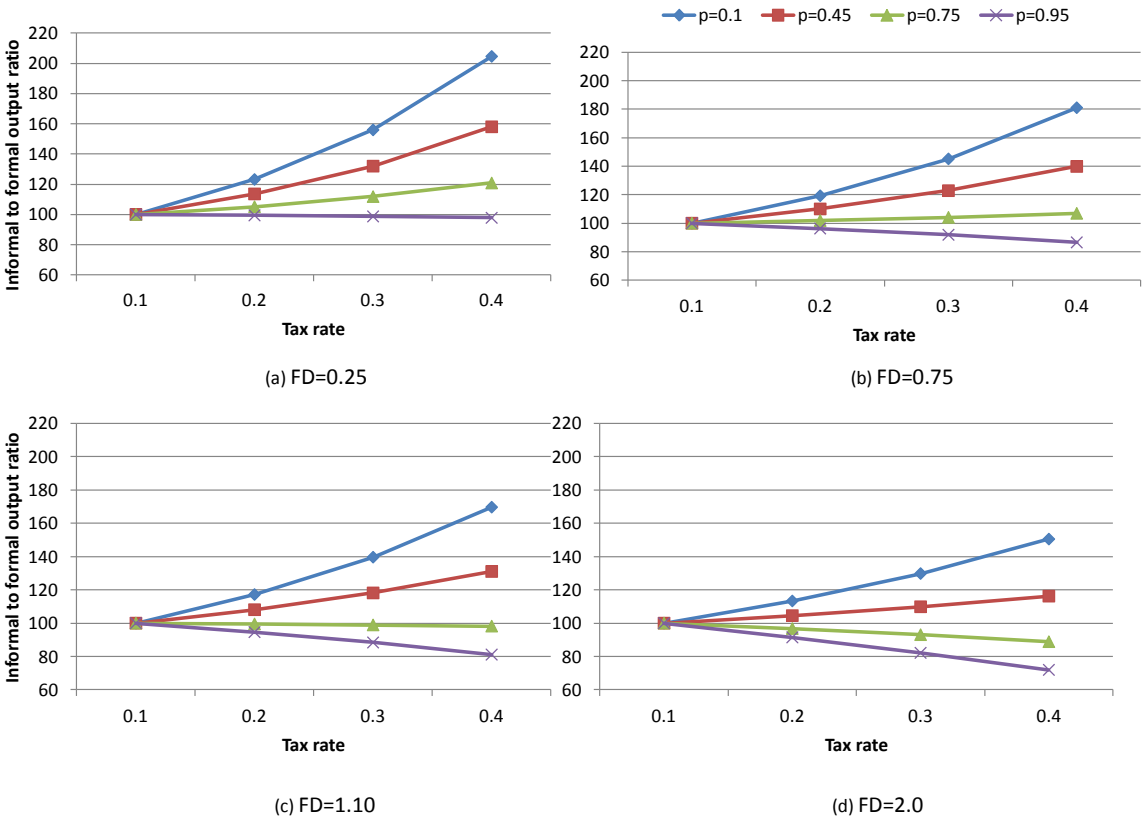


Figure 4: Percentage changes in informal to formal output ratio with tax rates for different levels of enforcement and FD. Initial value of each curve in Figure 1 is indexed to 100.

A comparison, of all four panels of Figure 4 shows that as FD progresses, the slopes of the positive tax-informality curves fall at lower levels of $p$, and beyond $\bar{p}$ the slopes (and the number) of the negatively sloped curves increase. When FD is only 25%, the tax-informality relationship turns negative beyond a high $\bar{p} = 0.93$ according to Table 3, such that in panel (a) of Figure 4, only at $p = 0.95$ does the tax-informality curve become downward sloping, although the effect is negligible. However, at a much higher FD of 110% the relationship becomes negative beyond $p = 0.75$ as indicated by Table 3 and therefore in panel (c) of Figure 4, the tax-informality curve becomes very slightly

downward sloping at $p = 0.75$ but discernibly so by the time $p$ reaches 0.95. Finally, when FD is 200%, representing an economy that is highly financially developed, the tax-informality relationship is negative for any $p$ beyond the $\bar{p} = 0.625$ according to Table 3. In panel (d) of Figure 4, therefore, the tax-informality curves are strongly downward sloping both at $p = 0.75$ and $p = 0.95$.

## 5.3. Sensitivity analysis

How does $\bar{p}$ change across countries? From equation (17), the only parameter that $\bar{p}$ depends on, other than the policy variable $\theta$, is the ratio $\beta/\gamma$. Holding $\gamma$ constant, we vary this ratio by changing the values of $\beta$[2]. Recall $\beta$ is given by the inverse of the gross real interest rate and the latter differs across countries.

Table 4 reports the quarterly real interest rates in a selected group of countries encompassing both developed and developing economies, and the corresponding values of $\beta$ for the year 2004[3]. The column $\theta$ reports the level of financial development given by the private credit to GDP ratios in these economies during the same year and the final column reports the model generated values of $\bar{p}$ given the country-specific values of $\beta/\gamma$ and $\theta$. Real interest rate data are from the World Bank website. All other data sources are the same as in Section 2.

[2] I am not aware of any cross-country studies of $\gamma$.

[3] I choose this year since it lies near the middle of the time period considered in our correlation analysis of Section 2 (1999-2007).

| Country | $r$ | $R$ | $\beta$ | $\theta$ | $\bar{p}$ |
|---|---|---|---|---|---|
| India | 1.23 | 1.01 | 0.987 | 0.36 | 0.87 |
| Italy | 0.73 | 1.007 | 0.993 | 0.68 | 0.78 |
| Spain | 0.045 | 1.0005 | 0.999 | 0.99 | 0.70 |
| South Africa | 1.12 | 1.011 | 0.988 | 1.27 | 0.656 |
| Denmark | 1.16 | 1.012 | 0.989 | 1.42 | 0.63 |
| United Kingdom | 0.36 | 1.004 | 0.996 | 1.45 | 0.62 |

Table 4: Enforcement threshold $\bar{p}$ for country-specific values of $\theta$ and $\beta$. $r$ is the quarterly real interest rate while $R$ is its gross value. All values are for 2004 except Spain and Denmark for which 2002 values are reported since this was the latest date for which interest rate data was available for these countries.

The countries in Table 4 are arranged in increasing order of FD ($\theta$) and as in our earlier quantitative analysis, we find that $\bar{p}$ decreases as $\theta$ rises, only in this case, $\beta$'s are changing too, since we take into account country-specific interest rates.

Although $\beta$ does not vary by much across countries in Table 4, from equation (17), it can be shown that the ratio $\beta/\gamma$ is negatively related to $\bar{p}$. Thus a rise in $\beta$ holding $\gamma$ constant should lead to a lower $\bar{p}$ all else equal. In Table 4 this implies that between Spain and Denmark, for instance, Denmark enjoys a lower $\bar{p}$ than Spain due to the former's more developed financial markets. However, Spain has a higher $\beta$ than Denmark, implying Spain's $\bar{p}$ is lower than it would have been if it had the same $\beta$ as Denmark.

The intuition is that a higher discount factor implies households value the future more relative to the entrepreneurs or the degree of patience of households increases further relative to the entrepreneurs. This implies households are willing to save more thus making more funds available in the economy for borrowing for the same level of FD. In

other words, at higher $\beta$ more debt is available as a fraction of formal output making formal production more lucrative, which, all else equal, makes for a lower enforcement threshold. FD however, is by far the bigger influence on $\bar{p}$.

The results of this and the previous section imply, economies with both well developed domestic financial markets and better enforcement mechanisms in place can generally enjoy a negative relationship between tax and informality while the opposite is true for economies with poorer financial markets and lax enforcement. From Section 2, developed economies have much better enforcement and higher levels of FD on average, compared to developing economies which have poorer enforcement mechanisms and underdeveloped financial markets making the latter more prone to experiencing the non-negative relationship between tax and informality documented in the same section. Furthermore, given the strong positive correlation between enforcement and FD in Section 2, for both country groups, the tradeoff between an enforcement threshold and FD, implied by equation (17) above, becomes more relevant as countries become more developed.

## 5.4. Discussion

The threshold values of enforcement obtained in Sections 4.2 and 4.3 above may seem quite high still especially for the higher levels of FD considered. However, recall that $p$ includes both the probability of audit and a penalty for evading which is usually greater than 1. For example, the enforcement threshold given by Table 3, of 0.63 at $FD = 2$, can be generated using a probability of audit of 35% and a penalty of 1.8 times the tax evaded. Similarly, a 40% probability of being detected and a penalty of 2 times the tax payable, implies an enforcement level of 0.8 while, even with a 25% probability of being

detected, a penalty of three times the tax rate, gives rise to an enforcement level of 0.75. These numbers are not far from what is observed in the data or reported in the literature. Prado (2011) backs out, using his model, the enforcement levels implied for a group of countries, given their informal sector size and tax and regulation costs. The enforcement numbers that emerge for high-tax, financially well developed economies (like Austria, Denmark, Sweden and France) are very close to the values reported for $\bar{p}$ in Table 3 above, for levels of FD between $100 - 200\%$. In my sample of developed economies, the highest level of FD is 327% for Luxembourg - which would correspond to $\bar{p} = 0.51$ in the calibrated model.

In Brazil, the country to which the model is calibrated, tax evasion may be considered a crime and get reported to Ministerio Publico. In this case, the penalty for tax evasion, according to the Brazilian Constitution varies from six months to two years of detention and requires a fine that varies from 2-5 times the amount of tax to be paid. Prado (2011), however, generates an enforcement level for Brazil, that is around 43%. Given the high penalties for evasion, this would imply a very low probability of audit (between 9-20% for associated penalties of between 5 and 2 times the tax rate). Given that Brazil's financial markets are not as highly developed (World Bank's private credit to GDP ratio for Brazil is 69% for 2014), an enforcement level of 43% would be much below the threshold implied by equation (17) indicating a positive relationship between tax and informality in Brazil.

Brazil recently instituted the National Plan to Combat Informality (Plancite), in May 2014, which includes among other things, stepping up visits by inspection teams to the private sector to detect informality, and increasing the fines of violators. Given Brazil's large informal sector and poor state of public finances, this seems to be a step in the right direction. Especially if Brazil were to raise taxes, in light of our results, a higher degree

of enforcement is imperative in order to prevent pushing an even larger share of economic activity into the informal sector. However, the present paper also suggests that Brazil should pay equal attention to developing its largely bank-based financial markets. Bank lending spreads in Brazil are about five times the OECD average which according to the OECD survey (2011) on Brazil, are symptoms of a poorly functioning financial system and increases the cost of capital. According to this paper, developing Brazil's domestic financial markets will increase the capacity and growth of the formal sector which will raise the demand for formal labor contributing to higher market wages and making it difficult for the informal sector to hire workers and grow even if taxes rise or enforcement levels fall.

# 6. Productive government expenditures

Following Barro's (1990) seminal paper there has been a lot of work on the role of productive public expenditures in economic growth. In my model so far, government expenditures are assumed to be wasteful. In this section I allow for productive government expenditures in an alternative formulation of government spending to check whether such an inclusion affects in any way the characterization of the enforcement threshold in Section 4. Specifically, I assume that government expenditures enter the production functions of entrepreneurs as follows,

$$y_{i,t+1} = A_{i,t} G_{i,t}^{\zeta} l_{i,t}^{\alpha}.$$

$i = \{1, 2\}$ stand for formal and informal entrepreneurs respectively and $G$ is the amount of public services available to each sector. Following Loayza (1997) I assume that the amount of public services available to the informal sector is lower than the formal sector. More specifically, $G_{2,t} = \delta G_{1,t}$, where $\delta < 1$[4]. Notice that the assumption of a less productive informal sector relative to the formal sector implies that in addition to labor, public services are also less productive in the former. This is similar to Zhang (2015) who shows that disproportionate effects of public expenditures on different sectors play an important role in the structural change of an economy as government spending grows endogenously.

Entrepreneurs' and the households' solve the same problems as in Section 3. Of the total tax revenue, $T = \tau y_{1,t} + p\tau y_{2,t}$, collected by the government, now a fraction, $G_t = \psi T_t$ is productive while the rest, $g = (1 - \psi)T$, is not. The first order conditions with respect to labor in the two sectors are given by,

$$w_t \frac{1}{c_{1,t}} = (\gamma \frac{1}{c_{1,t+1}}(1 - \tau) + \lambda_1 \theta)\alpha A_t G_t^{\zeta} l_{1,t}^{\alpha-1} \tag{18}$$

$$w_t \frac{1}{c_{2,t}} = (\gamma \frac{1}{c_{2,t+1}}(1 - p\tau))\alpha \phi A_t \delta G_t^{\zeta} l_{2,t}^{\alpha-1} \tag{19}$$

Equations (10) and (11) are the equivalent of equations (3) and (4) in Section 3. Note that the amount of public services used by each sector now matter for the amount of labor demanded in the respective sectors. Thus public services directly affect the labor demand of formal and informal sectors. Proceeding as in Section 4, I calculate the steady

[4]Results do not change if we assume instead that only formal sectors have access to public services as in Elgin (2015).

state allocation of labor across sectors which in this case is given by,

$$s' = \left( \frac{(1-p\tau)\phi\delta^{\zeta}}{(1-\tau)+\frac{(\beta-\gamma)\theta}{\gamma}} \right)^{\frac{1}{1-\alpha}}. \tag{20}$$

The relative size of the informal sector that emerges from equation (12) is now a direct function of the share of public services in use by the informal sector, $\delta$. The intuition is that there is an added benefit to being informal in this economy which comes in the form of free public services. In other words, informal firms do not pay taxes but enjoy the productivity arising from the use of tax-paid public services, which makes them better off than when there were no productive government spending in the economy. The larger the share of public services available to informal firms relative to the formal sector, the greater the gain from informality and larger the informal sector's size.

Since the focus of my investigation is not what determines the informal sector but what influences the tax-informality relationship, I differentiate, as in Section 4, the new steady state allocation of labor $s'$ in equation (12) with respect to the tax rate, $\tau$, to obtain

$$\frac{\delta s'}{\delta \tau} = \frac{1}{1-\alpha} \left( \frac{(1-p\tau)\phi\gamma\delta^{\zeta}}{\gamma(1-\tau)+(\beta-\gamma)\theta} \right)^{\frac{\alpha}{1-\alpha}} \left( \frac{-p\phi\gamma\delta^{\zeta}(\gamma(1-\tau)+(\beta-\gamma)\theta)-(1-p\tau)\phi\gamma\delta^{\zeta}(-\gamma)}{(\gamma(1-\tau)+(\beta-\gamma)\theta)^2} \right)$$

From above, for $\delta s'/\delta\tau > 0$ it must be that

$$(1-p\tau)\phi\gamma^2\delta^{\zeta} > p\phi\gamma\delta^{\zeta}(\gamma(1-\tau)+(\beta-\gamma)\theta)$$

or,

$$p < \frac{\gamma}{\theta\beta + (1-\theta)\gamma}$$

which implies $\bar{p} = \frac{\gamma}{\theta\beta+(1-\theta)\gamma}$. This is the same enforcement threshold as in equation (17). Thus how productive government expenditures are do not matter for the value of $\bar{p}$ in this economy. It does matter, however, for the relative size of the informal sector.

# 7. Conclusion

Reducing informality is a common goal of policy in developing economies with their large informal sectors. The benefits of a smaller informal sector range from higher productivity, greater competitiveness and more tax revenue for the government to more micro-level gains such as better access to finance, better working hours, more unemployment insurance coverage and generally improved working conditions. Thus understanding the determinants of informality has become an important goal for academics and policy makers as evidenced by the burgeoning research in this area. This paper contributes to this agenda by exploring the link between taxation and informality.

I argue that this relationship depends importantly on the level of development of an economy's enforcement and credit market institutions. In other words, the diverse quality and level of tax enforcement and financial markets contribute to the contrasting effects of tax rates on informal sector sizes across developed and developing economies with informality rising with taxes in the former and falling with taxes in the latter. In a two-sector dynamic general equilibrium model with borrowing constraints, I show that there is a threshold level of tax enforcement below which informality and tax rates are positively related and above which they are negatively related. This enforcement threshold in turn depends

negatively on the degree of financial development in the economy. Enforcement works by raising the expected cost of production in the informal sector through a combination of higher probability of detection and stricter punishment while FD works by raising the actual cost of informal production due to a higher competitive market wage. When FD is higher, enforcement has to rise less before the informal sector is affected negatively by the tax rate giving rise to a lower enforcement threshold. Productive government expenditures do not play a role in the determination of the enforcement threshold but it matters for the size of the informal sector itself. How would this last prediction change if tax enforcement was costly? Intuitively, if higher enforcement entailed a greater cost in terms of tax revenues, an increase in enforcement would cause productive government expenditures to fall making less public services available to the formal (and informal) sector. This would mean a relative detrimental effect of higher enforcement on the formal sector since this sector is the main beneficiary of public services. Also, what happens if the formal sector is allowed to default? In this paper we do not learn the answers to these questions. These are, however, interesting questions for future research.

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