

# Political Turnover, Taxes and the Shadow Economy\*

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## Abstract

Several cross-section empirical studies argue that a higher tax burden or different indicators of statutory tax rates are associated with a smaller informal economy. I show that the turnover of governments provides the key to understanding this relation. To this end, I present evidence that once political turnover is controlled for, the data shows no association between the tax burden and the size of the informal economy. This result is empirically robust in a panel data consisting of 80 countries and 5 years. To account for this observation, I develop a dynamic political economy model with two political parties alternating in office. In equilibrium, if the incumbent party faces a higher probability of staying in office, it sets a higher tax rate to invest more in productive public capital, while spending less for current office rent. I argue that public capital is mainly utilized by the formal sector and this implies that countries in which incumbent parties are more likely to stay in power, have a higher tax burden but a smaller informal sector. Finally, I compare the model against the data and present evidence that my theory is consistent with empirical observations.

**Keywords:** tax evasion, informal sector, political turnover, Markov-perfect equilibrium

**JEL Classification Numbers:** E26, H26, O17

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# 1 Introduction

## 1.1 Motivation

Several cross-section and panel data empirical studies associate higher tax rates with a smaller informal economy<sup>1</sup>. Examples of such studies are Johnson et. al. (1997, 1998), Friedman et. al. (2000), and more recently Torgler and Schneider (2007)<sup>2</sup>. Graphically, plotting informal sector size vs. tax burden, corporate tax rate, average labor income tax rate, or top marginal income tax rate<sup>3</sup> in a cross-section clearly indicates a negative relationship between these variables.

In this paper, I first employ cross-section, static and dynamic panel data techniques to show that the negative relationship between various measures of tax rates and the size of the informal sector is significant and robust. Moreover, the econometric analysis also explores what factors might have caused it. To this end, I present evidence that once political turnover is controlled for, the data shows no significant association between tax rates or tax burden and the size of the informal economy. Next, building upon the empirical analysis, I develop a dynamic political economy model to account for this observation. In the model, the government that lacks the ability to commit to future policy choices uses taxes on capital and labor income of the formal sector to finance the provision of a productive public capital and some office rent. The government is not fully benevolent and also gets utility from some office rent, the amount of which is chosen by the incumbent government. Then I introduce political frictions to the model, specifically by allowing two political parties to alternate the office with

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<sup>1</sup>Informal economy or informal sector, sometimes also called as shadow, hidden or underground economy is defined by Hart (2008) as a set of economic activities that take place outside the framework of bureaucratic public and private sector establishments. Another paper by Ihrig and Moe (2004) defines it as a sector which produces legal goods, but does not comply with government regulations.

<sup>2</sup>More recently, Aruoba (2009) also documents a negative correlation between taxes and the size of the informal economy.

<sup>3</sup>At this point it may be important to emphasize the distinction between the tax burden and various statutory tax rates. Tax burden is defined as the ratio of total tax revenues to GDP and one might suspect that the negative relation between the tax burden and the informal sector may arise simply because a larger informal economy implies a smaller tax base, thereof a lower level of tax revenue. However, considering that only imperfect estimates of the informal economy are included in the national income calculations, a larger informal economy also implies a lower level of official GDP. Moreover, as the empirical analysis in the next section clearly shows, the negative relation is also evident between various statutory tax rates and the size of the informal sector.

some exogenous probability (i.e. Incumbency follows a simple Markov chain.), and focus on the symmetric differentiable (interior) Markov perfect equilibrium of this environment. In equilibrium, if the incumbent party faces a higher probability of keeping the office (i.e. the lower the political turnover), it has higher stakes in the future (because probability of enjoying future office rent is higher) and it values future output more. Therefore, it charges a higher tax rate today on the formal sector to invest more on productive public capital, while spending less for current office rent. This result is based on the fact that a higher probability of keeping the office next period (i.e. the incumbent gets more certain of its tenure) changes the marginal rate of substitution between future office rent and current office rent and therefore the incumbent spends less for the office rent today (i.e. steals less today) and invests more in the productive public capital of tomorrow. Even though the tax burden is higher, the tax revenue is increasingly used for the productive public good in the formal sector. This stimulates incentives for being formal and reduces the size of the informal sector. This result captures the main empirical findings of the above mentioned papers and my empirical analysis.

As described above, the model suggests that political frictions, more specifically political turnover affecting corruption (office-rent in my model's terms ) and the provision of a productive public capital in the formal sector are among the underlying causes of the negative relationship between taxes and size of the informal sector. In the last part of the paper, I compare the implications of the model against the data. Specifically, I take the exogenously given probability of reelection data from a recent paper by Brender and Drazen (2008), feed them into the model, and then compare various variables of interest generated by the model against their counterparts in the data. Once calibrated to match certain specific moments, the model performs quite well to account for the cross-country correlation between the tax burden and the size of the informal sector.

My paper is distinct in the growing literature on the informal sector. As opposed to the above mentioned empirical analyses, a common result in models dealing with an informal sector is a positive relationship between the level of tax rate and the size of the informal

sector. A non-exhaustive list of the papers in this literature include Rauch (1991), Loayza (1996), Fortin et.al (1997), Ihrig and Moe (2004), Busato and Chiarini (2004) and Amaral and Quintin (2006). This result seems to be intuitive because higher tax rates may create incentives for people to avoid them and one way of doing this is participating in the informal sector. Keeping taxes exogenous and letting the informal sector not paying any taxes (or letting it pay a smaller fraction than the formal sector), this result is also immediate in a two-sector neoclassical growth model with formal and informal sectors, where the variation in taxes is exogenous. An alternative theoretical possibility might be that a higher tax rate results from some institutional frictions (such as a low degree of tax enforcement) which may create a larger informal sector and therefore, a smaller formal sector tax base. Following this reasoning, in a two-sector environment with a benevolent government which taxes the formal sector to finance some exogenous stream of government expenditures, a Ramsey equilibrium features a positive relationship between tax rates and the size of the informal sector, i.e. a larger informal sector resulting due to some friction (i.e. lower tax enforcement, or lower productivity gap between the formal and the informal sectors) leads to a higher tax rate in the formal sector. So existing theoretical frameworks cannot account the somewhat surprising negative relationship between tax rates and the size of the informal sector.

Some of the above mentioned empirical papers indicating a negative relationship between tax rates and the informal sector deserve more discussion as they are more closely related to my paper.

Both Johnson et. al (1997) and Johnson et. al (1998) use different sets of countries in their empirical analyses; however, both end up with the conclusion that tax rates are negatively correlated with the size of the informal sector. Johnson et. al (1997) also provide a very simple model in which the only two stable equilibria of the model feature totally formal and totally informal economy. However, their model, contrary to their empirical findings, implies a positive relationship between the tax rates and the size of the informal sector. On the other hand, Johnson et. al (1998) claim that both administration of taxes and regulatory discretion are playing key roles in this result and once they take composite

indices of both tax rates and quality of tax administrations into account, they find that these indices are positively correlated with the size of the informal sector. However, the quality indices they use are largely based on subjective evaluations of certain experts and institutions and therefore prone to measurement errors and endogeneity issues.

Friedman et. al (2000) suggest that the positive correlation might have been caused by several institutional factors such as corruption and bureaucratic quality. Accordingly, these factors could let the businesses hide their activities from the government, which by reducing the tax revenues and harming the quality of public administration further reduces a firms incentives to remain formal. In their empirical study, they also find that increasing tax rates by one point implies that the share of the unofficial economy falls by 9.1%. Controlling for several variables and instrumenting on others reduces this number by half, but the negative tax coefficient remains significant. The conclusion of their empirical study is that this is probably because higher tax rates generate revenue that provides productivity enhancing public goods, a strong legal environment and low corruption. However, they only consider the production side of the economy and their highly stylized partial equilibrium model only focuses on the corruption part of the story.<sup>4</sup>

The modeling of public finance in my paper is related to the growing literature of Markov-perfect taxation models. Earlier work in this literature includes Cohen and Michel (1988) and Currie and Levine (1993). Later, Klein and Rios-Rull (2003) analyzed Markov-perfect labor and capital taxes in a model where the government can only commit to the following period's capital tax. More recently, Klein, Krusell and Rios-Rull (2008) and Martin (2009) study a model of public expenditure and characterize and solve for the equilibrium of the dynamic game between successive governments. As opposed to my work, none of the above mentioned papers have a political economy dimension or an informal sector.

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<sup>4</sup>In the next section of my paper I show that the negative correlation between taxes and informal sector remains significant, even after controlling for corruption. This suggests that corruption only does not explain this phenomenon.

## 1.2 Contribution of This Paper

This paper contributes mainly to the literature on informal economy and taxes, informal economy and corruption, and informal economy and productive public goods in three dimensions. First, noticing that most work done in these areas are empirical and lack a strong theoretical basis, this paper provides a general equilibrium model and fills in the theoretical gap in the literature with a novel mechanism. Second, to the best of my knowledge, this paper is one of the few attempts to utilize empirical results of a panel data set among the set of empirical papers on the informal sector. Lastly, this paper also contributes to the literature on optimal Markov-perfect fiscal policy by adding an informal sector and a political economy dimension to standard models of this literature.

## 1.3 Road Map

The rest of the paper is organized as follows: Empirical evidence indicating a robust negative relationship between taxes and the informal sector is provided in the next section. In this section, I also provide some empirical support to motivate the political turnover's role in the mechanism of the paper. Specifically, I empirically investigate what causes the negative relationship between taxes and the size of the informal sector. In section 3 the benchmark model is presented. Here, I first describe the environment and then define and characterize the competitive equilibrium. Next, given the competitive equilibrium, the symmetric differentiable Markov-perfect equilibrium is defined and characterized. Section 4 describes empirical implications of the model and then compare model simulations against the data. Lastly, section 5 concludes.

## 2 What Do Data Tell?

This section presents the relevant data and empirically investigates the relationship between the size of the informal sector and various measures of tax rates. In the first part of this section I show that the negative relationship between taxes and the size of the informal

sector is robust. Then in the second subsection I investigate what factor might be causing this surprising result and present empirical evidence to motivate the main mechanism of the model.

## 2.1 Taxes and the Informal Sector

This subsection investigates the relationship between different measures of taxes and the size of the informal sector. First, I describe the data and then present results of several econometric estimations.

### 2.1.1 Data

**Informal Sector Size:** The informal sector consists of economic activities that are not reported to the government statistical offices. Statistical offices usually try to estimate these activities in the unofficial economy; however, these estimations are imperfect by their nature. In the literature people used various methods to estimate the size of the informal sector in a given economy. One method is exploiting the fact that the short-run electricity-to-GDP elasticity is usually close to one and uses electricity consumption to estimate the informal sector size.<sup>5</sup> An alternative method is the MIMIC (multiple-indicator multiple-cause) approach<sup>6</sup> in which the size of the informal economy is estimated from observations of the likely causes and effects of the underground economy. Lastly, there is also the currency demand approach which is based on demand for cash-to-GDP elasticity, similar to the electricity consumption. Obviously, each method has its own advantages and disadvantages<sup>7</sup> the discussion of which is out of the scope of this paper. In this paper, I use panel estimates of Schneider (2007) running from 1999 to 2005<sup>8</sup> which combines a dynamic version of MIMIC with the currency demand approach.<sup>9</sup>

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<sup>5</sup>See Kaufman and Kaliberda (1996) for details of this method.

<sup>6</sup>MIMIC method is first suggested by Loayza (1996).

<sup>7</sup>See Tanzi (1999) and Schneider (2007) for a discussion.

<sup>8</sup>Schneider (2007) reports one estimate for two consecutive years, so the span of the time series is 5.

<sup>9</sup>See Schneider (2007) for details and superiority of this methodology to others and comparisons of various methods previously used to estimate the size of the informal sector.

## Taxes:

In the econometric estimations I use various measures of taxes to check the robustness of the analysis. One such measure is the tax burden data from the Government Finance Statistics (GFS) data of IMF.<sup>10</sup> I also use taxes on income, profits and capital gains (as percentage of GDP) from the World Development Indicators. Moreover, I also used the fiscal freedom indicator of the Heritage Foundation which is a composite index stemming from the top tax rate on individual income, the top tax rate on corporate income, and total tax revenue as a percentage of GDP. Yet another alternative source is the data on top marginal income tax rate from the Fraser Institute. The reported regression results mainly use the tax burden data from the GFS; however, the results do not change if one uses other types of taxation data from the above mentioned sources.<sup>11</sup> Notice that results also do not depend on whether one uses data on statutory taxes (main part of the Heritage Foundation's fiscal freedom index) or actual taxes, such as the tax burden data from GFS.<sup>12</sup>

To illustrate the negative correlation, figure 1 depicts the relationship between the informal sector size and tax burden in a cross-section. Figure 2 uses the ratio of revenue from taxes on income, capital gains and profits to the GDP on the x-axis. Moreover, figure 3 draws<sup>13</sup> informal sector size vs. the fiscal freedom index provided by the Heritage Foundation.<sup>14</sup>

One can also argue that a large (small) informal sector resulting in a small (large) formal sector; therefore, a small (large) tax base could lead to a low (high) level of tax revenue and therefore reduce (increase) the tax burden which makes the informal sector size and the tax burden to be negatively correlated. However, since the official GDP statistics include only imperfect estimates of the informal sector, a large informal sector also reduces the official GDP which is the denominator in the tax burden formula. Moreover, in case official GDP statistics include perfect estimates of the informal sector size I also check the correlation

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<sup>10</sup>Throughout this paper tax burden is defined as the ratio of total tax revenues to GDP.

<sup>11</sup>Estimation results using the various different tax data are available upon request.

<sup>12</sup>Also see Aruoba (2009) for a discussion.

<sup>13</sup>All figures use cross-section averages for 80 countries between the years 1999 and 2005. The list of these 80 countries is provided in appendix 6.4.

<sup>14</sup>Notice that the freedom index gets higher values when tax rates get smaller, therefore a positive correlation between the index and informal sector size is qualitatively equivalent to a negative correlation between taxes and the size of the informal sector.



between the informal sector size and a different measure of the tax burden, by dividing the total tax revenue not by GDP but instead to GDP subtracted by the total informal sector size. The correlation between this measure of the tax burden and the size of the informal sector is  $-0.46$ . This indicates that the negative correlation between the tax burden and the size of the informal sector does not arise from a variable tax base depending on the size of the formal sector.

### **Other variables:**

In the regression analysis I also use several control variables, such as GDP per-capita, corruption and bureaucratic quality. I got the data for GDP per-capita from the Groningen Economic Growth and Development Center. For corruption, I use corruption index data both from Transparency International and Political Risk Services (ICRG).<sup>15</sup> Similarly, the measure of bureaucratic quality is obtained from ICRG, too. These three variables are the ones extensively used in the empirical literature on the causes of the informal sector.

### **2.1.2 Estimation and Results**

There are a number of studies analyzing the empirical relationship between taxes and the size of the informal sector. In certain studies, especially those who do not control for variables measuring institutional quality, found some empirical support suggesting a positive relationship between taxes and the shadow economy. Schneider and Enste (2000) provide an excellent review of this empirical literature.

However, other empirical studies such as Johnson et.al. (1998), Friedman et.al (2000), Kucera and Xenogiani (2009) revealed that, once institutional quality is taken into account, the size of the informal sector and various measures of tax rates are negatively correlated.

To check the robustness of the negative relationship evident in figures 1, 2 and 3, I run a number of regressions using different explanatory variables.

In the static panel data analysis<sup>16</sup>, the estimated equations are of the following form:

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<sup>15</sup>Reported results use data from ICRG, however using Corruption Perceptions Index from Transparency International do not change the results of the estimations.

<sup>16</sup>I also report results of a cross-section estimation using the 5-year averages of the panel data.

$$IS_{i,t} = \beta_0 + \beta_1 tax_{i,t} + \sum_{k=2}^n \beta_k X_{k,i,t} + \theta_i + \gamma_t + \epsilon_{i,t}$$

where  $X_{k,i,t}$  are the other explanatory variables in addition to taxes and  $\theta_i$ ,  $\gamma_t$  are the country and period fixed effects, respectively. Moreover  $IS_{i,t}$  is the size of the informal sector relative to GDP and  $tax_{i,t}$  is the tax rate. Notice that, when I include institutional variables such as corruption, and bureaucratic quality in  $X_{k,i,t}$  (and to some extent even the GDP per-capita) the estimation may become prone to endogeneity issues. Therefore, I also redo the estimation using instrumental variables, namely latitude (Hall and Jones (1999)), an indicator variable for presidential vs. parliamentary regimes (Lederman et. al. (2005)), an indicator variable for transition countries, and indicator variables for the legal system (La Porta et al. (1999)).

One should also notice that, in addition to the cross-country pooled regression and the static panel data analysis, I also perform a dynamic panel data analysis in which I use one-period lagged value of the informal sector size as an additional independent variable. Specifically, I estimate the following equation:

$$IS_{i,t} = \beta_0 + \beta_1 tax_{i,t} + \beta_2 IS_{i,t-1} + \sum_{k=3}^n \beta_k X_{k,i,t} + \theta_i + \gamma_t + \epsilon_{i,t}$$

Static panel data models and their estimators do not take the serial correlation, heteroscedasticity and endogeneity problems that may occur in such dynamic models into account. To overcome these kind of problems, dynamic panel data model estimation techniques a la Anderson and Hsiao (1981) and Anderson and Hsiao (1982) can be used since they were first to develop an instrumental variables technique to estimate dynamic models. Then, as well known, Griliches and Hausman (1986), Holtz-Eakin et al. (1988) also developed similar estimators. These estimators use lagged values of the dependent variable as instruments in the differenced equations. They are consistent but generally not efficient since they do not take all restrictions on the covariances between regressors and the error term into account. To overcome this issue, Arellano and Bond (1991) developed a dynamic version of the gen-

eralized method of moments estimator. They argued that the estimators obtained through this method are also efficient since this method is based on using additional instruments (lagged values of the dependent variables and other explanatory variables) which satisfy the orthogonality conditions.

All the results of the above described estimations are presented in table 1. First column presents the cross-section regression results whereas second, third and the fourth columns show the fixed effect panel data regression outputs. In column 5 I report the results of the IV estimation and lastly in the sixth column I present the results of the dynamic panel data analysis using the above discussed Arellano-Bond GMM estimation. The results indicate that that negative relationship between the tax burden and the size of the informal sector is quite robust. Moreover, in table 2, analogous to table 1, I report the results when I use the fiscal freedom index, instead of the tax burden. Notice that the fiscal freedom index is an index which gets smaller as statutory taxes increase. So positive sign of its coefficient is expected. In addition to these estimations, I replicate the same analysis using a measure of tax burden which I obtain by dividing total tax revenue by GDP subtracted by the total informal sector size. Signs of the coefficients do not change and t-statistics become even larger. Moreover, suspecting that the tax burden might be endogenous with respect to the size of the informal sector, I also run a system estimation using 3SLS which doesn't show any evidence against the negative correlation.<sup>17</sup>

## 2.2 Do the Data Tell More?

The previous subsection presented results indicating a negative relationship between tax rates and the size of the informal sector. The model I present in the next section to account for this phenomenon relates this finding to political frictions, specifically to the varying degree of political turnover in different countries. As briefly discussed in introduction, the model implies that countries in which the political turnover is high, the level of tax burden is low. However, tax revenues are mainly wasted due to corruption which makes the level of

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<sup>17</sup>Results of further econometric analysis are available upon request.

productive public investment also low. This leads to a larger informal sector. This subsection provides empirical evidence to support this argument, i.e. investigates political turnover's role in results of the previous subsection.

### 2.2.1 Data

#### **Political Turnover:**

In addition to the control variables used in the previous subsection, here I include a measure of political turnover among the independent variables. Specifically, I use two measures of political turnover. One is the probability of reelection index developed by a recent paper by Brender and Drazen (2008) using election data from a large number of countries. Another measure is obtained from ICRG's political stability index<sup>18</sup> which is a composite measure for government unity, legislative strength and popular support.<sup>19</sup>

### 2.2.2 Estimation and Results

The estimations here aim to test the following hypothesis: Political frictions play an important role in the composition and the level of public finance. The estimations investigate the role of political stability as the key frictions. The idea is that, if the political stability is higher, in other words the incumbent is more certain that it will stay in the office, it will direct more of the tax revenues for productive public investment and less for wasteful government spending, specifically office rent and corruptive activities. Even though, the overall tax rate increases due to increasing political stability, the change in the composition of public spending makes the formal sector more attractive for households.

The hypothesis above predicts that a higher political stability (or probability of reelection) is associated with lower level of corruption, higher level of productive government spending, higher tax burden and also a smaller shadow economy. In this section, I provide

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<sup>18</sup>When using the political stability index I also use the level of democracy index from Polity IV database among the control variables.

<sup>19</sup>Probability of reelection database is available for 58 countries of 80 countries in my informal sector dataset. Also, it is only a cross-section data whereas the political stability index of ICRG is a yearly panel and available for all the 80 countries from 1999 to 2005.

some empirical evidence for these predictions.

The results of this section's analysis are presented in different panels of the tables 3 and 4. The first column, Pooled 1, reports the cross-section regression results with probability of reelection as a measure of political stability. Other columns use ICRG's political stability index instead. First, in table 3, I use tax burden as the dependent variable and estimate several equations with it. The estimations support the hypothesis, namely the positive relationship between the tax burden and political stability. Next, I estimate the relationship between corruption and political stability. Results support the hypothesized negative relationship. Moreover, political stability also seems to be positively correlated with GDP per-capita. Lastly and most importantly, in table 4 I investigate the relationship between the informal sector size and political stability using different equations and estimation techniques. According to the empirical analysis, informal sector size and political stability seem to be negatively correlated. Moreover, once political stability or probability of reelection are controlled for, the correlation between the tax burden and the informal sector size, even though negative, ceases to be significant. To close the order of the logic it would be nice to get some results on the relationship between productive public spending and political stability. Unfortunately, since there isn't any widely accepted way of distinguishing between productive and wasteful public spending in the data, I cannot report any results about this. However, there are some empirical studies supporting the logic of my paper.<sup>20</sup>,

### 3 Model

In this section I present the model of the paper. First, I describe the general environment and define the competitive equilibrium. Then, I describe the Markovian environment, define a politico-economic (symmetric, differentiable, interior Markov-perfect) equilibrium and characterize it. Next, I provide and discuss the analytical solution in a simplified envi-

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<sup>20</sup>Kneller et.al. (1999) distinguish between productive and unproductive expenditures in a government spending database of a subset of OECD countries and conclude that productive government spending is positively associated with income and growth. Fiva and Natvik (2009) come to a similar conclusion using local data from Norway. Also, Mauro (1998) finds evidence that corruption is negatively associated with productive government spending.

ronment. Lastly, I briefly discuss an extension of the benchmark model.

To study the relationship between taxes and the size of the informal sector, I use a two-sector growth model with public investment. In this economy, there is a unit measure of households and a government.

### 3.1 Households

Households can divide their labor endowment between two sectors: formal and informal. These two sectors produce a single non-storable consumption good. Specifically, a stand-in household maximizes the following discounted utility from consumption<sup>21</sup>:

$$\sum_{t=1}^{\infty} \beta^{t-1} U(c_t)$$

subject to the following budget constraint

$$c_t + k_{t+1} - (1 - \delta_k)k_t = r_t k_t (1 - \tau_{k_t}) + w_{ft} n_{ft} (1 - \tau_{n_t}) + y_{it}(n_{it})$$

and the time constraint

$$n_{ft} + n_{it} = 1$$

where  $n_{ft}$  is the amount of time the household spends in the formal labor market, and  $n_{it}$  in the informal labor market. Labor and capital income in the formal sector are taxed at rates  $\tau_{k_t}$  and  $\tau_{n_t}$  respectively. Moreover  $r_t$  and  $w_{ft}$  stand for the rental rate of capital and formal wage rate respectively.  $y_{it}(n_{it})$  represent the informal sector income. Lastly,  $\delta_k$  is the depreciation rate for private capital. The budget constraint suggests that a household has 3 sources of income: Labor and capital income in the formal sector net of taxes (the first two terms on the right hand side of the budget constraint) and income from the informal sector. Hence, given  $k_1, \{r_t, w_t, \tau_{k_t}, \tau_{n_t}\}_{t=1}^{\infty}$  the representative consumer's problem can be written

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<sup>21</sup>In the benchmark model, I assume that leisure is not valued. Since adding leisure involve no significant changes in the main results at the expense of much more notation, I decided not to include the extension in this version of the paper. However, I shortly discuss the implications of relaxing this assumption at the very end of this section.

as:

$$\max_{c_t, k_{t+1}, n_{ft}} \sum_{t=1}^{\infty} \beta^{t-1} U(c_t)$$

subject to the following budget constraint

$$c_t + k_{t+1} - (1 - \delta_k)k_t = r_t k_t (1 - \tau_{k_t}) + w_t n_{ft} (1 - \tau_{n_t}) + y_{it}(n_{it})$$

and the non-negativity and time constraints

$$c_t, k_{t+1}, n_{it}, n_{ft} \geq 0$$

$$n_{it} + n_{ft} = 1$$

Simplifying the notation to save some space, one can obtain the following first-order conditions at an interior solution of the consumer's problem:

$$-U_{c_t} + \beta U_{c_{t+1}} (1 - \tau_{k_{t+1}}) r_{t+1} = 0$$

$$U_{c_t} (1 - \tau_{n_t}) w_{ft} - U_{c_t} w_{it} = 0$$

where  $w_{it}$  stands for the wage rate in the informal sector.<sup>22</sup>

## 3.2 Technology

Technology for each firm in the formal sector is given by

$$y_{ft} = f_1(k_t, n_{ft}, G_t)$$

$G_t$  stands for the productive public capital.

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<sup>22</sup>Moreover,  $U_{c_t}$  and  $U_{c_{t+1}}$  represent the derivatives of the utility function with respect to  $c_t$  and  $c_{t+1}$ , respectively.

On the other hand, I assume that each firm in informal sector produces according to the following decreasing returns to scale technology<sup>23</sup>:

$$y_{it} = f_2(n_{it})$$

Notice that the informal sector uses only labor as an input.<sup>24</sup>

### 3.3 Government

The source of uncertainty in the economy arises due to the following political structure: There are two political parties, party 1 and party 2, which can be in power at any  $t \geq 0$ . Technically, let the state of incumbency be defined at any period  $t$ , as  $z_t \in \mathcal{Z}_t = \{1, 2\}$ . I further assume that the uncertainty follows a Markov process, i.e. at the end of each period, the incumbent political party stays in the office with an exogenous probability of  $\rho$  or loses the office to the other party with probability  $1 - \rho$ , i.e.  $Pr(z_{t+1} = i | z_t = j) = \Pi_{ij} = 1 - \rho$  and  $Pr(z_{t+1} = i | z_t = i) = \Pi_{ii} = \rho$ , for  $i, j \in \{1, 2\}$

In other words,  $\Pi_{ij}$ , for  $i, j \in \{1, 2\}$  is defined by the following simple two-state Markov chain:

$$\Pi_{ij} = \begin{bmatrix} \rho & 1 - \rho \\ 1 - \rho & \rho \end{bmatrix}$$

One can interpret  $1 - \rho$  as the measure of the degree of political turnover.<sup>25</sup>

I also assume that the incumbent balances the government budget each period. In the budget there are two potential sources of revenue: Labor and capital income taxes from the formal economy. The incumbent party also chooses how much of this revenue to spend for productive public investment  $G_{t+1}$  and for the office rent  $S_t$ .<sup>26</sup> Hence, the government

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<sup>23</sup>Technically, I assume that  $\frac{\partial f_2}{\partial n_{it}} > 0$  and  $\frac{\partial^2 f_2}{\partial n_{it}^2} < 0$

<sup>24</sup>None of the results of the paper would change if I had allowed the informal sector use a lower share of public and private capital than the formal sector. The current setup however simplifies the environment a lot without affecting the basic results. Notice that, this simplifying assumption is also used in Loayza (1996).

<sup>25</sup>Alternatively  $\rho$  can be interpreted as the degree of political stability or probability of reelection. I use all these three terms interchangeably throughout the paper.

<sup>26</sup> $S_t$  can be interpreted as nonproductive public spending, office rent or embezzlement. This is why this



budget is given by:

$$r_t K_t \tau_{kt} + w_{ft} N_{ft} \tau_{nt} = S_t + G_{t+1} - (1 - \delta_g) G_t$$

where  $\delta_g$  is the depreciation rate of public capital,  $K_t$  and  $N_{ft}$  are the aggregate private capital and formal labor, respectively.

I further assume that the objective functions of the two political parties are symmetric, i.e. the period utility of the incumbent party  $i \in \{1, 2\}$  is given by

$$U(C_t) + U^g(S_t)$$

whereas the period utility of the opposition party is simply  $U(C_t)$ . Notice that, under this assumption, it doesn't matter for households whether party 1 or party 2 is in power at any period  $t$ , because the policy choice of each incumbent is symmetric, i.e. the same. Therefore, households' decision is independent of the party in power. This makes the decision of households and the competitive equilibrium environment deterministic.<sup>27</sup>

This form of the government utility generated a non-benevolent government which gets utility from the office rent it acquires from the tax revenue, in addition to private consumption. Lastly, I define the aggregate resource constraint of this economy as:

$$C_t + K_{t+1} + S_t + G_{t+1} = Y_{ft} + Y_{it} + (1 - \delta_k) K_t + (1 - \delta_g) G_t$$

Here,  $Y_{ft}$  and  $Y_{it}$  stand for aggregate formal and informal output, respectively.

### 3.4 Competitive Equilibrium

Now, having described the general environment, I can define the competitive equilibrium of this economy for a given policy.

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is party specific and can only be benefited from when in office.

<sup>27</sup>To be precise I could have defined the households' problem and the technologies as functions of the history of the realization of the uncertainty. However, this would only create an excess of notation, without any need for it.

**Definition 3.1** For a given government policy  $\Pi = \{\tau_{k_t}, \tau_{n_t}, S_t, G_{t+1}\}_{t=1}^{\infty}$  and  $k_1, G_1$ , a competitive equilibrium for this economy is an allocation vector for households  $\{c_t, k_{t+1}, n_{ft}, n_{it}\}_{t=1}^{\infty}$  and a price vector  $\{r_t, w_{ft}, w_{it}\}_{t=1}^{\infty}$  such that

1. Given prices and government policy, the allocation vector of households solves the households' problem.
2. Prices satisfy  $r_t = \frac{\partial Y_{ft}}{\partial K_t}$ ,  $w_{ft} = \frac{\partial Y_{ft}}{\partial N_{ft}}$ , and  $w_{it} = \frac{\partial Y_{it}}{\partial N_{it}}$
3. Government budget constraint is satisfied.
4. Aggregate resource constraint holds.

### 3.4.1 Characterizing Competitive Equilibrium

The competitive equilibrium is characterized by the following conditions which hold for all  $t \geq 1$

1.  $C_t + K_{t+1} - (1 - \delta_k)K_t = r_t K_t (1 - \tau_{k_t}) + w_t N_{ft} (1 - \tau_{n_t}) + Y_{it}(N_{it})$
2.  $-U_{c_t} + \beta U_{c_{t+1}} (1 - \tau_{k_{t+1}}) r_{t+1} = 0$
3.  $U_{c_t} (1 - \tau_{n_t}) w_t - U_{c_t} w_{it} = 0$
4.  $r_t K_t \tau_{k_t} + w_t N_{ft} \tau_{n_t} = S_t + G_{t+1} - (1 - \delta_g) G_t$
5.  $C_t + K_{t+1} + S_t + G_{t+1} = Y_{ft} + Y_{it} + (1 - \delta_k) K_t + (1 - \delta_g) G_t$
6.  $\lim_{t \rightarrow \infty} \beta^t \lambda_t K_{t+1} = 0$

where  $\lambda_t$  is the Lagrangian multiplier associated with the household budget constraint at time  $t$ . The first equation is simply the aggregate household budget constraint, the second equation is the Euler equation from the households' first-order condition. Similarly, the third equation comes from the households' first-order conditions equating the marginal products net of taxes in the formal and informal sectors. The fourth equation is the aggregate resource constraint and lastly, the last constraint is the transversality condition.

## 3.5 Politico-Economic Equilibrium

### 3.5.1 Environment

The equilibrium concept employed here is the same as that in Krusell, Quadrini, and Rios-Rull (1996), Krusell and Rios-Rull (1999) and more recently Martin (2009). The key assumption is that the government does not commit to any of its future policy choices. In each period, the government acts first, choosing current period policies. The equilibrium is called to be Markov-perfect since the government's choices depend only on the value of the current periods state, in this case just the aggregate private and public capital stocks. Additionally, I only consider equilibria where policy depends differentiably<sup>28</sup> on the private and public capital stock. (i.e. I assume that the policy functions are differentiable with respect to the state variables.) Lastly, after the government has moved, the private sector chooses its current period action.

### 3.5.2 Definition

Consider the two first-order conditions of the problem of the household and notice that in a Markov-perfect equilibrium, the government follows a set of policy functions that are only functions of public and private capital today. After setting  $\varsigma = (K, G)$  to be the vector of state variables<sup>29</sup>, let me define  $G' = \Gamma(\varsigma)$ ,  $\tau_k = \Theta_k(\varsigma)$  and  $\tau_n = \Theta_n(\varsigma)$  to be these objects. Households will understand that in equilibrium government follows policy functions  $\Gamma$ ,  $\Theta_k$ , and  $\Theta_n$ ; thus, the first-order conditions of the private sector yield stationary decision rules for private capital tomorrow and labor in the formal sector today<sup>30</sup> that only depend on the private and public capital stock today. Calling them  $\mathcal{K}(\varsigma)$ , and  $\mathcal{N}_f(\varsigma)$  respectively, I can

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<sup>28</sup>For details of an environment with non-differentiable finite-horizon equilibria, see Krusell, Martin and Rios-Rull (2006)

<sup>29</sup>Also to save some space I define  $\varsigma' = (K', G')$ .

<sup>30</sup>Notice that informal sector labor is known once the formal sector labor is calculated.

write the two household first-order conditions in a more compact form as follows:

$$\eta(\varsigma, \varsigma', \mathcal{K}(\varsigma'), \Gamma(\varsigma'), \mathcal{N}_f, \mathcal{N}_f(\varsigma'), \tau_k, \Theta_K(\varsigma'), \tau_n, \Theta_n(\varsigma')) = 0 \quad (1)$$

$$\varphi(\varsigma, \varsigma', \mathcal{N}_f, \tau_n, \tau_k) = 0 \quad (2)$$

The two equations above characterize household behavior for the current period for any arbitrary policy of the current government given that the government follows  $\Theta_K$ ,  $\Theta_n$  and  $\Gamma$  and thus implement  $\mathcal{K}$ , and  $\mathcal{N}_f$ .

Moreover, I can define the following aggregate functions for the office rent and private consumption.

$$\mathcal{S}(\varsigma) = rK\tau_k + wN_f\tau_n - G' + (1 - \delta_g)G \quad (3)$$

$$\mathcal{C}(\varsigma) = rK(1 - \tau_k) + wN_f(1 - \tau_n) + Y_i - K' + (1 - \delta_k)K \quad (4)$$

Now, given the perception that governments follows some policy  $\Gamma$ ,  $\Theta_K$ , and  $\Theta_n$  which in turn induces household and government behavior given by  $\mathcal{K}(\varsigma)$ , and  $\mathcal{N}_f(\varsigma)$ , I can write the problem of the current incumbent party as follows:

$$V(\varsigma) = \max_{\{K', G', N_f, \tau_k, \tau_n\}} U(\mathcal{C}(\varsigma)) + U^g(\mathcal{S}(\varsigma)) + \beta\{\rho V(\varsigma') + (1 - \rho)W(\varsigma')\} \quad (5)$$

subject to the equations (1), (2), (3) and (4).

Also notice that

$$W(\varsigma) = U(\mathcal{C}^*) + \beta\{\rho W(\varsigma'^*) + (1 - \rho)V(\varsigma'^*)\} \quad (6)$$

is the value function of the current opposition party where  $C^*$  and  $\varsigma'^* = (K'^*, G'^*)$  are consumption, tomorrow's private and public capital, respectively, chosen by the incumbent.

I restrict my focus on (differentiable) symmetric Markov-perfect equilibria (SMPE) of

the above described game. This leads to the following definition of equilibrium:

**Definition 3.2** *An interior SMPE is defined by two value functions  $W(\varsigma)$  and  $V(\varsigma)$  and policy functions,  $\mathcal{K}, \Gamma, \Theta_k, \Theta_n, \mathcal{N}_f$  such that for all  $K \in (0, \bar{K}]$  and for all  $G \in (0, \bar{G}]$ , where  $K^* = \mathcal{K}(K^*, G^*) < \bar{K}$  and  $G^* = \Gamma(K^*, G^*) < \bar{G}$  and given the Markov chain regulating the probability of reelection  $\rho$  the following conditions are satisfied:*

1. *Given the value functions  $W(\varsigma)$  and  $V(\varsigma)$ , policy functions  $\mathcal{K}, \Gamma, \Theta_k, \Theta_n, \mathcal{N}_f$  solve the government maximization problem for the variables  $K', G', \tau_k, \tau_n$ , and  $N_f$ , respectively.*
2. *Given the policy functions  $\mathcal{K}, \Gamma, \Theta_k, \Theta_n, \mathcal{N}_f$  value functions  $W(\varsigma)$  and  $V(\varsigma)$  satisfy the functional equations in (5) and (6).*
3. *Policy functions are differentiable in both of their arguments.*

### 3.5.3 Characterizing Markov-Perfect Equilibrium

In this subsection, I characterize the interior symmetric differentiable Markov-perfect equilibrium in the general environment defined above. To this end, I state the following characterization theorem:

**Proposition 3.3** *The interior symmetric differentiable Markov-perfect equilibrium (interior) is a set of smooth functions  $\{\Theta_n, \Theta_k, \mathcal{K}, \Gamma, \mathcal{N}_f\}$ , that for all  $K \in (0, \bar{K}]$  and  $G \in (0, \bar{G}]$  satisfy the equations (1) and (2), together with the following equations:*

$$\Theta_n = 0$$

$$\begin{aligned}
& -U_c + \lambda F_1 + \beta[\rho U_{s'}[Y_{K'}^{f'} + 1 - \delta_k]] + \beta(1 - \rho) \\
\left\{ U_{c'} \{ [1 - \gamma \tau_{k'}] Y_{K'}^{f'} - \mathcal{K}'_{K'} + 1 - \delta_k \} + \beta \frac{\mathcal{K}'_{K'}}{1 - \rho} \left[ \rho \frac{U_{c'} - \lambda' F_1}{\beta} + (1 - 2\rho) U_{c'} [Y_{K''}^{f''} + 1 - \delta_k] \right] \right. \\
& \left. + \beta \frac{\Gamma'_{K'}}{1 - \rho} \left[ \rho \frac{U_{s'} - \lambda' F_2}{\beta} + (1 - 2\rho) U_{s''} [Y_{G''}^{f''} + 1 - \delta_g] \right] + \lambda' F_3 \right\} = 0 \\
& -U_s + \lambda F_2 + \beta[\rho U_{s'}[Y_{G'}^{f'} + 1 - \delta_g]] + \beta(1 - \rho) \\
\left\{ U_{c'} \{ [1 - \gamma \tau_{k'}] Y_{G'}^{f'} - \mathcal{K}'_{G'} \} + \beta \frac{\mathcal{K}'_{G'}}{1 - \rho} \left[ \rho \frac{U_{c'} - \lambda' F_1}{\beta} + (1 - 2\rho) U_{c'} [Y_{K''}^{f''} + 1 - \delta_k] \right] \right. \\
& \left. + \beta \frac{\Gamma'_{G'}}{1 - \rho} \left[ \rho \frac{U_{s'} - \lambda' F_2}{\beta} + (1 - 2\rho) U_{s''} [Y_{G''}^{f''} + 1 - \delta_g] \right] + \lambda' F_4 \right\} = 0
\end{aligned}$$

**Proof.** See Appendix 6.1 ■

The first equation above simply states that all the burden of taxation in this environment falls on capital. The other two equations are the generalized euler equations characterizing the Markov-perfect equilibrium. Even though they seem somewhat complicated and the derivation of them are quite difficult, they show two simple things and are very intuitive: For example, the second one shows the trade-off that the incumbent faces by investing one more unit of public capital today. Investing one more unit of public capital  $G_{t+1}$  today directly reduces  $S_t$  by one unit. That is why the the second equation starts with the term  $-U_s$ . It also distorts the euler equation of the households which is represented by the term  $\lambda F_2$ . However, depending on the value of  $\rho$  it brings benefits tomorrow and thereafter. These benefits are represented by the terms after  $\beta$ . With probability  $\rho$ , the incumbent of today stays as the incumbent tomorrow and continues to enjoy the office rent, which is represented by the term  $\beta[\rho U_{s'}[Y_{G'}^{f'} + 1 - \delta_g]]$ . On the other hand, the incumbent loses the power with probability  $1 - \rho$ . However, even if it loses the power, it can still affect the decisions of the next period's government. This is because the current incumbent plays as a Stackelberg leader against the next period's incumbent. This incumbency advantage of the current incumbent is represented by the last three terms in the curly bracket.

In a similar fashion, the first equation illustrates the trade-off the incumbent faces by investing one more unit of private capital today. All the discussion for the second equation above also applies to the first one.

### 3.5.4 A Simple Finite Period Analysis

Before conducting numerical experiments with the general environment of the infinite horizon economy which is characterized above, here I first discuss the Markov-perfect equilibrium in a much simpler finite-period economy. The finite horizon allows me to get certain crucial analytical results under some specific simplifying assumptions. On the other hand, in the next section I present numerical solutions of the infinite horizon economy without using some of the specific assumptions below.

Now, for this subsection I make the following assumptions on the form of the utility and production functions and the depreciation rates of private and public capital:

**Assumption 1**  $U(C_t) = \alpha_c \log(C_t)$  and  $U^g(S_t) = \alpha_s \log(S_t)$ , where  $\alpha_c + \alpha_s = 1$

**Assumption 2**  $Y_{ft} = F_1(K_t, N_{ft}, G_t) = K^\gamma N_{ft}^{1-\gamma} (\frac{G_t}{K_t})^\gamma$  and  $Y_{it} = F_2(N_{it}) = N_{it}^{1-\gamma}$

**Assumption 3**  $\delta_k = \delta_g = 1$

Notice that in this setup the formal sector production function exhibits constant returns to scale both at individual and aggregate levels. Barro and Sala-i Martin (1992) argue that the way that  $G$  enters the formal sector production function with congestion reflects public goods which are rival but not excludable. However, since the informal sector cannot utilize these public goods in this setting, makes them excludable for the informal sector.<sup>31</sup>

Assume for now that the economy only lasts for  $T$  periods and  $T = 2$ . Below I consider the symmetric Markov-perfect equilibrium in this environment. By definition, in a Markov-perfect equilibrium, households and the government base their decisions only on the current state variables; in this case, the aggregate private and public capital stock at the beginning of each period.

The timing of choices in this setup is as follows: In the first period, the incumbent, after observing  $G_1$  and  $K_1$  (which are initially given), chooses  $S_1$ ,  $G_2$ ,  $\tau_{n_1}$ , and  $\tau_{k_1}$  subject to the government budget constraint, taking the following as given:

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<sup>31</sup>Notice that, using other forms of production functions without congestion, such as  $Y_t^f = K^\gamma N_{ft}^\beta G_t^{1-\gamma-\beta}$  wouldn't change the results. However, it would make the household's problem more complicated due to the fact that the production function would be of decreasing returns to scale in individual firm level.

1. Households maximize utility subject to their budget constraints and markets are competitive.
2. The policy implemented by the government in period 2, which is a function of  $K_2$  and  $G_2$ .
3. The exogenous probability  $\rho$  of keeping the office in period 2.

In the second period the government in office observes  $K_2$  and  $G_2$  and chooses  $\tau_{n_2}$ ,  $\tau_{k_2}$ , and  $S_2$ , taking as given that households maximize utility. I further assume that the incumbent lacks commitment, even if it had been in power in the previous period which implies that the government in period 2 will not internalize how its actions affected the decisions made in period 1.

Lastly, using the timing described above, I solve the model by backward induction. The results can be summarized by the following proposition:

**Proposition 3.4** *Under assumptions 1-3 and for  $\alpha_s$  small enough<sup>32</sup> symmetric Markov-perfect equilibrium allocations of the first period feature <sup>33</sup>*

1. *Tax rate on formal labor income is zero in both periods.*
2. *Tax burden falls on capital in both periods.*
3. *As probability of reelection ( $\rho$ ) increases, the first-period incumbent invests more in the productive public good and spends less in the office rent.*
4. *As probability of reelection increases, the increase in the productive public investment is more than decrease for the first-period office rent, i.e. the tax burden in the first period also increases.*

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<sup>32</sup>This assumption is needed for an interior solution. Otherwise, if  $\alpha_s$  is above some threshold value, then the incumbent confiscates the entire private capital stock and this shuts down the economy.

<sup>33</sup>Technically, the proposition can be summarized by  $\tau_{n_1} = \tau_{n_2} = 0$ ,  $\tau_{k_1} > 0$ ,  $\tau_{k_2} > 0$ ,  $\frac{\partial \tau_{k_1}}{\partial \rho} > 0$ ,  $\frac{\partial G_2}{\partial \rho} > 0$ ,  $\frac{\partial S_1}{\partial \rho} < 0$ ,  $\frac{\partial(G_2+S_1)}{\partial \rho} > 0$ ,  $\frac{\partial N_{f2}}{\partial \rho} > 0$ ,  $\frac{\partial N_{i2}}{\partial \rho} < 0$ ,  $\frac{\partial Y_{f2}}{\partial \rho} > 0$ ,  $\frac{\partial Y_{i2}}{\partial \rho} < 0$



5. *An increase in the probability of reelection reduces the amount of labor spent in the informal sector for the second period.*

6. *An increase in the probability of reelection reduces the size of the informal sector in the second period.*

**Proof.** See Appendix 6.2 ■

Notice that, the results of the two-period model can be somewhat misleading for the desired results of the paper. This arises due to the fact that the finite period model implicitly assumes that  $T = 2$  is the end period, where no private and public investment is made anymore. Obviously, such a period does not exist for the infinite horizon economy. Also, for a two-period economy, some of the first-period allocations generally depend on the initially given state variables, namely  $K_1$  and  $G_1$ . However, the two-period model still provides helpful insights for the understanding of the main mechanism of the model which will still be valid for the results of the infinite horizon economy.

The formal proof of the proposition is provided in the appendix, however below I briefly discuss the intuition of the above stated results.

First result in the above proposition states that the tax rate on formal labor in both periods is equal to zero and the burden of taxation falls on capital. The labor tax in the second period is equal to zero, because the incumbent of the second period is facing a static problem and due to the existence of an informal sector, the tax on formal labor income is distortionary, whereas since the capital of the second period is already invested, the capital income tax is not distortive. Hence, all the burden of taxation falls on capital. However, the tax rate on capital in the second period depends on the value of  $\alpha_s$ , and  $\tau_{k_2} < 1$  if only if  $\alpha_s$  is sufficiently low. Otherwise,  $K_2 = 0$  and the economy shuts down in the second period. That is why an interior solution requires  $\alpha_s$  to be small enough. Now, under this assumption, the economy is at the first-best ( $U_{c_2} = U_{s_2}$ ) in the second period because the only used tax instrument, the capital tax, is non-distortionary. Therefore, both  $S_2$  and  $C_2$  are constant fractions of the second period total output. Next, using this result, assumption 2 and equation 2, I can express  $S_2$ ,  $C_2$ ,  $N_{f_2}$  and  $N_{i_2}$  as functions of  $G_2$  only. More specifically,

one can also obtain  $N_{f2}$  as an increasing function of  $G_2$ .

Having all the second period allocations derived as a function  $G_2$  only, one can write the problem of the incumbent in the first period. Now of course,  $\rho$  plays an important role here, because from the first period's perspective, whether the first-period incumbent will enjoy office rent in the second period or not, depends on the value of  $\rho$ . In this sense,  $\rho$  increases the weight of the office rent of the second period in the first period incumbent's utility function. Therefore, as the probability of reelection, i.e.  $\rho$ , increases, the marginal rate of substitution between current office rent and future office rent and the marginal rate of substitution between current private consumption and future office rent changes in favor of the future office rent. This lets the current incumbent decrease the current office rent and increase the tax rate on current capital to reduce current private consumption. With more tax revenue at hand, the incumbent invests more on the productive public investment. Notice that, the labor tax in the first period is also equal to zero and the burden of taxation fall on capital again. However, the government in the first period additionally faces an inter-temporal distortion created by the capital tax in the second period. This distorts the margin between private consumption and office rent in the first period.<sup>34</sup>

For the last two statements, one might be curious to ask what happens to the formal and informal sector labor in the first period. Formal and informal sector labor in the first period depend on first period's stock of private and public capital,  $K_1$  and  $G_1$ , and the labor tax rate. Since  $K_1$  and  $G_1$  are exogenously given and  $\tau_{n1} = 0$ , formal and informal labor in the first period together with formal and informal output are fixed. However, formal and informal labor of the second period are functions of the public capital of the second period which is an increasing function of  $\rho$ . So, as the probability of reelection increases, so do the formal sector labor and the formal sector output in the second period; which in turn reduce the relative size of the informal sector in the second period.

The two-period economy with the simplifying assumptions can be generalized to a an arbitrary  $T$  period economy. Moreover, letting  $T \rightarrow \infty$ , I can state the following result for

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<sup>34</sup>Technically  $U_{c1} < U_{s1}$ .

the equilibrium of the infinite horizon economy as the limit of the above described finite horizon economy:

**Proposition 3.5** *For  $\alpha_s$  small enough and assuming that the assumptions 1, 2 and 3 hold, there exists an interior Markov-perfect equilibrium of the infinite horizon economy in the above described environment in which the steady state statistics feature:*

$$\tau_n = 0, \tau_k > 0 \quad \frac{\partial \tau_k}{\partial \rho} > 0, \frac{\partial(G/Y)}{\partial \rho} > 0, \frac{\partial(S/Y)}{\partial \rho} < 0, \frac{\partial(G+S)/Y}{\partial \rho} > 0, \frac{\partial(Y_i/Y_f)}{\partial \rho} < 0$$

where  $Y = Y_i + Y_f$ . This proposition is actually an extension of proposition 3.4. The proof is discussed in appendix 6.2. I should also note that proposition 3.5 does not actually give much information in addition to proposition 3.4. It simply states the key results of the two-period environment extend to an infinite horizon environment.<sup>35</sup> Notice that with both propositions at hand, I have an environment in which both the relative size of the informal sector and the tax burden depend on the exogenous probability of reelection. An increase in this probability also increases the tax burden but reduces the size of the informal sector, exactly as we observe in the data.

### 3.5.5 Adding Leisure-Labor Choice

Even though the model above assumes that households do not value leisure, it can easily be extended to include leisure in the utility function without changing main results, most importantly the one concerning the relationship between the tax burden and the size of the informal sector. Since it only brings more notation and longer derivations, I decided not to include this extension in this version of the paper. However, I still can state the main results of the model extended with leisure. However, first the assumptions have to be adjusted to the environment with leisure:

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<sup>35</sup>Notice that the steady state features a labor tax rate which is equal to zero. However, the tax rate on formal labor can be easily be made positive by making the current capital tax also distortionary. One way of doing this is extending the model with endogenous capital utilization by allowing households to choose the amount of private capital to be utilized in the formal sector production function. This way, without changing the desired result of the negative correlation between the tax burden and the informal sector size one can have both positive capital and labor taxes in the steady state. Since such an extension does not change any of this paper's results, I refer to Martin (2009) for such an extension.

**Assumption 4**  $U(C_t, \ell_t) = \alpha_c \log(C_t) + \alpha_\ell \log(L_t)$  and  $U^g(S_t) = \alpha_s \log(S_t)$ , where  $\alpha_c + \alpha_\ell + \alpha_s = 1$

Notice that  $L_t$  stands for aggregate leisure. In this environment, I can state the following theorem:

**Proposition 3.6** *For  $\alpha_s$  small enough and under assumptions 2, 3, and 4 there exists an interior Markov-perfect equilibrium of the infinite horizon economy in the above described environment in which the steady state statistics feature:  $\frac{\partial(G/Y)}{\partial \rho} > 0$ ,  $\frac{\partial(S/Y)}{\partial \rho} < 0$ ,  $\frac{\partial(G+S)/Y}{\partial \rho} > 0$ ,  $\frac{\partial Y_i/Y_f}{\partial \rho} < 0$*

The proof is simply an extension of proposition 3.5 and is briefly discussed in the appendix.<sup>36</sup>

## 4 Numerical Analysis

This section conducts a quantitative analysis of the model's results without the assumption 3, i.e. in this section I relax this assumption to the following:

**Assumption 5**  $\delta_k \in [0, 1]$  and  $\delta_g \in [0, 1]$ ,

Moreover, I keep the assumption 1; however, I also relax the assumption 2 to the following:

**Assumption 6**  $Y_{ft} = K^\gamma N_{ft}^{1-\gamma} (\frac{G_t}{K_t})^\mu$  and  $Y_{it} = F(N_{it}) = N_{it}^\phi$

Krusell and Smith (2003) show that this class of dynamic policy games may feature both differentiable and non-differentiable Markov-perfect equilibria. However, I restrict my attention only on differentiable Markov-perfect equilibrium and numerically calculate the steady state statistics of this economy. I describe the relevant computational algorithm in appendix 6.2.

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<sup>36</sup>One setback of the environment with leisure is that the tax on formal labor which was zero in the previous environment becomes negative now. So in equilibrium there is a labor subsidy which turns out to be a decreasing function of  $\rho$ . The idea here is that the incumbent uses labor subsidy to correct part of the distortion created by the capital tax. One way of having a positive labor tax is to introduce endogenous capital utilization a la Martin (2009). However, all these complications do not involve any significant changes in the main results, therefore are not included in this text.

## 4.1 Parametrization and Calibration

The parameterization of the baseline economy is standard. The capital share, as standard in the RBC literature is assumed to be equal to  $\gamma = 0.36$ . Moreover, I assume that  $\beta = 0.96$ ,  $\delta_k = 0.08$ ,  $\delta_g = 0.1$ . Lastly, I take  $\mu = 0.15$  from Eicher and Turnovsky (2000).

Now, the only remained parameters are  $\alpha_s$  in the utility function and  $\phi$  in the informal sector production function. These, I calibrate. What I do in the next subsection is that, once I calibrate these two parameters, I take the probability of reelection data given by Brender and Drazen (2008), feed their series into the model as  $\rho$  and then obtain generated series of relevant endogenous variables in the steady state, i.e. tax burden,  $\frac{r_t K_t \tau_{k_t}}{Y_t}$ , the relative size of the informal sector,  $\frac{Y_i}{Y_f}$ , public capital-output ratio  $G/Y$ , and lastly office rent-output ratio  $S/Y$ .

## 4.2 Quantitative Results and Experiments

I calibrate  $\alpha_s$  and  $\phi$  to match the average size of the tax burden and the informal sector size in my dataset.<sup>37</sup> Specifically, I calculate the average probability of reelection in the data, feed this average value into the model as the  $\rho$  and then back out the values of the two parameters mentioned above required to match the average size of the tax burden and the informal sector size. In figures 4 to 7, using the calibrated values for  $\alpha_s$  and  $\phi$ , I plot certain endogenous variables of interest against various values of  $\rho$  to see the mechanism behind the model's crucial result. As figure 4 shows, increasing  $\rho$  reduces the size of the informal sector, and as the next figure, figure 5 shows, it increases the tax burden. However, the two components of government spending go into different directions. As probability of reelection increases, public capital-output ratio goes up and office rent to output ratio goes down. These two are illustrated in figure 6 and 7. Next, figure 8 compares the model's performance against the data. The model performs remarkably well in accounting for the observed negative relationship between the tax burden and the size of the informal sector. Moreover, in figure 9, I compare the linear regression lines drawn for the actual data and for

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<sup>37</sup>The calibrated values are  $\alpha_s = 0.11$  and  $\phi = 0.45$

the model generated data. The slopes are almost the same and the two lines almost overlap.

## 5 Conclusion

In this paper I have developed a model to account for the surprising negative relationship between the tax burden and the size of the informal sector. First, I established this relationship in a panel data analysis and showed that the empirical result is robust. Moreover, the empirical analysis hints that the key to understanding this phenomenon might be a specific political friction, namely political turnover. However, existing models of the informal sector are not capable of accounting for this relationship. Towards this purpose I developed model of fiscal policy with two sectors where the government lacks commitment and incumbency follows a Markov chain with two political parties which can be in power at any time. Political turnover, with the way I introduce it, crucially affects both the level and the composition of government revenue and spending. The lower the turnover, the lower the unproductive office rent and the higher the productive public spending. Moreover the tax burden increases with political stability. Even though the tax burden is higher, the tax revenue is increasingly used for the productive public good in the formal sector which creates incentives for being formal and thereby reduces the relative size of the informal sector.

The contribution of this paper is threefold: First, it mainly contributes to the literature on informal economy and taxes, informal economy and corruption, and informal economy and productive public goods. Noticing that most work done in these areas are empirical and lack a strong theoretical basis, this paper provides a general equilibrium model and fills in the theoretical gap in the literature with a novel mechanism. Second, to the best of my knowledge, this paper is the first attempt to utilize empirical results of a panel data set among the other empirical papers on the informal sector. Lastly, this paper also contributes to the literature on optimal Markov-perfect fiscal policy by adding an informal sector and a political economy dimension to standard models of this literature.

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## 6 Appendix

### 6.1 Proof of Proposition 3.3

First-order conditions of the maximization problem (specified by the functional equation 5 subject to the constraints 1, 2, 3, and 4 with respect to  $K', G', N_f, \tau_k, \tau_n$  are as follows, respectively:

$$U_c C_{K'} + \beta(\rho V_{K'} + (1 - \rho)W_{K'}) + \lambda F_1 + \mu \varphi_{K'} = 0 \quad (7)$$

$$U_c C_{G'} + \beta(\rho V_{G'} + (1 - \rho)W_{G'}) + \lambda F_2 + \mu \varphi_{G'} = 0 \quad (8)$$

$$U_c C_{N_f} + U_s \mathcal{S}_{N_f} + \lambda \eta_{N_f} + \mu \varphi_{N_f} = 0 \quad (9)$$

$$U_c C_{\tau_k} + U_s \mathcal{S}_{\tau_k} + \lambda \eta_{\tau_k} + \mu \varphi_{\tau_k} = 0 \quad (10)$$

$$U_c C_{\tau_n} + U_s \mathcal{S}_{\tau_n} + \lambda \eta_{\tau_n} + \mu \varphi_{\tau_n} = 0 \quad (11)$$

Notice that  $\lambda$  and  $\mu$  are the Lagrangian multipliers on the constraints  $\eta$  and  $\varphi$ , and  $F_1$  and  $F_2$  are defined as follows:

$$F_1 = \eta_{K'} + \eta_{K''} \mathcal{K}'_K + \eta_{G''} \Gamma'_K + \eta_{n'_f} \mathcal{N}'_{fK} + \eta_{n'_i} \mathcal{N}'_{iK} + \eta_{\tau'_k} \theta'_{kK} + \eta_{\tau'_n} \theta'_{nK}$$

$$F_2 = \eta_{G'} + \eta_{G''} \mathcal{K}'_G + \eta_{G''} \Gamma'_G + \eta_{n'_f} \mathcal{N}'_{fG} + \eta_{n'_i} \mathcal{N}'_{iG} + \eta_{\tau'_k} \theta'_{kG} + \eta_{\tau'_n} \theta'_{nG}$$

Since  $C_{\tau_k} = -\mathcal{S}_{\tau_k}$ ,  $C_{\tau_n} = -\mathcal{S}_{\tau_n}$ ,  $\eta_{\tau_k} = -\lambda U_{cc} C_{\tau_k}$  and  $\eta_{\tau_n} = -\lambda U_{cc} C_{\tau_n}$ , first-order conditions with respect to  $\tau_n$  and  $\tau_k$  can be rewritten as:

$$-U_c \mathcal{S}_{\tau_k} + U_s \mathcal{S}_{\tau_k} + \lambda U_{cc} \mathcal{S}_{\tau_k} + \mu \varphi_{\tau_k} = 0 \quad (12)$$

$$-U_c \mathcal{S}_{\tau_n} + U_s \mathcal{S}_{\tau_n} + \lambda U_{cc} \mathcal{S}_{\tau_n} + \mu \varphi_{\tau_n} = 0 \quad (13)$$

Notice that  $\varphi_{\tau_k} = 0$ , whereas  $\varphi_{\tau_n} = -U_c w_f$ . This implies that  $\mu = 0$  as long as  $N_f > 0$ . Exploiting this result,  $\lambda$  can be obtained from the first-order condition  $\tau_n$  or  $\tau_k$  as  $\lambda = -\frac{U_s - U_c}{U_{cc}}$ .

With this result, and using  $\mathcal{S}_{N_f} = \tau_n w_f$ ,  $C_{N_f} = (w_f(1 - \tau_n) - w_i)$  the first-order condition with respect to  $N_f$  becomes now:

$$U_c(w_f(1 - \tau_n) - w_i) + U_s \tau_n w_f + \lambda U_{cc}(w_f(1 - \tau_n) - w_i) = 0$$

Since  $w_f(1 - \tau_n) = w_i$  this implies that  $\tau_n = 0$ , as long as  $N_f > 0$ , so all the tax burden falls on capital every period.

Now, I turn my attention to the first-order conditions with respect to  $K'$  and  $G'$ . It can be easily shown that the envelope condition holds for  $V$  but not to  $W$ .<sup>38</sup> Hence, after some work I obtain:

$$V_G = U_s[Y_G^f + 1 - \delta_g]$$

$$V_K = U_c[Y_K^f + 1 - \delta_k]$$

Now, forwarding these for one period I get expressions for  $V_{G'}$  and  $V_{K'}$ . Since I cannot apply the envelope theorem to  $W$ , I derive  $W'_{K'}$  and  $W'_{G'}$  by the following operations: First, to get  $W'_{K'}$ , I derive  $W$  with respect to  $K$ .

$$\begin{aligned} W_K = U_C \{ [1 - \gamma \tau_k] Y_K^f - \mathcal{K}_K + 1 - \delta_k \} + \beta \mathcal{K}_K \{ \rho W'_{K'} + (1 - \rho) V'_{K'} \} \\ + \beta \Gamma_K \{ \rho W'_{G'} + (1 - \rho) V'_{G'} \} + \lambda F_3 \end{aligned}$$

where  $F_3$  the derivative of  $\eta$  with respect to  $K$ , i.e.  $F_3 = -U_{cc}C_K + \mathcal{K}_K F_1 + \Gamma_K F_2$

To find expressions for  $W'_{K'}$  and  $W'_{G'}$  I solve for these from the first-order conditions as

$$W'_{K'} = \frac{1}{1 - \rho} \left[ \frac{U_c - \lambda F_1}{\beta} - \rho V'_{K'} \right]$$

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<sup>38</sup>This is because the functional equation defining  $W$  is not a maximization problem.

$$W'_{G'} = \frac{1}{1-\rho} \left[ \frac{U_s - \lambda F_2}{\beta} - \rho V'_{G'} \right]$$

Plugging these back into the expression for  $W_K$ :

$$\begin{aligned} W_K = U_C \{ [1 - \gamma \tau_k] Y_K^f - \mathcal{K}_K + 1 - \delta_k \} &+ \beta \frac{\mathcal{K}_K}{1-\rho} \left[ \rho \frac{U_c - \lambda F_1}{\beta} + (1-2\rho) V'_{K'} \right] \\ &+ \beta \frac{\Gamma_K}{1-\rho} \left[ \rho \frac{U_s - \lambda F_2}{\beta} + (1-2\rho) V'_{G'} \right] + \lambda F_3 \end{aligned}$$

Inserting  $V'_{K'}$  and  $V'_{G'}$  into this expression and forwarding one period yields

$$\begin{aligned} W'_{K'} = U'_{c'} \{ [1 - \gamma \tau_{k'}] Y'_{K'}{}^{f'} - \mathcal{K}'_{K'} + 1 - \delta_k \} &+ \beta \frac{\mathcal{K}'_{K'}}{1-\rho} \left[ \rho \frac{U'_{c'} - \lambda' F'_1}{\beta} + (1-2\rho) U'_{c''} [Y'_{K''}{}^{f''} + 1 - \delta_k] \right] \\ &+ \beta \frac{\Gamma'_{K'}}{1-\rho} \left[ \rho \frac{U'_{s'} - \lambda' F'_2}{\beta} + (1-2\rho) U'_{s''} [Y'_{G''}{}^{f''} + 1 - \delta_g] \right] + \lambda' F'_3 \end{aligned}$$

Plugging everything back into the first-order condition with respect to  $K'$  and simplifying yields:

$$\begin{aligned} & -U_c + \lambda F_1 + \beta [\rho U_s [Y'_{K'}{}^{f'} + 1 - \delta_k]] + \beta(1-\rho) \\ \left\{ U'_{c'} \{ [1 - \gamma \tau_{k'}] Y'_{K'}{}^{f'} - \mathcal{K}'_{K'} + 1 - \delta_k \} &+ \beta \frac{\mathcal{K}'_{K'}}{1-\rho} \left[ \rho \frac{U'_{c'} - \lambda' F'_1}{\beta} + (1-2\rho) U'_{c''} [Y'_{K''}{}^{f''} + 1 - \delta_k] \right] \right. \\ & \left. + \beta \frac{\Gamma'_{K'}}{1-\rho} \left[ \rho \frac{U'_{s'} - \lambda' F'_2}{\beta} + (1-2\rho) U'_{s''} [Y'_{G''}{}^{f''} + 1 - \delta_g] \right] + \lambda' F'_3 \right\} = 0 \end{aligned}$$

One can get the equation with  $G'$  exactly in the same way

$$\begin{aligned} & -U_s + \lambda F_2 + \beta [\rho U_s [Y'_{G'}{}^{f'} + 1 - \delta_g]] + \beta(1-\rho) \\ \left\{ U'_{c'} \{ [1 - \gamma \tau_{k'}] Y'_{G'}{}^{f'} - \mathcal{K}'_{G'} \} &+ \beta \frac{\mathcal{K}'_{G'}}{1-\rho} \left[ \rho \frac{U'_{c'} - \lambda' F'_1}{\beta} + (1-2\rho) U'_{c''} [Y'_{K''}{}^{f''} + 1 - \delta_k] \right] \right. \\ & \left. + \beta \frac{\Gamma'_{G'}}{1-\rho} \left[ \rho \frac{U'_{s'} - \lambda' F'_2}{\beta} + (1-2\rho) U'_{s''} [Y'_{G''}{}^{f''} + 1 - \delta_g] \right] + \lambda' F'_4 \right\} = 0 \end{aligned}$$

where  $F'_4$  is defined analogous to  $F'_3$ .

## 6.2 Proofs of Propositions 3.4 and 3.5

Consider the two-period version of the model. I will solve the model by backward induction starting from the second period:

Since the second period is the final period, households do not invest in private capital and consume all of their income. Similarly, the government does not invest in the public capital either. Therefore, from the budget constraint we can write  $C_2 = Y_{f2} + Y_{i2} - S_2$ . Moreover, the labor and capital taxes can be obtained as functions of  $N_{f2}$  and  $S_2$  only using  $(1 - \tau_{n2})w_{f2} = w_{i2}$  and  $\tau_{k2} = \frac{S_2}{\gamma Y_{f2}} - \tau_{n2}w_{f2}$ . Now, for any given  $G_2$  and  $K_2$ , the problem of the incumbent in period 2 can be written as, choosing  $S_2$  and  $N_{f2}$  to maximize

$$U(Y_{f2} + Y_{i2} - S_2) + U^g(S_2)$$

Under assumption 1, first-order conditions with respect to  $S_2$  and  $N_{f2}$  respectively are:

$$U_{c2} = U_{s2}$$

$$U_{c2}(w_{f2} - w_{i2}) = 0$$

Comparing the second equation with equation 2 in the paper, I obtain  $\tau_{n2} = 0$ , i.e. all the tax burden falls on  $K_2$ . Now, the first equation, together with assumption 1 implies that consumption and office rent in the second period are constant fractions of total output, i.e.  $C_2 = \alpha_c Y_2$  and  $S_2 = \alpha_s Y_2$ . Moreover, from the second first-order condition above and assumption 2, I obtain  $\frac{N_{i2}}{N_{f2}} = G_2^{-1}$ . Hence all the second period allocations can be defined as a function of  $G_2$  only.<sup>39</sup>

Next, using the Euler equation I obtain  $K_2 = m_1(Y_1 - G_2 - S_1)$ , where  $m_1$  is an increasing

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<sup>39</sup>Notice that simplifying assumption 2 allows to define all the variables with respect to  $G_2$  only. In a more general environment, everything should be a function  $K_2$  and  $G_2$ .

function of  $G_2$ .<sup>40</sup> By the resource constraint of period 1, it follows that  $C_1 = (1 - m_1)(Y_1 - G_2 - S_1)$ . Next, I consider the maximization problem of the first period incumbent: Given some initial  $K_1$ ,  $G_1$ , and the probability of reelection  $\rho$ , the first period incumbent chooses  $S_1$ ,  $G_2$ , and  $N_{f1}$  to maximize

$$U(C_1) + U^g(S_1) + \beta\{\rho[U(C_1) + U^g(S_2)] + (1 - \rho)U(C_2)\}$$

or equivalently

$$U(C_1) + U^g(S_1) + \beta U(C_2) + \beta \rho U^g(S_2)$$

subject to the following constraints:

$$C_1 = (1 - m_1)(Y_1 - G_2 - S_1)$$

$$K_2 = m_1(Y_1 - G_2 - S_1)$$

$$C_2 = \alpha_c Y_2$$

$$S_2 = \alpha_s Y_2$$

So this objective function clearly shows the effect of the  $\rho$ . Increasing  $\rho$  affects the marginal rate of substitution between tomorrow's office rent and current office rent, current private consumption and tomorrow's private consumption. Notice that  $C_2$  and  $S_2$  are functions of  $G_2$  only. Now, combining the first order conditions with respect to  $S_1$  and  $N_{f1}$  yields:

$$U_{S_1}^g(w_{f1} - w_{i1}) = 0$$

This implies that  $\tau_{n1} = 0$ . Hence, all the burden of taxation falls again on capital. However, the incumbent of the first-period cannot avoid the distortion created by the second

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<sup>40</sup>In this specific example  $m_1 = \left\{1 + \frac{\alpha_c}{\beta(\gamma \frac{G_2}{1+G_2} - \alpha_s)}\right\}^{-1}$

period capital tax. This distorts the margin between the private consumption and office rent in the first period. (i.e.  $U_{C_1} \neq U_{S_1}^g$ ) Specifically, the first-order condition with respect to  $S_1$  implies:

$$U_{S_1}^g = (1 - m_1)U_{C_1}$$

This shows that a higher  $G_2$  makes  $S_1$  more expensive.

With assumption 1, on the form of the utility functions one can also obtain

$$S_1 = \alpha_s(Y_1 - G_2)$$

This equation shows that, given  $K_1, G_1$  which since  $\tau_{n1} = 0$  directly determine  $N_{f1}$  and  $N_{i1}$ , an increase in  $G_2$  implies a reduction in  $S_1$ . Moreover, the reduction  $S_1$  is less than the increase in  $G_2$ , because  $\alpha_s < 1$ .

Lastly, the first-order condition with respect to  $G_2$  allows us express  $G_2$  as a function of initially given  $K_1, G_1$ , and all the parameters, including  $\rho$ . Specifically,

$$(\alpha_c + \rho\alpha_s)\gamma = [G_2(\gamma - \alpha_s) - \alpha_s]f(G_2)$$

where  $f(G_2)$  is an increasing function<sup>41</sup> of  $G_2$ , provided that  $\alpha_s < \gamma$ . So as one can see from the above equation, increasing  $\rho$  increases  $G_2$  and hence by the equation defining  $S_1$  reduces  $S_1$ . Moreover, since  $\alpha_s < 1$ , the increase in  $G_2$  is more than the reduction in  $S_1$  causing the tax burden of the first period to increase. Since the capital tax is the only tax instrument used by the government, this means that  $\tau_{k1}$  increases due to an increase in  $\rho$ .

Now, having proved the proposition 3.4, one can easily generalize the results of the above described finite period economy, first to an arbitrary  $T$  period economy and then letting  $T \rightarrow \infty$  to an infinite horizon economy. To this end I briefly discuss the proof proposition 3.5 here. I consider a finite  $T$  period economy. The two-period environment can be interpreted

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<sup>41</sup>Specifically  $f(G_2) = \left\{ \frac{1-m_1}{m_1(1-\alpha_s)(Y_1-G_2)} + \frac{\partial m_1}{\partial G_2} \right\}$



as results valid for periods  $T$  and  $T - 1$ . By continuing to iterate backwards I can write for any  $j \in \{0, 1, 2, \dots, T - 1\}$

$$\begin{aligned} C_{T-j} &= (1 - m_{T-j})(Y_{T-j} - G_{T-j+1} - S_{T-j}) \\ K_{T-j+1} &= m_{T-j}(Y_{T-j} - G_{T-j+1} - S_{T-j}) \end{aligned}$$

where  $m_{T-j}$  is an increasing function of  $G_{T-j+1}$ . Having defined  $C_{T-j}$  and  $K_{T-j+1}$ , given  $K_1 > 0$  and  $G_1 > 0$ , I can define the problem of the incumbent in period  $T - j$  as the following<sup>42</sup>:

$$\begin{aligned} V^{T-j}(G_{T-j}) &= \max_{\{S_{T-j}, G_{T-j+1}, N_{f,T-j}\}} U(C_{T-j}) + U^g(S_{T-j}) + \\ &\quad \beta\{\rho V^{T-j+1}(G_{T-j+1}) + (1 - \rho)W^{T-j+1}(G_{T-j+1})\} \end{aligned}$$

subject to the expressions for  $C_{T-j}$  and  $K_{T-j+1}$  defined above. Now taking the first order conditions of the above defined maximization problem and as analogous to the case in the two-period world the first order conditions with respect to  $S_{T-j}$  and  $N_{f,T-j}$  imply  $\tau_{n,T-j} = 0$ . Moreover, from the first-order condition with respect to  $S_{T-j}$  implies

$$U_{S_{T-j}}^g = (1 - m_{T-j})U_{C_{T-j}}$$

Furthermore, using the form of the utility functions one ends up with  $S_{T-j} = \alpha_s(Y_{T-j} - G_{T-j+1})$ . As it can be seen from the repetitive pattern of the equations all the results of first period allocations in the two-period model generalize to any period  $T - j$ . The same is also true for  $G_{T-j+1}$  which can be expressed as an increasing function of  $\rho$  from the first-order condition with respect to  $G_{T-j+1}$ . Once  $G_{T-j+1}$  is obtained as an increasing function of  $\rho$ , the rest follows from the above for period 1 in the two-period economy which happens to be the period  $T - 1$  in a  $T$ -period economy. Now, using the expressions coming from the first-order conditions and exploiting the fact that all the parameters entering into the formulae

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<sup>42</sup>Again I exploit the very special form of the production function of the formal sector here were compared to the general case  $\mu = \gamma$ . This allows me to write the value functions in terms of the public capital only.

for the relevant variables are between 0 and 1,  $T \rightarrow \infty$ , the first period  $T - j = 1$  allocations converge to a limit, in which their behaviors with respect to  $\rho$  become unchanged.

Proposition 3.6 is an extension of the proposition 3.5 with leisure in the utility function. The only difference between this case and the previous environment is that, even though all the burden of taxation falls on capital again, formal labor is now subsidized. Moreover, as  $\rho$  increases, the level of tax subsidy also increases. However, the increase in public investment is still more than the reduction in the office rent, which increases the capital tax rate more than the previous case. See Martin (2009) for more details in an environment with leisure in the utility function.

### 6.3 Computational Algorithm

To compute the interior differentiable Markov-perfect equilibrium, I use<sup>43</sup> the global method described in Martin (2009). Given any  $\rho$ , the basic algorithm is as follows:

1. Define a pair of grids over  $K$  and  $G$ .
2. Guess the decision rules:  $\mathcal{K}^0, \Gamma^0, \Theta_k^0, \Theta_n^0, \mathcal{N}_f^0$
3. For every  $(K, G)$  pair in the grid, solve for  $K', G', \tau_k, \tau_n$ , and  $N_f$ , given that  $\mathcal{K}^0, \Gamma^0, \Theta_k^0, \Theta_n^0, \mathcal{N}_f^0$  followed from tomorrow on, using the equations characterizing Markov-perfect equilibrium. Call the solution  $\mathcal{K}^1, \Gamma^1, \Theta_k^1, \Theta_n^1$ , and  $\mathcal{N}_f^1$ .
4. Check the convergence of all decision rules. If the convergence error is not small enough, go back to the previous step and set  $\mathcal{K}^0 = \mathcal{K}^1, \Gamma^0 = \Gamma^1, \Theta_k^0 = \Theta_k^1, \Theta_n^0 = \Theta_n^1$ , and  $\mathcal{N}_f^0 = \mathcal{N}_f^1$ .

Notice that, since I assume differentiability of the policy functions, I interpolate the points between the grid points to evaluate the policy functions and calculate the derivatives of them. To be able to do so, I use cubic splines.

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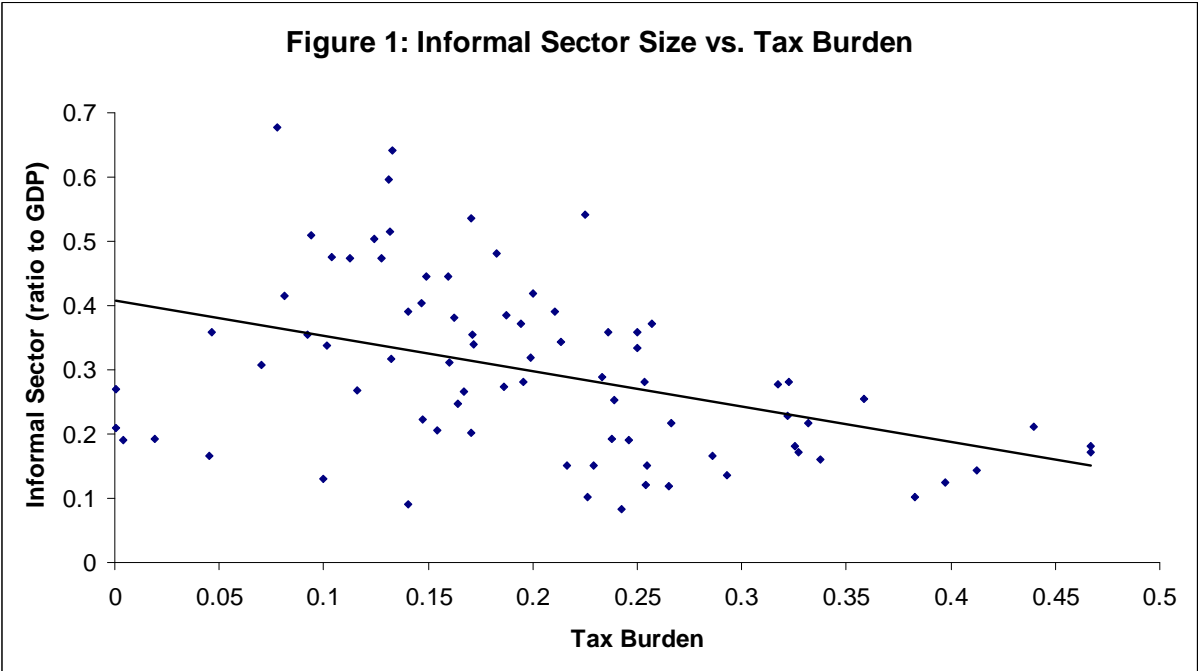
<sup>43</sup>I thank Fernando Martin for sharing his codes with me.

## 6.4 Country List

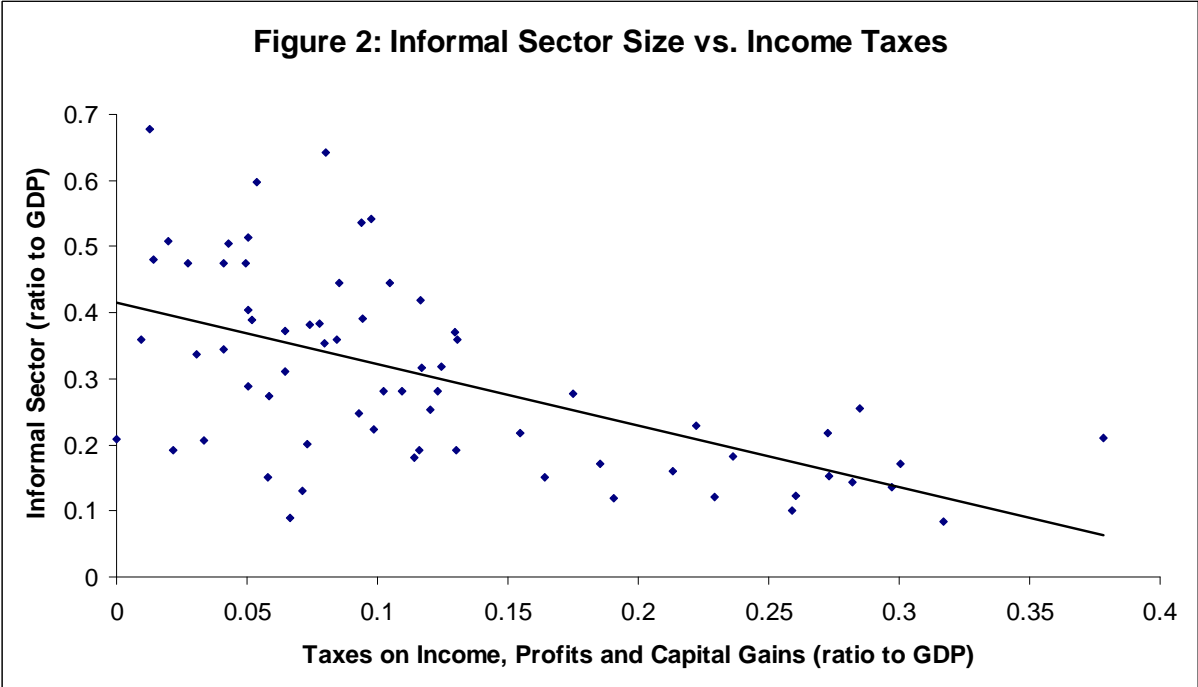
**List of Countries Included in the Panel and 80-Country Cross-Section Regressions:** Argentina, Australia, Austria, Belgium, Bolivia, Botswana, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Germany, Greece, Guatemala, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kuwait, Latvia, Lebanon, Lithuania, Malaysia, Mexico, Moldova, Morocco, Netherlands, New Zealand, Nicaragua, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, USA, Uruguay, Venezuela, Vietnam.

**List of Countries Included in the 58-Country Cross-Section Regressions:** Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Dominican Republic, Ecuador, El Salvador, Estonia, Finland, France, Germany, Greece, Guatemala, Honduras, Hungary, India, Ireland, Israel, Italy, Jamaica, Japan, Lithuania, Malaysia, Mexico, Moldova, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Thailand, Turkey, United Kingdom, USA, Venezuela.

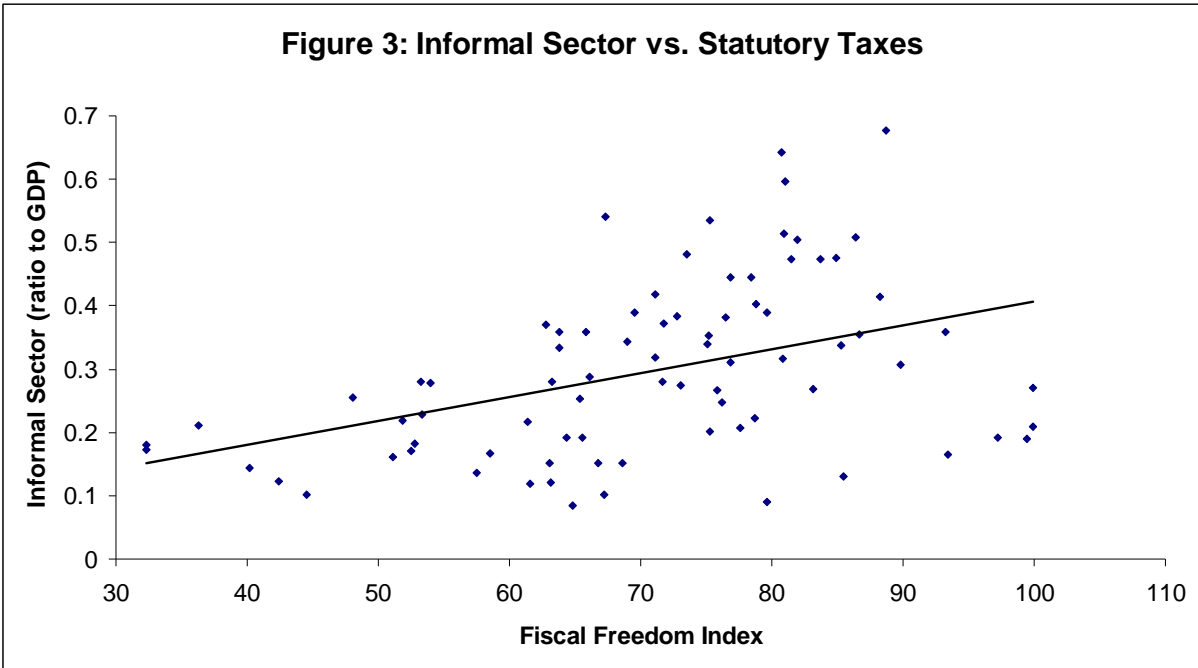
### 6.5 Figures and Tables



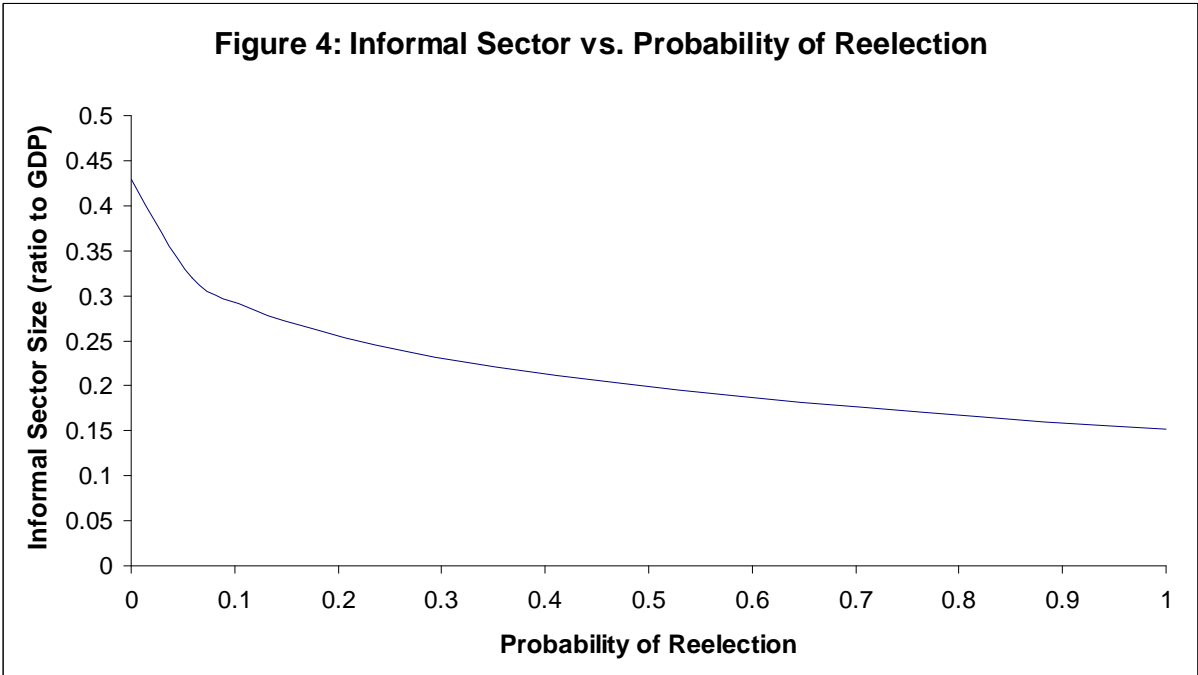
**Source:** Scatter plot of informal sector size (as a ratio to GDP) against the tax burden (tax revenue to GDP ratio) I plotted averages from 1999 to 2005. Tax burden is calculated from the Government Finance Statistics and informal sector size data is taken from Schneider (2007).



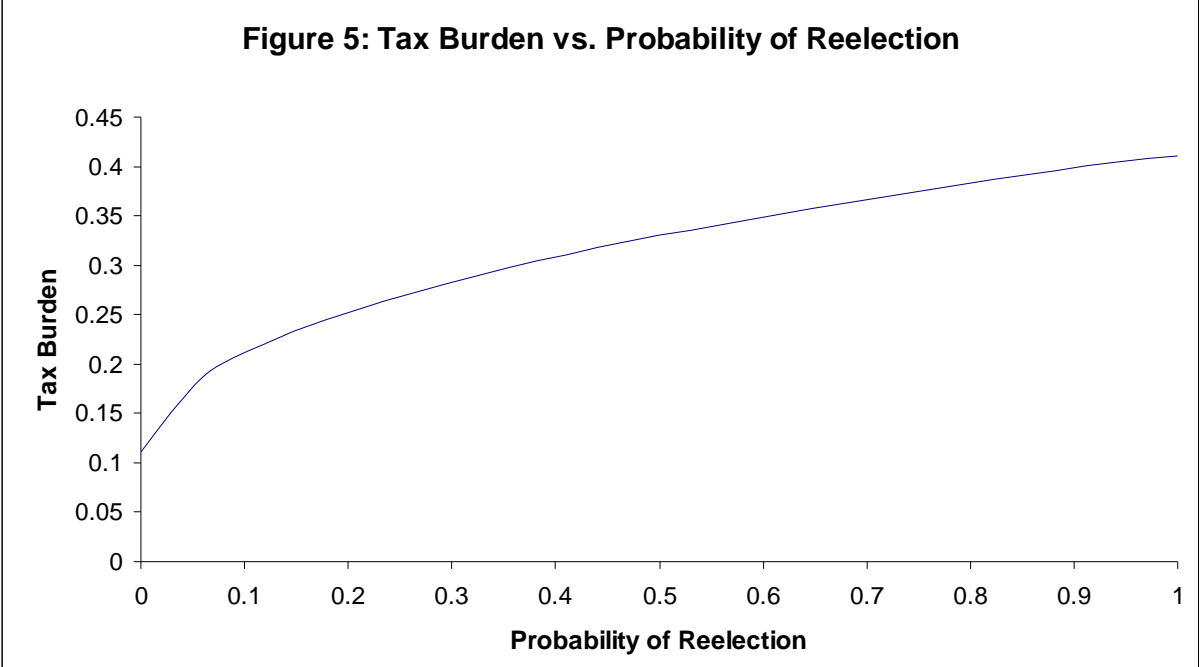
**Source:** Scatter plot of informal sector size (as a ratio to GDP) against the taxes on income profits and capital gains (Revenue to GDP ratio). I plotted averages from 1999 to 2005. Tax burden is calculated from the World Development Indicators Database and informal sector size data is taken from Schneider (2007).



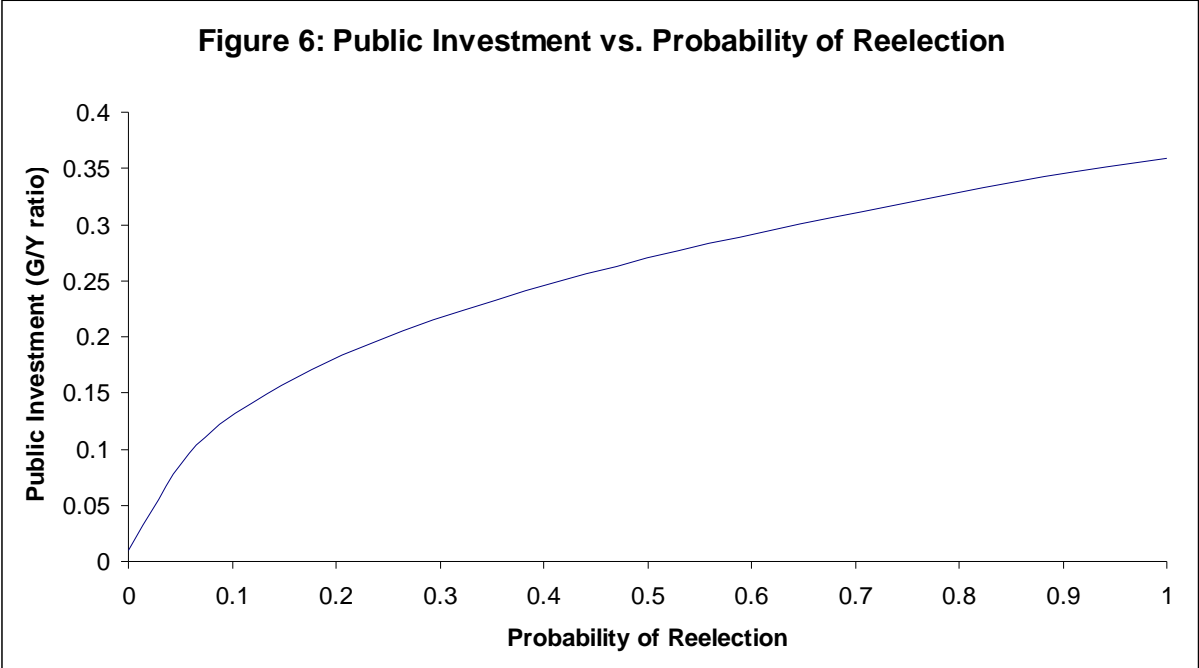
**Source:** Scatter plot of informal sector size (as a ratio to GDP) against the fiscal freedom index. I plotted averages from 1999 to 2005. Fiscal freedom index is obtained from the Heritage Foundation's Economic Freedom Database and informal sector size data is taken from Schneider (2007).



**Figure 5: Tax Burden vs. Probability of Reelection**



**Figure 6: Public Investment vs. Probability of Reelection**



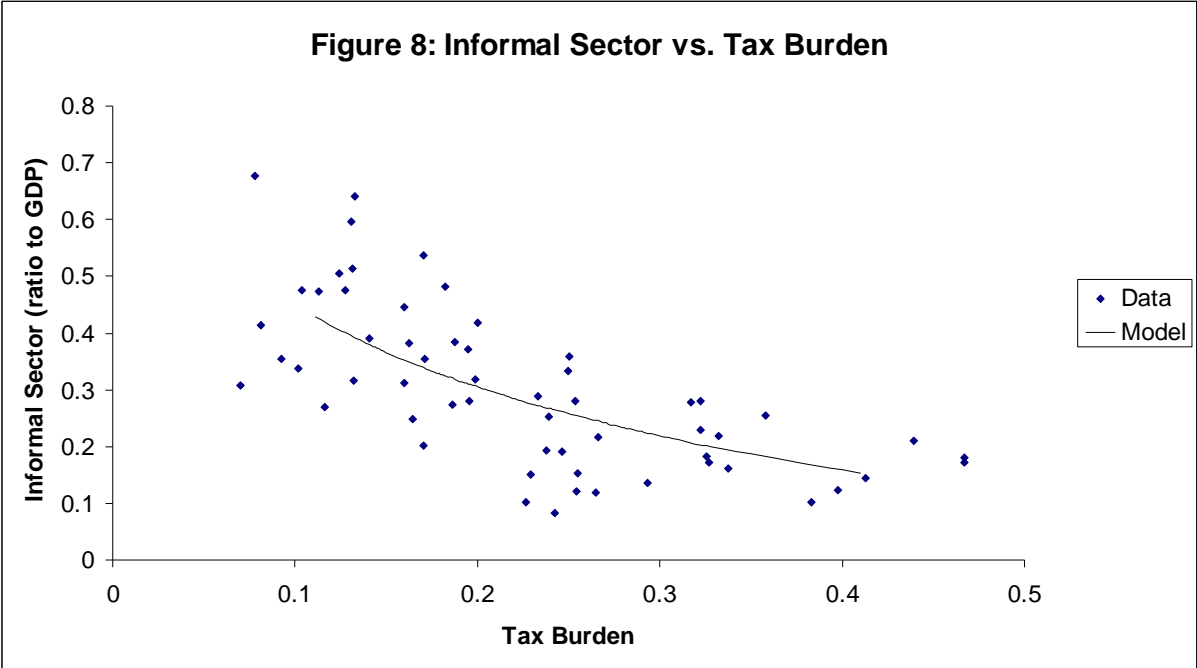
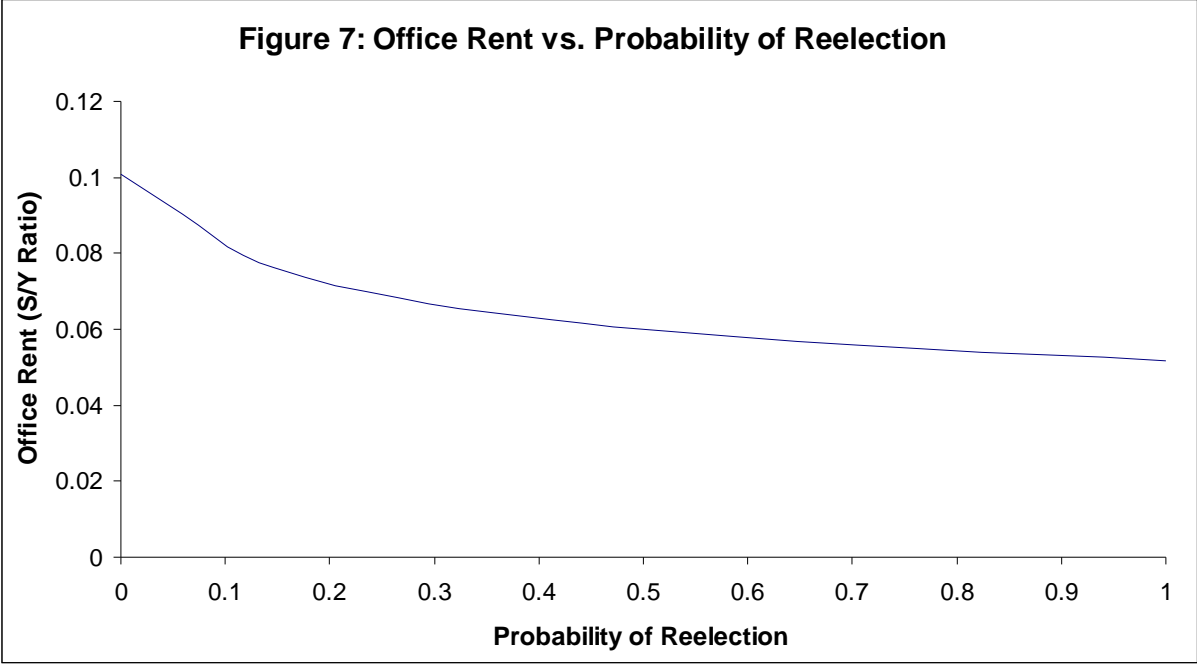
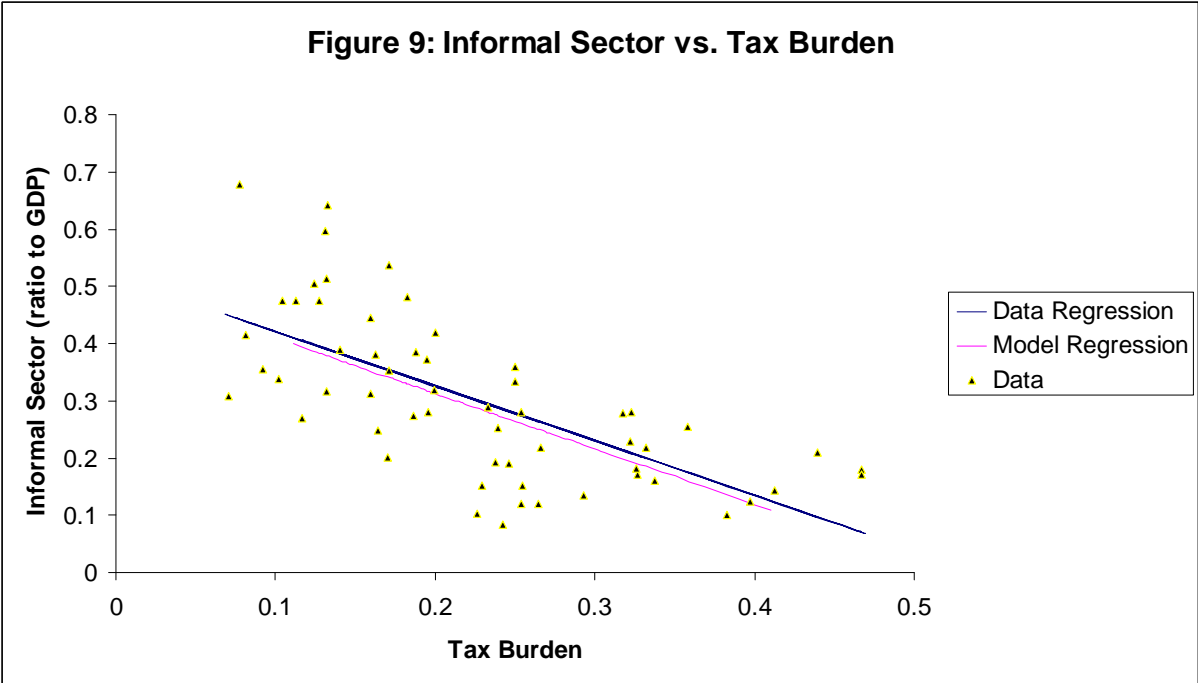


Figure 9: Informal Sector vs. Tax Burden





**Table 1: Informal Sector and Tax Burden**

Dependent variable: IS

	Pooled	Panel-OLS	Panel-OLS	Panel-OLS	Panel-OLS-IV	GMM
Tax Burden	-0.45 (0.169)	-0.52 (0.19)	-0.51 (0.13)	-0.48 (0.14)	-0.49 (0.15)	-0.55 (0.15)
GDP per-capita	-0.08 (0.01)	-0.075 (0.024)	-0.07 (0.027)	-0.072 (0.028)	-0.069 (0.021)	-0.072 (0.024)
Bureaucratic Quality	-1.95 0.85		-1.92 (0.76)	-1.79 (0.73)	-1.8 (0.79)	-1.78 (0.74)
Corruption	-1.7 (0.67)			-1.4 (0.65)	-1.42 (0.69)	-1.41 (0.63)
IS(-1)						0.39 (0.12)
<i>R</i> -squared	0.57	0.35	0.41	0.44	0.45	
Observations	80	400	400	400	400	240
F-Test	29.18	78.71	49.52	63.38		
Hansen J-Test						0.11
AR(2) Test						0.28

All panel regressions include year and country fixed effects. Standard errors are reported coefficient in parentheses. Corruption (which gets a larger value as the countries get less corrupt) and bureaucratic quality indices are from ICRG, GDP per-capita from Groningen Economic Growth and Development Center. Tax Burden Data is from GFS and informal sector data is from Schneider (2007).

**Table 2: Informal Sector and Fiscal Freedom**

Dependent var: IS

	Pooled	Panel-OLS	Panel-OLS	Panel-OLS	Panel-OLS-IV	GMM
Fiscal Freedom Index	0.14 (0.059)	0.17 (0.06)	0.12 (0.05)	0.19 (0.06)	0.23 (0.05)	0.18 (0.04)
GDP per-capita	-0.093 (0.025)	-0.075 (0.024)	-0.077 (0.026)	-0.079 (0.029)	-0.081 (0.031)	-0.082 (0.034)
Bureaucratic Quality	-1.84 0.75		-1.74 (0.78)	-1.76 (0.91)	-1.74 (0.89)	-1.68 (0.92)
Corruption	-1.76 (0.67)			-1.44 (0.62)	-1.41 (0.69)	-1.42 (0.65)
IS(-1)						0.40 (0.13)
<i>R</i> -squared	0.52	0.33	0.39	0.44	0.46	
Observations	80	400	400	400	400	240
F-Test	21.45	71.84	44.18	58.67		
Hansen J-Test						0.09
AR(2) Test						0.23

All panel regressions include year and country fixed effects. Standard errors are reported coefficient in parentheses. Corruption (which gets a larger value as the countries get less corrupt) and bureaucratic quality indices are from ICRG, GDP per-capita from Groningen Economic Growth and Development Center. Informal sector data is from Schneider (2007) and the fiscal freedom index is from the Heritage Foundation's Economic Freedom Index Database.

**Table 3: Regressions with Political Turnover**

Dep. Var: Tax Burden						
	Pooled 1	Pooled 2	Panel-OLS	Panel-OLS	Panel-OLS-IV	GMM
Political Stability		4.58 (2.3)	4.32 (1.01)	4.01 (1.15)	4.22 (1.14)	4.41 (1.11)
Probability of Reelection	17.23 (5.4)					
Tax Burden(-1)				0.92 (0.39)	0.85 (0.29)	0.88 (0.31)
<i>R</i> -squared	0.14	0.11	0.29	0.44	0.49	
Observations	58	80	400	320	400	240
Hansen J-Test						0.12
AR(2) Test						0.14
Dep. Var: Corruption						
	Pooled 1	Pooled 2	Panel-OLS	Panel-OLS	Panel-OLS-IV	GMM
Political Stability		0.41 (0.21)	0.44 (0.14)	0.42 (0.17)	0.42 (0.17)	0.41 (0.21)
Probability of Reelection	3.7 (1.01)					
Corruption(-1)			0.89	0.73 (0.17)	0.74 (0.15)	(0.12)
<i>R</i> -squared	0.13	0.21	0.24	0.29	0.32	
Observations	58	80	400	320	400	240
Hansen J-Test						0.11
AR(2) Test						0.13
Dep. Var: GDP per-capita						
	Pooled 1	Pooled 2	Panel-OLS	Panel-OLS	Panel-OLS-IV	GMM
Political Stability		21.19 (4.12)	21.26 (3.12)	21.44 (4.52)	20.65 (2.99)	20.99 (3.43)
Probability of Reelection	11.99 (3.4)					
GDP(-1)				0.29 (0.13)	0.31 (0.15)	0.32 (0.15)
<i>R</i> -squared	0.17	0.21	0.29	0.35	0.39	
Observations	58	80	400	320	400	240
Hansen J-Test						0.19
AR(2) Test						0.21

All panel regressions include year and country fixed effects. Standard errors are reported coefficient in parentheses. Political stability and corruption indices (which gets a larger value as the countries get less corrupt) are from ICRG and probability of reelection data is from Brender and Drazen (2008). Informal sector data is from Schneider (2007) and the data for tax burden is obtained from GFS. Lastly, GDP per-capita is from the Groningen Growth and Development Center.

**Table 4: Regressions with Political Turnover**

Dep. Variable: IS						
	Pooled 1	Pooled 2	Panel-OLS	Panel-OLS	Panel-OLS-IV	GMM
Political Stability		-2.91 (0.71)	-2.96 (0.72)	-2.87 (0.82)	-2.84 (0.89)	-2.99 (0.93)
Probability of Reelection	-0.12 (0.04)					
IS(-1)				0.34 (0.07)	0.34 (0.11)	0.36 (0.12)
Tax Burden	-0.26 (1.4)		-0.05 (0.12)			
<i>R</i> -squared	0.22	0.11	0.21	0.22	0.29	
Observations	58	80	400	320	400	240
Hansen J-Test						0.14
AR(2) Test						0.18

All panel regressions include year and country fixed effects. Standard errors are reported coefficient in parentheses. Political stability index is from ICRG and probability of reelection data is from Brender and Drazen (2008). Informal sector data is from Schneider (2007) and the data for tax burden is obtained from GFS.

**Table 5: Summary Statistics**

	Mean	Std. Deviation	Minimum	Maximum
Tax Burden (in %)	0.19	0.15	0.03	0.47
Informal Sector Size (in %)	29	14	8.0	67
Political Stability Index	9.15	0.98	6.99	11.17
GDP per-capita(in thousand GK\$)	13.65	9.52	1.23	34.76
Fiscal Freedom Index	70.71	15.27	32.3	99.9
Corruption Index	3.09	1.18	0.6	6
Bureaucratic Quality Index	2.17	1.15	1	4
Probability of Reelection	0.37	0.33	0	1

These are cross-section summary statistics of the panel averages. All the variables except the probability of reelection consist of 80 countries. For probability of reelection I have data for only 58 countries.