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INFORMAL ECONOMY IN A DYNAMIC POLITICAL FRAMEWORK

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I develop a dynamic political economy model with an informal sector and two political parties alternating in office. In equilibrium, if the incumbent political party faces a higher probability of staying in office, it sets a higher tax rate on the formal economy to invest more in productive public capital, while spending less for current office rent. Moreover, 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. I also present some empirical evidence that supports the main results of the model.

Keywords: Tax Evasion, Informal Sector, Political Turnover, Markov Perfect Equilibrium

1. INTRODUCTION

The informal sector, sometimes also called the 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 that produces legal goods, but does not comply with government regulations. In this sense it includes unreported income from the production and exchange of goods and services that would be taxable were it reported to the tax authorities.[1] Even though informality is prevalent and poses serious economic, social, and political challenges across the world, many issues about its nature and consequences remain largely underexplored. For example, the evidence presented in the existing literature has failed to generate a wide consensus among researchers about the determinants of the informal sector. There are also many other open questions, including whether informal sector size would be larger in low-income or high-income economies [Dreher and Schneider (2010)]; whether taxes are positively correlated with informal sector size or not [Friedman et al. (2000); Schneider and Enste (2000), among many others], whether informal sector size is procyclical or countercyclical [Cicek and Elgin (2011) and Elgin (2012)], and whether shadow economy and corruption are

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substitutes or complements [Dreher and Schneider (2010)]. One main reason for such disagreements is the lack of quantitative models of informality using tools of dynamic macroeconomics.

Building upon the lack of formal models of informality, and seeking to enhance our understanding of how informality interacts with taxes and other macroeconomic variables in a dynamic political economy setting, in this paper I first develop a dynamic political economy model with an informal sector. In the model, a government that lacks the ability to commit to future policy choices uses taxes on the capital and labor income of the formal sector to finance the provision of productive public capital and some office rent. The government is not fully benevolent and also gets utility from office rent, the amount of which is chosen by the incumbent government. Then I introduce political frictions into the model, specifically by allowing two political parties to alternate in political office with some exogenous probability, and focus on the symmetric differentiable Markov perfect equilibrium of this environment. At equilibrium, if the incumbent party faces a higher probability of keeping the office (i.e., if the political turnover is lower), it has higher stakes in the future (because the 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 changes the marginal rate of substitution between future office rent and current office rent, and therefore the incumbent spends less for office rent 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.[2] This increases incentives to participate in the formal sector and therefore reduces the size of the informal sector. To summarize, the model implies that a lower level of political turnover (or a higher political stability) is associated with a higher tax burden, less corruption, larger public investment, and smaller informal sector size. It also establishes a negative correlation between taxes and informal sector size, which is a highly discussed topic in the informal sector literature. (See the discussion later.) When I compare the implications of the model against the data and calibrate the model to match certain specific moments, the model performs remarkably well in accounting for the cross-country correlation between the tax burden and the size of the informal sector. Following the theoretical analysis, I employ several cross-sectional, 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, as suggested by the model, I also present evidence that several proxies of political stability interact strongly with the relationship between taxes and informal sector size.

My paper is distinct in the growing literature on the informal sector in three respects: First, it is the first in the literature that models informality within a dynamic political framework and therefore makes it possible to understand the economic mechanism behind several observations in the data regarding informality. Second,

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it also contributes to the Markov perfect optimal taxation literature by extending the benchmark framework in this literature with informality and a political dimension. Finally, it also sheds light on the relationship between informality and several economic and political variables such as taxes, public investment, and corruption. The most important among these relationships is the one with taxes, as tax burden is one of the most often referred-to causes of informality.

Considering that informality and tax evasion are frequently used interchangeably to refer to the same phenomenon, one expects a positive correlation between taxes and the size of the informal sector, which generally is not supported by various empirical studies. In addition to the current paper, several empirical studies also associate higher tax rates with a smaller informal economy. Examples of such studies are Johnson et al. (1997, 1998), Friedman et al. (2000), Torgler and Schneider (2007), and Kucera and Xenogiani (2009). More recently, Aruoba (2010) also documents a negative correlation between taxes and the size of the informal economy. Graphically, plotting informal sector size vs. tax burden, corporate tax rate, average labor income tax rate, or top marginal income tax rate[3] in a cross section clearly indicates a negative relationship between these variables.

As opposed to these empirical analyses, a common result in a few models dealing with an informal sector is a positive relationship between the tax rate and the size of the informal sector. A list of the papers in this literature includes Rauch (1991), Loayza (1996), Fortin et al. (1997), Busato and Chiarini (2004), Ihrig and Moe (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. By keeping taxes exogenous and not letting the informal sector pay 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 in exogenous. In this regard, existing theoretical frameworks cannot account for the surprising negative relationship between tax rates and the size of the informal sector.

Some of these empirical papers indicating a negative relationship between tax rates and the informal sector deserve more discussion, as they are more closely related to the present study.

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 a totally formal and a 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 play 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

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largely based on subjective evaluations of certain experts and institutions and therefore are 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. They find that increasing tax rates by 1% 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.[4] Much more recently, Aruoba (2010) developed a general equilibrium model, where the key factor creating the variation in taxes and the size of the shadow economy is the quality of institutions, and more specifically the degree of tax auditing by the government.

Finally, as mentioned earlier, the modeling of public finance in the present study is also related to the growing literature on 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 et al. (2008) and Martin (2010) studied a model of public expenditure and characterized and solved for the equilibrium of the dynamic game between successive governments. As opposed to my work, none of these papers have a political economy dimension or an informal sector.

The rest of the paper is organized as follows: In the next section I present the model and characterize the symmetric differentiable Markov perfect equilibrium, along with presenting some theoretical results in simplified cases. Then, in the third section, I simulate the model in a more general (and therefore realistic) environment and then compare the model simulations against the data. In Section 4, I conduct an empirical analysis to investigate the robustness of the model's implications in an econometric framework. Finally, in the last section I provide some concluding remarks.

2. MODEL

The model is essentially a simple two-sector growth model that consists of a unit measure of households and a government.

2.1. Households

Households can divide their labor endowment between two sectors: formal and informal. These two sectors produce a single consumption good. Specifically, given k_1, $\{r_t, w_t, \tau_{k_t}, \tau_{n_t}\}_{t=1}^{\infty}$, a stand-in household maximizes the following discounted

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utility from consumption:[5]

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

subject to the 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 τ_{k_t} and τ_{n_t}, respectively. The utility function is assumed to be strictly increasing, concave, and twice continuously differentiable and satisfies the Inada conditions. Moreover, r_t and w_{ft} stand for the rental rate of capital and the formal wage rate, respectively. $y_{it}(n_{it})$ represents the informal sector income. Last, δ_k is the depreciation rate for private capital.

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.[6]

2.2. Technology

The informal sector is generally viewed as a highly labor-intensive sector that operates on a small scale and cannot utilize public capital as much or as easily as the formal sector.

From the definition of informality, I assume that each firm in the informal sector produces according to the following decreasing-returns-to-scale technology:[7]

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

On the other hand, technology for each firm in the formal sector is given by

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

Here, G_t stands for the productive public capital.

Notice that the informal sector uses only labor as an input.[8] A possible justification for this could be that firms in the informal sector use significantly less capital because of lack of access to external finance [Amaral and Quintin (2006)] and that public capital is a complement to private capital [Aschauer (1989)].

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2.3. Government

The source of uncertainty in the economy arises from the existence of two political parties, party 1 and party 2, which can be in power at any $t \geq 0$. I define the state of incumbency at any period t as $z_t \in \mathcal{Z}_t = \{1, 2\}$ and assume that the uncertainty follows a Markov process; i.e., at the end of each period, the incumbent political party stays in office with an exogenous probability of ρ or loses the office to the other party with a 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 $i, j \in \{1, 2\}$.

One can interpret $1 - \rho$ as a measure of the degree of political turnover.[9]

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.[10] Hence, the government budget is given by

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

where δ_g is the depreciation rate of public capital, and 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 $U(C_t)$. Similarly to U, U^g is also assumed to be strictly increasing, concave, and twice continuously differentiable and satisfies the Inada conditions.

Last, 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.

2.4. Competitive Equilibrium

DEFINITION 2.1. *For a given government policy* $\prod = \{\tau_{k_t}, \tau_{n_t}, S_t, G_{t+1}\}_{t=1}^{\infty}$ *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* $r_t = \partial Y_{ft} / \partial K_t$, $w_{ft} = \partial Y_{ft} / \partial N_{ft}$, *and* $w_{it} = \partial Y_{it} / \partial N_{it}$.
3. *The government budget constraint is satisfied.*
4. *The aggregate resource constraint holds.*

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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. $\lim_{t\to\infty} \beta^t \lambda_t K_{t+1} = 0$,

where λ_t is the Lagrangian multiplier associated with the household budget constraint at time t. The first equation is simply the aggregate household budget constraint, and 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 the last constraint is the transversality condition.

2.5. Politico-economic Equilibrium

A simple finite-period analysis. Before presenting results in the general environment, I first discuss the Markov perfect equilibrium in a simple finite-period economy. The finite horizon allows me to get certain crucial analytical results under some specific simplifying assumptions.

Now, in this subsection, I make the following assumptions on the forms 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. $Y_{ft} = F_1(K_t, N_{ft}, G_t) = K^{\gamma} N_{ft}^{1-\gamma}(G_t/K_t)^{\gamma}$ 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 at both individual and aggregate levels.[11] Barro and Sala-i-Martin (1992) argue that the way that G enters the formal sector production function with congestion reflects public goods that are rival but not excludable for the formal sector firms. However, because the informal sector cannot utilize these public goods in this setting, this assumption makes G excludable for the informal sector.[12]

Assume for now that the economy only lasts for T periods and $T = 2$. In the following 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,

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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, τ_{n_1}, and τ_{k_1} subject to the government budget constraint, taking the following as given:

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 ρ of staying in office in period 2.

In the second period the government in office observes K_2 and G_2 and chooses τ_{n_2}, τ_{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. Last, using the timing described previously, I solve the model by backward induction. The results can be summarized by the following proposition:

PROPOSITION 2.2. *Under assumptions 1–3 and for* $\alpha_s > 0$, $\rho > 0$, *symmetric Markov perfect equilibrium allocations of the first period have the following features:*[13]

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

Notice that the results of the two-period model can be somewhat misleading for the desired results of the paper. This arises because the finite-period model implicitly assumes that $T = 2$ is the end period, where no private and public investment is made any more. 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 understanding the main mechanism of the model, which will still be valid for the results of the infinite-horizon economy.

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The formal proof of the proposition is provided in Appendix A. However, I briefly discuss here the intuition of the previously stated results.

The first result in the 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 because of the existence of an informal sector, the tax on formal labor income is distortionary, whereas because the capital of the second period is already invested, the capital income tax is not distortionary. Hence, all the burden of taxation falls on capital. However, the tax rate on capital in the second period depends on the value of α_s, and $\tau_{k_2} < 1$ if only if α_s is sufficiently low. Otherwise, $K_2 = 0$ and the economy shuts down in the second period. This is why an interior solution requires α_s to be small enough. Now, under this assumption, the economy is at the first best ($U_{c2} = U_{s2}$) in the second period, because the only tax instrument used, that is, the capital tax, is nondistortionary. 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), one can express S_2, C_2, N_{f2}, and N_{i2} as functions of G_2 only. More specifically, one can also obtain N_{f2} as an increasing function of G_2.

Having derived all the second-period allocations as a function G_2 only, I can write the problem of the incumbent in the first period. Now, of course, ρ 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 ρ. In this sense, ρ 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., ρ, 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 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 in productive public investment. Notice that the labor tax in the first period is also equal to zero and the burden of taxation falls on capital again. However, the government in the first period additionally faces an intertemporal distortion created by the capital tax in the second period. This distorts the margin between private consumption and office rent in the first period.[14]

For the last two statements, one might be curious to ask what happens to the formal and informal sector labor in the first period. These depend on the first period's stock of private and public capital, K_1 and G_1, and the labor tax rate. Because K_1 and G_1 are exogenously given and $\tau_{n_1} = 0$, 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 ρ. 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 reduces the relative size of the informal sector in the second period.

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The two-period economy with the simplifying assumptions can be generalized to an arbitrary T-period economy. Moreover, letting $T \to \infty$, I can state the following result for the equilibrium of the infinite-horizon economy as the limit of the previously described finite-horizon economy:

PROPOSITION 2.3. *For α_s small enough and assuming that Assumptions* 1, 2, *and* 3 *hold, there exists an interior Markov perfect equilibrium of the infinite-horizon economy that is the limit of the Markov perfect equilibrium of the finite-horizon economy, in which the steady state statistics feature*
$\tau_n = 0, \tau_k > 0, \partial\tau_k/\partial\rho > 0, \partial(G/Y)/\partial\rho > 0, \partial(S/Y)/\partial\rho < 0, \partial(G+S)/Y/\partial\rho > 0, \partial(Y_i/Y_f)/\partial\rho < 0$, *where* $Y = Y_i + Y_f$.

This proposition is actually an extension of Proposition 2.2. The proof is discussed in Appendix A. I should also note that Proposition 2.3 does not actually give much information in addition to Proposition 2.2. It simply states that the key results of the two-period environment extend to an infinite-horizon environment.[15] 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.

Even though this model assumes that households do not value leisure, it can easily be extended to include leisure in the utility function without changing the main results, most importantly the one concerning the relationship between the tax burden and the size of the informal sector. To this end, the following assumption is made on preferences:

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 2.4. *For α_s small enough and under Assumptions* 2, 3, *and* 4, *there exists an interior Markov perfect equilibrium of the infinite-horizon economy in the previously described environment in which the steady state statistics feature the following:* $\tau_n < 0$, $\tau_k > 0$, $\frac{\partial(G/Y)}{\partial\rho} > 0$, $\frac{\partial(S/Y)}{\partial\rho} < 0$, $\frac{\partial(G+S)/Y}{\partial\rho} > 0$, $\frac{\partial Y_i/Y_f}{\partial\rho} < 0$.

The proof is simply an extension of Proposition 2.3 and is briefly discussed in Appendix A.[16]

A more general environment. The equilibrium concept employed here is the same as that in Krusell, et al. (1996) and more recently Martin (2010). The key assumption is that the government does not commit to any of its future policy

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choices. In each period, the government acts first, choosing current period policies. The equilibrium is called Markov perfect because the government's choices depend only on the value of the current period's state, in this case just the aggregate private and public capital stocks. Additionally, I only consider equilibria where policy depends differentially[17] on the private and public capital stock (i.e., I assume that the policy functions are differentiable with respect to the state variables). Finally, after the government has moved, the private sector chooses its current-period action.

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 I set $\varsigma = (K, G)$ to be the vector of state variables,[18] 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 at equilibrium government follows the policy functions Γ, Θ_k, and Θ_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[19] that depend only on the private and public capital stock today. Calling them $\mathcal{K}(\varsigma)$ and $\mathcal{N}_f(\varsigma)$, respectively, I can write the two household first-order conditions in a more compact form as follows:

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

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

These two equations characterize household behavior for the current period for any arbitrary policy of the current government given that the government follows Θ_K, Θ_n, and Γ and thus implements $\mathcal{K}$ and $\mathcal{N}_f$.

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

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

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

Now, given the perception that governments follows some policy Γ, Θ_K, and Θ_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:

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

subject to the equations (1)–(4).

Also, notice that

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

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

I restrict my focus to (differentiable) interior symmetric Markov perfect equilibria (SMPE) of the previously described game. This leads to the following definition of a politico-economic equilibrium:

DEFINITION 2.5. *An interior SMPE is defined by two value functions $W(\varsigma)$ and $V(\varsigma)$ and policy functions $\mathcal{K}$, Γ, Θ_k, Θ_n, and $\mathcal{N}_f$ 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 ρ, the following conditions are satisfied:*

1. *Given the value functions $W(\varsigma)$ and $V(\varsigma)$, policy functions $\mathcal{K}$, Γ, Θ_k, Θ_n, $\mathcal{N}_f$ solve the government maximization problem for the variables K', G', τ_k, τ_n, and N_f, respectively.*
2. *Given the policy functions $\mathcal{K}$, Γ, Θ_k, Θ_n, and $\mathcal{N}_f$, 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.*

Moreover, the following proposition fully characterizes the symmetric (interior) differentiable Markov perfect equilibrium in this economy:

PROPOSITION 2.6. *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 equations* (1) *and* (2)*, together with the following equations:*

$$\Theta_n = 0,$$

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

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$$+\beta\frac{\mathcal{K}'_{G'}}{1-\rho}\left[\rho\frac{U_{c'}-\lambda'F'_1}{\beta}+(1-2\rho)U_{c''}\left(Y^{f''}_{K''}+1-\delta_k\right)\right]$$

$$+\beta\frac{\Gamma'_{G'}}{1-\rho}\left[\rho\frac{U_{s'}-\lambda'F'_2}{\beta}+(1-2\rho)U_{s''}\left(Y^{f''}_{G''}+1-\delta_g\right)\right]+\lambda'F'_4\Bigg\}=0.$$

Proof. See Appendix B. ■

The first equation 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. They show two simple things and are very intuitive: For example, the second one shows the trade-off that the incumbent political party 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 second equation starts with the term $-U_s$. It also distorts the Euler equation of the households, which is represented by the term λF_2. However, depending on the value of ρ, it brings benefits tomorrow and thereafter. These benefits are represented by the terms after β. With probability ρ, the incumbent of today stays in office and continues to enjoy the office rent, which is represented by the term $\beta[\rho U_{s'}[Y^{f'}_{G'}+1-\delta_g]]$. Notice that the term in the brackets refers to the extra office rent effect of one additional unit of public investment today. On the other hand, the incumbent loses power with probability $1-\rho$. The first term within the large braces refers to the additional present value of discounted utility of today's incumbent in this case. Even if it loses power, there are still benefits from additional public investment today, which manifest themselves as extra gains from formal sector output (enjoyed by today's incumbent even if it loses the office). Moreover, the current incumbent 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 braces, which are a continuation value of the decision made by the incumbent today. 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 also applies to the first one.

3. NUMERICAL ANALYSIS

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

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

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

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

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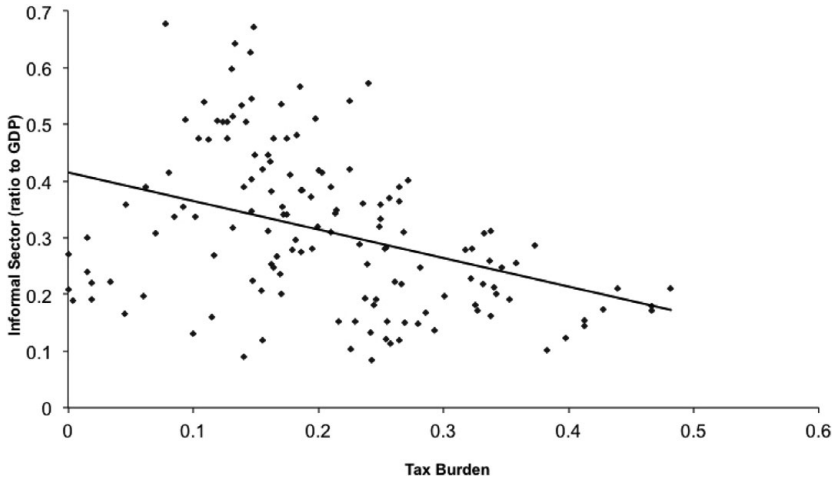


FIGURE 1. Informal sector vs. tax burden.

Krusell and Smith (2003) show that this class of dynamic policy games may feature both differentiable and nondifferentiable Markov perfect equilibria. However, I restrict my attention only to differentiable Markov perfect equilibrium and numerically calculate the steady state statistics of this economy.[20] I describe the relevant computational algorithm in Appendix C.

3.1. Some Preliminary Observations

In the numerical simulations, I give special emphasis to the relationship between taxes and informal sector size. Therefore, before I present the simulations of the model, Figures 1–3 aim to illustrate this relationship in the data. Figure 1 depicts the relationship between informal sector size and tax burden for a cross section of 141 countries.[21] Additionally, when the burden from taxes is calculated, Figure 2 uses the ratio of revenue from taxes on income, capital gains, and profits to GDP on the x-axis. Finally, to illustrate the relationship between informal sector size and a measure of statutory taxes (as opposed to the previous two measures, which were calculated based on actual tax revenues). Figure 3 shows informal sector size vs. the fiscal freedom index[22] provided by the Heritage Foundation.[23]

3.2. Parameterization 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 $\beta = 0.96$.

To determine the depreciation rates of private capita δ_k and public capital δ_g, I jointly match[24] the average capital–output ratio from my data set (2.33) and the public investment–output ratio (0.04). This procedure implies a depreciation rate

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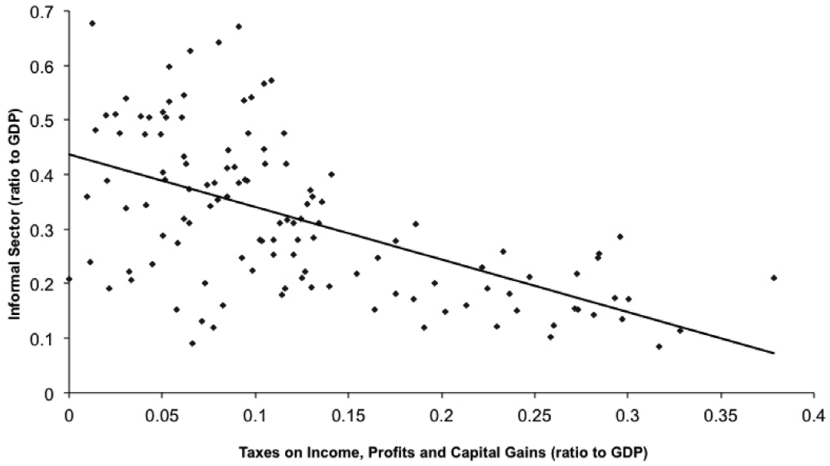


FIGURE 2. Informal sector vs. income taxes.

of about 0.08 on private physical capital and a depreciation rate of about 0.10 on public capital. Finally, I take $\mu = 0.15$ from Eicher and Turnovsky (2000), which also uses the same functional form for the production function in an optimal taxation environment similar to that in the current paper. However, to check the sensitivity of my results with respect to this nonstandard parameter, I will also conduct two simulations using different values of μ.

Now, the only remaining parameters are α_s in the utility function and ϕ in the informal sector production function. Regarding the calibration of these two parameters, I conduct two exercises. In one, I choose their values so that I match average informal sector size (8.38%) and tax burden (24.30%) in the United States

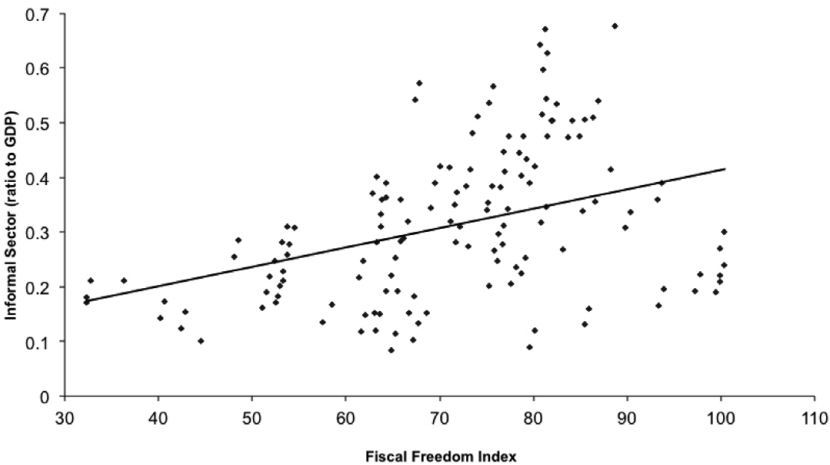


FIGURE 3. Informal sector vs. statutory taxes.

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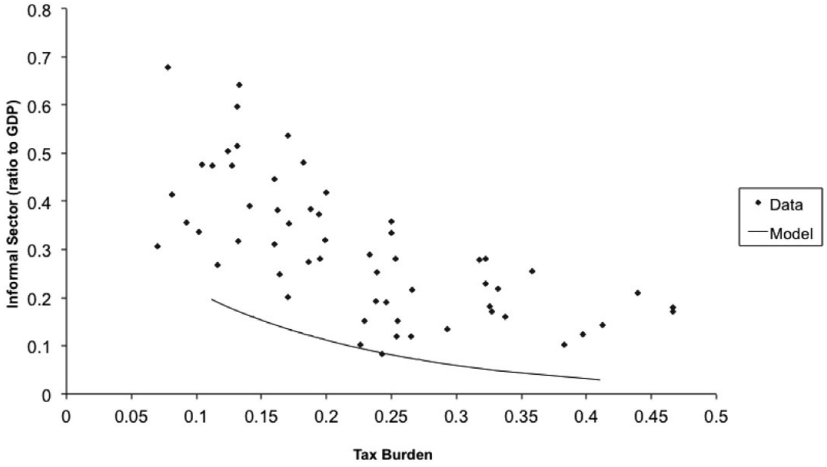


FIGURE 4. Informal sector vs. tax burden: matching U.S. data.

for the period 1999 to 2007. (The calibrated values are 0.06 and 0.35, respectively.) In the second exercise I calibrate α_s and ϕ to match the average size of the tax burden (18.01%) and the informal sector size (34.19%) in my data set.The calibrated values in the second exercise are $\alpha_s = 0.11$ and $\phi = 0.45$. Moreover, once I calibrate these two parameters, I take the probability of reelection data given by Brender and Drazen (2008) for 58 countries,[25] feed their series for the 58 countries into the model as the ρ, and then obtain the generated series of relevant endogenous variables in the steady state, i.e., the tax burden, $r_t K_t \tau_{k_t} / Y_t$, the relative size of the informal sector, Y_i / Y_f, the public capital–output ratio, G/Y, and last the office rent–output ratio, S/Y.

3.3. Quantitative Results and Experiments

Figure 4 plots the relationship between informal sector size and tax burden using the calibrated values of α_s and ϕ for the United States. As evident from the figure, the model series goes through the U.S. data and can account for the negative relationship between informal sector size and taxes; however, it does not perform well in matching the correlation between these two variables in the cross-country setting.

Next, in Figure 5, I plot the same relationship using values of α_s and ϕ matching the average values of informal sector size and tax burden. As Figure 5 clearly illustrates, the model can now account for both the sign and magnitude of the correlation between these two variables. Moreover, using the same series, in Figure 6 I compare the linear regression lines drawn for the actual data and for the model-generated data. The slopes are very similar and the two lines almost overlap.[26]

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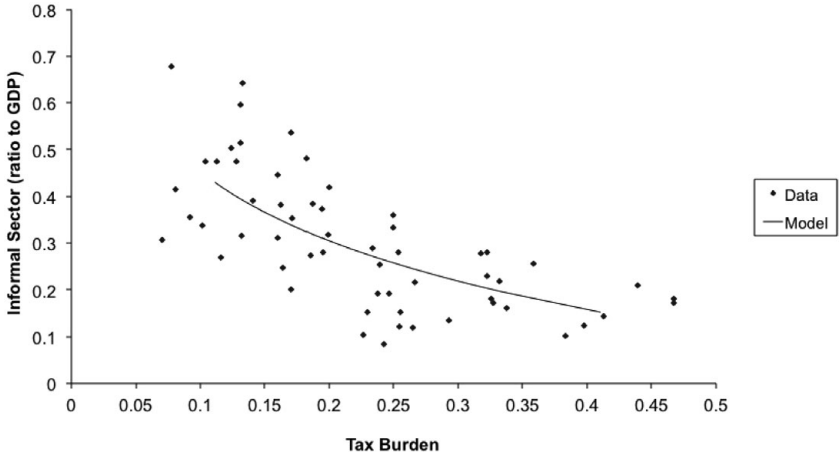


FIGURE 5. Informal sector vs. tax burden: matching average data.

In Figures 7–10, using the calibrated values for α_s and ϕ, I plot certain endogenous variables of interest against various values of ρ to see the mechanism behind the model's crucial result. As Figure 7 shows, increasing ρ reduces the size of the informal sector, and as the next figure, Figure 8, shows, it increases the tax burden. However, the two components of government spending go into different directions. As the probability of reelection increases, the public capital–output ratio goes up and the office rent–output ratio goes down. These two relationships are illustrated in Figures 9 and 10, respectively.

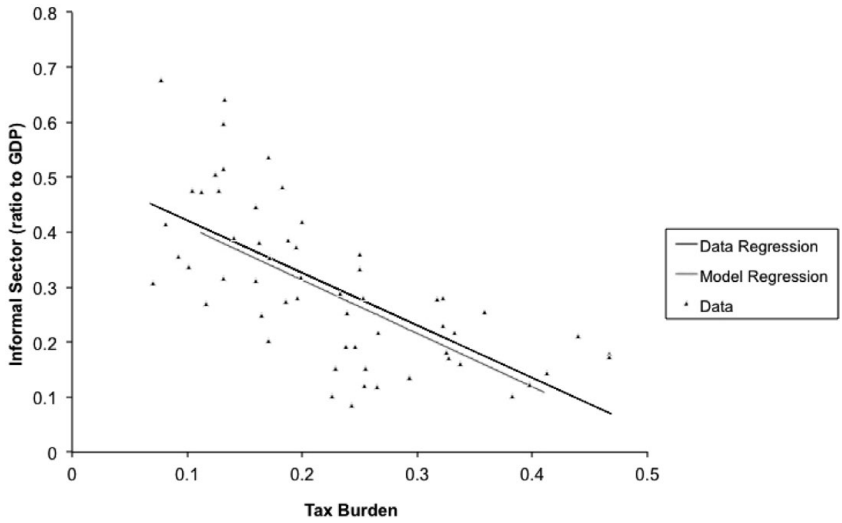


FIGURE 6. Informal sector vs. tax burden: data vs. model regression.

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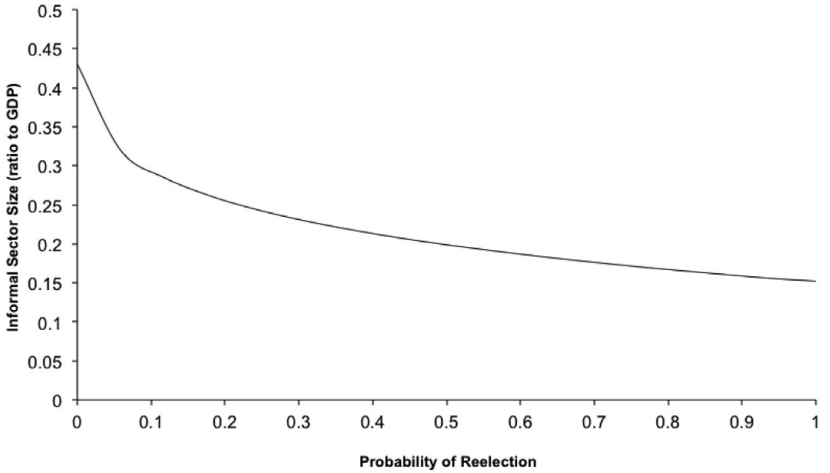


FIGURE 7. Informal sector vs. probability of reelection.

Next, Figure 11 conducts a sensitivity analysis with respect to the choice of μ. Here, in addition to the benchmark simulation with $\mu = 0.15$ (line in the middle), I run two additional simulations with $\mu = 0.25$ (lower line) and $\mu = 0.05$ (upper line). As, in both cases, the model can still match the negative correlation between informal sector size and tax burden, I conclude that the model's performance is generally robust to the choice of μ.[27]

Finally, Figure 12 runs another sensitivity check with respect to the informal sector production function. Remember that so far I have assumed that the informal sector does not employ private or public capital. Here, I relax this assumption

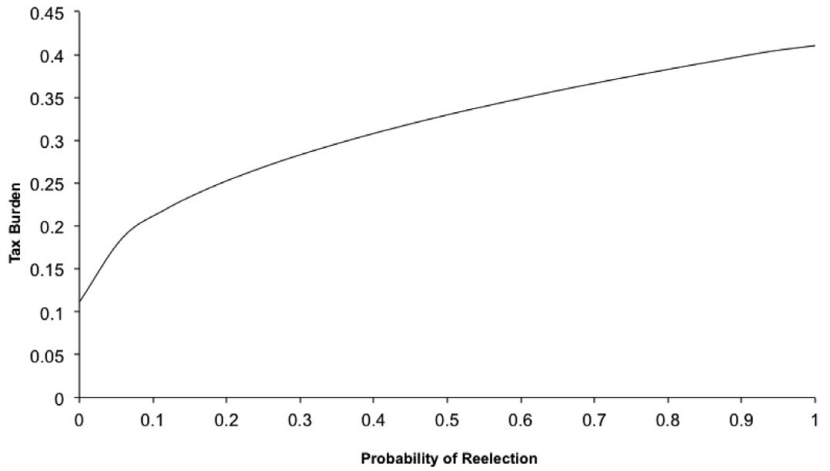


FIGURE 8. Tax burden vs. probability of reelection.

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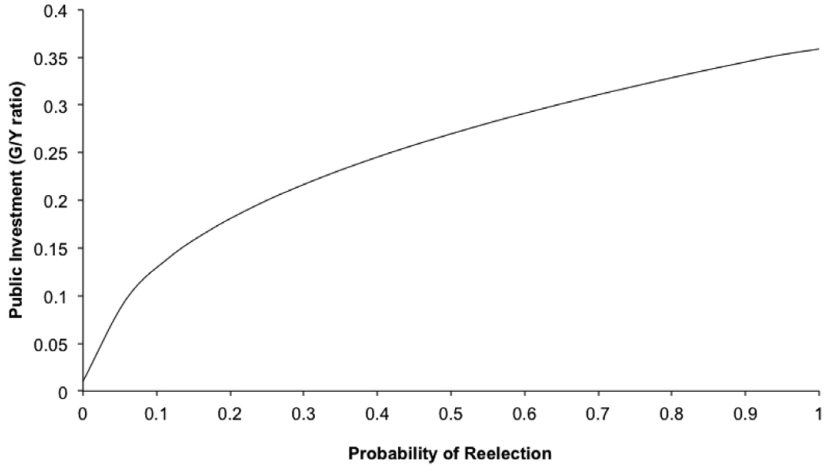


FIGURE 9. Office rent vs. probability of reelection.

and assume that $Y_{it} = K_{it}^{\gamma_i} N_{it}^{\phi} (G_t / K_{it})^{\mu_i}$. For this specific exercise, I assume that $\gamma_i = 0.25$, $\mu = 0.10$.[28] Then I use the same procedure as before and calibrate α_s and ϕ to match the average values of informal sector size and tax burden in the data. (The calibrated values are 0.08 and 0.27, respectively.) Figure 12 plots informal sector size vs. tax burden using these values. Here the solid line represents the benchmark, whereas the dashed line corresponds to the simulation corresponding to the sensitivity check. Similarly to the previous sensitivity check, as expected, the results are quantitatively similar to the benchmark case.

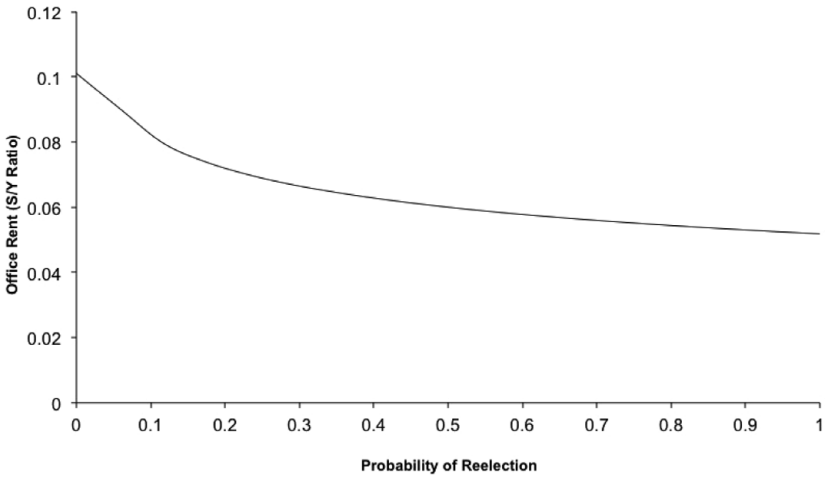


FIGURE 10. Informal sector vs. tax burden.

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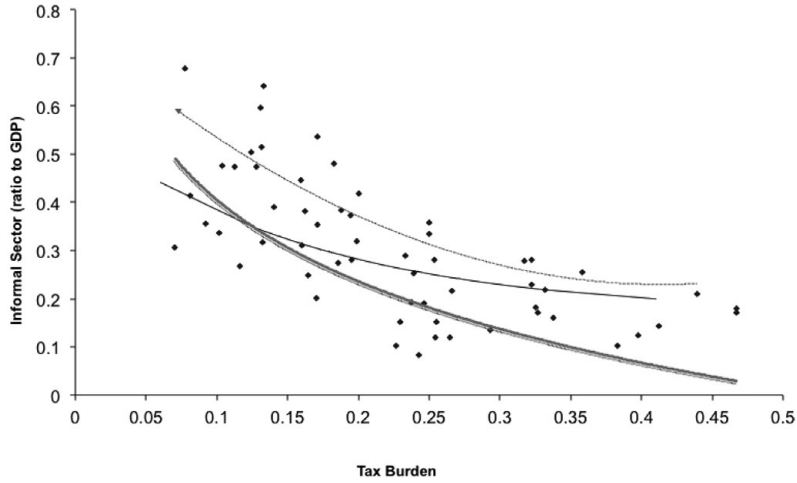


FIGURE 11. Informal sector vs. statutory taxes: different values of μ.

4. EMPIRICAL ANALYSIS

In this section I present empirical evidence testing the main results of the model presented in the previous section. First I describe the data set, then discuss the econometric methodology, and finally present estimation results.

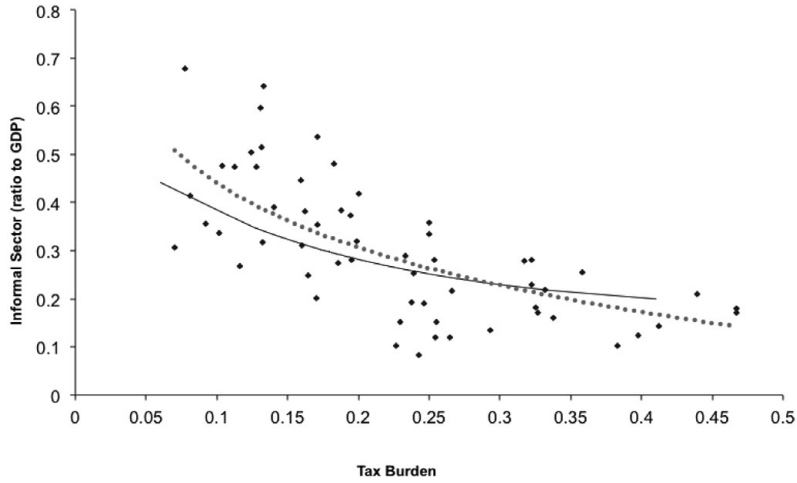


FIGURE 12. Informal sector vs. statutory taxes: different informal sector production functions.

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4.1. Data

Informal sector size. There are different methods for measuring the size of the informal sector. Obviously, each method has its own advantages and disadvantages,[29] the discussion of which is out the scope of this paper. In this paper, I use panel estimates of Schneider et al. (2010) running from 1999 to 2007.[30]

Taxes. In the econometric estimates 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 the IMF.[31] I also use taxes on income, profits, and capital gains (as percentages of GDP) from the World Development Indicators. Moreover, I also obtained the fiscal freedom index 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[32] if I use other types of taxation data.[33]

Political turnover. I use two measures of political turnover. One of these measures is the political stability index, which is a composite measure for government unity, legislative strength, and popular support and is obtained from the International Country Risk Guide (ICRG). Another measure is the probability of reelection index developed in a recent paper by Brender and Drazen (2008) using election data from a significant number of countries. However, the probability of reelection database is available for 58 of 141 countries in my informal sector data set.[34] Also, it is only a cross-sectional data set, whereas the political stability index of the ICRG is a yearly panel and available for all 141 countries from 1999 to 2007.

Other variables. In the regression analysis I also use several control variables, such as GDP per capita, growth of GDP, capital— ratio, and measures of law and order, corruption, bureaucratic quality, and democratic accountability. I obtained the data for GDP per capita, growth, and capital–output ratio[35] from the Penn World Tables 7.1. For measures of institutional quality, I use data from the ICRG.

I present descriptive statistics for all the variables in Table 1.

4.2. Econometric Methodology

To check the robustness of the negative relationship evident in Figures 1–3, I run a number of regressions using different sets of explanatory variables and econometric specifications.

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TABLE 1. Summary statistics

	Mean	Std. Dev.	Min.	Max.
Tax burden (%)	18.01	7.14	0.80	52.13
Fiscal freedom index	71.49	15.87	32.20	99.9
Informal sector size (%)	34.19	12.98	7.95	68.75
Political stability index	9.15	0.98	6.99	11.17
Probability of reelection	0.37	0.33	0.00	1.00
GDP per capita (PPP in thousand US$)	11.70	13.93	0.17	75.49
Law and order index	3.89	1.35	0.50	6.00
Bureaucratic quality index	2.23	1.11	0.00	4.00
Corruption index	2.78	1.22	0.00	6.00
Democracy	4.03	1.66	0.00	6.00
Capital–output ratio	2.33	1.97	0.30	6.09
Growth of GDP (%)	3.43	3.53	−4.41	12.32

Notes: These are cross-sectional summary statistics of the panel averages. All the variables except the probability of reelection are for 141 countries. For the probability of reelection I have data for only 58 countries.

In the static panel data analysis with fixed effects, the estimated equations are of the form

$$\mathrm{IS}_{i,t} = \beta_0 + \beta_1 \mathrm{tax}_{i,t} + \sum_{k=2}^{n} \beta_k X_{k_{i,t}} + \theta_i + \gamma_t + \epsilon_{i,t},$$

where $X_{k_{i,t}}$ are the other explanatory variables in addition to taxes and θ_i, γ_t are the country and period fixed effects, respectively. $\mathrm{IS}_{i,t}$ is the size of the informal sector relative to GDP and $\mathrm{tax}_{i,t}$ is the tax rate. In addition to the fixed-effects (FE) estimator, I will also run regressions using three additional estimators: the ordinary least squares estimator (OLS), the instrumental variable estimator (IV) using the method of Anderson and Hsiao (1982) with clustered standard errors, and finally the GMM estimator à la Arellano and Bond (1991), in which I use lagged independent variables as instruments for the levels of these variables. In these regressions, I expect the estimate of β_1 to be significantly negative.

Moreover, I also run regressions using measures of political turnover on the right-hand side. In these cases, I estimate the following equation with an interaction term of political stability and taxes on the right-hand side:

$$\mathrm{IS}_{i,t} = \beta_0 + \beta_1 \mathrm{tax}_{i,t} + \beta_2 \mathrm{tax}_{i,t} \mathrm{pols}_{i,t} \sum_{k=3}^{n} \beta_k X_{k_{i,t}} + \theta_i + \gamma_t + \epsilon_{i,t.}$$

In this specification, when using the panel political stability series, I again conduct estimations with the four different estimators that I mentioned in the panel data setting. However, when I use the cross-country probability of

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TABLE 2. Informal sector and tax burden

	OLS	FE	IV	GMM	OLS	FE	IV	GMM
Tax	−0.33*	−0.42**	−0.24**	−0.25**	−0.36*	−0.34**	−0.20**	−0.28**
	(3.08)	(2.19)	(2.11)	(2.04)	(2.96)	(2.02)	(1.98)	(2.14)
GDP	−0.02**	−0.03*	−0.03*	−0.01***	−0.02**	−0.02**	−0.01**	−0.01
	(2.07)	(3.01)	(3.10)	(1.76)	(1.99)	(2.01)	(2.09)	(1.54)
Law	−0.75*	−0.49*	−0.56*	−0.59*	−0.59*	−0.48*	−0.51*	−0.55*
	(4.21)	(3.83)	(3.24)	(3.08)	(3.70)	(4.08)	(3.06)	(3.21)
Bureaucracy	−1.12***	−0.92	−0.80	−0.75	−1.01	−0.96	−0.88	−0.79
	(1.80)	(1.14)	(1.65)	(1.49)	(0.95)	(1.01)	(0.94)	(1.20)
Corruption	−1.00**	−0.85**	−0.71*	−0.79*	−1.03**	−0.89*	−0.85*	−0.75*
	(2.03)	(2.11)	(2.98)	(3.02)	(2.24)	(2.94)	(3.00)	(3.11)
Democracy					−0.78	−0.69	−0.92	0.80
					(0.36)	(0.54)	(0.45)	(0.61)
Capital					−2.17*	−2.14*	−2.28*	−2.35*
					(3.94)	(3.65)	(3.88)	(4.13)
Growth					0.18	0.11	0.12	0.10
					(0.46)	(0.16)	(0.30)	(0.24)
IS(-1)					0.39*	0.74	0.88***	0.96**
					(3.04)	(1.12)	(1.78)	(2.01)
R^2	0.49	0.52			0.63	0.59		
Obs.	1,269	1,269	1,128	1,128	1,128	1,128	989	989
J-Test				0.21				0.18
AR(2)-Test				0.44				0.47

Notes: Dependent variable: IS. Robust t-statistics are reported in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included but is not reported.

reelection series, I simply run an OLS regression with heteroskedasticity-consistent standard errors. Given the results of the theoretical model of the previous section, in the regressions with political stability, I expect the estimates of β_1 and β_2 to be positive and negative, respectively. That is, when political stability is controlled for, I expect the effect of taxes on informality to interact with political stability. More specifically, with higher political stability, I expect the correlation between informal sector size and tax burden to turn negative.

4.3. Estimation and Results

Tables 2 and 3 report the results of the benchmark estimation. In Table 2, I use the tax burden series, whereas in Table 3, I use the FFI index as the relevant independent variable. In both of these tables, I first run OLS, FE, IV, and GMM regressions with tax burden, GDP per capita, and three institutional quality indices on the right-hand side of the regression equation. Then I also add democratic accountability, growth of GDP, capital–output ratio, and lagged informal sector size to the right-hand side. As one can observe from both tables, higher taxes (actual

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TABLE 3. Informal sector and fiscal freedom

	OLS	FE	IV	GMM	OLS	FE	IV	GMM
FFI	0.12*	0.14**	0.09*	0.05**	0.10*	0.12**	0.10**	0.07**
	(2.97)	(2.24)	(3.01)	(2.04)	(3.02)	(2.22)	(2.60)	(1.99)
GDP	−0.02**	−0.03*	−0.03*	−0.01***	−0.02**	−0.02**	−0.01**	−0.01
	(2.05)	(2.98)	(3.10)	(1.79)	(1.99)	(2.01)	(2.09)	(1.52)
Law	−0.76*	−0.49*	−0.56*	−0.58*	−0.58*	−0.48*	−0.50*	−0.54*
	(4.18)	(3.83)	(3.24)	(3.05)	(3.68)	(4.06)	(3.05)	(3.22)
Bureaucracy	−1.10***	−0.92	−0.80	−0.75	−1.01	−0.96	−0.88	−0.79
	(1.80)	(1.14)	(1.65)	(1.49)	(0.95)	(1.01)	(0.94)	(1.20)
Corruption	−0.99***	−0.85**	−0.71*	−0.79*	−1.03**	−0.89*	−0.85*	−0.75*
	(1.82)	(2.11)	(2.98)	(3.02)	(2.24)	(2.94)	(3.00)	(3.11)
Democracy					−0.76	−0.68	−0.90	0.82
					(0.35)	(0.54)	(0.45)	(0.60)
Capital					−2.18*	−2.11*	−2.29*	−2.35*
					(3.94)	(3.66)	(3.88)	(4.11)
Growth					0.17	0.10	0.11	−0.09
					(0.46)	(0.15)	(0.32)	(0.23)
IS(-1)					0.38*	0.73	0.88**	0.95**
					(3.04)	(1.11)	(1.90)	(2.02)
R^2	0.37	0.41			0.55	0.56		
Obs.	1,269	1,269	1,128	1,128	1,128	1,128	989	989
J-Test				0.18				0.17
AR(2)-Test				0.33				0.38

Notes: Dependent variable: IS. Robust *t*-statistics are reported in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included is but not reported.

or statutory[36]) are (significantly) associated with smaller informal sector size in all specifications.[37] Moreover, these two tables also indicate that GDP per capita, law and order, corruption control, and capital–output ratio are significantly associated with informal sector size. Accordingly, a higher level of law enforcement, corruption control, capital intensity and GDP per capita are all associated with a smaller informal sector size.

Next, in Table 4, I report estimation results for political stability using panel data from 141 countries. Utilizing the panel nature of the political stability series, I run regressions with four different panel specifications. As expected, we observe in Table 4 that the estimate of the coefficient of the tax burden is positive; however, the correlation between tax burden and informal sector size is generally negative at higher levels of political stability. Table 5 runs several regressions[38] reported in Table 4 for different subsets of the data. These regions are OECD and European Union economies (OECD-EU), Asian and Australian countries (Asia), Latin American and Caribbean economies (Latin), Middle East and North Africa (MENA), and post-socialist (transition) economies. Moreover, we also divide

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TABLE 4. Regressions with political stability

	OLS	FE	IV	GMM	OLS	FE	IV	GMM
Tax	0.09***	0.12**	0.07**	0.15*	0.06**	0.13**	0.09**	0.13*
	(1.78)	(2.09)	(2.07)	(3.04)	(1.96)	(2.12)	(2.08)	(2.94)
Pols.	−2.00**	−2.06**	−2.16***	2.18**	−1.98***	−2.04**	−2.40**	−2.19**
	(2.10)	(2.33)	(1.73)	(1.89)	(1.74)	(2.01)	(2.12)	(2.20)
Pols.·tax	−0.05*	−0.07*	−0.06*	−0.09*	−0.09*	−0.09*	−0.07*	−0.08*
	(3.99)	(3.53)	(3.37)	(3.96)	(2.94)	(3.01)	(3.08)	(3.10)
GDP	−0.01***	−0.02***	−0.02	−0.01	−0.02	−0.02	−0.01	−0.02
	(1.77)	(1.81)	(1.51)	(1.60)	(1.49)	(1.01)	(1.09)	(1.34)
Law	−0.75*	−0.49*	−0.56*	−0.54*	−0.58*	−0.46*	−0.50*	−0.53*
	(4.21)	(3.83)	(3.24)	(3.09)	(3.70)	(4.08)	(3.06)	(3.22)
Bureaucracy	−1.11***	−0.97	−0.81	−0.76	−0.83	−0.96	−0.88	−0.54
	(1.80)	(1.18)	(1.65)	(1.49)	(0.96)	(0.97)	(0.94)	(1.04)
Corruption	−1.02**	−0.86**	−0.72*	−0.79*	−1.03*	−0.89*	−0.84*	−0.75*
	(2.33)	(2.41)	(3.11)	(3.08)	(2.93)	(2.99)	(3.04)	(3.12)
Democracy					−0.78	−0.69	−0.92	0.80
					(0.35)	(0.54)	(0.45)	(0.61)
Capital					−2.15*	−2.12*	−2.29*	−2.38*
					(3.99)	(3.95)	(4.01)	(4.12)
Growth					0.15	0.09	0.11	0.01
					(0.44)	(0.15)	(0.30)	(0.20)
IS(-1)					0.34**	0.58***	0.85**	0.94**
					(2.44)	(1.82)	(1.95)	(2.03)
R^2	0.52	0.54			0.67	0.61		
Obs.	1269	1269	1128	1128	1128	1128	989	989
J-Test				0.30				0.21
AR(2)-Test				0.29				0.18

Notes: Dependent variable: IS. Robust standard errors are in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included but is not reported.

the data set into two: Countries with a real GDP per capita less than the mean value in the whole data set (about 11,700 US$), denoted as emerging markets (EM), and those above that level, denoted as developed countries (DC). Surely, results change qualitatively in different subsets of the data; however, the signs of the coefficients of tax burden and the interaction term are in line with the model.

Table 6 complements the analysis reported in Table 4, now with only 58 countries, for which the cross-country probability-of-reelection data are available. Here, the first two columns report the results of the cross-sectional regressions with probability-of-reelection series. The next eight regressions, on the other hand, report the panel regressions with political stability for the 58-country subset. As one can observe, results are very similar to those reported in Table 4.

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TABLE 5. Regressions with political stability: Different subsets

	OECD-EU	Asia	Latin	MENA	Subs.	Transition	EM	DC
Tax	0.08**	0.17**	0.05*	0.06***	0.08**	0.12**	0.11**	0.08**
	(1.99)	(2.09)	(4.07)	(1.84)	(2.09)	(2.23)	(2.45)	(2.24)
Pols.	−2.20***	−3.05*	−1.96**	1.48**	−2.10**	−2.00**	−2.07**	−1.75**
	(1.87)	(4.33)	(2.03)	(2.08)	(2.44)	(2.33)	(2.19)	(1.99)
Pols.·tax	−0.08*	−0.11**	−0.09*	−0.06*	−0.05**	−0.10*	−0.08*	−0.04**
	(3.01)	(2.53)	(3.14)	(3.12)	(2.23)	(4.01)	(3.05)	(2.19)
GDP	−0.01	−0.01**	−0.01	−0.01	−0.01	−0.01	−0.01	−0.02
	(1.47)	(2.09)	(1.41)	(1.23)	(1.15)	(1.17)	(1.34)	(0.79)
Law	−0.25	−0.23**	−0.39*	−0.40*	−0.61*	−0.39**	−0.47**	−0.27***
	(0.21)	(2.43)	(3.49)	(3.89)	(4.05)	(2.75)	(2.13)	(1.79)
Bureaucracy	−0.51	−0.65**	−0.68***	−0.59***	−0.63	−0.60	−0.55	−0.39
	(0.48)	(1.98)	(1.79)	(1.75)	(1.56)	(1.43)	(0.99)	(0.45)
Corruption	−1.19	−0.43	−0.64*	−0.85*	−1.04**	−0.75**	−0.65**	−0.44
	(0.33)	(0.99)	(3.51)	(3.39)	(2.77)	(2.49)	(2.46)	(1.02)
Democracy	0.71	−0.04***	−0.68	−0.79	−0.78	−0.57	−0.92	−0.12
	(0.14)	(1.81)	(1.42)	(1.01)	(1.55)	(0.51)	(1.35)	(0.29)
Capital	−1.59*	−2.04*	−2.84*	−2.92*	−2.67*	−2.11*	−3.09*	−2.99*
	(3.97)	(4.03)	(3.77)	(3.20)	(3.82)	(3.29)	(3.98)	(3.09)
Growth	0.07	−0.04**	−0.10	−0.09	−0.08	0.09	0.11	−0.02
	(0.19)	(2.07)	(0.76)	(0.38)	(0.29)	(0.65)	(0.41)	(1.02)
R^2	0.29	0.44	0.40	0.37	0.42	0.31	0.39	0.30
Obs.	211	126	155	112	224	161	589	400

Notes: Dependent variable: IS. Robust standard errors are in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included but is not reported.

Finally, I also report regression results investigating the behavior of the key variables of the model with respect to political stability. The estimates here aim to test the following hypothesis: Political frictions play an important role in the composition and the level of public finance. The estimates investigate the role of political stability as the key friction. The idea is that, if the political stability is higher, in other words, if the incumbent is more certain that it will stay in the office, it will direct more of the tax revenues to productive public investment and less to wasteful government spending, specifically office rent and corruptive activities. Even though the overall tax rate increases because of increasing political stability, the change in the composition of public spending makes the formal sector more attractive for households. The hypothesis predicts that higher political stability (or probability of reelection) is associated with a lower level of corruption, a higher level of productive government spending, a higher tax burden, and also a smaller shadow economy. In the final set of regressions, I provide some empirical evidence for these predictions.

The results are presented in different panels of Tables 7 and 8. In the first columns of each panel in these tables, titled "OLS," I report the cross-sectional

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TABLE 6. Probability of reelection vs. political stability for 58 countries

	OLS	OLS	OLS	FE	IV	GMM	OLS	FE	IV	GMM
Tax	0.09*	0.11*	0.14*	0.15*	0.11**	0.14**	0.10*	0.16**	0.12**	0.09*
	(3.03)	(3.04)	(3.11)	(3.22)	(3.46)	(3.49)	(3.45)	(2.44)	(2.61)	(3.10)
Reelect.	−0.14**	−0.16**								
	(2.11)	(2.53)								
Reelect.·tax	−0.20*	−0.26*								
	(4.01)	(3.53)								
Pols.			−1.76**	−1.48**	−1.59**	−1.69**	−2.01**	1.53**	1.64**	1.70**
			(2.13)	(1.96)	(1.95)	(2.01)	(2.09)	(2.03)	(2.05)	(2.19)
Pols.·tax			−0.09*	−0.08*	−0.11*	−0.10*	−0.07*	0.08*	0.09*	0.11*
			(3.73)	(2.96)	(3.04)	(3.02)	(2.98)	(3.10)	(3.20)	(3.11)
GDP	−0.02	−0.04	−0.01**	−0.01**	−0.01**	−0.01**	−0.01**	−0.02**	−0.01**	−0.02***
	(0.70)	(0.73)	(2.13)	(1.96)	(2.04)	(2.01)	(1.98)	(2.07)	(2.18)	(1.74)
Law	−1.19	−1.21	−0.88**	−0.84**	−0.89**	−0.78**	−0.81*	−0.90**	−0.84**	−0.75**
	(1.44)	(1.52)	(2.67)	(2.11)	(2.08)	(2.08)	(2.96)	(2.14)	(2.10)	(2.10)
Bureaucracy	−0.18	−0.22	−0.75	−0.68	−0.72	−0.76	−0.78	−0.69	−0.72	−0.79
	(1.25)	(1.12)	(0.90)	(0.94)	(0.86)	(0.90)	(0.88)	(1.11)	(1.10)	(0.99)
Corruption	−0.49***	−0.45**	−0.29	−0.32	−0.38	−0.44	−0.28	−0.33	−0.39	−0.39
	(1.71)	(1.98)	(0.90)	(0.99)	(1.10)	(1.02)	(0.68)	(0.77)	(0.80)	(0.96)
Democracy	−0.04	−0.06					−0.12	−0.16	−0.09	−0.10
	(0.12)	(0.18)					(0.29)	(0.40)	(0.37)	(0.30)
Capital		−1.21*					2.09*	2.17*	−2.10*	−1.90*
		(3.01)					(3.08)	(3.11)	(3.04)	(3.19)
Growth		−0.04					−0.07	−0.09	−0.10	−0.12
		(0.42)					(0.15)	(0.19)	(0.21)	(0.20)
IS(-1)							0.36*	0.39*	0.41*	0.44
							(3.01)	(3.13)	(3.07)	(3.60)
R^2	0.48	0.59	0.49	0.58			0.56	0.60		
Obs.	58	58	522	522	464	464	464	464	406	406
J-Test						0.27				0.20
AR(2)-Test						0.21				0.19

Notes: Robust standard errors are in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included but is not reported.

regression results with probability of reelection as a measure of political stability. Other columns use ICRG's political stability index in a panel data framework. The second and third columns use only the 58-country subset of this panel; the rest use the 141-country whole data with different econometric specifications.

First, in Table 7, I use tax burden as the dependent variable and estimate several equations for it. The estimates support the hypothesis, namely a positive relationship between the tax burden and political stability (or probability of reelection). Next, in the lower panel of Table 7, I estimate the relationship between corruption and political stability. Results support the hypothesized negative relationship; i.e., a higher level of political stability increases the control for corruption index (i.e., reduces the extent of corruption). Moreover, as reported in the upper panel of Table 8, political stability also seems to be positively correlated with GDP per

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TABLE 7. Further regressions of other variables

	OLS	OLS (58)	FE (58)	OLS	FE	FE	GMM	IV
				Dependent variable: Tax burden				
Pols.		2.29*	2.80*	4.58**	4.12*	4.10**	4.31*	3.10*
		(3.12)	(3.24)	(2.00)	(4.01)	(2.00)	(3.90)	(3.04)
Reelect.	17.23*							
	(3.10)							
Tax (-1)						0.92*	0.88*	0.76*
						(2.89)	(2.97)	(3.12)
R^2	0.14	0.21	0.33	0.19	0.29	0.38		
Observations	58	522	522	1,269	1,269	1,128	989	989
Hansen J-Test							0.14	
AR(2) Test							0.19	
				Dependent variable: Corruption				
Pols.		0.32**	0.29**	0.41**	0.44*	0.42*	0.42**	0.40**
		(2.12)	(2.23)	(1.99)	(3.04)	(2.86)	(2.00)	(2.14)
Reelect.	3.70*							
	(3.65)							
Corruption(-1)						0.73*	0.67*	0.59*
						(4.04)	(4.12)	(3.10)
R^2	0.13	0.12	0.19	0.21	0.25	0.29		
Observations	58	522	522	1,269	1,269	1,128	989	989
Hansen J-Test							0.11	
AR(2) Test							0.13	

Notes: Robust standard errors are in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included but is not reported.

capita. Finally, in the lower panel of Table 8, I regress public investment[39] (as a ratio to GDP) on political stability and obtain a positive correlation between these two variables, in line with the theoretical model.

5. CONCLUSION

In this paper, I have developed a dynamic political economy model of fiscal policy with an informal sector and two political parties alternating in office, where the government lacks commitment and incumbency follows a Markov chain with two political parties that can be in power at any time. Political turnover, in 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.

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TABLE 8. Further regressions of other variables

	OLS	OLS (58)	FE (58)	OLS	FE	FE	GMM	IV
				Dependent variable: GDP per capita				
Pols.		18.11*	19.23*	21.19*	21.26*	21.44*	20.98*	17.99*
		(4.10)	(3.96)	(4.11)	(4.10)	(4.80)	(4.34)	(4.01)
Reelect.	11.99*							
	(3.99)							
GDP(-1)						0.29*	0.32*	0.34*
						(4.01)	(7.11)	(5.99)
R^2	0.17	0.20	0.28	0.29	0.32			
Observations	58	522	522	1,269	1,269	1,128	989	989
Hansen J-Test							0.18	
AR(2) Test							0.21	
				Dependent Variable: Pub. inv.				
	OLS	OLS (58)	FE (58)	OLS	FE	FE	GMM	IV
Pols.		5.04**	3.19***	2.98**	2.76**	2.54**	2.98*	3..09**
		(2.10)	(1.76)	(2.11)	(2.10)	(2.25)	(2.34)	(2.31)
Reelect.	7.12**							
	(2.09)							
Pub. inv.(-1)						0.29***	0.32***	0.34**
						(1.69)	(1.71)	(2.19)
R^2	0.05	0.09	0.12	0.15	0.17	0.19		
Observations	58	522	522	1,269	1,269	1,128	989	989
Hansen J-Test							0.24	
AR(2) Test							0.29	

Notes: Robust standard errors are in parentheses. *, **, *** denote 1, 5, and 10% confidence levels, respectively. In all regressions a constant is also included but is not reported.

The model produces a number of results that are testable with empirical analysis. Using panel data estimation techniques, I compare the model's implications against the data and find support for the model.

I believe that the contribution of this paper is threefold: First, it 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 is empirical and lacks 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. Last, this paper also contributes to the literature on optimal Markov perfect fiscal policy by adding an informal sector and a political economy dimension to the standard models of this literature.

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NOTES

1. Also see Frey and Pommerehne (1984), Thomas (1992), and Schneider and Enste (2000) for similar definitions.

2. Notice that the model does not specify any endogenous turnover process, whether it is a democratic transition through an election, coup d'état, or political transition by the death of the ruler. The use of political parties in the model is a theoretical construct; therefore one might interpret the underlying mechanism of the model as applying to nondemocratic countries as well. In that sense, the incumbent political party might be interpreted as a democratically elected president or prime minister, or as a king or dictator.

3. 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, and therefore a lower level of tax revenue. However, considering that only imperfect estimates of the informal economy are included in national income calculations, a larger informal economy also implies a lower level of official GDP. Moreover, as the empirical analysis clearly shows, the negative relation is also evident between various statutory tax rates and the size of the informal sector.

4. In the next section I show that the negative correlation between taxes and the informal sector remains significant, even after controlling for corruption, bureaucratic quality, or tax enforcement. This suggests that these factors do not explain the whole story.

5. In the benchmark model, I assume that leisure is not valued. Because adding leisure involves 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 briefly discuss the implications of relaxing this assumption at the very end of this section.

6. 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.

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

8. As I will discuss in numerical simulations, none of the results of the paper would change if I had allowed the informal sector to use a smaller share of public and private capital than the formal sector. The current setup, however, significantly simplifies the environment without affecting the basic results. Notice that this simplifying assumption is also used in Loayza (1996) and Ihrig and Moe (2004).

9. Alternatively, ρ can be interpreted as the degree of political stability or the probability of reelection in a democratic country. I use these three terms interchangeably throughout the paper.

10. S_t can be interpreted as nonproductive public spending, office rent, or embezzlement. This is why this is party-specific and can only be benefited from when in office.

11. The assumption that K and G/K have the same shares as in the production function is quite limiting, albeit necessary to obtain an analytical solution. However, notice that this is not equivalent to assuming the absence of K, as the household still must choose a positive amount of K in the steady state to have apositive amount of formal output. Nevertheless, I will relax this assumption later on in the numerical analysis.

12. Notice that, using other forms of production functions without congestion, such as $Y_t^f = K^\gamma N_{ft}^\beta G_t^{1-\gamma-\beta}$ would not change the results. However, it would make the household's problem more complicated because that the production function would have decreasing returns to scale at the firm level.

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

14. Technically $U_{c1} < U_{s1}$.

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15. Notice that the steady state features a labor tax rate that is equal to zero. However, the tax rate on formal labor can easily be made positive by making the current capital tax 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. In 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. Because such an extension does not change any of this paper's results, I refer to Martin (2010) for such an extension.

16. 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 at equilibrium there is a labor subsidy that turns out to be a decreasing function of ρ. The idea here is that the incumbent uses the labor subsidy to correct part of the distortion created by the capital tax. One way of having a positive labor tax is again to introduce endogenous capital utilization à la Martin (2010). However, all these complications do not involve any qualitative changes in the main results, and therefore are not included in this text.

17. For details of an environment with nondifferentiable finite-horizon equilibria, see Klein et al. (2008).

18. Also, to save some space, I define $\varsigma' = (K', G')$.

19. Notice that the informal sector labor is known once the formal sector labor is calculated.

20. Krusell and Smith (2003) restrict strategies to differentiable strategies precisely to restrict the number of possible equilibria, but argue that uniqueness cannot be proved in general even when the strategy space is restricted to differentiable strategies. Similarly, in this case uniqueness cannot be generally proven. However, I have conducted several robustness checks with respect to the starting values and found that the equilibrium to which the algorithm converges is not sensitive to starting values.

21. More details will be given about data sources in the next section. See Appendix D for the list of countries.

22. Notice that the freedom index (FFI) becomes larger when tax rates become lower; 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.

23. More details will be given in the next section on the robustness of this relationship to various econometric specifications.

24. See Baier and Glomm (2001) for a similar procedure.

25. See Appendix D for a list of countries.

26. Because of space constraints, I omit the presentation of further robustness checks and sensitivity analysis; however, these are available from the author upon request.

27. Simulated series of other variables do not change significantly with different values of μ. I do not include these simulations because of space constraints.

28. These values ensure that the shares of private and public capital in the informal sector are less than those in the formal.

29. See Tanzi (1999) and Schneider (2007) for a discussion.

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

31. Throughout this paper, tax burden is defined as the ratio of total tax revenues to GDP.

32. Estimation results using the various tax data are available upon request.

33. Notice that results also do not depend on whether one uses data on statutory taxes (the main part of the Heritage Foundation's fiscal freedom index) or actual taxes, such as the tax burden data from GFS. See Aruoba (2010) for a discussion of this issue.

34. In this paper the authors construct a series of probabilities of reelection in a narrow sample of 58 democratic countries over the period from 1960 to 2000.

35. I constructed the capital stock series using the perpetual inventory method and investment series from the Penn World Tables.

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36. Notice that the fiscal freedom index gets smaller as statutory taxes increase. So a positive sign of its coefficient is expected.

37. In addition to these estimates, I replicate the same analysis using a measure of tax burden that I obtain by dividing total tax revenue by GDP after subtracting the total informal sector size. Signs of the coefficients do not change and t-statistics become even larger. These results are available upon request.

38. Here we only report results of the FE estimations, because of space constraints.

39. The source for public investment series is World Development Indicators.

40. Notice that simplifying Assumption 2 makes it possible to define all the variables with respect to G_2 only. In a more general environment, everything should be a function of K_2 and G_2.

41. In this specific example, $m_1 = \left\{1 + \frac{\alpha_c}{\beta(\gamma \frac{G_2}{1+G_2} - \alpha_s)}\right\}^{-1}$.

42. Specifically, $f(G_2) = \left\{\frac{1-m_1}{m_1(1-\alpha_s)(Y_1-G_2)} + \frac{(\partial m_1/\partial G_2)}{m_1}\right\}$.

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

44. This is because the functional equation defining W is not a maximization problem.

45. I thank Fernando Martin for sharing his codes with me.

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APPENDIX A: PROOFS OF PROPOSITIONS 2.2, 2.3, AND 2.4

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

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Because the second period is the final period, households do not invest in private capital, but consume all of their income. Similarly, the government does not invest in 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, choosing S_2 and N_{f2} to maximize, as

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

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

$$U_{c2} = U_{s2},$$
$$U_{c2}(w_{f2} - w_{i2}) = 0.$$

Comparing the second equation with equation (2) in the paper, I obtain ; 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 just given and Assumption 2, I obtain $N_{i2}/N_{f2} = G_2^{-1}$. Hence all the second-period allocations can be defined as a function of G_2 only.[40]

Next, using the Euler equation, I obtain $K_2 = m_1(Y_1 - G_2 - S_1)$, where m_1 is an increasing function of G_2.[41] 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 ρ, the first-period incumbent chooses S_1, G_2, and N_{f1} to maximize

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

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 ρ. Increasing ρ affects the marginal rate of substitution between tomorrow's office rent and the current office rent, and between the 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

$$U^g_{S1}(w_{f1} - w_{i1}) = 0.$$

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-period capital tax. This distorts the margin between the private consumption and

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office rent in the first period (i.e., $U_{C1} \neq U^g_{S1}$). Specifically, the first-order condition with respect to S_1 implies

$$U^g_{S1} = (1 - m_1)U_{C1}.$$

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 after $\tau_{n1} = 0$ directly determine N_{f1} and N_{i1}, an increase in G_2 implies a reduction in S_1. Moreover, the reduction in S_1 is less than the increase in G_2, because $\alpha_s < 1$.

Last, 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 ρ. 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[42] of G_2, provided that $\alpha_s < \gamma$. So, as one can see from the preceding equation, increasing ρ increases G_2 and hence, by the equation defining S_1, reduces S_1. Moreover, because $\alpha_s < 1$, the increase in G_2 is greater then the reduction in S_1, causing the tax burden of the first period to increase. Because the capital tax is the only tax instrument used by the government, this means that τ_{k1} increases because of an increase in ρ.

Now, having proved Proposition 2.2, one can easily generalize the results of the described finite-period economy, first to an arbitrary T-period economy and then letting $T \to \infty$ to an infinite-horizon economy. To this end, I briefly discuss the proof of Proposition 2.3 here. I consider a finite-T-period economy. The two-period environment can be interpreted as results valid for periods T and $T - 1$. By continuing to iterate backward, I can write for any $j \in \{0, 1, 2, ..., T - 1\}$

$$C_{T-j} = (1 - m_{T-j})(Y_{T-j} - G_{T-j+1} - S_{T-j}),$$
$$K_{T-j+1} = m_{T-j}(Y_{T-j} - G_{T-j+1} - S_{T-j}),$$

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 follows:[43]

$$V^{T-j}(G_{T-j}) = \max_{\{S_{T-j}G_{T-j+1},N_{f,T-j},\}} U(C_{T-j}) + U^g(S_{T-j})$$
$$+ \beta\left[\rho V^{T-j+1}(G_{T-j+1}) + (1 - \rho)W^{T-j+1}(G_{T-j+1})\right],$$

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

$$U^g_{S_{T-j}} = (1 - m_{T-j})U_{C_{T-j}}.$$

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 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

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is also true for G_{T-j+1}, which can be expressed as an increasing function of ρ from the first-order condition with respect to G_{T-j+1}. Once G_{T-j+1} is obtained as an increasing function of ρ, the rest follows from the result 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 for the relevant variables are between 0 and 1, $T \to \infty$, the first-period $T-j=1$ allocations converge to a limit, in which their behavior with respect to ρ becomes unchanged.

Proposition 2.4 is an extension of Proposition 2.3 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 ρ increases, the level of tax subsidy also increases. However, the increase in public investment is still greater then the reduction in the office rent, which increases the capital tax rate more than in the previous case. See Martin (2010) for more details in an environment with leisure in the utility function.

APPENDIX B: PROOF OF PROPOSITION 2.6

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, τ_k, and τ_n are as follows, respectively:

$$U_c C_{K'} + \beta[\rho V_{K'} + (1-\rho) W_{K'}] + \lambda F_1 + \mu \varphi_{K'} = 0, \tag{B.1}$$

$$U_c C_{G'} + \beta[\rho V_{G'} + (1-\rho) W_{G'}] + \lambda F_2 + \mu \varphi_{G'} = 0, \tag{B.2}$$

$$U_c C_{N_f} + U_s \mathcal{S}_{N_f} + \lambda \eta_{N_f} + \mu \varphi_{N_f} = 0, \tag{B.3}$$

$$U_c C_{\tau_k} + U_s \mathcal{S}_{\tau_k} + \lambda \eta_{\tau_k} + \mu \varphi_{\tau_k} = 0, \tag{B.4}$$

$$U_c C_{\tau_n} + U_s \mathcal{S}_{\tau_n} + \lambda \eta_{\tau_n} + \mu \varphi_{\tau_n} = 0. \tag{B.5}$$

Notice that λ and μ are the Lagrangian multipliers on the constraints η and φ, and F_1 and F_2 are defined as follows:

$$F_1 = \eta_{K'} + \eta_{K''} K'_K + \eta_{G''} \Gamma'_K + \eta_{n'_f} \mathcal{N}'_{f_K} + \eta_{n'_i} \mathcal{N}'_{i_K} + \eta_{\tau'_k} \theta'_{k_K} + \eta_{\tau'_n} \theta'_{n_K},$$

$$F_2 = \eta_{G'} + \eta_{G''} K'_G + \eta_{G''} \Gamma'_G + \eta_{n'_f} \mathcal{N}'_{f_G} + \eta_{n'_i} \mathcal{N}'_{i_G} + \eta_{\tau'_k} \theta'_{k_G} + \eta_{\tau'_n} \theta'_{n_G}.$$

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

$$-U_c \mathcal{S}_{\tau_k} + U_s \mathcal{S}_{\tau_k} + \lambda U_{cc} \mathcal{S}_{\tau_k} + \mu \varphi_{\tau_k} = 0, \tag{B.6}$$

$$-U_c \mathcal{S}_{\tau_n} + U_s \mathcal{S}_{\tau_n} + \lambda U_{cc} \mathcal{S}_{\tau_n} + \mu \varphi_{\tau_n} = 0. \tag{B.7}$$

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, λ can be obtained from the first-order condition τ_n or τ_k as $\lambda = -\frac{U_s - U_c}{U_{cc}}$.

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With this result, and using the derivatives of $\mathcal{S}$ and C with respect to N_f, one can write the first-order condition with respect to N_f as

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

Because $w_f(1-\tau_n)=w_i$ 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 easily be shown that the envelope condition holds for V but not for W.[44] Obtaining the expressions for V_K and V_G and forwarding these for one period, I get expressions for $V'_{G'}$ and $V'_{K'}$. Because 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 differentiate W with respect to K:

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

where F_3 is the derivative of η with respect to ; 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

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

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

Plugging these back into the expression for W_K gives

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

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

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

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

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

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

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

where $F_4^{'}$ is defined analogously to $F_3^{'}$.

APPENDIX C: COMPUTATIONAL ALGORITHM

To compute the interior differentiable Markov perfect equilibrium, I use[45] the global method described in Martin (2010). Given any ρ, the basic algorithm is as follows:

1. Define a pair of grids over K and G.
2. Guess the decision rules: $\mathcal{K}^0$, Γ^0 Θ_k^0 Θ_n^0, $\mathcal{N}_f^0$.
3. For every (K, G) pair in the grid, solve for K', G', τ_k, τ_n, and N_f, given that $\mathcal{K}^0$, Γ^0, Θ_k^0, Θ_n^0, $\mathcal{N}_f^0$ followed from tomorrow on, using the equations characterizing Markov perfect equilibrium. Call the solution $\mathcal{K}^1$, Γ^1, Θ_k^1, Θ_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, because I assume differentiability of the policy functions, I interpolate the points between the grid points to evaluate the policy functions and calculate their derivatives. To do so, I use cubic splines.

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APPENDIX D: COUNTRY LISTS

D.1. LIST OF COUNTRIES INCLUDED IN THE PANEL AND 141-COUNTRY CROSS-SECTION REGRESSIONS

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Chile, China, Colombia, Democratic Republic of Congo, Republic of Congo, Costa Rica, Cote Divore, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea Republic, Kuwait, Kyrgyzstan, Latvia, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syria, Taiwan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe

OECD-EU: Australia, Austria, Belgium, Canada, Chile, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea (South), Luxemburg, Malta, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Latin American and Caribbean: Argentina, Bahamas, Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Venezuela.

Post-socialist: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Slovenia, Ukraine.

Middle East and North Africa: Algeria, Bahrain, Egypt, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, UAE, Yemen.

Sub-Saharan Africa: Angola, Botswana, Burkina Faso, Cameroon, Democratic Republic of Congo, Republic of Congo, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

Asia and Oceania: Bangladesh, Brunei, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam.

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D.2. 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, United States, Venezuela.

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