A General Equilibrium Model of Corruption

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November, 2025

Abstract

This paper develops a General Equilibrium model to illustrate the economic cost of corruption by incorporating it as a distinct activity within a closed economy. Our model endogenizes the choice between productive labor and rent-seeking activities. Specifically, we introduce an auxiliary technology that captures the role of corruption in diverting resources away from the formal sector and distorting allocation, thereby reducing output. Complementing the theory, we provide new empirical evidence based on a global panel covering most countries in the world. Exploiting within-country variation with country and year fixed effects and controlling for a robust set of covariates that capture the main determinats of each variable, we find that a one-unit shock to corruption, measured as a change in the World Governance Indicators Control of Corruption Index, is associated with a decline of near 4 percent in GDP per capita, mainly driven by investment, which falls by roughly 12 percent per capita, while consumption decreases by about 3 percent. Taken together, the model and the empirical results highlight that corruption significantly reduces economic welfare and suggests that policies such as reduced labor taxes or improved oversight could mitigate these losses by discouraging the shift of resources into unproductive corruption activities.

Keywords: Corruption, General Equilibrium, Rent-Seeking.

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Acknowledgments: I thank Andy Neumeyer for his useful comments and assistance in this work.

1 Introduction

Corruption is a widespread phenomenon across countries, affecting both developed and developing economies. Its consequences extend beyond immediate losses of resources, as it undermines institutional quality, weakens incentives for investment, and distorts the allocation of public spending. Although its precise impact on economic output is difficult to quantify, the evidence suggests that corruption generates persistent costs for growth and welfare, making it a central issue in the study of economic development.

The classical approach to study the aggregate effects of corruption is to analyze how it affects growth. As in Mauro (1995), corruption affects the output via private investment rate as the main channel. In his seminal paper, he presents the estimation of how much corruption lowers output. This is due to the malfunction of government institutions. A one-standard-deviation increase (improvement) in the corruption index[1] is associated with an increase in the investment rate by 2.9 percent of the GDP. In the Latin-American and the Caribbean context, we have the estimation developed in Carvalho, Tigre & de Paulo (2022). They show that a one standard deviation increase in corruption, as measured by the reversed Transparency International's corruption perception index, is associated with a decrease of 12.2% in gross domestic product per capita and a decrease of 3.05% in output growth.

There is another branch of the literature that associates corruption and lobby with the bureaucratic capacity of the government, as if corruption would have an effect on the output through another means. The influence of bureaucratic authority structures on fostering economic growth has been a topic of sociological interest since Max Weber's foundational work nearly a century ago. While some suggest that bureaucracy affects negatively efficiency as it is a heavy regulatory environment foreign firms must face when seeking approvals and permits for investment as in Mauro (1995), others like in Acemoglu & Verdier (2000), believe

[1]The corruption index is taken from the Business International (BI), now incorporated into The Economist Intelligence Unit, a private firm that sells these indices to banks, multinational companies and other international investors.

bureaucracy could increase efficiency as it is an important tool to cope with market failures: government intervention requires "bureaucrats" to gather information and implement policies more efficiently.

In this paper, unlike related literature, a novel way of modeling the effect corruption has in a general equilibrium model is presented. Corruption will be an activity in the economy which will not contribute to the final output. Our approach will be similar as in Bhagwati (1982). Corruption will be a directly unproductive rent-seeking activity. The micro problem will affect the output and will be related to the fact that each individual will have the choice of employing itself in the main formal activity or to choose to participate in corruption activities. The choice of participating in these activities will be the one affecting the final output, as in Krueger (1974). It is in the capacity of each country to deal with corruption that the corruption participation will be big or small related to the main activity firm's labor. Corruption will have a technology to produce these spurious activities and will not affect the final output. This technology will have a stochastic component. As in Angeletos & Kollintzas (2000), we will observe that higher corruption will imply higher benefits for those employed in the rent-seeking activity. This will be presented as the main obstacle to the elimination of corruption.

The main activity firm will be modeled in a classical way; it will be a constant return-to-scale firm that will require capital and labor to produce the final output and will have a technology shock that we will assume constant in this environment.

Corruption generated by the government will be seen in the form of labor and capital taxes. The trade off the agent has will be in working in the main sector and having the after-tax salary or participating in corruption activities whose salaries do not pay labor tax as it cannot be observed by the government. A trivial result this paper will bring will be that to seize the effects of corruption, the government will have to lower the labor and capital taxes and correct that incentive scheme. We will not focus on the amount of public spending as a percentage of GDP, as is often the case in the literature, but rather on the portion of government revenue allocated to corrupt activities.

2 The Model

We consider an economy populated by a continuum of i (types of) infinitely-lived agents where $i \in [0,1]$ represents a typical consumer. Time is discrete and denoted by $t = 0, 1, 2, \ldots$ where $T = \infty$ (infinite horizon). There is only one consumption good which can be either consumed or invested in the capital market.

Each agent is the owner of a representative firm and is endowed with one unit of time every period. They can use this unit for leisure, to work in the main activity or to perform corruption activities. Thus, h_i represents hours of leisure, L_i^w represents labor supplied by each agent at each unit of time t in its main activity and we will call L_i^c the unproductive hours spent in corruption activities for agent i at time t.

So, normalizing time to 1, we have that:

$$h_i^i + (L_i^i)^w + (L_i^i)^c = 1$$

The representative consumer's preferences on $\mathcal{C}$ are given by time-separable discounted utility. That is, if $(C_i, h_i) \in \mathcal{C}$ then:

$$U\left(C_t^i, h_t^i\right) = E_0 \sum_{t=0}^{\infty} \beta^t u\left(C_t^i, h_t^i\right)$$

where $u : R_+ \times [0,1] \to R_+$ is strictly increasing with respect to consumption C and leisure h, strictly concave and differentiable such that $(C, h) > 0$. Let E_0 represent the household's expectations at the beginning of period 0. In period t, C_t^i denotes the household's private consumption. The parameter β, where $0 < \beta < 1$, is the household's discount factor.

At the outset, the household has an initial stock of physical capital, $K_0 > 0$, and must decide how much new investment to undertake. The evolution of physical capital follows the equation:

$$K_{t+1}^i = X_t^i + (1-\delta)K_t^i$$

where $0 < \delta < 1$ is the capital depreciation rate. The household earns capital income based on the real interest rate, r_t, resulting in capital income of $r_t K_t$ in period t.

In addition to capital income, the household earns labor income. Hours worked for the representative firm are compensated at the wage rate w_t, while the corruption activity also provides an income. We will go into more detail about that later. The government can only tax the labor and capital income from the main sector. Finally, since each household owns a percentage of the firm, it is entitled to the firm's profits, let Π_t^i be the percentage of benefits of the firm owned by agent i. Since the firm will have constant returns to scale, these profits will be equal to 0 in equilibrium.

2.1 Budget Constraint

Each agent will face a trade-off between time spent in leisure, corruption and work on their main activity. They can rent units of capital at a risk free interest rate to the capital market a proportion to be saved each period. They also face labor tax on working in the main activity and capital tax.

Its budget constraint at time t will be:

$$C_t^i + X_t^i = (1-\tau^k) r_t K_t^i + (1-\tau^l)(L_t^i)^w w_t + \Psi_t^i((L_t^i)^c) + \underbrace{\Pi_t^i}_{=0}$$

$$X_t^i = K_{t+1}^i - (1-\delta)K_t^i$$

$$h_t^i + (L_t^i)^w + (L_t^i)^c = 1$$

2.2 Corruption Process

The corruption process is characterized by a technology owned by each agent that is increasing and concave at each unit of time t. It is unproductive in terms of the consumption good so in the aggregate goods market equation, it won't have any impact. We will call it $\Psi_t(L_t^c)$. This function won't use capital for production.

In this model, corruption is formalized as an alternative occupation to productive work. Agents can allocate part of their labor endowment to rent-seeking activities, which yield income but do not contribute to aggregate output. The return to such activities is governed by the productivity of corruption, denoted by Υ_t.

To allow for time variation in corruption intensity without introducing a trend, we assume that the logarithm of corruption productivity follows a stationary stochastic process with regime switching. Formally, the process is given by:

$$\ln \Upsilon_{t+1} = \rho \ln \Upsilon_t + (1-\rho)\mu(s_t) + \varepsilon_{t+1}, \tag{1}$$

where $\rho \in (0,1)$ is the autoregressive coefficient and $\varepsilon_{t+1} \sim \mathcal{N}(0,1)$ is an i.i.d. innovation. The regime variable $s_t \in \{L, H\}$ follows a two-state Markov chain with transition matrix:

$$\mathcal{P} = \begin{bmatrix} \phi_1 & 1-\phi_1 \\ 1-\phi_2 & \phi_2 \end{bmatrix}$$

where ϕ_1 and ϕ_2 denote the probabilities of remaining in the low- and high-corruption regimes, respectively. The mean of the process depends on the regime: $\mu(s_t) = \ln \Upsilon^L$ when $s_t = L$ and $\mu(s_t) = \ln \Upsilon^H$ when $s_t = H$, with $\Upsilon^H > \Upsilon^L > 0$.

This specification implies that $\ln \Upsilon_t$ is a mean-reverting process with regime-dependent long-run means. Since the autoregressive coefficient satisfies $|\rho| < 1$, the process is stationary and does not exhibit a deterministic or stochastic trend. In particular, the level of corruption productivity fluctuates over time around a weighted average of the two regime-specific means, but it does not grow or shrink unboundedly. The presence of the Markov-switching component allows for persistent shifts between low and high corruption environments, capturing the idea that political or institutional regimes affect the incentives for rent-seeking behavior.

Because the regime s_t is not observable to agents, they must form beliefs about the prevailing corruption regime using available aggregate indicators. These beliefs enter their expectations of future values of Υ_t and influence their decisions regarding labor supply and capital accumulation. In equilibrium, these expectations are consistent with the law of motion governing Υ_t.

2.3 Agent's Problem

Now, we assume a particular form for the preferences and the production function and find the equilibrium. The parameter η is a constant affecting the disutility of working. We will use a standard Cobb-Douglas separable utility form. In this setup, we know that we can represent the problem of all the households with a representative agent (see proof in Appendix 11.1). Each household will maximize its utility subject to its budget constraint each period. We will assume the logarithmic specification for the utility function because it guarantees global concavity and yields closed form expressions for marginal utilities, simplifying the derivation of Euler equations and intratemporal conditions.

$$U\left(C_t, h_t\right) = E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln C_t + \eta \ln h_t\right]$$

So, the FOC reduce to:

$$\{C_t\} \quad \lambda_t = \frac{1}{C_t} \tag{2}$$

$$\{L_t^w\} \quad \frac{\eta}{1 - L_t^w - L_t^c} = \lambda_t (1 - \tau^l) w_t \tag{3}$$

$$\{L_t^c\} \quad \frac{\eta}{1 - L_t^w - L_t^c} = \lambda_t \Upsilon_t (1 - \varphi) \left(L_t^c\right)^{-\varphi} \tag{4}$$

$$\{K_{t+1}\} \quad \lambda_t = E_t \left(\beta \lambda_{t+1} (1 - \delta + (1 - \tau^k) r_{t+1})\right) \tag{5}$$

$$\{\lambda_t\} \quad C_t + X_t = (1 - \tau^k) r_t K_t + (1 - \tau^l) L_t^w w_t + \Upsilon_t \left(L_t^c\right)^{1-\varphi} \tag{6}$$

$$\{TC_K\} \quad \lim_{t \to \infty} \beta^t \lambda_t K_{t+1} = 0 \tag{7}$$

Taking the FOC with respect to $\{L^w\}$ and equating it with $\{L^c\}$ we get the standard non-arbitrage equality where the salary with taxes from the main activity must be the same as the corruption marginal revenue the agent has from that activity:

$$(1 - \tau^l) w_t = \Upsilon_t^i (1 - \varphi) \left((L_t)^c\right)^{-\varphi} \tag{8}$$

This condition helps us to rule out corner solutions in each sector.

Now, taking the FOC $\{C_t\}$ and $\{K_{t+1}\}$ we get the Euler condition for our model:

$$E_t \left[\beta \left(\frac{C_t}{C_{t+1}}\right) \left((1 - \tau^k) r_{t+1} + 1 - \delta\right)\right] = 1 \tag{9}$$

2.4 Representative Firm's Problem

As we mentioned before, there is a representative firm in the economy that produces the final output. The firm's production follows a Cobb-Douglas technology and uses both physical capital, K_t, and labor hours of the agent's main activity, L_t^w, to maximize its profit at each point in time. The production function thus is economy is $Y_t = A_t K_t^{\alpha} (L_t^w)^{1-\alpha}$, where A_t represents the level of technology at time t. We will assume technology does not vary from one period to the other as frequently used in literature, thus, the only source of uncertainty will be in the Markov process that affects the corruption technology. We will set:

$$A_t = A \quad \forall t$$

The price of this output is set to one for simplicity. The firm's profit function is:

$$\max_{L_t^w, K_t} \Pi_t = AK_t^{\alpha} (L_t^w)^{1-\alpha} - r_t K_t - w_t L_t^w \tag{10}$$

Since the firm rents capital from households, its problem is to maximize profit in each period independently.

$$\{K_t\} : \alpha \frac{Y_t}{K_t} = r_t \tag{11}$$

$$\{L_t^w\} : (1-\alpha) \frac{Y_t}{L_t^w} = w_t \tag{12}$$

In equilibrium, the firm earns zero profits, and each input is paid according to its marginal product, then, $\Pi_t = 0$ for all t.

2.5 The Government

We assume the Government levies labor tax to the Representative Agent and returns it to the agent in the form of the corruption function.

$$\Upsilon_t (L_t^c)^{1-\varphi} = \tau^l w_t L_t^w + \tau^k r_t K_t \tag{13}$$

3 Equilibrium

The equilibrium conditions for this problem are:

Factor markets

$$K_t^d = K_t^s = K_t$$

$$(L_t^w)^d = (L_t^w)^s = L_t^w$$

Market for goods

$$Y_t = C_t + X_t$$

$$Y_t = AK_t^\alpha \left(L_t^w\right)^{1-\alpha}$$

$$\Psi_t = \Upsilon_t \left(L_t^c\right)^{1-\varphi}$$

$$X_t = K_{t+1} - (1-\delta)K_t$$

Profit maximization of the representative firm.

$$r_t = \alpha \frac{Y_t}{K_t}$$

$$(1-\alpha)\frac{Y_t}{L_t^w} = w_t$$

Utility maximization

$$\frac{\eta}{1 - L_t^w - L_t^c} = \frac{1}{C_t}(1-\tau^l)w_t$$

$$\frac{\eta}{1 - L_t^w - L_t^c} = \frac{1}{C_t}\Upsilon_t(1-\varphi)\left(L_t^c\right)^{-\varphi}$$

$$E_t\left[\beta \frac{C_t}{C_{t+1}}\left((1-\tau^k)r_{t+1} + 1 - \delta\right)\right] = 1$$

Government Budget Constraint:

$$\Upsilon_t \left(L_t^c\right)^{1-\varphi} = \tau^l w_t L_t^w + \tau^k r_t K_t$$

Equilibrium in the market for goods together with the zero-profit condition and the government's budget constraint ensure that the problem will have a solution.

3.1 System

$$
\begin{aligned}
&Y_t = C_t + X_t \\
&Y_t = AK_t^{\alpha}\left(L_t^w\right)^{1-\alpha} \\
&\Psi_t = \Upsilon_t\left(L_t^c\right)^{1-\varphi} \\
&X_t = K_{t+1} - (1-\delta)K_t \\
&r_t = \alpha\frac{Y_t}{K_t} \\
&(1-\alpha)\frac{Y_t}{L_t^w} = w_t \\
&(1-\tau^l)w_t = (1-\varphi)\frac{\Psi_t}{L_t^c} \\
&E_t\left[\beta\frac{C_t}{C_{t+1}}\left((1-\tau^k)r_{t+1} + 1 - \delta\right)\right] = 1 \\
&\Upsilon_t\left(L_t^c\right)^{1-\varphi} = \tau^l w_t L_t^w + \tau^k r_t K_t \\
&\ln\Upsilon_{t+1} = \rho\ln\Upsilon_t + (1-\rho)\mu(s_t) + \varepsilon_{t+1} \\
&\Upsilon_t \in \{\Upsilon^L, \Upsilon^H\} \text{ with transition } \mathcal{P} = \begin{bmatrix} \phi_1 & 1-\phi_1 \\ 1-\phi_2 & \phi_2 \end{bmatrix}
\end{aligned}
$$

We have 10 equations per period to solve for the evolution of 10 variables: 9 endogenous variables $(K_t, Y_t, \Psi_t, C_t, X_t, L_t^w, L_t^c, r_t, w_t)$ and 1 exogenous variable (Υ_t). Of the 9 endogenous variables, one is a state variable (K_t) and eight are jump variables $(Y_t, \Psi_t, C_t, X_t, L_t^w, L_t^c, r_t, w_t)$. The model also includes an exogenous process: the corruption productivity Υ_t follows a two-state Markov process. For simplicity of notation, we do not explicitly write each variable as a function of the history of states (e.g., $C(s^t)$), and instead use C_t, with the understanding that all endogenous variables are state-contingent.

3.2 Non-Stochastic Steady State

In Appendix 11.2, we derive all the calculations for the steady state variables. We get the following results for our model:

$$
\begin{aligned}
&\overline{\overline{\Upsilon}} = \exp\left(\frac{1-\phi_2}{2-\phi_1-\phi_2}\ln\overline{\Upsilon}^L + \frac{1-\phi_1}{2-\phi_1-\phi_2}\ln\overline{\Upsilon}^H\right)\\
&\overline{r} = \left(\frac{1}{\beta}-1+\delta\right)\frac{1}{1-\tau^k}\\
&\left(\frac{\overline{K}}{\overline{\overline{L^w}}}\right) = \left(\frac{\alpha A}{\overline{r}}\right)^{\frac{1}{1-\alpha}}\\
&(1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}} = \overline{w}\\
&\overline{L^c} = \left(\frac{(1-\varphi)\overline{\Upsilon}}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\\
&\overline{\Psi} = \overline{\Upsilon}\left(\overline{L^c}\right)^{1-\varphi}\\
&\overline{X} = \delta\overline{K}\\
&\overline{L^w} = \left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\overline{K}\\
&\overline{Y} = \frac{1}{\alpha}\overline{r}\overline{K}\\
&\overline{C} = \left(\frac{\overline{r}}{\alpha}-\delta\right)\overline{K}\\
&\overline{\Upsilon}\left(\overline{L^c}\right)^{1-\varphi} = \tau^l\overline{w}\overline{L^w} + \tau^k\overline{r}\overline{K}\\
&\overline{K} = \frac{\left(1-\left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)(1-\tau^l)\left((1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}}\right)}{\left(\eta\left(\frac{\overline{r}}{\alpha}-\delta\right)+(1-\tau^l)\left((1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}}\right)\left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\right)}
\end{aligned}
$$

3.3 Log-Linearization

To log-linearize the model we follow the approach in Uhlig (1999). For any variable X we will define the period t log-deviation from its nonstochastic steady-state value:

$$\widetilde{X}_t \equiv \ln X_t - \ln \overline{X}$$

Then:

$$X_t = \overline{X} e^{\widetilde{X}_t}$$

We have the following system of log-linearized equations (find the calculations in Appendix 11.3):

$$\overline{Y}\widetilde{Y}_t = \overline{C}\widetilde{C}_t + \overline{X}\widetilde{X}_t$$

$$\widetilde{Y}_t = \widetilde{A}_t + \alpha\widetilde{K}_t + (1-\alpha)\widetilde{L_t^w}$$

$$\widetilde{\Psi}_t = \widetilde{\Upsilon}_t + (1-\varphi)\widetilde{L_t^c}$$

$$\widetilde{w}_t = \widetilde{Y}_t - \widetilde{L_t^w}$$

$$\widetilde{r}_t = \widetilde{Y}_t - \widetilde{K}_t$$

$$\delta\widetilde{X}_t = \widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t$$

$$\widetilde{C}_t = \widetilde{w}_t - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}}\widetilde{L_t^w} - \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}}\widetilde{L_t^c}$$

$$\widetilde{C}_t = \widetilde{\Upsilon}_t - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}}\widetilde{L_t^w} - \left(\varphi + \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}}\right)\widetilde{L_t^c}$$

$$0 = E_t\left\{\widetilde{C}_{t+1} - \beta(1-\tau^k)\overline{r}\widetilde{r}_{t+1} - \widetilde{C}_t\right\}$$

$$\widetilde{\Upsilon}_{t+1} = \rho\,\widetilde{\Upsilon}_t + (1-\rho)\,\widetilde{\mu}_t + \varepsilon_{t+1}$$

Where $\varepsilon_{t+1} \sim iid\ N\left(0, \sigma_\varepsilon^2\right)$.

4 Calibration and Results

The calibration we are going to select will be related to what we see in the US time series data and from previous bibliography.

Table 1: Parameter calibration: Hansen (1985) and own estimates with corruption shocks.

Parameter	**Method**	**Value**	**Description**
β	Estimated	0.98	Discount factor
α	Hansen (1985)	0.36	Capital share
$1-\varphi$	Calibrated	0.9	Labor share in the corruption sector
η	Calibrated	0.5	Relative weight on leisure
δ	Hansen (1985)	0.025	Depreciation rate of capital
τ_l	Data	0.242	Labor income tax rate
τ_k	Calibration	0.20	Capital income tax rate
A	Calibration	1	Technology in main activity normalized to one
$\varUpsilon^H$	Calibration	1.4	Technology in corruption activity (high regime)
$\varUpsilon^L$	Calibration	1.0	Technology in corruption activity (low regime)
ϕ_1	Calibrated	0.758	Persistence of low corruption regime
ϕ_2	Calibrated	0.908	Persistence of high corruption regime
ρ	Estimated	0.8	Persistence parameter of corruption process
σ_Υ	Calibrated	1	Std. dev. of corruption innovation shock

$\alpha = 0.36$ because the time series data for the USA from Kydland and Prescott (1982) indicates that the participation of capital in the product is approximately 36%. $\delta = 0.025$ (quarterly) implies an annual depreciation rate of around 10%. $\beta = 0.98$ implies a steady-state annual interest rate equal to 4.5%. $\eta = 0.5$ implies that in a steady state households will decide to work 1/3 of their time allocation, divided between corruption and main activity labor, which matches the data indicating that agents usually allocate 8 of the 24 hours a day to labor market activities. The employee net average tax rate τ^l has been taken from the US data in 2023 according to the US Department of State. We assume that the labor share in the corruption sector $1-\varphi = 0.9$. To estimate the process for $\varUpsilon$, the objective was to match the decline in output with what is typically observed in the data, as similar patterns are also found for the United States. For the calibration of the regimes' transition probabilities (ϕ_1 and ϕ_2), I used a Markov-switching regression approach. We estimate a two-state Markov-switching model for the dependent variable:

$$\text{Corruption Index}_{tt} = \mu_{s_t} + \varepsilon_t, \quad \varepsilon_t \mid s_t \sim \mathcal{N}(0, \sigma_{s_t}^2), \quad s_t \in \{1, 2\}.$$

State 1: $CI_t = \mu_1 + \varepsilon_t$, with $\varepsilon_t \sim \mathcal{N}(0, \sigma_1^2)$.

State 2: $CI_t = \mu_2 + \varepsilon_t$, with $\varepsilon_t \sim \mathcal{N}(0, \sigma_2^2)$.

The regimes allow distinct variances, i.e., σ_1^2 may differ from σ_2^2.

This estimation suggests that the average duration of each regime (high or low corruption) is about 4 to 5 years in the United States and most western economies, which provides a realistic benchmark for the persistence parameters of the model.

Regarding taxation, I distinguish between two rates. First, the labor income tax τ^l, calibrated directly from the St. Louis Federal Reserve Bank database at 0.242, captures the average effective taxation on wages in the main activity. Second (following Prescott 2004), we calibrate the effective capital income tax at $\tau^k = 0.20$, which delivers a steady-state after-tax real interest rate close to 4 percent in our model. This separation allows the model to account for heterogeneous distortions: while τ^l directly affects households' labor-leisure trade-off, τ^k influences intertemporal savings and investment decisions.

With this calibration, the non-stochastic steady state values of our model are:

Table 2: Data Averages and Long-run Solution

Variable	**Data**	**Model**	**Description**
$\overline{Y}$	N/A	1.11	Steady-state output
$\overline{C}/\overline{Y}$	0.686	0.8018	Consumption-to-output ratio
$\overline{X}/\overline{Y}$	0.201	0.1982	Investment-to-output ratio
$\overline{K}/\overline{Y}$	3.500	7.9281	Capital-to-output ratio
$\overline{\Psi}/\overline{Y}$	0.010	0.0120	Corruption-to-output ratio
$\overline{w}\overline{L^w}/\overline{Y}$	0.629	0.6400	Labor main activity income-to-output ratio
$\overline{r}\overline{K}/\overline{Y}$	0.359	0.3599	Capital income-to-output ratio
$\overline{L^w}$	0.333	0.3379	Share of total time spent working in the main activity
$\overline{L^c}$	N/A	0.0262	Share of total time spent working in the corruption activity
$\overline{r}$	0.040	0.0454	After-tax net return on capital

The calibration for consumption is the one that seems to be a little far off from the actual data. The reason is because in this model we do not have government spending, the aggregate output is only the sum of consumption and investment. With respect to the rest of the calibrations, like the case of the capital-to-output ratio, we follow Kydland & Prescott (1982). The investment-to-output ratio is the share we see in the actual data. The corruption-to-output ratio is the new share this model presents. It represents the percentage of output that is lost due to corruption. In our model, 4% of the US Output is lost on average every year. On the other hand, we can see that the output, consumption and productive labor falls instantly when we face a corruption shock of 1%. Investment also falls 12% approximately when facing a corruption shock. One empirical pattern frequently observed in the data is that countries with high levels of corruption and weak institutions tend to experience significantly lower levels of gross investment. This negative relationship between institutional quality and investment is well documented across various contexts.

The HP simulated series for the main variables are available in Figures 8 and 9.

5 Data

The empirical analysis relies on a balanced panel dataset that combines aggregate indicators, institutional quality measures, and additional controls. The main sources are the World Development Indicators (WDI), the Worldwide Governance Indicators (WGI), and the most recent release of the Penn World Table (PWT).

The World Development Indicators (WDI) are published annually by the World Bank. From this source, I extract annual series for the period 1960–2024. These include GDP at purchasing power parity (PPP) and market exchange rates, total population, labor force, unemployment rates, employment ratios, and the main components of aggregate demand such as total consumption, private consumption, government expenditure, investment, exports, and imports. All aggregate variables are expressed in real terms, that is, PPP-adjusted at constant prices (using 2017 as the base year). This ensures comparability across countries and over time, eliminating the influence of inflation and nominal exchange rate fluctuations. In addition, I use GDP deflators, official exchange rates, and PPP conversion factors. From these variables I construct per capita measures of GDP, consumption, investment, government expenditure, exports, imports, and employment, as well as aggregate indicators such as absorption and the trade balance.

The Penn World Table (PWT, latest version) is compiled and published by the Groningen Growth and Development Centre (University of Groningen). From this dataset, I use complementary information on productivity, capital stock, and relative prices. These variables serve both as additional controls and as robustness checks, since they provide alternative measures of output and factor accumulation that are consistent across countries.

The key variable of interest is corruption, denoted as CI. This measure is built from the Control of Corruption indicator provided by the Worldwide Governance Indicators (WGI), also compiled by the World Bank. The indicator is available annually from 1996 onward and is based on expert assessments and survey evidence. It captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as state capture. In its original scale, higher values indicate better governance outcomes and therefore lower levels of corruption. For the purposes of this study, I invert the scale so that higher values correspond to higher corruption. This inversion ensures consistency with the theoretical framework, where an increase in CI represents a deterioration in institutional quality.

In addition to inverting the scale, I compute standardized z-scores of the WGI corruption indicator by country. This normalization adjusts for global shifts in the distribution of corruption over time, allowing for cross-country comparisons that are not biased by the overall dispersion of the index in a given country. As a result, the variable CI can be interpreted both in its absolute inverted form and relative to the worldwide average of each country and year.

The final dataset therefore integrates long-run aggregate information from WDI and PWT with a consistently defined measure of corruption from WGI, which constitutes the central explanatory variable of the empirical analysis. Since the Control of Corruption indicator is available from 1996 onward, the effective time span of the analysis extends from 1996 to 2024. This period encompasses almost three decades of variation in both corruption and the variables of interest shown in table 3. In table 4, the most and least corrupt countries and their respective Corruption Index are shown for the year 2023.

Table 3: Summary Statistics of Main Variables

	Mean	SD	Min	P25	Median	P75	Max	Obs
Log(GDP pc)	9.323	1.158	6.236	8.375	9.388	10.265	12.069	8461
Corruption Index (WGI)	0.025	1.000	-2.459	-0.669	0.253	0.791	1.970	4988
Log(Employment pc)	-0.966	0.259	-2.166	-1.070	-0.931	-0.793	-0.283	7981
Log(Investment pc)	6.935	1.597	-2.420	5.833	7.022	8.231	10.581	8062
Log(Government Exp pc)	6.580	1.705	-0.466	5.276	6.656	8.003	9.989	8375
Log(Worker Productivity)	0.688	0.359	0.007	0.390	0.706	0.995	1.471	7844
Real XR	0.669	1.509	0.000	0.380	0.520	0.765	51.137	6006
Log(Exports pc)	7.023	1.911	-0.460	5.727	7.013	8.411	12.370	8763
Log(Imports pc)	7.168	1.717	0.451	5.951	7.117	8.402	12.209	8859
Log(Consumption pc)	8.218	1.377	1.725	7.146	8.164	9.348	11.138	8819
Log(Capital Stock pc)	10.005	1.577	4.899	8.903	10.072	11.239	14.150	9279
Log(TFP level PPP)	-0.406	0.439	-3.357	-0.691	-0.326	-0.091	1.307	5945

Source: WGI, World Bank, Penn World Tables

Table 4: Least and Most 20 Corrupt Countries according to their Corruption Index (CI), 2023

Least Corrupt		Most Corrupt	
Country	CI	Country	CI
Denmark	-2.38	South Sudan	1.97
Finland	-2.22	Syria	1.75
Norway	-2.11	Somalia	1.73
New Zealand	-2.08	Venezuela	1.69
Singapore	-2.04	Yemen	1.65
Sweden	-2.03	North Korea	1.58
Switzerland	-2.02	Equatorial Guinea	1.57
Luxembourg	-1.93	Burundi	1.56
Netherlands	-1.87	Libya	1.53
Australia	-1.78	Sudan	1.50
Liechtenstein	-1.71	Chad	1.48
Canada	-1.67	Democratic Republic of Congo	1.48
Germany	-1.66	Eritrea	1.48
Seychelles	-1.63	Haiti	1.44
Hong Kong	-1.63	Turkmenistan	1.42
Ireland	-1.58	Nicaragua	1.39
Uruguay	-1.57	Tajikistan	1.38
Iceland	-1.55	Congo	1.35
Estonia	-1.54	Iraq	1.32
Bhutan	-1.53	Central African Republic	1.31

6 Panel VAR Specification, Identification, and Inference

Let $i = 1, \dots, N$ index countries and $t = 1, \dots, T$ index years. The vector of endogenous variables in the Panel VAR is

$$y_{i,t} = \begin{bmatrix} \ln \mathrm{Corr}_{i,t} \\ \ln \mathrm{GDPpc}_{i,t} \\ \ln \mathrm{Cons}_{i,t} \\ \ln \mathrm{Inv}_{i,t} \\ \ln \mathrm{TFP}_{i,t} \\ \ln \mathrm{Hours}_{i,t} \end{bmatrix} = \begin{bmatrix} \ln \text{Corruption Perception Index}_{i,t} \\ \ln \text{Real GDP per capita}_{i,t} \\ \ln \text{Consumption per capita}_{i,t} \\ \ln \text{Investment per capita}_{i,t} \\ \ln \text{Total Factor Productivity}_{i,t} \\ \ln \text{Hours worked per worker}_{i,t} \end{bmatrix}.$$

We estimate a Panel VAR of order p in levels with country fixed effects (and, where relevant, common time effects),

$$y_{i,t} = \sum_{\ell=1}^{p} A_\ell \, y_{i,t-\ell} + \mu_i + \tau_t + u_{i,t}, \qquad E[u_{i,t} \mid \mathcal{F}_{t-1}] = 0, \qquad E[u_{i,t} u_{i,t}'] = \Sigma_u,$$

where μ_i captures time-invariant country heterogeneity and τ_t captures global shocks common to all countries. Estimation is carried out using the least squares dummy variable (LSDV) estimator for dynamic panels as discussed in Bun and Kiviet (2006), i.e., the model is estimated by OLS after including the full set of country dummies (and, when included, time dummies). Structural shocks are recovered from reduced-form innovations via

$$u_{i,t} = B \, \varepsilon_{i,t}, \qquad E[\varepsilon_{i,t} \varepsilon_{i,t}'] = I, \qquad \Rightarrow \qquad \Sigma_u = BB',$$

and identification is achieved through a recursive (Cholesky) scheme with B lower triangular under the ordering

$$\ln \mathrm{Corr}_{i,t} \;\to\; \ln \mathrm{GDPpc}_{i,t} \;\to\; \ln \mathrm{Cons}_{i,t} \;\to\; \ln \mathrm{Inv}_{i,t} \;\to\; \ln \mathrm{TFP}_{i,t} \;\to\; \ln \mathrm{Hours}_{i,t}.$$

This ordering allows corruption to affect all macroeconomic aggregates contemporaneously within the year, while restricting contemporaneous feedback from output and other aggregates to corruption to occur only with at least one lag.

The empirical sample is restricted to a strongly balanced panel with $N = 52$ countries and $T = 29$ consecutive annual observations per country. We impose $T = 29$ because it is the longest uninterrupted time window that maximizes the cross-sectional sample size while eliminating missing observations and time gaps. Operationally, we identify consecutive-year blocks within each country and retain the country only if it contains a full 29-year block without gaps, ensuring that the final panel is the largest possible strongly balanced sample given the available data.

Inference for impulse responses is conducted using the double-bootstrap resampling procedure proposed by Kapetanios (2008), which bootstraps whole cross-sectional units and preserves within-country serial dependence. The stability of the estimated system is verified by the roots of the companion matrix (Figure 11); all eigenvalues lie strictly within the unit circle, ensuring that the model is dynamically stable and the IRFs are well-defined. The impulse responses to a corruption innovation are reported in Figure 10. Forecast error variance decompositions are reported in Figures 12–17, which quantify the contribution of each structural shock to the forecast error variance of each variable across horizons.

The impulse responses in Figure 10 suggest that corruption shocks are highly persistent in their macroeconomic effects: the responses of GDP per capita, consumption, investment, and TFP remain below baseline for many horizons, with only slow mean reversion. This persistence indicates that the corruption innovation captured by the model behaves like a sustained disturbance rather than a purely transitory fluctuation, and its propagation to real activity is long-lived. The FEVD results reinforce this interpretation and provide an additional argument against reverse-causality narratives in which higher income mechanically generates higher corruption. In particular, Figure 12 shows that virtually all of the forecast error variance of the corruption index is explained by its own shocks at all horizons, with only negligible contributions from GDP and the other variables. Under our recursive identification, this pattern is consistent with corruption behaving as an autonomous driver of the system rather than an outcome primarily driven by short-run movements in economic activity. At the same time, Figure 13 indicates that, even after controlling for consumption, investment, TFP, and hours within the full multivariate system, the corruption shock explains a non-trivial share of GDP per capita forecast error variance at medium horizons. Taken together, the IRFs and FEVDs point to a coherent dynamic picture: corruption shocks are persistent and propagate meaningfully to real outcomes, while the reverse channel from GDP to corruption appears limited in the data at these horizons.

Finally, we emphasize why a pooled Panel VAR is preferred to estimating separate country-by-country VARs. With only $T = 29$ annual observations, estimating a six-variable VAR for each country requires fitting a large number of coefficients relative to available time-series information, yielding imprecise dynamics and highly noisy country-specific innovations. In small samples, the estimated reduced-form residual covariance matrix can become ill-conditioned or effectively singular (not positive definite), making orthogonalization (e.g., via Cholesky factorization) numerically unstable and producing erratic identified shocks and unreliable confidence intervals. Pooling information across countries through a Panel VAR improves precision and regularizes the covariance structure while still allowing for country heterogeneity via fixed effects, delivering more stable and interpretable dynamic results.

7 Main Results and Robustness Checks

7.1 Fixed Effects Model

Table 5 presents the panel estimates of the effect of corruption on log GDP per capita. Columns (1), (2) and (3) correspond to static panel models, columns (4) and (5) introduce dynamics by including the lagged dependent variable. The static specifications are useful to establish a baseline causality between corruption and output, controlling for observed covariates and fixed effects of year and country. Including the lagged dependent variable allows us to net out the variable's own dynamic component, an effect that is conceptually independent from corruption, so that the estimated coefficient on the Corruption Index reflects the impact beyond these inherent adjustment dynamics. This is consistent with the standard treatment of persistence in panel models with highly autocorrelated variables. To further analyze these results, I will model the relationship between corruption and output using a dynamic panel framework of the form

$$y_{jt} = \alpha y_{jt-1} + \beta x_{jt} + c_j + u_{jt},$$

where y_{jt} is log GDP per capita in country j at time t, y_{jt-1} is its lag capturing persistence, x_{jt} represents corruption, c_j are country fixed effects, and u_{jt} is the error term. This specification allows to distinguish short-run from long-run effects and to account explicitly for the inertia in output. The estimated coefficients imply that a one-unit increase in the corruption index is associated with a reduction in GDP per capita of about 1 percent in the dynamic final specification, in column (5). This specification will also be used for other interest variables, such as log consumption per capita and log investment per capita for example.

In column (1), the model includes only corruption, showing a strong negative relationship: higher corruption levels are linked with lower GDP per capita; yet, as expected, the adjusted R^2 remains low, suggesting that corruption alone is clearly not the only variable that helps explain GDP. Column (2) adds controls such as employment, investment, government expenditure, and labor productivity, all expressed in per capita terms. The effect of corruption remains negative and significant but decreases in magnitude, indicating that part of its correlation with output operates through these channels. From column (4) onwards, the panel becomes dynamic with the inclusion of the lagged dependent variable.

Figure 1 provides a complementary graphical illustration of this negative relationship. This binned scatter plot (50 bins), as facilitated by Cattaneo et al. (2024), shows this relationship between log GDP per capita and corruption, conditional on country fixed effects, year dummies, and controls such as the ones used in table 5. This visual evidence is consistent with the regression results, indicating that when corruption increases within a country, it will systematically exhibit lower levels of output per capita.

The analysis of investment mirrors the specification used for GDP per capita, including country and year fixed effects as well as controls. Table 6 shows that corruption has a negative and significant relationship with investment per capita. In the static specification with controls, a one-unit increase in the corruption index is associated with a reduction of about 12 percent in investment per capita. The graphical evidence in Figure 2 reinforces these findings. Taken together, the regression estimates and the binscatter suggest that investment is a key channel through which corruption translates into lower output.

Table 7 reports the panel estimates of the effect of corruption on log consumption per capita. The structure of the specifications mirrors the ones presented previously. The static models show a strong negative relationship between corruption and consumption, with the magnitude of the effect becoming smaller as before once controls are included.

When dynamics are introduced, the lagged dependent variable is highly significant, reflecting strong persistence in consumption levels across countries as is expected. The coefficient on corruption remains negative and significant, although its size diminishes, indicating that the adverse effect of corruption on consumption is partly absorbed by past levels of consumption.

Figure 3 complements these regression results with its corresponding binned scatter plot of consumption per capita against corruption, conditional on country fixed effects, year effects, and controls. The figure shows a negative slope as well, reinforcing the regression evidence that higher corruption perception is systematically associated with lower levels of consumption per capita.

Table 8 presents the results for the log of capital stock per capita as the dependent variable.

The estimates suggest that corruption is negatively associated with capital accumulation, although the effects appear weaker than in the previous specifications. The binscatter in Figure 4 displays this relationship. Overall, the evidence indicates that corruption has a detrimental effect on capital accumulation, but the magnitude of the effect is weaker than compared previously.

Tables 9 and 10 present the results for government expenditure and employment per capita. Unlike the cases of GDP, investment, and consumption, the estimates here do not show robust evidence of an effect of corruption perception. In the static specifications, the coefficient of corruption on government expenditure is sometimes negative and marginally significant, but this result disappears once additional controls and dynamics are introduced. The lagged dependent variable in the dynamic models captures most of the variation, leaving the effect of corruption small and statistically insignificant.

For employment per capita, the results are even clearer: across all specifications, the estimated effect of corruption is essentially zero, with no statistical significance once fixed effects, controls, and dynamics are taken into account. The persistence of employment levels, as indicated by the large and significant lag coefficient, dominates the dynamics of the model, and corruption does not appear to play a systematic role in explaining cross-country differences in employment per capita.

Overall, these findings suggest that while corruption has a negative and significant impact on output, investment, and consumption, its effects on government expenditure and employment are not robust. This conclusion is reinforced by the binned scatter plots in Figures 5 and 6, where no clear negative slope is observed once country fixed effects, year dummies, and controls that are included.

7.2 Robustness Checks

A fundamental limitation of the dynamic panel specification is that the lagged dependent variable becomes mechanically correlated with the error term once fixed effects are introduced. This generates the well-known Nickell bias, which does not vanish even as the number of countries grows, making the fixed-effects estimator inconsistent in dynamic settings. As a consequence, the estimated persistence and the effect of corruption may be distorted. To address this source of endogeneity, it is necessary to rely on estimators specifically designed for dynamic panels, such as difference GMM or system GMM. To evaluate the robustness of the baseline findings, I estimate these dynamic panel models using the Arellano–Bond and Blundell–Bond GMM estimators. Column (1) in Tables 12 to 14 reports the Arellano–Bond one-step Difference GMM estimator, which instruments first differences with lagged levels of the endogenous variables. Column (2) applies the two-step Difference GMM estimator, which improves efficiency by using a more efficient weighting matrix, though standard errors may be biased downward. Comparing these two specifications helps verify whether the results are sensitive to such efficiency gains. Finally, column (3) turns to the Blundell–Bond System GMM estimator, which combines difference and level equations, using lagged differences as instruments for the levels. This approach is particularly useful when the variables are highly persistent, as it reduces finite-sample bias and improves efficiency relative to Difference GMM. Across the three estimators, the specification tests generally validate the instruments: AR(1) rejects as expected, AR(2) does not, and the Hansen J-test mostly confirms instrument validity. The results consistently indicate that corruption exerts a negative effect on these per capita variables, replicating the coefficients we had in the static panel model with controls.

Another possible concern is the common assertion that an increase in GDP per capita may itself generate higher corruption: by expanding fiscal revenues, enlarging the scope of public spending, and increasing the availability of rents, a positive income shock could mechanically raise opportunities for rent-seeking activities. To assess this reverse-causality channel, we implement panel Granger non-causality tests using the approach of Juodis, Karavias and Sarafidis (2021). The Granger causality evidence reported in Tables 15–17 does not support this mechanism in our data. While innovations in corruption perception Granger-cause subsequent movements in GDP per capita (Table 15), we find no evidence that shocks to GDP per capita predict subsequent changes in corruption. A similar pattern holds for investment and consumption per capita (Tables 16 and 17), where the null of causality running from these macroeconomic aggregates to corruption cannot be rejected. Taken together, these results mitigate concerns that the estimated relationship is driven by GDP increases leading to higher corruption; instead, corruption appears to precede—and help forecast—changes in key macroeconomic outcomes.

8 Conclusion

The empirical analysis confirms a robust negative relationship between corruption perception and key outcomes such as GDP, investment, consumption, and capital stock per capita. These results are consistent across different specifications and highlight corruption as a persistent drag on economic performance. At the same time, the effect on employment and government expenditure appears more muted, which suggests that institutional rigidities and fiscal smoothing may dampen part of the direct impact of corruption shocks.

The RBC model with corruption shocks replicates many of these empirical patterns, especially the declines in output, capital, consumption, and investment. Nevertheless, the model cannot fully account for certain dimensions that remain open for future research. In particular, we do not capture the heterogeneous impact of corruption across emerging and advanced economies, nor do we address how corruption interacts with open-economy dynamics such as trade or capital flows. These limitations, partly due to data availability and the need to keep the model tractable, point to promising avenues for further research. We leave the exploration of these issues for future work.

9 References

Mauro, Paolo. "Corruption and Growth." *Quart. J. Econ.*, (Aug. 1995), 11093), pp. 681–712.

De Paulo, Lucas Dutra, Carvalho de Andrade Lima, Ricardo and Tigre, Robson. "Corruption and economic growth in Latin America and the Caribbean." *Review of Development Economics 26*, (2022), pp 756–73.

Acemoglu, D., & Verdier, T. (2000). "The choice between market failures and corruption." *The American Economic Review*, 90: 194-211.

Krueger, Anne O. "The Political Economy of the Rent-Seeking Society." *The American Economic Review*, June 1974, 64(3), pp. 291-303.

Bhagwati, J. N. (1982) "Directly unproductive, profit-seeking (DUP) activities." *Journal of Political Economy*, 90, 988-1002.

Angeletos, G.M., Kollintzas, T., (2000), "Rent Seeking/Corruption and Growth." *CEPR Discussion Paper* 2464.

Kydland, Finn E. and Edward C. Prescott, "Time to Build and Aggregate Fluctuations." *Econometrica* Vol. 50, No. 6 (Nov., 1982), pp. 1345-1370.

Hansen, Gary D. (1985). "Indivisible Labor and the Business Cycle." *Journal of Monetary Economics*, 16(3): 309-27.

Hodrick, Robert. J., and Edward. C. Prescott, "Postwar US Business Cycles: An Empirical Investigation," *Carnegie Mellon University discussion paper* 451 (1980).

Uhlig, H. 1999. "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily." In Computational Methods for the Study of Dynamic Economies, edited by R. Marimon and A. Scott, 30-61. *Oxford Univ. Press.*

Bianchi, Francesco (2013), "Regime Switches, Agents' Beliefs, and Post-World War II U.S. Macroeconomic Dynamics." *Review of Economic Studies*, 80(2): 463–490.

Farmer, Roger E.A., Daniel F. Waggoner, and Tao Zha (2009), "Understanding Markov-switching Rational Expectations Models." *Journal of Economic Theory*, 144(5): 1849–1867.

Juodis, A., Karavias, Y. and Sarafidis, V. (2021) “A practical approach to testing for weak exogeneity in panel VAR models.” *Journal of Econometrics*, 221, 361–382.

Cattaneo, M. D., Crump, R. K., Farrell, M. H., & Feng, Y. (2024). On Binscatter. *American Economic Review*, 114(5), 1488-1514.

Arellano, M. and Bond, S. (1991) "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." *Review of Economic Studies*, 58(2), 277–297.

Arellano, M. and Bover, O. (1995) "Another look at the instrumental variable estimation of error-components models." *Journal of Econometrics*, 68(1), 29–51.

Blundell, R. and Bond, S. (1998) "Initial conditions and moment restrictions in dynamic panel data models." *Journal of Econometrics*, 87(1), 115–143.

Prescott, E. C. (2004) "Why Do Americans Work So Much More than Europeans?" *NBER Working Paper*, No. 10316, National Bureau of Economic Research.

Kapetanios, G. (2008). A bootstrap procedure for panel data sets with many cross-sectional units. *Econometrics Journal*, 11(2), 377–395.

Bun, M. J. G., & Kiviet, J. F. (2006). The effects of dynamic feedbacks on LS and MM estimator accuracy in panel data models. *Journal of Econometrics*, 132(2), 409–444.

10 Figures and Tables

10.1 Panel Figures

Figure 1: Binned scatter plot of corruption and log GDP per capita with controls.

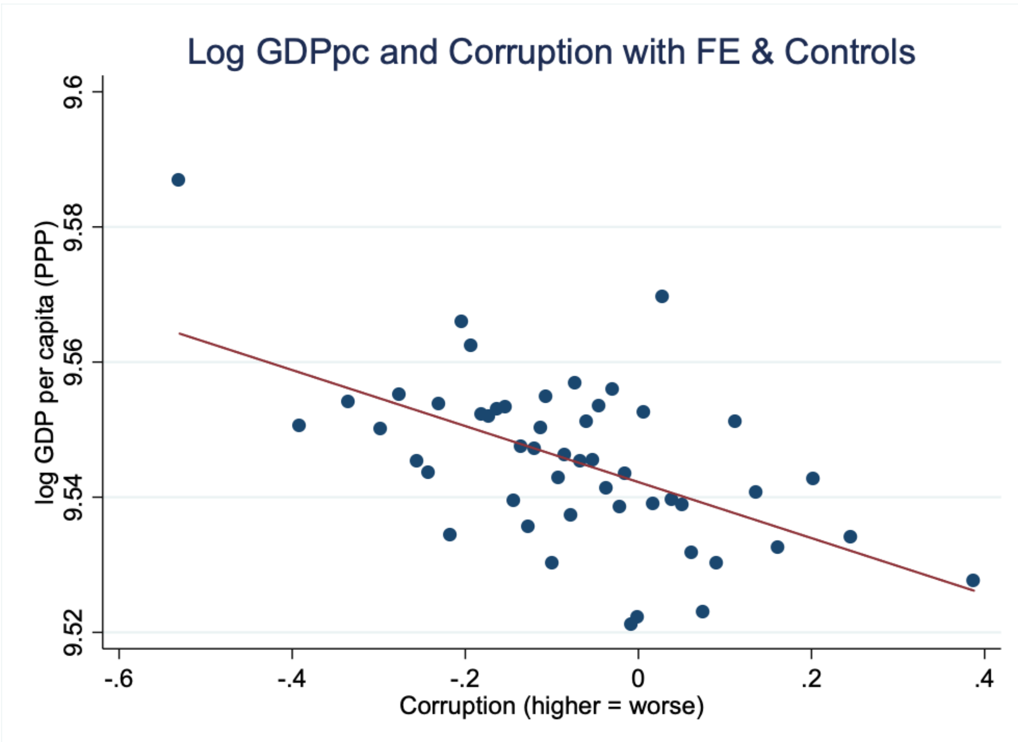


Figure 2: Binned scatter plot of corruption and log investment per capita with controls.

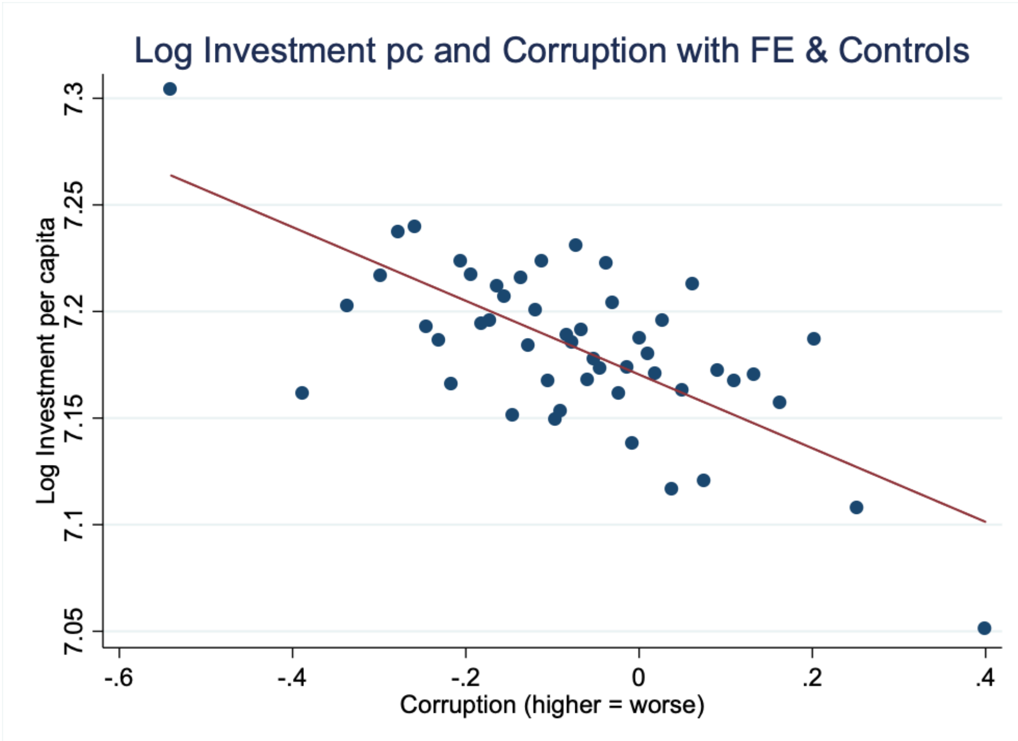


Figure 3: Binned scatter plot of corruption and log consumption per capita with controls.

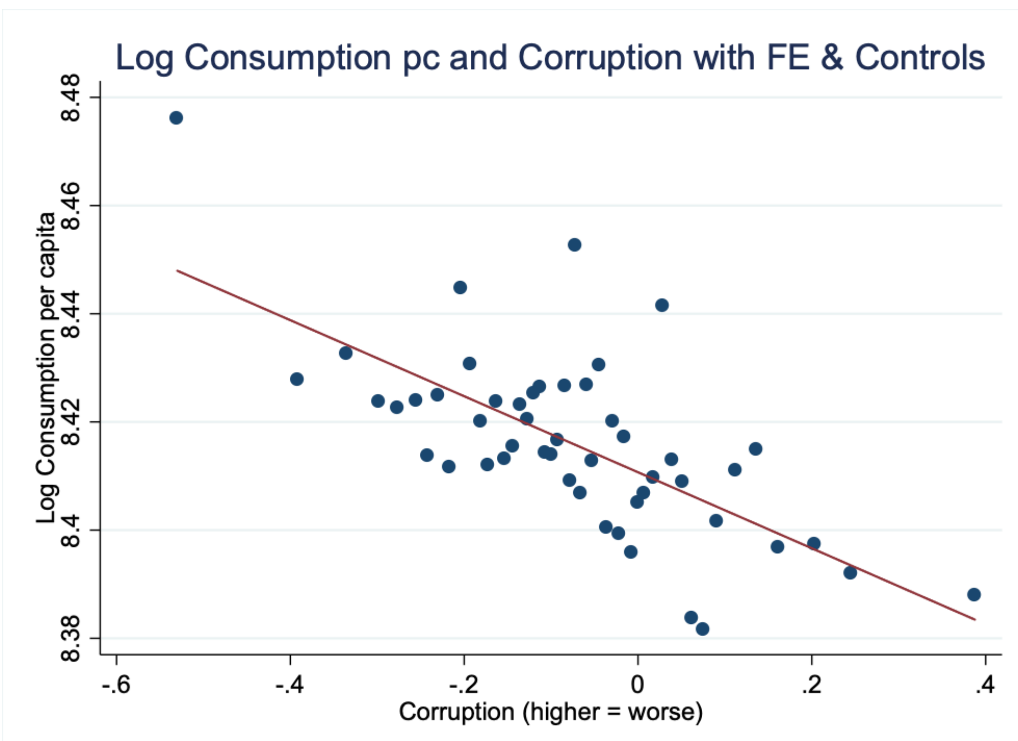


Figure 4: Binned scatter plot of corruption and log Capital Stock per capita with controls.

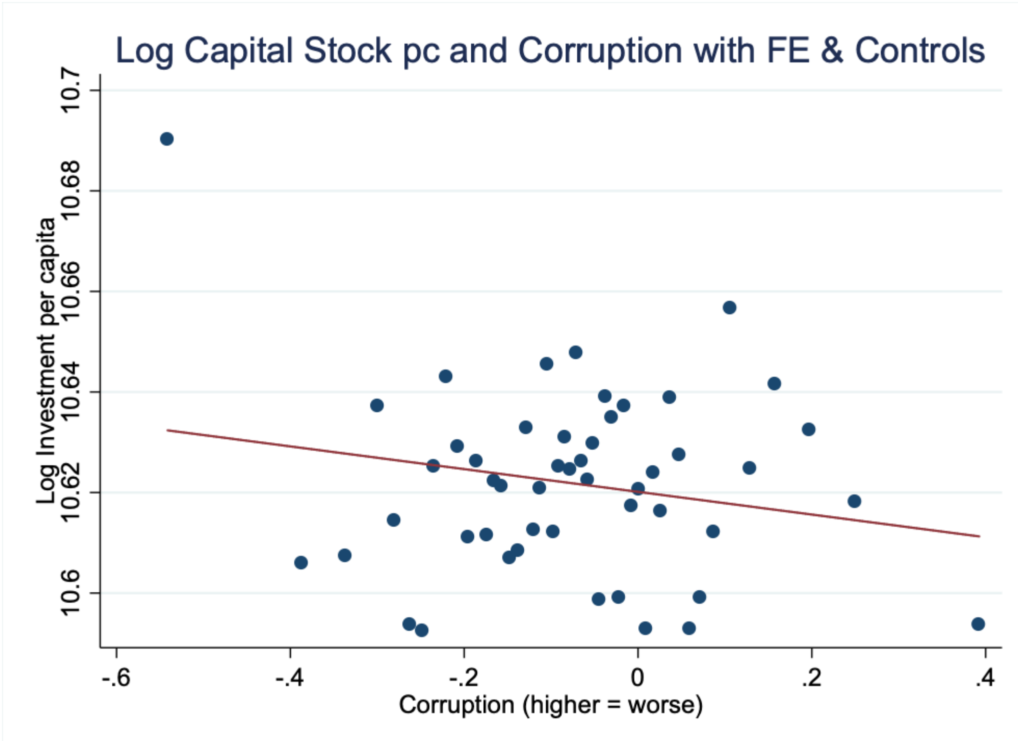


Figure 5: Binned scatter plot of corruption and log government expenditure per capita with controls.

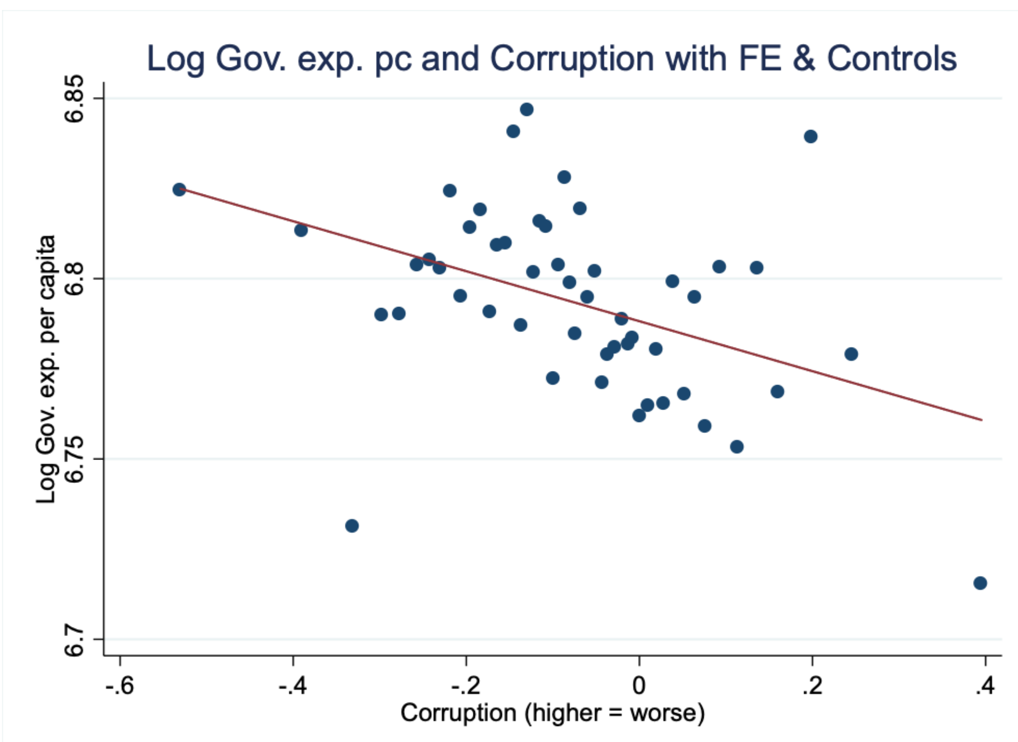


Figure 6: Binned scatter plot of corruption and log employment per capita with controls.

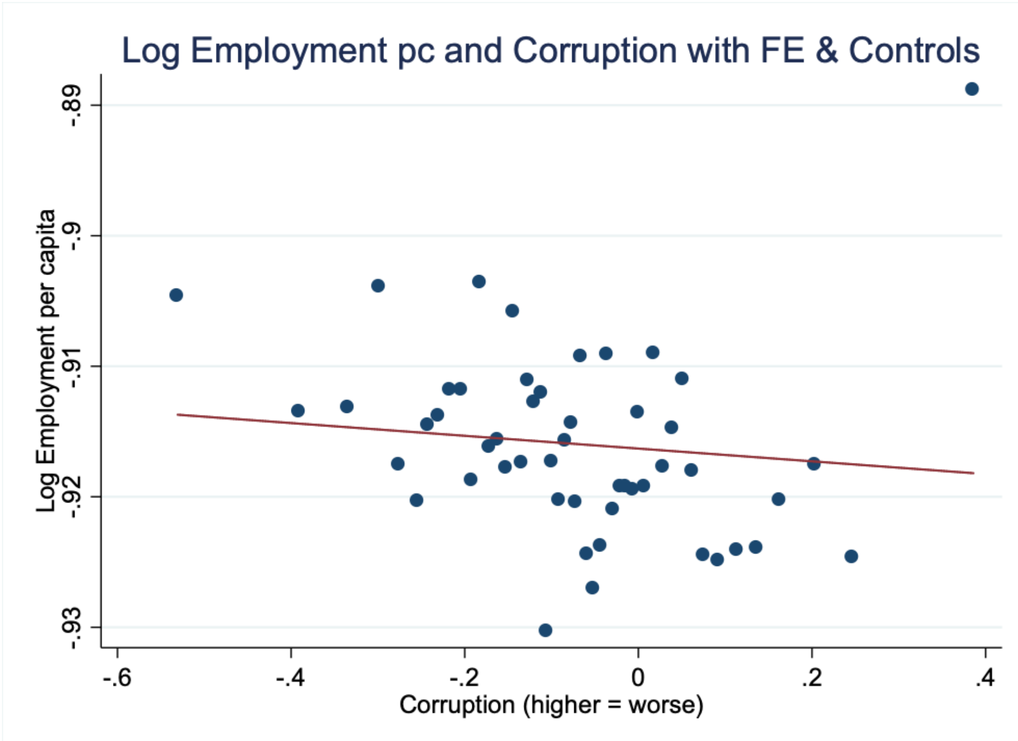
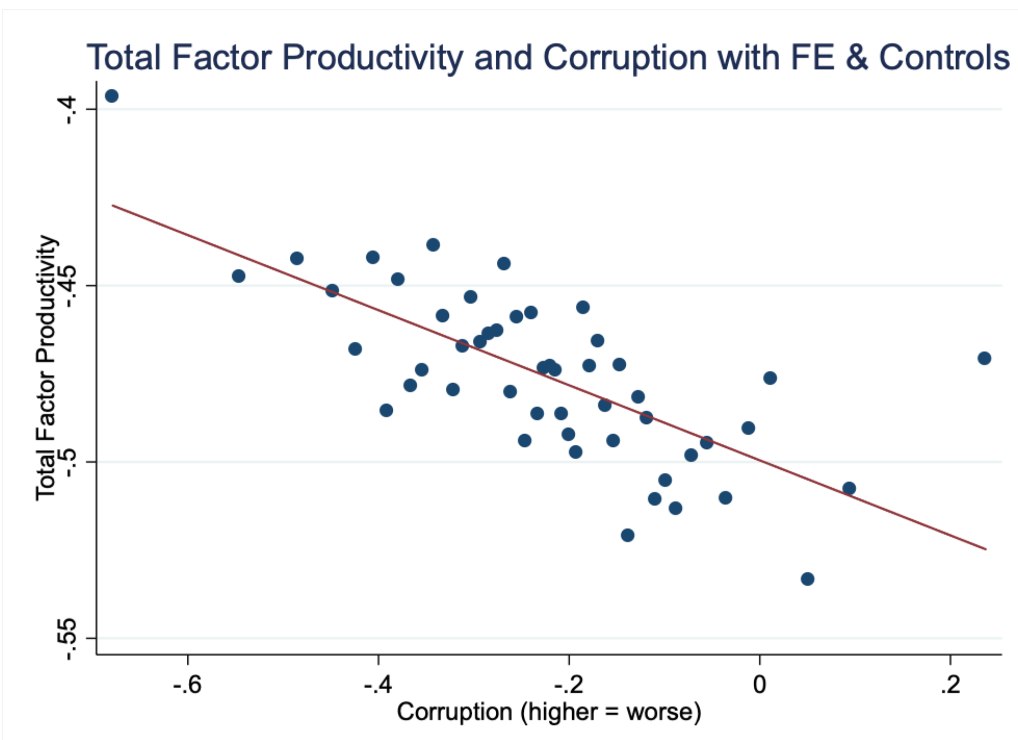


Figure 7: Binned scatter plot of corruption and TFP level at current PPPs.



10.2 Model Figures

Figure 8: Impulse responses to a 1% increase in corruption productivity. Responses in percentage deviations from the steady state.

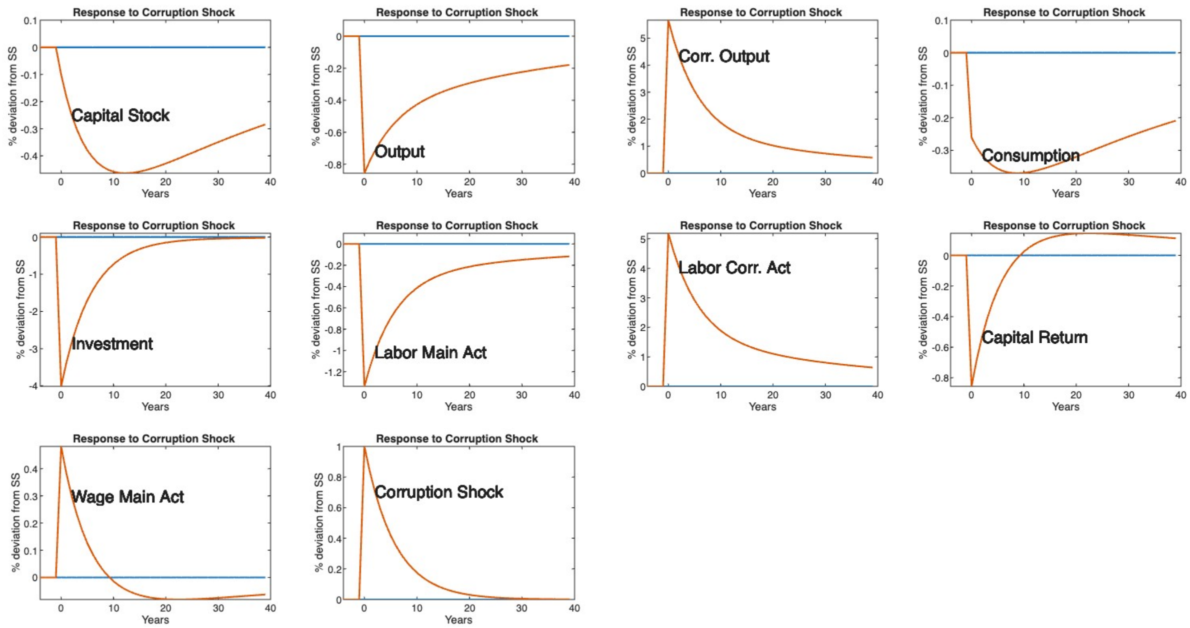
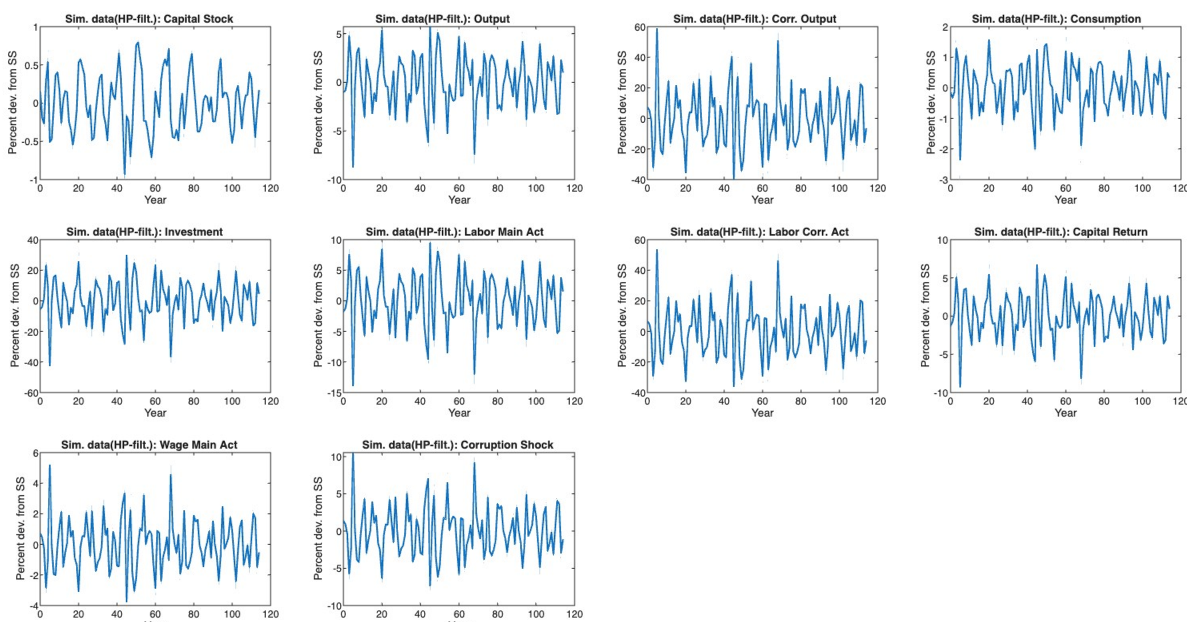


Figure 9: HP filter simulations ($\lambda = 1600$, quarterly data). Horizon: 32 periods.



10.3 Panel Tables

Table 5: Corruption and Output: Log GDP per capita (Panel FE)

	(1)	(2)	(3)	(4)	(5)
	Log(GDP pc)$_t$	Log(GDP pc)$_t$	Log(GDP pc)$_t$	Log(GDP pc)$_t$	Log(GDP pc)$_t$
Corruption Index$_t$	-0.20***	-0.05**	-0.04*	-0.01*	-0.01*
	(0.03)	(0.03)	(0.02)	(0.00)	(0.00)
Log(Inv pc)$_t$		0.16***	0.18***	0.04***	0.05***
		(0.03)	(0.03)	(0.01)	(0.01)
Log(Govxp pc)$_t$		0.25***	0.19***	0.02***	0.02***
		(0.05)	(0.04)	(0.01)	(0.01)
Log(Emp pc)$_t$		0.34***	0.36***	0.08***	0.10***
		(0.13)	(0.10)	(0.02)	(0.02)
Log(Labor Prod)$_t$		0.05	-0.03	-0.01	-0.01
		(0.20)	(0.14)	(0.03)	(0.02)
Log(Exports pc)$_t$			0.27***		0.05***
			(0.04)		(0.01)
Log(Imports pc)$_t$			-0.12**		-0.01
			(0.06)		(0.01)
Real XR$_t$			0.04**		-0.01***
			(0.02)		(0.00)
Log(GDP pc)$_{t-1}$				0.89***	0.83***
				(0.02)	(0.02)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2(*within*)	0.08	0.42	0.63	0.94	0.95
Observations	4,743	2,351	2,299	2,351	2,299

Note: Standard errors in parentheses, clustered at the country-year level.

Table 6: Corruption and Investment: Log Investment per capita (Panel FE)

	(1)	(2)	(3)	(4)	(5)
	Log(Inv pc)$_t$	Log(Inv pc)$_t$	Log(Inv pc)$_t$	Log(Inv pc)$_t$	Log(Inv pc)$_t$
Corruption Index$_t$	-0.36***	-0.25***	-0.17**	-0.08***	-0.07***
	(0.06)	(0.07)	(0.07)	(0.02)	(0.02)
Log(Govxp pc)$_t$		0.54***	0.16*	0.09***	0.01
		(0.10)	(0.09)	(0.03)	(0.04)
Log(Emp pc)$_t$		0.69**	0.46*	0.17*	0.17*
		(0.32)	(0.24)	(0.09)	(0.10)
Log(Labor Prod)$_t$		0.34	0.14	0.07	0.06
		(0.30)	(0.35)	(0.10)	(0.13)
Log(Exports pc)$_t$			-0.36***		-0.16***
			(0.07)		(0.03)
Log(Imports pc)$_t$			0.97***		0.39***
			(0.09)		(0.05)
Real XR$_t$			-0.04		-0.06***
			(0.05)		(0.02)
Log(Inv pc)$_{t-1}$				0.82***	0.69***
				(0.02)	(0.03)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2(*within*)	0.05	0.17	0.48	0.74	0.78
Observations	3,578	2,351	2,299	2,331	2,280

Note: Standard errors in parentheses, clustered at the country level.

Table 7: Corruption and Consumption: Log Consumption per capita (Panel FE)

	(1)	(2)	(3)	(4)	(5)
	Log(Cons pc)$_t$	Log(Cons pc)$_t$	Log(Cons pc)$_t$	Log(Cons pc)$_t$	Log(Cons pc)$_t$
Corruption Index$_t$	-0.20***	-0.06***	-0.07***	-0.02***	-0.02***
	(0.04)	(0.02)	(0.02)	(0.00)	(0.00)
Log(Inv pc)$_t$		0.10***	0.04	0.03***	0.01
		(0.02)	(0.03)	(0.01)	(0.01)
Log(Govxp pc)$_t$		0.38***	0.31***	0.08***	0.06***
		(0.04)	(0.05)	(0.01)	(0.01)
Log(Emp pc)$_t$		0.31***	0.32***	0.15***	0.14***
		(0.10)	(0.10)	(0.02)	(0.02)
Log(HC)$_t$		-0.06	-0.06	-0.01	-0.00
		(0.17)	(0.17)	(0.04)	(0.03)
Log(Exports pc)$_t$			-0.01		-0.03***
			(0.03)		(0.01)
Log(Imports pc)$_t$			0.14**		0.07***
			(0.06)		(0.02)
Real XR$_t$			0.02		-0.00
			(0.03)		(0.01)
Log(Cons pc)$_{t-1}$				0.81***	0.80***
				(0.03)	(0.02)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2(*within*)	0.09	0.46	0.52	0.89	0.91
Observations	3,844	2,351	2,299	2,333	2,281

Note: Standard errors in parentheses, clustered at the country level.

Table 8: Corruption and Capital: Log Capital stock per capita (Panel FE)

	(1)	(2)	(3)	(4)	(5)
	Log(K pc)$_t$	Log(K pc)$_t$	Log(K pc)$_t$	Log(K pc)$_t$	Log(K pc)$_t$
Corruption Index$_t$	-0.11*	0.01	0.01	0.00	0.00
	(0.06)	(0.04)	(0.03)	(0.00)	(0.00)
Log(Govxp pc)$_t$		0.30***	0.25***	0.02***	0.02***
		(0.07)	(0.06)	(0.01)	(0.01)
Log(Inv pc)$_t$		0.16***	0.15***	0.05***	0.05***
		(0.03)	(0.04)	(0.00)	(0.01)
Log(Emp pc)$_t$		0.34*	0.33*	0.00	0.00
		(0.18)	(0.17)	(0.02)	(0.01)
Log(Labor Prod)$_t$		0.65**	0.56**	0.01	0.01
		(0.28)	(0.24)	(0.02)	(0.02)
Log(Exports pc)$_t$			0.18***		-0.00
			(0.04)		(0.00)
Log(Imports pc)$_t$			-0.04		-0.00
			(0.07)		(0.01)
Real XR$_t$			0.07**		0.00
			(0.04)		(0.00)
Log(K pc)$_{t-1}$				0.95***	0.96***
				(0.01)	(0.01)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2 (within)	0.01	0.35	0.43	0.99	0.99
Observations	3,580	2,351	2,299	2,351	2,299

Note: Standard errors in parentheses, clustered at the country level.

Table 9: Corruption and Government Expenditure: Log Gov. exp. per capita (Panel FE)

	(1)	(2)	(3)	(4)	(5)
	Log(Govxp pc)$_t$	Log(Govxp pc)$_t$	Log(Govxp pc)$_t$	Log(Govxp pc)$_t$	Log(Govxp pc)$_t$
Corruption Index$_t$	-0.15***	-0.07	-0.00	-0.00	0.00
	(0.04)	(0.05)	(0.00)	(0.00)	(0.00)
Log(Inv pc)$_t$		0.19***	0.00***	0.00	0.00
		(0.04)	(0.00)	(0.00)	(0.00)
Log(Emp pc)$_t$		0.03	0.00	0.00**	-0.00***
		(0.19)	(0.00)	(0.00)	(0.00)
Log(Labor Prod)$_t$		0.20	0.00	0.00	-0.00
		(0.24)	(0.00)	(0.00)	(0.00)
Log(Exports pc)$_t$			0.00***		-0.00*
			(0.00)		(0.00)
Log(Imports pc)$_t$			-0.00		-0.00*
			(0.00)		(0.00)
Real XR$_t$			-0.00		0.00***
			(0.00)		(0.00)
Log(Govxp pc)$_{t-1}$				0.00***	-0.00***
				(0.00)	(0.00)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2 (within)	0.03	0.13	1.00	1.00	1.00
Observations	3,758	2,351	2,299	2,332	2,281

Note: Standard errors in parentheses, clustered at the country level.

Table 10: Corruption and Employment: Log Employment per capita (Panel FE)

	(1) Log(Emp pc)	(2) Log(Emp pc)	(3) Log(Emp pc)	(4) Log(Emp pc)	(5) Log(Emp pc)
Corruption Index$_t$	-0.01	-0.00	-0.00	-0.00	0.00
	(0.01)	(0.02)	(0.02)	(0.00)	(0.00)
Log(Inv pc)$_t$		0.03**	0.03**	0.01***	0.00**
		(0.01)	(0.01)	(0.00)	(0.00)
Log Gov. exp. pc$_t$		0.00	0.02	-0.01***	-0.00
		(0.02)	(0.02)	(0.00)	(0.00)
Log(Labor Prod)$_t$		0.22***	0.22***	0.01	-0.01
		(0.08)	(0.08)	(0.02)	(0.01)
Real XR$_t$			0.03		-0.00
			(0.02)		(0.00)
Log(Exports pc)$_t$			-0.01		0.01***
			(0.02)		(0.00)
Log(Imports pc)$_t$			-0.00		-0.00
			(0.02)		(0.00)
Log(Emp pc)$_{t-1}$				0.94***	0.37***
				(0.01)	(0.01)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2 (within)	0.00	0.05	0.07	0.87	0.84
Observations	4,556	2,351	2,299	2,351	2,299

Note: Standard errors in parentheses, clustered at the country level.

Table 11: Corruption and Total Factor Productivity at current PPPs (Panel FE)

	(1) Log(TFP)$_t$	(2) Log(TFP)$_t$	(3) Log(TFP)$_t$	(4) Log(TFP)$_t$	(5) Log(TFP)$_t$
Corruption Index$_t$	-0.18***	-0.12***	-0.11***	-0.02**	-0.01
	(0.05)	(0.04)	(0.03)	(0.01)	(0.01)
Log(Inv pc)$_t$		0.07*	0.06	0.01	0.01
		(0.04)	(0.05)	(0.01)	(0.01)
Log(Employment pc)$_t$		0.12	0.12	0.05	0.04
		(0.14)	(0.13)	(0.03)	(0.03)
Log Gov. exp. pc$_t$		0.16**	0.19**	0.03	0.02
		(0.08)	(0.09)	(0.02)	(0.02)
Log(Labor Prod)$_t$		-0.29	-0.31	-0.08	-0.07
		(0.27)	(0.27)	(0.06)	(0.05)
Real XR$_t$			-0.00		-0.03***
			(0.03)		(0.01)
Log(Exports pc)$_t$			0.05		0.01
			(0.06)		(0.01)
Log(Imports pc)$_t$			-0.02		0.01
			(0.10)		(0.02)
Log(TFP)$_{t-1}$				0.84***	0.85***
				(0.03)	(0.02)
Country Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes
R^2 (within)	0.04	0.14	0.15	0.79	0.80
Observations	2,415	1,955	1,908	1,955	1,908

Note: Standard errors in parentheses, clustered at the country level.

10.4 Panel VAR

Figure 10: Impulse response functions to a corruption shock.

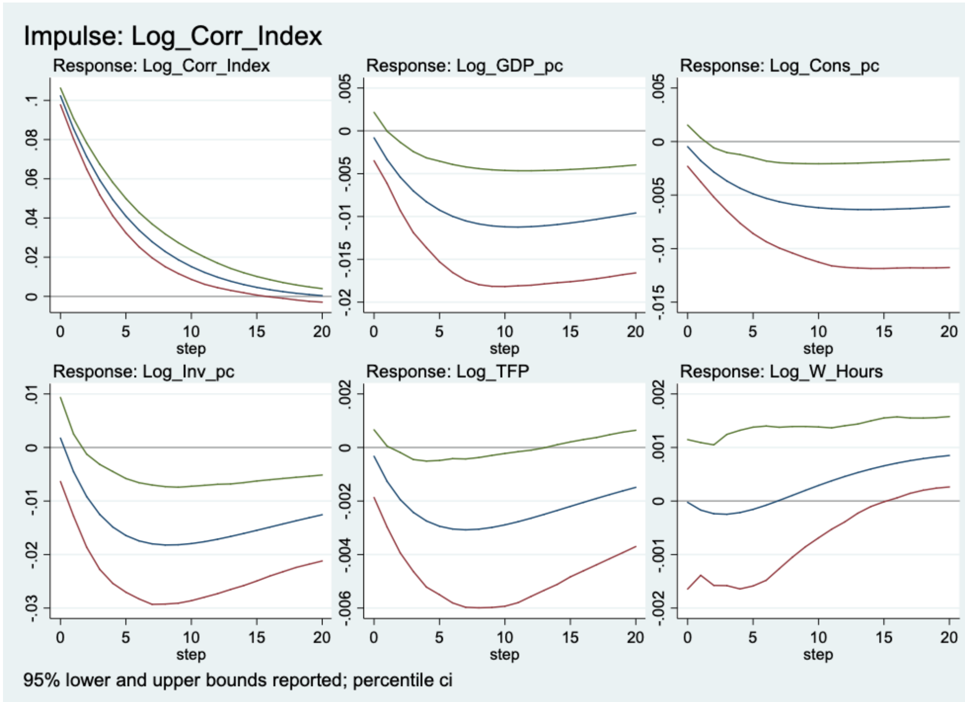


Figure 11: Roots of the companion matrix of the Panel VAR system. Notes: The model is estimated with 52 countries and 29 annual observations per country.

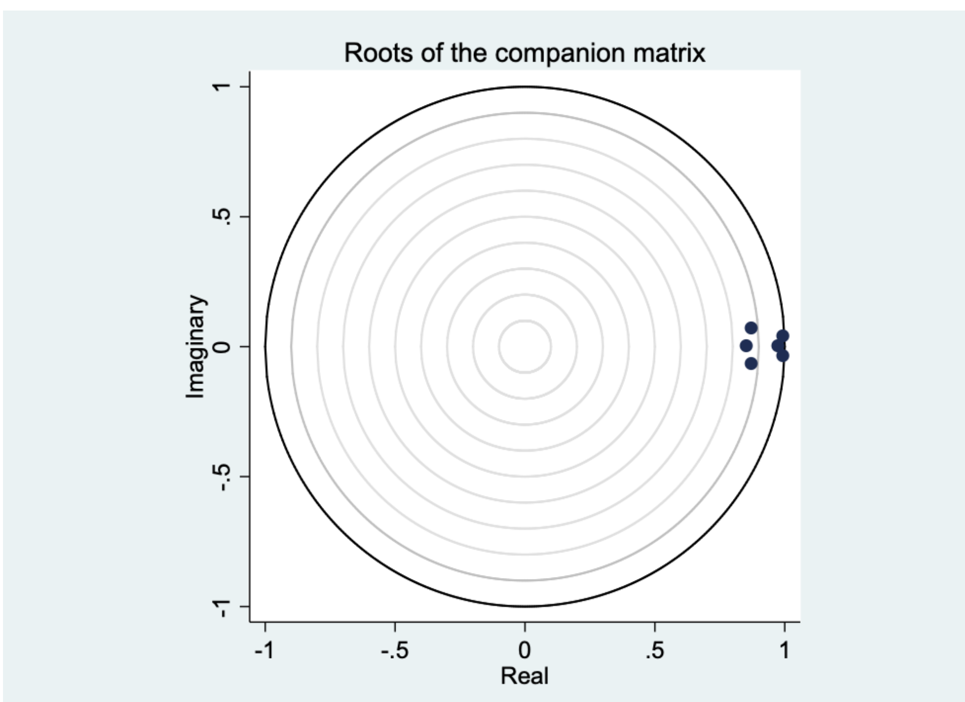


Figure 12: Forecast error variance decomposition of the corruption index.

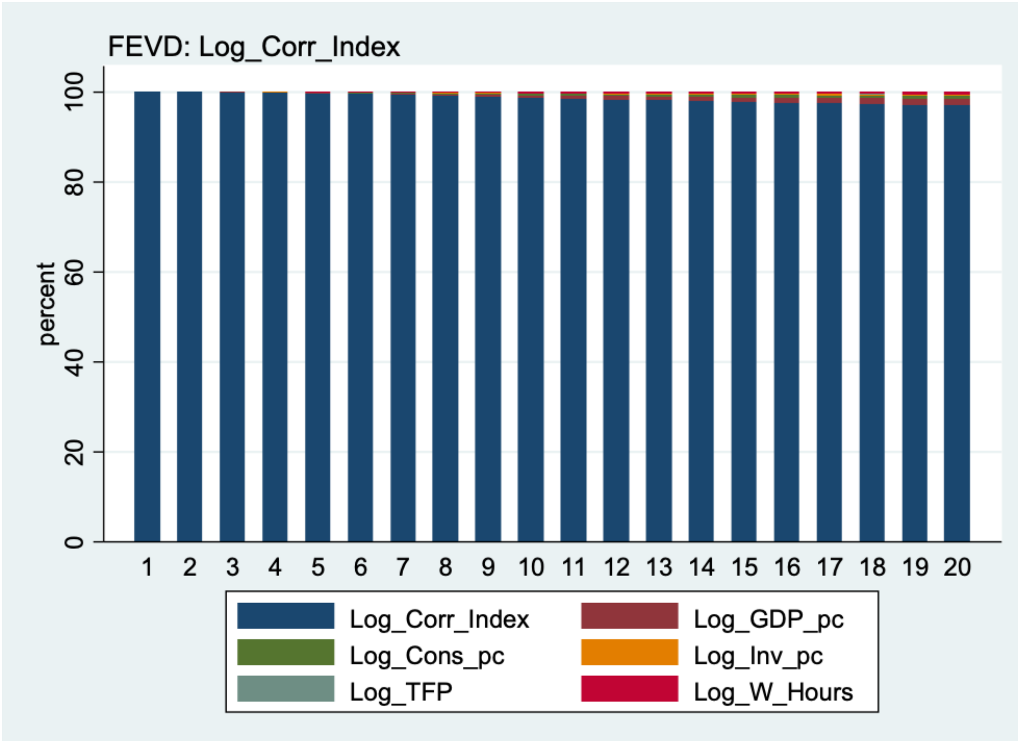


Figure 13: Forecast error variance decomposition of real GDP per capita.

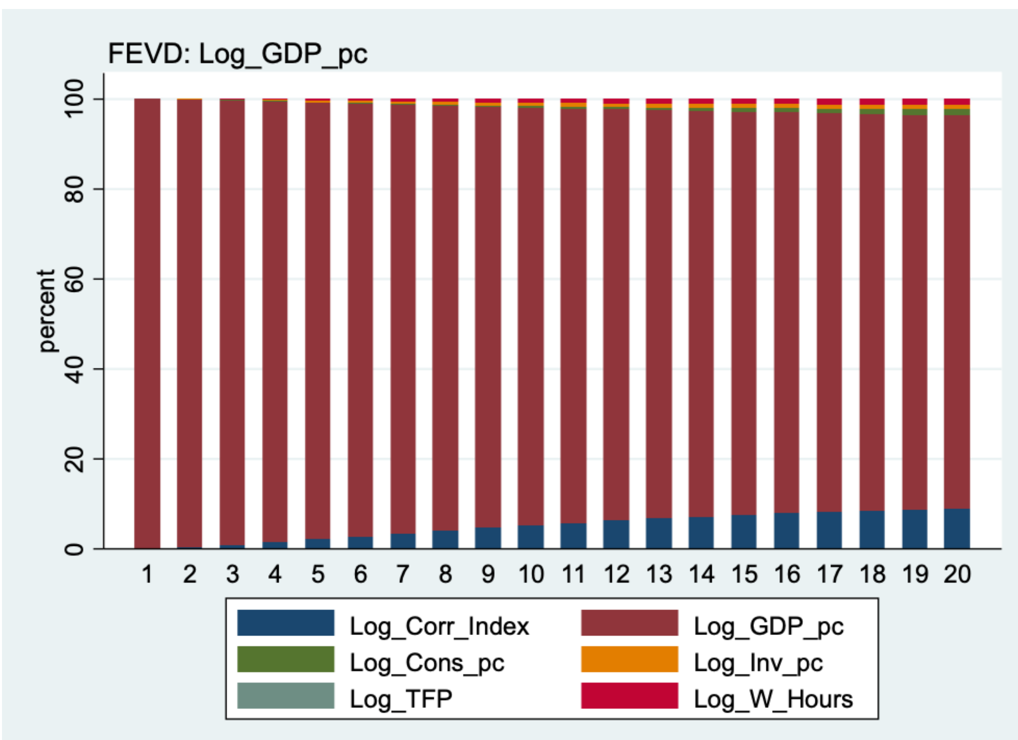


Figure 14: Forecast error variance decomposition of real consumption per capita.

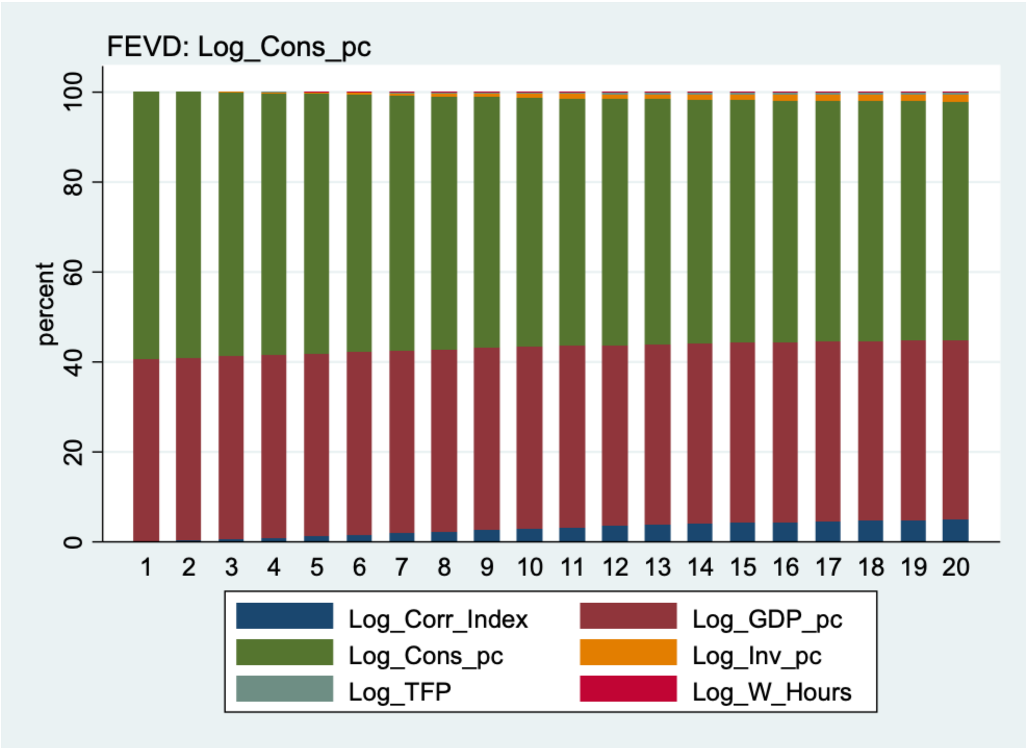


Figure 15: Forecast error variance decomposition of real investment per capita.

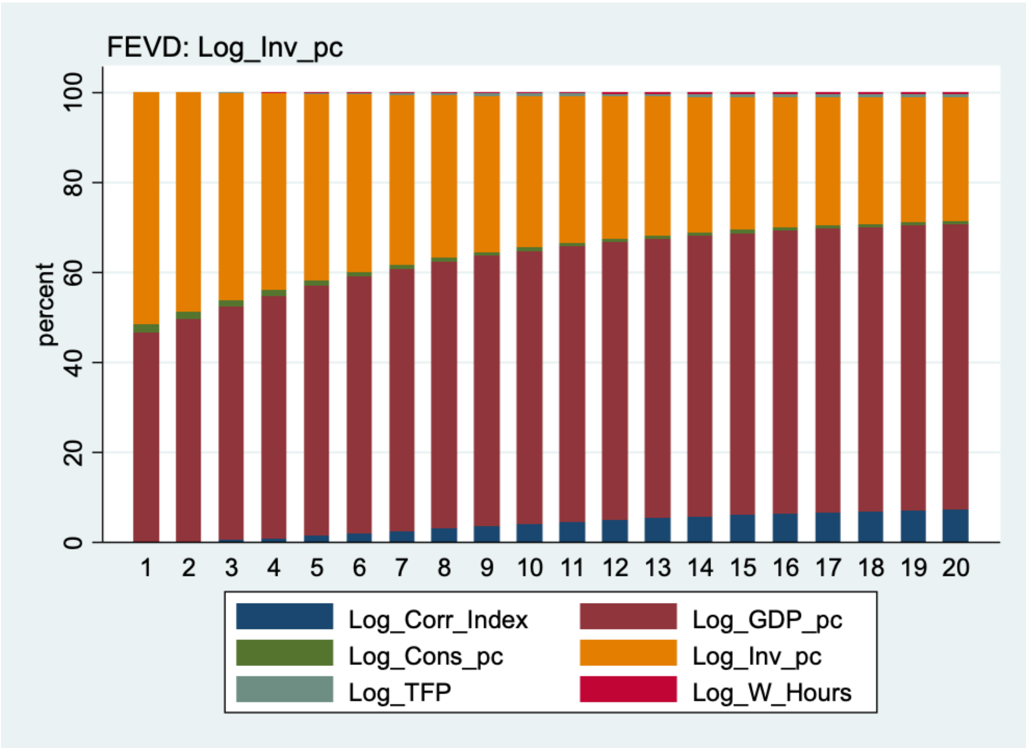


Figure 16: Forecast error variance decomposition of TFP.

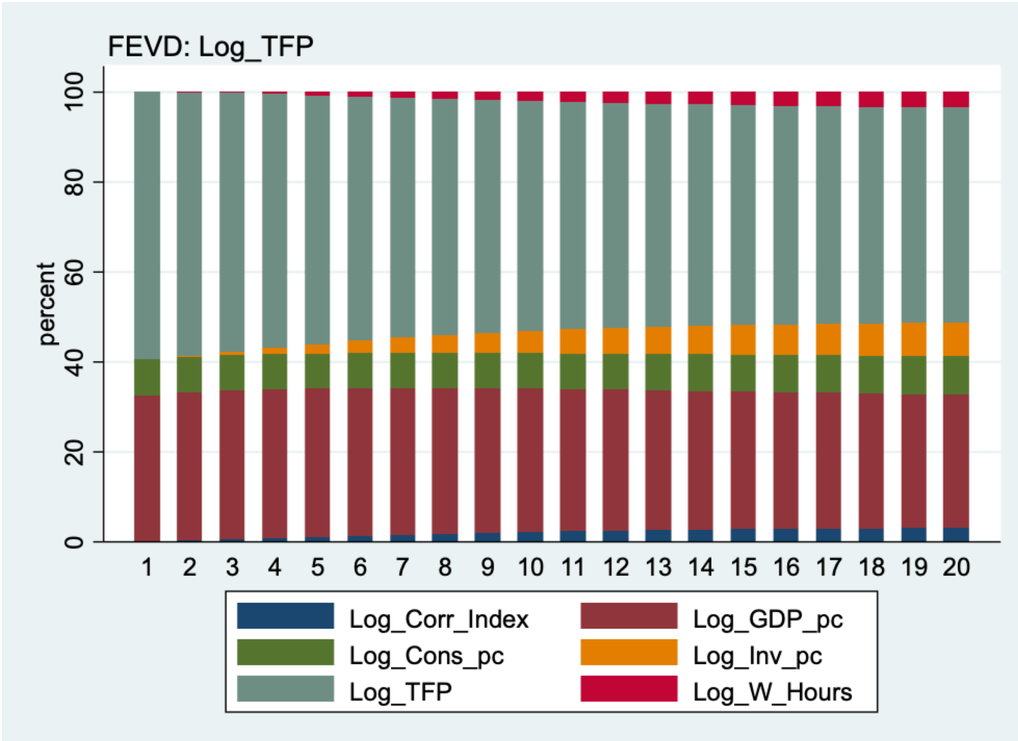
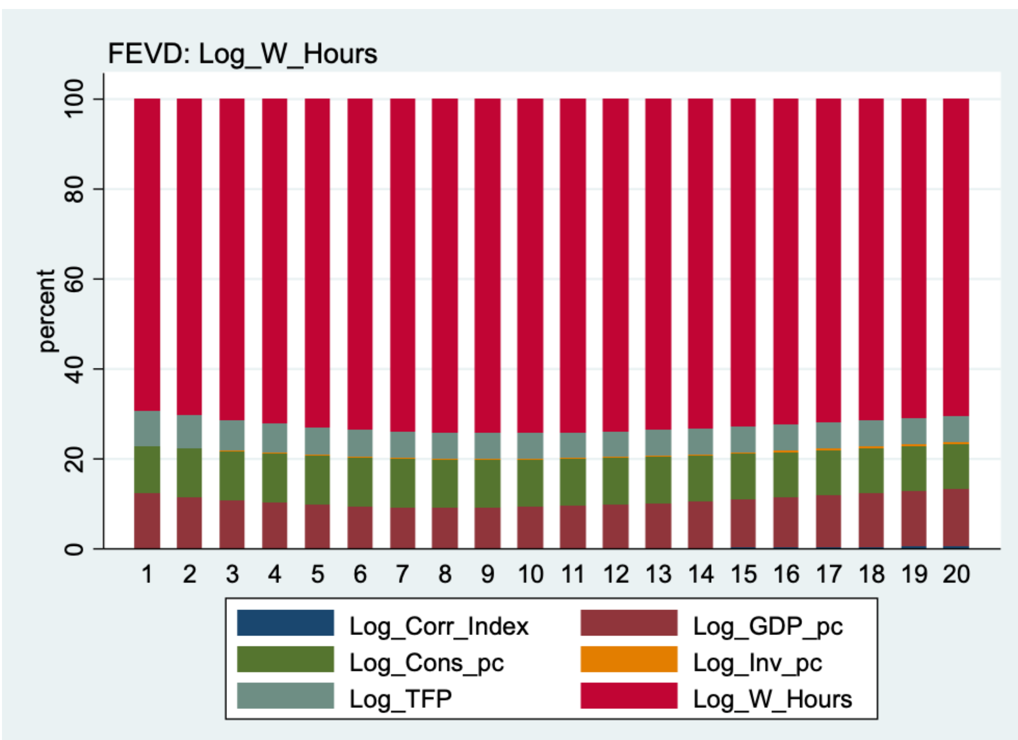


Figure 17: Forecast error variance decomposition of hours worked per worker.



11 Appendix

11.1

In this appendix, we will prove that with the separable utility function we've chosen, the household problem for the i agents can be solved as a representative agent's utility-maximization problem:

$$U\left(C_t^i, h_t^i\right) = E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln C_t^i + \eta \ln h_t^i\right]$$

The FOCs are:

$$\begin{aligned}
\{C_t^i\} \quad & \lambda_t^i = \frac{1}{C_t^i} \\
\{(L_t^i)^w\} \quad & \frac{\eta}{1-(L_t^i)^w-(L_t^i)^c} = \lambda_t^i(1-\tau^l)w_t \\
\{(L_t^i)^c\} \quad & \frac{\eta}{1-(L_t^i)^w-(L_t^i)^c} = \lambda_t^i \Upsilon_t^i \left(1-\varphi^i\right)\left((L_t^i)^c\right)^{-\varphi^i} \\
\{K_{t+1}^i\} \quad & \lambda_t^i = E_t\left(\beta\lambda_{t+1}^i(1-\delta+(1-\tau^k)r_{t+1})\right) \\
\{\lambda_t\} \quad & C_t^i + X_t^i = (1-\tau^k)r_t K_t^i + (1-\tau^l)(L_t^i)^w w_t + \Upsilon_t\left(L_t^c\right)^{1-\varphi} \\
\{TC_K^i\} \quad & \lim_{t\to\infty} \beta^t \lambda_t^i K_{t+1}^i = 0
\end{aligned}$$

Taking the FOC for consumption $\{C_t^i\}$ for $j \neq i$ and dividing them we get:

$$\frac{C_t^i}{C_t^j} = \frac{\lambda^i}{\lambda^j}$$

$$C_t^i = \left(\frac{\lambda^i}{\lambda^j}\right) C_t^j$$

Adding for all i:

$$\underbrace{\sum_{i=1}^{I} C_t^i}_{=C_t} = (\lambda^j) C_t^j \sum_{i=1}^{I} \left(\frac{1}{\lambda^i}\right)$$

$$C_t = (\lambda^j) C_t^j \sum_{i=1}^{I} \left(\frac{1}{\lambda^i}\right)$$

Clearing C_t^j:

$$C_t^j = \left(\frac{1}{\lambda^j}\right) C_t \frac{1}{\sum_{i=1}^{I} \left(\frac{1}{\lambda^i}\right)}$$

Now adding for all j:

$$\underbrace{\sum_{j=1}^{J} C_t^j}_{=C_t} = C_t \frac{1}{\sum_{i=1}^{I} \left(\frac{1}{\lambda^i}\right)} \sum_{i=1}^{J} \left(\frac{1}{\lambda^j}\right)$$

Since the sum for all j and i of the lambdas are equal, we can simplify them and we are left with:

$$C_t = C_t \quad \square$$

We see that it is the same aggregate as in an economy with a single agent. $\square$

11.2

In this appendix, we are going to derive the ergodic steady state equations.

The ergodic steady-state equilibrium in a regime-switching DSGE model is computed by solving for the values of endogenous variables that are constant across time but conditional on the persistence of the underlying Markov state. As shown in Farmer, Waggoner and Zha (2011) and applied in Bianchi (2013), the model's endogenous variables are defined for each regime: typically high and low productivity or corruption states, and the solution must satisfy the system of expectational equations conditional on each regime. The stationary equilibrium is obtained by setting all stochastic shocks to their unconditional means and solving for the variables such that they remain constant within each regime. This yields a system of nonlinear equations in which agents' expectations incorporate the transition probabilities across regimes. The final ergodic distribution is derived from the invariant distribution of the Markov process and the policy functions evaluated at the steady state of each regime.

We have defined before the Markov transition matrix for the corruption regime to be given by:

$$\mathcal{P} = \begin{bmatrix} \phi_1 & 1-\phi_1 \\ 1-\phi_2 & \phi_2 \end{bmatrix}$$

where ϕ_1 is the probability of staying in the low-corruption regime and ϕ_2 the probability of staying in the high-corruption regime. The ergodic distribution $\pi = (\pi_L, \pi_H)$ solves $\pi \cdot \mathcal{P} = \pi$ with $\pi_L + \pi_H = 1$. Solving this system yields:

$$\pi_L = \frac{1-\phi_2}{2-\phi_1-\phi_2}, \quad \pi_H = \frac{1-\phi_1}{2-\phi_1-\phi_2}$$

Thus, the ergodic expectation of log corruption productivity is given by:

$$\ln \overline{\Upsilon} = E[\ln \Upsilon] = \pi_L \ln \Upsilon^L + \pi_H \ln \Upsilon^H = \frac{1-\phi_2}{2-\phi_1-\phi_2} \ln \Upsilon^L + \frac{1-\phi_1}{2-\phi_1-\phi_2} \ln \Upsilon^H$$

$$\Rightarrow \overline{\Upsilon} = \exp\left(\ln \overline{\Upsilon}\right)$$

We use upper bars to denote nonstochastic steady-state values. Setting $\varepsilon_{t+1} = 0$ and

$\Upsilon_{t+1} = \Upsilon_t = \Upsilon$ into $\ln \Upsilon_{t+1} = \rho \ln \Upsilon_t + (1-\rho)\mu(s_t) + \varepsilon_{t+1}$, we get as we had before:

$$\Rightarrow \overline{\Upsilon} = \exp\left(\ln \overline{\Upsilon}\right)$$

This expression is used in the steady-state derivation to replace the constant corruption productivity Υ with its ergodic mean $\overline{\Upsilon}$, consistent with a Markov-switching model solved under rational expectations. Following Schorfheide (2005), we compute the ergodic steady-state value of $\ln \Upsilon$ by taking the expectation across regimes using the stationary distribution of the Markov process. Then, it is defined as:

$$\overline{\Upsilon} = \exp\left(\frac{1-\phi_2}{2-\phi_1-\phi_2} \ln \Upsilon^L + \frac{1-\phi_1}{2-\phi_1-\phi_2} \ln \Upsilon^H\right)$$

This average value captures the long-run expected productivity of the corruption technology across regimes and replaces the fixed parameter Υ in all subsequent steady state derivations.

Now, we want to observe how the ergodic mean of the steady state corruption productivity depends on ϕ_1 or the probability of being in a low corruption state the next period given that this period corruption is low and how this mean also depends on ϕ_2 that is the probability of remaining the next period with high corruption given that this period corruption is also high.

We now derive how $\overline{\Upsilon}$ changes with the transition probabilities ϕ_1 and ϕ_2 of the two-state Markov chain. Denote:

$$f(\phi_1, \phi_2) = \frac{1-\phi_2}{2-\phi_1-\phi_2} \ln \Upsilon^L + \frac{1-\phi_1}{2-\phi_1-\phi_2} \ln \Upsilon^H \Rightarrow \overline{\Upsilon} = \exp(f(\phi_1, \phi_2))$$

$$\frac{\partial \overline{\Upsilon}}{\partial \phi_l} = \exp(f(\phi_1, \phi_2)) \cdot \frac{\partial f(\phi_1, \phi_2)}{\partial \phi_l} \quad \forall l \in [1, 2]$$

As the exponential term is always strictly positive, the sign of the derivative $\frac{\partial \overline{\Upsilon}}{\partial \phi_l}$ depends solely on the sign of $\frac{\partial f(\phi_1,\phi_2)}{\partial \phi_l}$.

Let:

$$f(\phi_1, \phi_2) = \frac{1-\phi_2}{2-\phi_1-\phi_2} \ln \Upsilon^L + \frac{1-\phi_1}{2-\phi_1-\phi_2} \ln \Upsilon^H$$

We compute:

$$\frac{\partial f}{\partial \phi_1} = \frac{\partial}{\partial \phi_1} \left[\frac{1-\phi_2}{2-\phi_1-\phi_2} \ln \Upsilon^L + \frac{1-\phi_1}{2-\phi_1-\phi_2} \ln \Upsilon^H \right]$$

Let us differentiate each term:

$$\frac{\partial}{\partial \phi_1} \left(\frac{1-\phi_2}{2-\phi_1-\phi_2} \right) = \frac{(1-\phi_2)(1)}{(2-\phi_1-\phi_2)^2} = \frac{1-\phi_2}{(2-\phi_1-\phi_2)^2}$$

$$\frac{\partial}{\partial \phi_1} \left(\frac{1-\phi_1}{2-\phi_1-\phi_2} \right) = \frac{-(2-\phi_1-\phi_2)+(1-\phi_1)}{(2-\phi_1-\phi_2)^2} = -\frac{(1-\phi_2)}{(2-\phi_1-\phi_2)^2}$$

Therefore:

$$\frac{\partial f}{\partial \phi_1} = \frac{1-\phi_2}{(2-\phi_1-\phi_2)^2} \ln \Upsilon^L - \frac{1-\phi_2}{(2-\phi_1-\phi_2)^2} \ln \Upsilon^H$$

$$\frac{\partial f}{\partial \phi_1} = \underbrace{\frac{1-\phi_2}{(2-\phi_1-\phi_2)^2}}_{\geq 0} \cdot \underbrace{\left[\ln \Upsilon^L - \ln \Upsilon^H\right]}_{\leq 0}$$

$$\frac{\partial f}{\partial \phi_1} \leq 0$$

Similarly, for ϕ_2:

$$\frac{\partial f}{\partial \phi_2} = \frac{\partial}{\partial \phi_2} \left[\frac{1-\phi_2}{2-\phi_1-\phi_2} \ln \Upsilon^L + \frac{1-\phi_1}{2-\phi_1-\phi_2} \ln \Upsilon^H \right]$$

$$\frac{\partial}{\partial \phi_2}\left(\frac{1-\phi_2}{2-\phi_1-\phi_2}\right) = \frac{-(2-\phi_1-\phi_2)+(1-\phi_2)}{(2-\phi_1-\phi_2)^2} = -\frac{1-\phi_1}{(2-\phi_1-\phi_2)^2}$$

$$\frac{\partial}{\partial \phi_2}\left(\frac{1-\phi_1}{2-\phi_1-\phi_2}\right) = \frac{1-\phi_1}{(2-\phi_1-\phi_2)^2}$$

Hence:

$$\frac{\partial f}{\partial \phi_2} = -\frac{1-\phi_1}{(2-\phi_1-\phi_2)^2}\ln \Upsilon^L + \frac{1-\phi_1}{(2-\phi_1-\phi_2)^2}\ln \Upsilon^H$$

$$\frac{\partial f}{\partial \phi_2} = \underbrace{\frac{1-\phi_2}{(2-\phi_1-\phi_2)^2}}_{\geq 0} \cdot \underbrace{\left[-\ln \Upsilon^L + \ln \Upsilon^H\right]}_{\geq 0}$$

$$\frac{\partial f}{\partial \phi_2} \geq 0$$

Setting $C_t = C_{t+1} = \overline{C}$ and $r_{t+1} = \overline{r}$ into the Euler equation $E_t\left\{\beta\left(\frac{C_t}{C_{t+1}}\right)\left((1-\tau^k)r_{t+1}+1-\delta\right)\right\} = 1$ we get

$$\overline{r} = \left(\frac{1}{\beta}-1+\delta\right)\frac{1}{1-\tau^k}$$
$$\overline{r} = (\rho+\delta)\frac{1}{1-\tau^k}$$

We know from the firm's problem that $\alpha A\left(\frac{K_t}{L_t^w}\right)^{\alpha-1} = r_t$. So, given that we have set $r_t = \overline{r}$, we get:

$$\left(\frac{\overline{K}}{\overline{\overline{L^w}}}\right) = \left(\frac{\alpha A}{\overline{r}}\right)^{\frac{1}{1-\alpha}}$$

We also know that $(1-\alpha)A\left(\frac{K_t}{L_t^w}\right)^{\alpha} = w_t$. Using the expression found above for $\left(\frac{\overline{K}}{\overline{L^w}}\right)$:

$$(1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}} = \overline{w}$$

Moreover, from the Corruption production function (recalling that we have set $\Upsilon_t = \Upsilon$), due to the market clearing condition in the labor market (conditions (3) and (4)), we know that:

$$(1-\varphi)\Upsilon(\overline{L^c})^{-\varphi} = (1-\tau^l)\overline{w}$$

$$(1-\varphi)\Upsilon(\overline{L^c})^{-\varphi} = (1-\tau^l)\left((1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}}\right)$$

Working a little with the previous expression we get:

$$(\overline{L^c})^{-\varphi} = \frac{(1-\tau^l)}{(1-\varphi)\Upsilon}\left((1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}}\right)$$

$$\overline{L^c} = \left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)$$

From the production function of the corruption activity, we have that $\Psi_t = \Upsilon_t\left(L_t^c\right)^{1-\varphi}$. So, replacing the steady state variable for labor in the corruption function found before, we have the corruption production:

$$\overline{\Psi} = \Upsilon\left(\overline{L^c}\right)^{1-\varphi}$$

$$\overline{\Psi} = \Upsilon\left(\left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)^{1-\varphi}$$

Now, setting $K_{t+1} = K_t = \overline{K}$ into the capital accumulation condition ($X_t = K_{t+1} - (1-\delta)K_t$), we get:

$$\overline{X} = \delta\overline{K}$$

From $\left(\frac{\overline{K}}{\overline{L^w}}\right) = \left(\frac{\alpha A}{\overline{r}}\right)^{\frac{1}{1-\alpha}}$, we get:

$$\overline{L^w} = \left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\overline{K}$$

From the production function of the main activity, we have that $\overline{Y} = A\overline{K}^{\alpha}\left(\overline{L^w}\right)^{1-\alpha}$, so replacing the expression for $\overline{L^w}$ above we get:

$$\overline{Y} = \frac{1}{\alpha}\overline{r}\overline{K}$$

From the Aggregated Consistency in the market of the consumption good $Y_t = C_t + X_t$, we have that:

$$\overline{C} = \overline{Y} - \overline{X}$$

$$\overline{C} = \frac{1}{\alpha}\overline{r}\overline{K} - \delta\overline{K}$$

$$\overline{C} = \left(\frac{\overline{r}}{\alpha} - \delta\right)\overline{K}$$

So, taking the first order condition from the labor choice of the main activity: $\frac{\eta}{1-L_t^w-L_t^c} = \frac{1}{C_t}(1-\tau^l)w_t$. Re-arranging and taking the steady state, $\eta\overline{C} = \left(1 - \overline{L^w} - \overline{L^c}\right)(1-\tau^l)w_t$. Now, replacing the expressions found before for $\overline{L^c}$, $\overline{L^w}$, $\overline{C}$ and $\overline{w^c}$, we can clear the expression for the state variable $\overline{K}$ and solve our model:

$$\eta\left(\frac{\overline{r}}{\alpha} - \delta\right)\overline{K} = \left(1 - \left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\overline{K} - \left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)(1-\tau^l)\overline{w}$$

$$\eta\left(\frac{\overline{r}}{\alpha} - \delta\right)\overline{K} + (1-\tau^l)\overline{w}\left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\overline{K} = \left(1 - \left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)(1-\tau^l)\overline{w}$$

$$\left(\eta\left(\frac{\overline{r}}{\alpha} - \delta\right) + (1-\tau^l)\overline{w}\left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\right)\overline{K} = \left(1 - \left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)(1-\tau^l)\overline{w}$$

$$\overline{K} = \frac{\left(1 - \left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}}\left(A^{-\frac{1}{(1-\alpha)\varphi}}\left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)(1-\tau^l)\overline{w}}{\left(\eta\left(\frac{\overline{r}}{\alpha} - \delta\right) + (1-\tau^l)\overline{w}\left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\right)}$$

If we replace for the value of the salary of the main activity in the capital equation, we get:

$$\overline{K} = \frac{\left(1 - \left(\frac{(1-\varphi)\Upsilon}{(1-\tau^l)(1-\alpha)}\right)^{\frac{1}{\varphi}} \left(A^{-\frac{1}{(1-\alpha)\varphi}} \left(\frac{\alpha A}{\overline{r}}\right)^{-\frac{\alpha}{(1-\alpha)\varphi}}\right)\right)(1-\tau^l)\left((1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}}\right)}{\left(\eta\left(\frac{\overline{r}}{\alpha}-\delta\right)+(1-\tau^l)\left((1-\alpha)A^{\frac{1}{1-\alpha}}\left(\frac{\alpha A}{\overline{r}}\right)^{\frac{\alpha}{1-\alpha}}\right)\left(\frac{\overline{r}}{\alpha A}\right)^{\frac{1}{1-\alpha}}\right)} \qquad \square$$

11.3

In this appendix, we are going to derive the log-linearized equations of the model.

We will approximate functions $(\widetilde{X}_t, \widetilde{Y}_t)$ around (0,0). This will give us linear functions of $\widetilde{X}_t$ and $\widetilde{Y}_t$. We have to remember the following properties we are not going to prove. 1) $e^{\widetilde{X}_t + a\widetilde{Y}_t} \approx 1 + \widetilde{X}_t + a\widetilde{Y}_t$. Corollary: $e^{\widetilde{X}_t} \approx 1 + \widetilde{X}_t$, 2) $\widetilde{X}_t\widetilde{Y}_t \approx 0$ and 3) $E_t\left\{ae^{\widetilde{X}_{t+1}}\right\} \cong a + aE_t\left\{\widetilde{X}_{t+1}\right\}$

Now we log-linearize the 10 equations that characterize the equilibrium of our model.

For the corruption process, we get Start from

$$\ln \Upsilon_{t+1} = \rho \ln \Upsilon_t + (1-\rho)\,\mu(s_t) + \varepsilon_{t+1}, \qquad 0 < \rho < 1.$$

Let the Markov chain for s_t be ergodic with invariant probabilities $\{\pi_i\}$ and regime means $\{\mu_i\}$. In steady state (shocks off), the fixed point satisfies

$$\ln \overline{\Upsilon} = \rho \ln \overline{\Upsilon} + (1-\rho)\bar{\mu} \;\Rightarrow\; \ln \overline{\Upsilon} = \bar{\mu}.$$

Define deviations

$$\widetilde{\Upsilon}_t \equiv \ln \Upsilon_t - \ln \overline{\Upsilon}, \qquad \widetilde{\mu}_t \equiv \mu(s_t) - \bar{\mu}.$$

Subtract $\ln \overline{\Upsilon}$ from both sides:

$$\widetilde{\Upsilon}_{t+1} = \rho\,\widetilde{\Upsilon}_t + (1-\rho)\,\widetilde{\mu}_t + \varepsilon_{t+1}.$$

Setting $\widetilde{\mu}_t = 0$ yields the pure AR(1):

$$\widetilde{\Upsilon}_{t+1} = \rho\, \widetilde{\Upsilon}_t + \varepsilon_{t+1}$$

which is stationary around zero for $0 < \rho < 1$.

For output we get:

$$\begin{aligned}
\widetilde{Y}_t &\equiv \ln Y_t - \ln \overline{Y} \\
&= \big[\ln A + \alpha \ln K_t + (1-\alpha)\ln L_t^w\big] - \big[\ln A + \alpha \ln \overline{K} + (1-\alpha)\ln \overline{L^w}\big] \\
&= \alpha\big(\ln K_t - \ln \overline{K}\big) + (1-\alpha)\big(\ln L_t^w - \ln \overline{L^w}\big) \\
&= \alpha\, \widetilde{K}_t + (1-\alpha)\, \widetilde{L}_t^w.
\end{aligned}$$

Then

$$\widetilde{Y}_t = \alpha\, \widetilde{K}_t + (1-\alpha)\, \widetilde{L}_t^w$$

From the government budget constraint equation we had:

$$\varUpsilon_t\,(L_t^c)^{1-\varphi} = \tau^l w_t L_t^w + \tau^k r_t K_t \tag{14}$$

On the left side of the equality:

$$\Psi_t \;=\; \Upsilon_t \left(L_t^c\right)^{1-\varphi}, \qquad 0 < \varphi < 1.$$

$$\ln \Psi_t \;=\; \ln \Upsilon_t \;+\; (1-\varphi)\, \ln L_t^c.$$

$$\ln \bar{\Psi} \;=\; \ln \bar{\Upsilon} \;+\; (1-\varphi)\, \ln \bar{L}^c.$$

$$\underbrace{(\ln \Psi_t - \ln \bar{\Psi})}_{\widetilde{\Psi}_t} \;=\; \underbrace{(\ln \Upsilon_t - \ln \bar{\Upsilon})}_{\widetilde{\Upsilon}_t} \;+ (1-\varphi)\; \underbrace{(\ln L^c_t - \ln \bar{L}^c)}_{\widetilde{L}^c_t}.$$

$$\widetilde{\Psi}_t \;=\; \widetilde{\Upsilon}_t \;+\; (1-\varphi)\,\widetilde{L^c_t} \tag{15}$$

We will now work on the right side of the equation shown previously. We will log-linearize the government labor and capital revenue and we will call it:

$$R_t = \underbrace{\tau^l w_t L^w_t}_{T^L_t} + \underbrace{\tau^k r_t K_t}_{T^K_t}$$

$$R_t = T^L_t + T^K_t$$

$$\bar{R}\,e^{\widetilde{R}_t} \;=\; \bar{T}^L\,e^{\widetilde{T^L_t}} \;+\; \bar{T}^K\,e^{\widetilde{T^K_t}}.$$

We have the first order approximation around the steady state:

$$\bar{R}\,(1+\widetilde{R}_t) \;\approx\; \bar{T}^L\,(1+\widetilde{T^L_t}) \;+\; \bar{T}^K\,(1+\widetilde{T^K_t}) \;=\; (\bar{T}^L+\bar{T}^K) \;+\; \bar{T}^L\,\widetilde{T^L_t} \;+\; \bar{T}^K\,\widetilde{T^K_t}.$$

We know that $\bar{R} = \bar{T}^L + \bar{T}^K$, then, we replace it in the previous expression:

$$(\bar{T}^L+\bar{T}^K)\,(1+\widetilde{R}_t) = (\bar{T}^L+\bar{T}^K) \;+\; \bar{T}^L\,\widetilde{T^L_t} \;+\; \bar{T}^K\,\widetilde{T^K_t}.$$

$$(\bar{T}^L+\bar{T}^K)\,(\widetilde{R}_t) = \bar{T}^L\,\widetilde{T^L_t} \;+\; \bar{T}^K\,\widetilde{T^K_t}.$$

$$\widetilde{R}_t = \frac{\bar{T}^L}{\bar{T}^L+\bar{T}^K}\,\widetilde{T^L_t} \;+\; \frac{\bar{T}^K}{\bar{T}^L+\bar{T}^K}\,\widetilde{T^K_t}.$$

As we know that the labor and capital taxes are constant shares, they do not vary over time, $\widetilde{\tau^l_t} = \widetilde{\tau^k_t} = 0$, so, we have that:

$$\widetilde{T^L} = \widetilde{w}_t + \widetilde{L}_t \quad \text{and} \quad \widetilde{T^K} = \widetilde{r}_t + \widetilde{K}_t$$

Then, the log-linearized equation around the steady state government's revenue is:

$$\widetilde{R}_t = \frac{\tau^l \bar{w} \bar{L}^w}{\tau^l \bar{w} \bar{L}^w + \tau^k \bar{r} \bar{K}} \left(\widetilde{w}_t + \widetilde{L_t^w} \right) + \frac{\tau^k \bar{r} \bar{K}}{\tau^l \bar{w} \bar{L}^w + \tau^k \bar{r} \bar{K}} \left(\widetilde{r}_t + \widetilde{K}_t \right) \tag{16}$$

Finally, combining equations (15) and (16) we have the log-linearized version around the steady state of the government's budget constraint:

$$\widetilde{\Upsilon}_t + (1-\varphi) \widetilde{L_t^c} = \frac{\tau^l \bar{w} \bar{L}^w}{\tau^l \bar{w} \bar{L}^w + \tau^k \bar{r} \bar{K}} \left(\widetilde{w}_t + \widetilde{L_t^w} \right) + \frac{\tau^k \bar{r} \bar{K}}{\tau^l \bar{w} \bar{L}^w + \tau^k \bar{r} \bar{K}} \left(\widetilde{r}_t + \widetilde{K}_t \right) \tag{17}$$

From $w_t = (1-\alpha) \frac{Y_t}{L_t^w}$ we get

$$\begin{aligned} \widetilde{w}_t &\equiv \ln w_t - \ln \overline{w} \\ &= \ln \left((1-\alpha) \frac{Y_t}{L_t^w} \right) - \ln \left((1-\alpha) \frac{\overline{Y}}{\overline{L^w}} \right) \\ &= \ln(1-\alpha) + \ln Y_t - \ln L_t^w - \ln(1-\alpha) - \ln \overline{Y} + \ln \overline{L^w} \\ &= \left(\ln Y_t - \ln \overline{Y} \right) - \left(\ln L_t^w - \ln \overline{L^w} \right) \end{aligned}$$

Then

$$\widetilde{w}_t = \widetilde{Y}_t - \widetilde{L_t^w}$$

Analogously, from $\frac{\eta}{1-L_t^w-L_t^c} = \frac{1}{C_t}(1-\varphi)\frac{\Psi_t}{L_t^c}$, we get:

$$\widetilde{w}_t = \widetilde{\Psi}_t - \widetilde{L_t^c}$$

Notice that all the previous expressions are exact relations, no approximations were needed to derive them. For the following log-linearizations we use the approximations derived previously. For simplicity, we use the $=$ sign instead of $\approx$.

From $Y_t = C_t + X_t$ we get

$$\begin{aligned}
\overline{Y}e^{\widetilde{Y}_t} &= \overline{C}e^{\widetilde{C}_t} + \overline{X}_e^{\widetilde{X}_t} \\
\overline{Y}\left(1 + \widetilde{Y}_t\right) &= \overline{C}\left(1 + \widetilde{C}_t\right) + \overline{X}\left(1 + \widetilde{X}_t\right) \\
\overline{Y} + \overline{Y}\widetilde{Y}_t &= \overline{C} + \overline{C}\widetilde{C}_t + \overline{X} + \overline{X}\widetilde{X}_t \\
\overline{Y} + \overline{Y}\widetilde{Y}_t &= (\overline{C} + \overline{X}) + \overline{C}\widetilde{C}_t + \overline{X}\widetilde{X}_t \\
\overline{Y} + \overline{Y}\widetilde{Y}_t &= \overline{Y} + \overline{C}\widetilde{C}_t + \overline{X}\widetilde{X}_t
\end{aligned}$$

Then

$$\overline{Y}\widetilde{Y}_t = \overline{C}\widetilde{C}_t + \overline{X}\widetilde{X}_t$$

From $X_t = K_{t+1} - (1-\delta)K_t$ we get

$$\begin{aligned}
\overline{X}e^{\widetilde{X}_t} &= \overline{K}e^{\widetilde{K}_{t+1}} - (1-\delta)\overline{K}e^{\widetilde{K}_t} \\
\overline{X}\left(1 + \widetilde{X}_t\right) &= \overline{K}\left(1 + \widetilde{K}_{t+1}\right) - (1-\delta)\overline{K}\left(1 + \widetilde{K}_t\right) \\
\overline{X} + \overline{X}\widetilde{X}_t &= \overline{K} + \overline{K}\widetilde{K}_{t+1} - (1-\delta)\overline{K} - (1-\delta)\overline{K}\widetilde{K}_t \\
\overline{X} + \overline{X}\widetilde{X}_t &= \delta\overline{K} + \overline{K}\left[\widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t\right] \\
\overline{X} + \overline{X}\widetilde{X}_t &= \overline{X} + \overline{K}\left[\widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t\right] \\
\overline{X}\widetilde{X}_t &= \overline{K}\left[\widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t\right] \\
\delta\overline{K}\widetilde{X}_t &= \overline{K}\left[\widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t\right]
\end{aligned}$$

Then

$$\delta\widetilde{X}_t = \widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t$$

From $\frac{\eta}{1-L_t^w-L_t^c} = \frac{1}{C_t}(1-\tau^l)w_t$, we have:

$$\eta C_t = (1 - L_t^w - L_t^c)(1-\tau^l)w_t$$

$$\eta\overline{C}e^{\widetilde{C}_t} = (1 - \overline{L^w}e^{\widetilde{L^w_t}} - \overline{L^c}e^{\widetilde{L^c_t}})(1-\tau^l)\overline{w}e^{\widetilde{w_t}}$$

$$\eta\overline{C}e^{\widetilde{C}_t} = (1 - \overline{L^w}e^{\widetilde{L^w_t}} - \overline{L^c}e^{\widetilde{L^c_t}})(1-\tau^l)\overline{w}e^{\widetilde{w_t}}$$

$$\eta\overline{C}\left(1+\widetilde{C}_t\right) = \left[1 - \overline{L^w}\left(1+\widetilde{L^w_t}\right) - \overline{L^c}\left(1+\widetilde{L^c_t}\right)\right]\overline{w}\left(1+\widetilde{w}_t\right)\left(1-\tau^l\right)$$

$$\eta\overline{C} + \eta\overline{C}\widetilde{C}_t = \left[(1-\overline{L^w}-\overline{L^c}) - \overline{L^w}\widetilde{L^w_t} - \overline{L^c}\widetilde{L^c_t}\right](\overline{w}+\overline{w}\widetilde{w}_t)\underbrace{(1-\tau^l)}_{\Theta}$$

$$\eta\overline{C}+\eta\overline{C}\widetilde{C}_t = \overline{w}(1-\overline{L^w}-\overline{L^c})\Theta+\overline{w}\widetilde{w}_t(1-\overline{L^w}-\overline{L^c})\Theta-\overline{w}\overline{L^w}\widetilde{L^w_t}\Theta-\overline{w}\widetilde{w}_t\overline{L^w}\widetilde{L^w_t}\Theta-\overline{w}\overline{L^c}\widetilde{L^c_t}\Theta-\overline{w}\widetilde{w}_t\overline{L^c}\widetilde{L^c_t}\Theta$$

Now, recalling that, from the agent's FOC, $\eta\overline{C} = \overline{w}(1-\overline{L^w}-\overline{L^c})\Theta$:

$$\overline{w}(1-\overline{L^w}-\overline{L^c})\Theta+(1-\overline{L^w}-\overline{L^c})\overline{w}\Theta\widetilde{C}_t = \overline{w}(1-\overline{L^w}-\overline{L^c})\Theta+\overline{w}\widetilde{w_t}(1-\overline{L^w}-\overline{L^c})\Theta-\overline{w}\overline{L^w}\widetilde{L^w_t}\Theta-\underbrace{\overline{w}\overline{L^w}\widetilde{w_t}\widetilde{L^w_t}}_{\approx 0}\Theta-\overline{w}\overline{L^c}\widetilde{L^c_t}\Theta-\underbrace{\overline{w}\overline{L^c}\widetilde{w_t}\widetilde{L^c_t}}_{\approx 0}\Theta$$

$$(1-\overline{L^w}-\overline{L^c})\overline{w}\Theta\widetilde{C}_t = \overline{w}\widetilde{w_t}(1-\overline{L^w}-\overline{L^c})\Theta - \overline{w}\overline{L^w}\widetilde{L^w_t}\Theta - \overline{w}\overline{L^c}\widetilde{L^c_t}\Theta$$

$$\widetilde{C}_t = \widetilde{w_t} - \frac{\overline{L^w}\widetilde{L^w_t}}{1-\overline{L^w}-\overline{L^c}} - \frac{\overline{L^c}\widetilde{L^c_t}}{1-\overline{L^w}-\overline{L^c}}$$

We have an expression for consumption.

We will also have the expression for consumption depending on the corruption function's TFP. We start from the agent's first-order condition:

$$(1-\tau^l)w_t = \Upsilon_t(1-\varphi)\left(L^c_t\right)^{-\varphi}$$

We take logs on both sides:

$$\ln\left((1-\tau^l)w_t\right) = \ln\left(\Upsilon_t(1-\varphi)\left(L^c_t\right)^{-\varphi}\right)$$

$$\ln(1-\tau^l) + \ln w_t = \ln(1-\varphi) + \ln\Upsilon_t - \varphi\ln L^c_t$$

$$\ln w_t = \ln(1-\varphi) - \ln(1-\tau^l) + \ln \Upsilon_t - \varphi \ln L_t^c$$

Now, we subtract steady state values and define log deviations.[2]:

$$\ln w_t - \ln \overline{w} = (\ln \Upsilon_t - \ln \overline{\Upsilon}) - \varphi(\ln L_t^c - \ln \overline{L^c})$$

$$\widetilde{w}_t = \widetilde{\Upsilon}_t - \varphi \widetilde{L_t^c}$$

Recall the previous log-linearized expression for consumption:

$$\widetilde{C}_t = \widetilde{w}_t - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}} \widetilde{L_t^w} - \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}} \widetilde{L_t^c}$$

Now, we replace $\widetilde{w}_t$:

$$\widetilde{C}_t = \left(\widetilde{\Upsilon}_t - \varphi \widetilde{L_t^c}\right) - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}} \widetilde{L_t^w} - \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}} \widetilde{L_t^c}$$

$$\widetilde{C}_t = \widetilde{\Upsilon}_t - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}} \widetilde{L_t^w} - \left(\varphi + \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}}\right) \widetilde{L_t^c}$$

[2]The constants $\ln(1-\varphi)$ and $\ln(1-\tau^l)$ cancel out because they do not vary over time. They are already embedded in the steady-state wage $\overline{w}$.

From the Euler equation, $1 = E_t \left\{ \beta \frac{C_t}{C_{t+1}} \left(r_{t+1} + 1 - \delta \right) \right\}$ we get

$$1 = E_t \left\{ \beta \frac{\overline{C} e^{\tilde{C}_t}}{\overline{C} e^{\tilde{C}_{t+1}}} \left((1-\tau^k)\overline{r} e^{\tilde{r}_{t+1}} + 1 - \delta \right) \right\}$$

$$1 = E_t \left\{ \beta e^{\tilde{C}_t - \tilde{C}_{t+1}} \left[(1-\tau^k)\overline{r} \left(1 + \widetilde{r}_{t+1} \right) + 1 - \delta \right] \right\}$$

$$1 = E_t \left\{ \beta \left(1 + \widetilde{C}_t - \widetilde{C}_{t+1} \right) \left[(1-\tau^k)\overline{r} + (1-\tau^k)\overline{r}\widetilde{r}_{t+1} + 1 - \delta \right] \right\}$$

$$1 = E_t \left\{ \beta \left(1 + \widetilde{C}_t - \widetilde{C}_{t+1} \right) \left[((1-\tau^k)\overline{r} + 1 - \delta) + (1-\tau^k)\overline{r}\widetilde{r}_{t+1} \right] \right\}$$

$$1 = E_t \left\{ \left(\beta + \beta\widetilde{C}_t - \beta\widetilde{C}_{t+1} \right) \left(\frac{1}{\beta} + (1-\tau^k)\overline{r}\widetilde{r}_{t+1} \right) \right\}$$

$$1 = E_t \left\{ \beta \left(\frac{1}{\beta} + (1-\tau^k)\overline{r}\widetilde{r}_{t+1} \right) + \beta\widetilde{C}_t \left(\frac{1}{\beta} + (1-\tau^k)\overline{r}\widetilde{r}_{t+1} \right) - \beta\widetilde{C}_{t+1} \left(\frac{1}{\beta} + (1-\tau^k)\overline{r}\widetilde{r}_{t+1} \right) \right\}$$

$$1 = E_t \left\{ 1 + \beta(1-\tau^k)\overline{r}\widetilde{r}_{t+1} + \widetilde{C}_t + \beta(1-\tau^k)\overline{r}\widetilde{C}_t\widetilde{r}_{t+1} - \widetilde{C}_{t+1} - \beta(1-\tau^k)\overline{r}\widetilde{C}_{t+1}\widetilde{r}_{t+1} \right\}$$

$$0 = E_t \left\{ \beta(1-\tau^k)\overline{r}\widetilde{r}_{t+1} + \widetilde{C}_t - \widetilde{C}_{t+1} \right\}$$

Then:

$$0 = E_t \left\{ \widetilde{C}_{t+1} - \beta(1-\tau^k)\overline{r}\widetilde{r}_{t+1} - \widetilde{C}_t \right\}$$

So, summarizing, we have the following system of log-linearized equations:

$$\overline{Y}\widetilde{Y}_t = \overline{C}\widetilde{C}_t + \overline{X}\widetilde{X}_t$$

$$\widetilde{Y}_t = \alpha\widetilde{K}_t + (1-\alpha)\widetilde{L_t^w}$$

$$\widetilde{\Psi}_t = \widetilde{\Upsilon}_t \ + \ (1-\varphi)\,\widetilde{L_t^c}$$

$$\widetilde{w}_t = \widetilde{Y}_t - \widetilde{L_t^w}$$

$$\widetilde{r}_t = \widetilde{Y}_t - \widetilde{K}_t$$

$$\delta\widetilde{X}_t = \widetilde{K}_{t+1} - (1-\delta)\widetilde{K}_t$$

$$\widetilde{C}_t = \widetilde{w}_t - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}}\widetilde{L_t^w} - \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}}\widetilde{L_t^c}$$

$$\widetilde{C}_t = \widetilde{\Upsilon}_t - \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}}\widetilde{L_t^w} - \left(\varphi + \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}}\right)\widetilde{L_t^c}$$

$$0 = E_t\left\{\widetilde{C}_{t+1} - \beta(1-\tau^k)\overline{r}\widetilde{r}_{t+1} - \widetilde{C}_t\right\}$$

$$\widetilde{\Upsilon}_{t+1} = \rho\,\widetilde{\Upsilon}_t + \varepsilon_{t+1}$$

Where $\varepsilon_{t+1} \sim iid\ N\left(0, \sigma_\varepsilon^2\right)$.

We will define the following column vectors:

$$x_t \equiv \left[\widetilde{K}_{t+1}\right] \quad y_t \equiv \begin{bmatrix} \widetilde{Y}_t \\ \widetilde{\Psi}_t \\ \widetilde{C}_t \\ \widetilde{X}_t \\ \widetilde{L_t^w} \\ \widetilde{L_t^c} \\ \widetilde{r}_t \\ \widetilde{w}_t \end{bmatrix} \quad z_t \equiv \begin{bmatrix} \widetilde{\Upsilon}_t \end{bmatrix} \quad \epsilon_{t+1} \equiv \begin{bmatrix} \varepsilon_{t+1} \end{bmatrix}$$

Then, we can rewrite our log-linearized system in matrix form, as follows:

$$\mathbf{0} = Ax_t + Bx_{t-1} + Cy_t + Dz_t$$

$$\mathbf{0} = E_t \left\{ Fx_{t+1} + Gx_t + Hx_{t-1} + Jy_{t+1} + Ky_t + Lz_{t+1} + Mz_t \right\}$$

$$z_{t+1} = Nz_t + \epsilon_{t+1} \quad \text{with } E_t \left\{ \epsilon_{t+1} \right\} = \mathbf{0}$$

Note that the second equation corresponds solely to the stochastic Euler equation; the first equation corresponds to the following 8 equations of the system; and, finally, the third equation represents the AR(1) process for corruption's shock, which is the last equation of our log-linearized system.

Matrices A, B, C and D are:

$$A = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ -\alpha \\ 0 \\ 0 \\ -1 \\ -(1-\delta) \\ 0 \\ 0 \end{bmatrix}, C = \begin{bmatrix} \overline{Y} & 0 & -\overline{C} & -\overline{X} & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & -(1-\alpha) & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & -(1-\varphi) & 0 & 0 \\ 1 & 0 & 0 & 0 & -1 & 0 & 0 & -1 \\ 1 & 0 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -\delta & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}} & \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}} & 0 & -1 \\ 0 & 0 & 1 & 0 & \frac{\overline{L^w}}{1-\overline{L^w}-\overline{L^c}} & \left(\varphi + \frac{\overline{L^c}}{1-\overline{L^w}-\overline{L^c}}\right) & 0 & 0 \end{bmatrix}, \quad D = \begin{bmatrix} 0 \\ 0 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ -1 \end{bmatrix}.$$

Matrices F, G, H, J, K, L, M are the following:

$$F = [0] \quad G = [0] \quad H = [0]$$
$$J = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & -\beta(1-\tau^k)\bar{r} & 0 \end{bmatrix}$$
$$K = \begin{bmatrix} 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$
$$L = \begin{bmatrix} 0 \end{bmatrix} \quad M = \begin{bmatrix} 0 \end{bmatrix}$$

Matrix N is:

$$N = \begin{bmatrix} \rho \end{bmatrix}$$

With this matrices, we are now able to solve the model through the approach followed by Uhlig (1999). Matlab is the program used to write the algorithm. □

11.4

Table 12: Robustness: GMM Specifications (Log GDP pc)

	(1) Log GDP pc	(2) Log GDP pc	(3) Log GDP pc
Corruption Index	-0.04	-0.05***	-0.05***
	(0.03)	(0.01)	(0.01)
Log GDP pc lag	0.67***	0.68***	0.68***
	(0.05)	(0.02)	(0.02)
Log(Employment pc)	0.09***	0.05***	0.05***
	(0.04)	(0.02)	(0.02)
ln Investment pc	0.07***	0.08***	0.08***
	(0.01)	(0.01)	(0.01)
Log Gov. exp. pc	0.02	0.03***	0.03***
	(0.02)	(0.01)	(0.01)
Real XR	0.02	0.02***	0.02***
	(0.01)	(0.01)	(0.01)
Log(Labor Prod.)	0.01	0.04	0.04
	(0.04)	(0.03)	(0.03)
Log(Exports pc)	0.11***	0.12***	0.12***
	(0.02)	(0.01)	(0.01)
Log(Imports pc)	-0.00	-0.01	-0.01
	(0.03)	(0.01)	(0.01)
Specification	Diff-GMM one-step	Diff-GMM two-step	System GMM two-step
Observations	1,901	1,901	2,311
AR(1) p-val	0.000	0.001	0.001
AR(2) p-val	0.005	0.006	0.006
Hansen J-test p-val	0.074	0.074	0.061
Instruments	73	73	76

Note: Standard errors in parentheses.

Table 13: Robustness: GMM Specifications (Log Investment per capita)

	(1) Log(Inv pc)	(2) Log(Inv pc)	(3) Log(Inv pc)
Corruption Index	-0.11	-0.13	-0.13**
	(0.17)	(0.16)	(0.06)
Log Investment pc lag	0.70***	0.70***	0.90***
	(0.14)	(0.13)	(0.05)
Log(Employment pc)	0.15	0.16	-0.04
	(0.19)	(0.19)	(0.05)
Log Gov. exp. pc	-0.05	-0.06	-0.01
	(0.11)	(0.10)	(0.03)
Real XR	-0.02	-0.02	-0.14**
	(0.04)	(0.04)	(0.06)
Log(Labor Prod.)	-0.22	-0.22	0.07
	(0.28)	(0.28)	(0.04)
Log(Exports pc)	-0.46***	-0.45***	0.01
	(0.06)	(0.06)	(0.02)
Log(Imports pc)	0.82***	0.82***	0.03
	(0.09)	(0.09)	(0.04)
Specification	Diff-GMM one-step	Diff-GMM two-step	System GMM two-step
Observations	1,887	1,887	2,282
AR(1) p-val	0.000	0.000	0.000
AR(2) p-val	0.291	0.283	0.149
Hansen J-test p-val	0.929	0.929	0.442
Instruments	27	27	33

Note: Standard errors in parentheses.

Table 14: Robustness: GMM Specifications (Log Consumption per capita)

	(1) Log(Cons pc)	(2) Log(Cons pc)	(3) Log(Cons pc)
Corruption Index	-0.06**	-0.04***	-0.03***
	(0.03)	(0.01)	(0.01)
Log(Cons pc) lag	0.71***	0.73***	0.81***
	(0.06)	(0.02)	(0.02)
Log(Inv pc)	-0.06***	-0.05***	0.04***
	(0.02)	(0.01)	(0.00)
Log(Employment pc)	0.10**	0.09***	0.05***
	(0.04)	(0.01)	(0.01)
Log Gov. exp. pc	0.07**	0.08***	0.08***
	(0.03)	(0.01)	(0.01)
Real XR	0.01	0.00	0.01*
	(0.01)	(0.00)	(0.01)
Log(Labor Prod.)	0.03	0.04	0.11***
	(0.07)	(0.03)	(0.01)
Log(Exports pc)	-0.10***	-0.09***	-0.04***
	(0.03)	(0.01)	(0.00)
Log(Imports pc)	0.26***	0.23***	0.05***
	(0.05)	(0.01)	(0.01)
Specification	Diff-GMM one-step	Diff-GMM two-step	System GMM two-step
Observations	1,888	1,888	2,289
AR(1) p-val	0.001	0.003	0.001
AR(2) p-val	0.284	0.302	0.363
Hansen J-test p-val	0.201	0.201	0.217
Instruments	103	103	109

Note: Standard errors in parentheses.

11.5 Granger Causality Test of the Main Variables

Table 15: Granger-causality tests: Corruption and GDP per capita

	HPJ Wald	p-value	N	T	lags
CI causes ln(GDPpc)	6.434	0.011	128	25	1
ln(GDPpc) causes CI	2.332	0.127	128	25	1

Table 16: Granger-causality tests: Corruption and Investment per capita

	HPJ Wald	p-value	N	T	lags
CI causes ln(Inv pc)	0.001	0.974	128	25	1
ln(Inv pc) causes CI	0.118	0.731	128	25	1

Table 17: Granger-causality tests: Corruption and Consumption per capita

	HPJ Wald	p-value	N	T	lags
CI causes ln(Cons pc)	4.548	0.033	128	25	1
ln(Cons pc) causes CI	1.372	0.241	128	25	1