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The economic implications of corruption dynamics

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Abstract

Corruption is not a static phenomenon; it evolves over time and varies across countries. Using a second-order autoregressive model, we examine how corruption shocks influence key economic variables. Our findings indicate that persistent corruption significantly reduces capital stock, consumption, and wages. Moreover, corruption shocks have long-term repercussions, with high-corruption economies exhibiting weakened performance marked by increased working hours, lower wages, and marginally reduced interest rates.

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1 Introduction

Corruption is not a static phenomenon; it varies over time and across countries. This dynamic behavior introduces distortionary effects on economic performance, affecting key economic variables (e.g., output, consumption, investment, and labor market dynamics). Figure 1 shows the Corruption Perception Index (CPI) dynamics for groups of countries (Appendix A.1) from 1980 to 2011, using an HP filter to decompose the data.[1] The top (bottom) panel presents the median (std. deviation) CPI cyclical component for each group, highlighting short-term deviations from the long-term trend.

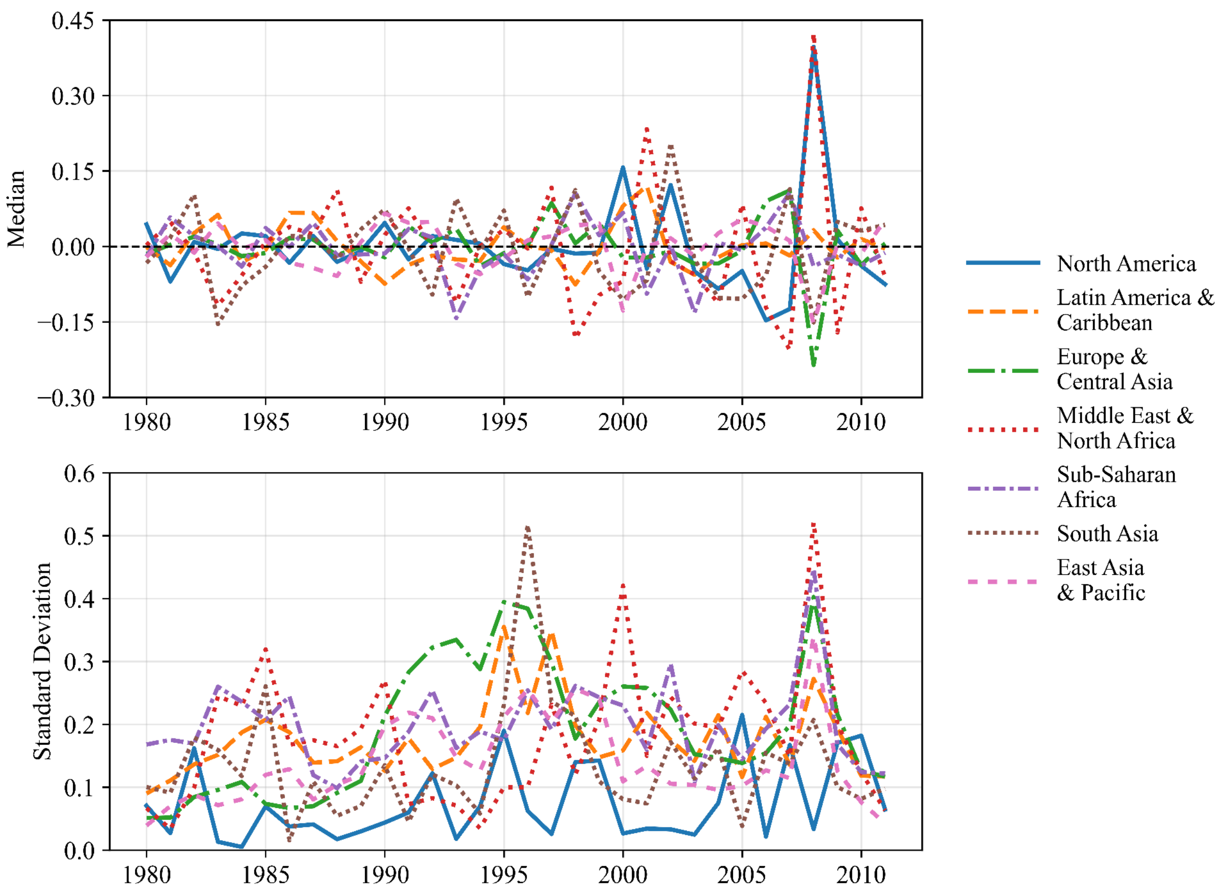

Figure 1: Moments of CPI (Corruption Perception Index) Cycles: Median and Standard Deviation by Region, 1980 - 2011 (HP filter, $\lambda = 6.25$). Data source: Transparency International; Castellacci and Natera (2011).

We study a model in which corruption is characterized as the embezzlement of public funds, which reduces resources available for public expenditures. This diversion of funds creates inefficiencies in the private sector, leading to lower investment, reduced capital stock, and diminished

[1] The Corruption Perception Index (CPI) ranks countries and territories around the world by their perceived levels of public sector corruption, scoring on a scale of 0 (highly corrupt) to 10 (very clean). It is available from 1995 to 2022, but a methodological change in 2012 makes indices post-2012 non-comparable to earlier data (see, e.g., Aidt, 2009).

productivity. Corruption affects households across both private and public sectors, with corrupt public sector workers benefiting from illicit income through embezzled tax collections.

We model corruption as a second-order autoregressive process and explore how shocks in corruption levels affect the economy, leading to larger decreases in capital stock, consumption, and wages. Our analysis highlights long-term economic repercussions of corruption shocks. Economies with higher corruption levels tend to experience weaker overall economic performance. Output and capital stock decline as corruption intensifies. As corruption constrains economic growth, working hours and wages fall. While corruption slightly reduces the interest rate, its overall impact is largely negative, with consumption falling even as tax revenues are diverted for illicit purposes.

We build on the literature that studies the impact of corruption on economic growth, focusing on how corruption distorts allocation of resources and macroeconomic variables.[2] Previous work has shown that corruption deters entrepreneurs, encourages inefficient business practices, and reduces investment, all of which negatively affect growth (Murphy et al., 1991, 1993). Previous research (e.g., Blackburn et al. (2006); Blackburn and Powell (2011) has established significant negative relationships between economic development and corruption. This paper highlights corruption's long-term impact by analyzing how it distorts macroeconomic variables through both steady-state and dynamic responses, particularly focusing on the dynamic adjustments influenced by corruption.

2 The Model

Assume a continuum of identical households with measure one. The representative household maximizes

$$\sum_{t=0}^{\infty} \beta^t N_t \left[\ln(c_t) + \theta \ln(1-h_t) + \ln(\chi_t)\right], \tag{1}$$

subject to the budget constraint:

$$(1+\tau^c) N_t c_t + K_{t+1} = \eta(1-\upsilon)\psi_t + \left(1-\tau^h\right) w_t N_t h_t - \left(1-\delta+\left(1-\tau^k\right) r_t\right) K_t. \tag{2}$$

where c_t is consumption, h_t hours worked, $1-h_t$ leisure; τ^c, τ^h, τ^k are taxes on consumption, labor and capital income, respectively (Azzimonti et al., 2009). Population N_t grows at rate ζ. A fraction $\upsilon \in (0,1)$ of individuals are private sector workers, employed in the productive sector, and a fraction $1-\upsilon$ individuals are bureaucrats, working for the government in public administration. A proportion $\eta \in (0,1)$ of bureaucrats engage in corruption, diverting public resources (ψ_t) that would otherwise be used to finance public expenditures and provide public goods (χ_t).

The representative firm profit maximization problem is

$$\Pi_t(K_t, H_t; \eta) = \max_{K_t, H_t \geq 0} \left\{(1-\tau^\eta) K_t^\alpha (A_t H_t)^{1-\alpha} - w_t H_t - r_t K_t\right\} \tag{3}$$

where K_t is the economy's capital stock, H_t the total worked, α capital share, and $A_t = (1+\gamma)A_{t-1}$ is the total factor productivity ($\gamma \geq 0$); r_t, w_t represent the rental rate, wage rate, respectively. We

[2] See Aidt (2003) for comprehensive review.

assume perfectly competitive markets. The capital law of motion is $K_{t+1} = (1-\delta)K_t + I_t$, where I_t is investment at t and δ is the depreciation rate.

The economy's output $Y_t = (1-\tau^\eta)\,K_t^\alpha\,(A_t H_t)^{1-\alpha}$ is affected by the number of corrupt bureaucrats in the economy. We define a corruption tax as $\tau^\eta = f(\eta,\iota)$. The inefficiency of the output is determined by the amount of corrupt public officials in the economy (η), along with an adjustment parameter that reflects the level of output lost by corruption (ι). That is, $\tau^\eta = 1 - e^{(-\eta/\iota)}$, where $f(0,\iota) = 0$ and $f(1,\iota) = \kappa$, with κ representing the upper bound of the inefficiency caused by corruption.

Corrupt bureaucrats appropriate a fraction of the taxes revenue $\mathscr{T}_t = \tau^c N_t c_t + \tau^h w_t N_t h_t + \tau^k r_t K_t$, i.e., $\psi_t = \mathscr{T}_t/(1-\upsilon)$.[3] Hence, the government budget constraint is $(1-\eta)\mathscr{T}_t = (1-\upsilon)w_t + \chi_t$, where $(1-\upsilon)w_t$ represents the bureaucrats' salaries paid by the government.[4]

The economy's resource constraint is

$$N_t c_t + K_{t+1} + G_t = (1-\tau^\eta)\,K_t^\alpha\,(A_t H_t)^{1-\alpha} + (1-\delta)K_t \tag{4}$$

where $N_t h_t = H_t$ and $G_t = (1-\eta)\mathscr{T}_t$. See Appendix A.2 for detailed derivations and equilibrium definition.

3 Economic Implications of Corruption Dynamics

Table I presents our benchmark parameters. Following Bezerra et al. (2014), we set the intertemporal discount factor $\beta = 0.94$. We assume the weight of leisure in the utility function is $\theta = 1.94$ (Santana et al., 2012). According to *Brazilian National Household Sample Survey* (PNAD), public employment represented only about 11.5% of the total employed in the country in 2010. Hence, we set $\upsilon = 0.885$. The depreciation rate (δ) is set to 3% (Santana et al., 2012). Using data from the *Brazilian Family Budget Survey* (2002/03) (Paes and Bugarin, 2006), we calibrate $\alpha = 0.43$. The corruption output loss parameter (ι) is calibrated to 6.39 to reproduce an annual GDP loss of 1.38% due to corruption in Brazil, relative to low-corruption countries (FIESP, 2010). Capital income is taxed at $\tau^k = 0.13$ (Santana et al., 2012). Taxes on consumption and labor income are set to $\tau^h = \tau^c = 0.16$ (Bezerra et al., 2014). We calibrate $1+\gamma$ at 2.05% which is the $1995-2010$ Brazilian compound annual growth rate (PWT data). Similarly, population growth rate is set to $\zeta = 0.01$. The model matches the Brazilian economy fairly well along a number of dimensions that were calibrated (Table A.1), as well as some statistics that were not calibrated, such as the capital to output ratio and the share of corrupt bureaucrats (Appendix A.3, Table A.1).

In order to further investigate the CPI dynamics, we estimate an ARIMA model:[5]

$$\mathrm{CPI}_t = \alpha + \phi_1 \mathrm{CPI}_{t-1} + \phi_2 \mathrm{CPI}_{t-2} + \varepsilon_t \tag{5}$$

where α is the constant term, ϕ_1 and ϕ_2 are the coefficients for the first and second lags of the

[3] Blackburn and Powell (2011) assume that government spending is financed via taxes on firm output.

[4] According to Blackburn et al. (2008), government bureaucrats are paid salaries that match what they would earn in the private sector (see also Acemoglu and Verdier, 1998; Blackburn et al., 2006; Blackburn and Forgues-Puccio, 2007.

[5] Figure A.1 shows the Corruption Perception Index (CPI) dynamics for Brazil from 1980 to 2011, using an HP filter to decompose the data.

Table I: Benchmark parameters

	Parameter	Value	Description	Sources
Household	β	0.94	Discount factor	(2)
	θ	1.94	Weight of leisure in utility	(5)
	υ	0.89	Private sector worker ratio	(6)
	δ	0.03	Depreciation rate	(5)
Firm	α	0.43	Capital share	(1)
	ι	6.39	Corruption output loss	(7)
Government	τ^k	0.13	Tax rate on capital	(5)
	τ^c	0.16	Tax rate on consumption	(2)
	τ^h	0.16	Tax rate on labor income	(2)
Economy	γ	0.02	Economy growth rate	(3)
	ζ	0.01	Population growth rate	(4)

Sources: (1) Paes and Bugarin (2006), (2) Bezerra et al. (2014), (3) PWT 9.1 (*rgdpna*), CAGR 1995-2010, (4) PWT 9.1 (*pop*), CAGR 1995-2010, (5) Santana et al. (2012), (6) PNAD (2010), (7) FIESP (2010), jointly calibrated.

cycle, respectively, and ε_t represents the error term. An ARIMA(2,0,0) model effectively captures the dynamics of the cycle variable, with significant autoregressive components indicating both positive ($\phi_1 = 0.2782$) and negative ($\phi_2 = -0.4878$) influences from past values (Appendix A.3, Table A.2).[6]

Permanent Corruption Shocks. The impact of varying corruption levels is measured by the log difference in utility, equating the consumption compensation needed for an agent to remain indifferent to the new corruption level. Let ω represent the percentage of consumption needed to compensate the household to accept the new corruption level, with η_{SS} indicating the benchmark corruption level and η_Δ the new corruption level, i.e.,

$$\ln\left[(1+\omega)c_\Delta\right] + \theta\ln(1-h_\Delta) + \ln(\chi_\Delta) = \ln(c_{SS}) + \theta\ln(1-h_{SS}) + \ln(\chi_{SS}) \tag{6}$$

The changes in η affect the efficiency gap $(1-\tau^\eta)y_t$. Rising corruption correlates with increased consumption and investment shares but reduced government spending due to diminished tax revenue. In the scenario where corruption increases ($\eta^* + 0.01$), there is a noticeable decline in key economic indicators, including output, capital stock, and consumption. Investment and tax collection also decrease. Additionally, wages and interest rates experience a decline. Interestingly, hours worked increase marginally, likely due to the negative impact on income, which necessitates a small increase in consumption to maintain utility in light of the higher corruption levels (Appendix A.3, Table A.3).

Extreme cases show that $\eta = 1$ (total corruption) results in a 22% output reduction, while $\eta = 0$ (no corruption) increases output, benefiting households with higher wages and interest rates. Maintaining utility in a corruption-free environment requires sacrificing 1.09% of consumption.

[6] We have also estimated an OLS AR(2) model of the CPI cycle. The results from this estimation are robust and consistent with those obtained from the ARIMA(2,0,0) model, indicating that the autoregressive dynamics of the cycle are captured similarly across both approaches.

Figure 2 illustrates the negative correlation between corruption and GDP per capita, i.e., increased corruption leads to longer working hours, aligning with empirical findings that countries with higher corruption experience increased labor demands.

Transitory Corruption Shocks. Figure 3 illustrates the dynamic responses of macroeconomic variables to a 1 percentage point increase in corruption, modeled as an AR(2) process (Table A.2). The initial corruption shock causes a sharp decline in output, driven by reductions in capital accumulation and labor supply. Investment contracts at first, but temporarily rises (higher marginal productivity of capital) in the subsequent periods due to a lower interest rate. However, this short-term boost fails to offset the longer-term slowdown in capital formation. As labor productivity falls, wages and labor supply decline, amplifying the reduction in output. Consumption also falls, with a slower recovery compared to output, indicating prolonged welfare losses. Overall, the results demonstrate that corruption generates persistent economic inefficiencies, with long-term negative effects on key macroeconomic variables.

4 Conclusions

This study highlights the dynamic nature of corruption and its significant impact on economic performance. We provide evidence that corruption is a dynamic phenomenon - modeled as a second-order autoregressive process - that evolves over time and varies across countries. Persistent corruption leads to profound economic consequences. Our findings indicate that corruption shocks significantly reduce capital stock, consumption, and wages, while also increasing working hours. The long-term repercussions of corruption extend beyond immediate economic disruptions. Economies with higher levels of corruption experience weakened performance characterized by diminished economic growth and reduced overall welfare. Furthermore, despite marginally lower

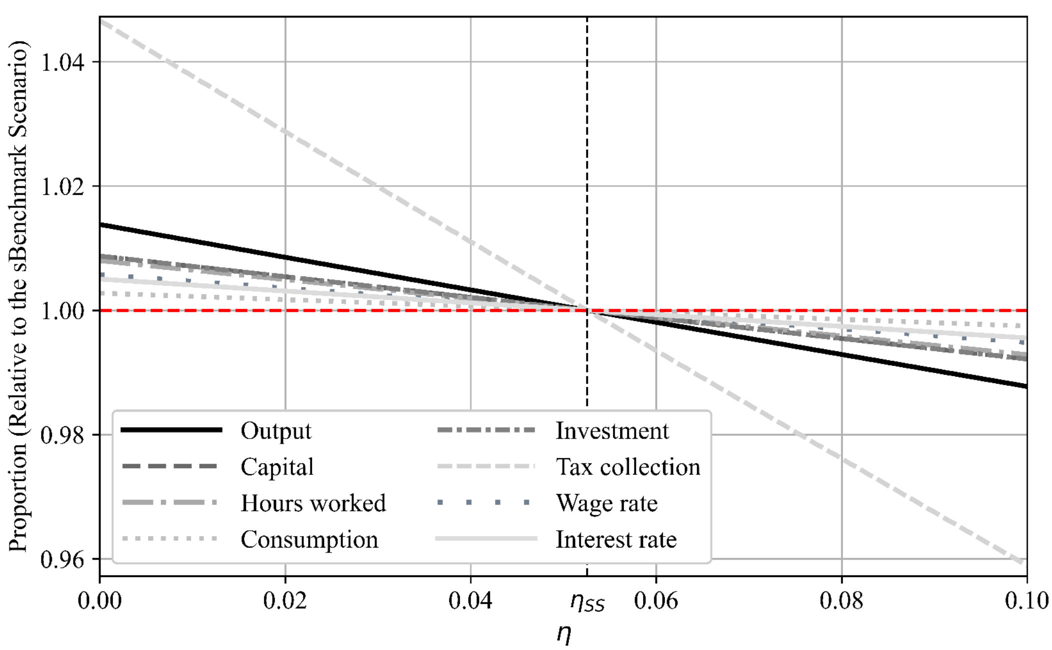

Figure 2: Proportions of economic aggregates across different values of η.

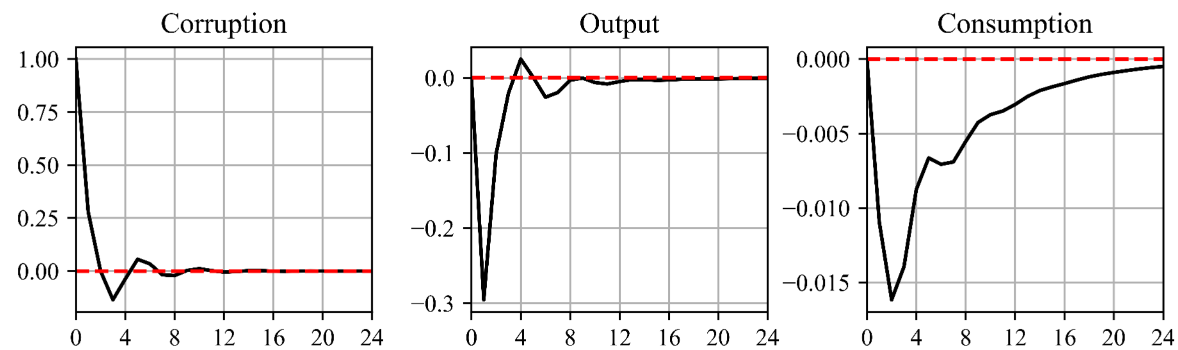

Figure 3: Variable responses to a 1pp increase in corruption. Note: Variables are in log-deviations from the steady-state, and have been multiplied by 100.

interest rates, the increased labor burden and suppressed wages highlight the broader societal costs of corruption. These results emphasize the importance of addressing corruption as a crucial economic policy challenge. Mitigating corruption could unlock substantial improvements in economic outcomes, fostering growth, and improving welfare in affected economies.

Appendix

A.1 Countries Grouped by Region for CPI Analysis

This list presents the countries grouped by region for the CPI cycle analysis, which are used in Figure 1 of the main text.

- **East Asia & Pacific**: Australia, China, Indonesia, Japan, Mongolia, Malaysia, New Zealand, Philippines, Singapore, Thailand, Vietnam.
- **Europe & Central Asia**: Albania, Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Switzerland, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Georgia, Greece, Croatia, Hungary, Ireland, Iceland, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Latvia, Republic of Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Sweden, Turkey, Ukraine, Uzbekistan.
- **Latin America & Caribbean**: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Haiti, Jamaica, Mexico, Nicaragua, Panama, Peru, Paraguay, El Salvador, Trinidad and Tobago, Uruguay, Venezuela.
- **Middle East & North Africa**: Egypt, Israel, Jordan, Morocco, Tunisia.
- **North America**: Canada, United States.
- **South Asia**: India, Sri Lanka, Pakistan.
- **Sub-Saharan Africa**: Angola, Burkina Faso, Botswana, Cameroon, Ethiopia, Ghana, Kenya, Madagascar, Mozambique, Mauritius, Malawi, Namibia, Nigeria, Senegal, Tanzania, Uganda, South Africa, Zambia, Zimbabwe.

A.2 Model Derivations and Definition of Equilibrium

The firm's profit maximization problem, equation (3), imply the following optimal capital and labor demand functions, isolated for the respective prices, i.e., the marginal products of capital and labor equal their marginal costs:

$$r_t = \alpha(1-\tau^\eta)K_t^{\alpha-1}(A_tH_t)^{1-\alpha} \tag{A.1}$$

$$w_t = (1-\alpha)(1-\tau^\eta)K_t^{\alpha}(A_tH_t)^{-\alpha} \tag{A.2}$$

The representative household's problem is to choose $\{c_t, h_t, K_{t+1}\}_{t=0}^{\infty}$ to maximize equation (1) subject to equation (2) and $c_t, h_t, K_{t+1} \geq 0$, given K_0, η and $\{w_t, r_t\}_{t=0}^{\infty}$. The Lagrangian associated with the household's problem is

$$\begin{aligned} \mathscr{L} = \sum_{t=0}^{\infty} \beta^t \left\{N_t \left[\ln(c_t) + \theta \ln(1-h_t) + \ln(\chi_t)\right]\right\} + \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{\eta(1-\upsilon)\psi_t\right. \\ \left. + \left(1-\tau^h\right) w_t N_t h_t + \left[1-\delta+\left(1-\tau^k\right) r_t\right] K_t - K_{t+1} - (1+\tau^c) N_t c_t \right\} \end{aligned} \tag{A.3}$$

The first order conditions are given by:

$$c_{t+1} = \beta \left[1 - \delta + \left(1 - \tau^{k}\right) r_{t+1}\right] c_t \tag{A.4}$$

$$\frac{\theta c_t}{1 - h_t} = \frac{w_t \left(1 - \tau^{h}\right)}{1 + \tau^{c}} \tag{A.5}$$

The equations (A.4) and (A.5) together with (A.1) and (A.2) deliver, respectively, the Euler's equation and the intratemporal marginal rate of substitution between consumption and leisure:

$$c_{t+1} = \beta \left[1 - \delta + \left(1 - \tau^{k}\right) \alpha \left(1 - \tau^{\eta}\right) K_{t+1}^{\alpha - 1} \left(A_{t+1} H_{t+1}\right)^{1-\alpha}\right] c_t \tag{A.6}$$

$$\frac{\theta c_t}{1 - h_t} = \frac{(1 - \alpha)\left(1 - \tau^{\eta}\right) K_t^{\alpha} A_t^{1-\alpha} H_t^{-\alpha} \left(1 - \tau^{h}\right)}{1 + \tau^{c}} \tag{A.7}$$

Imputing the marginal costs of capital and labor to the household budget constraint plus the income from corruption, that is, equations (A.1) and (A.2) in equation (2), and using the definition of ψ_t, we have that:

$$\begin{aligned}(1 + \tau^{c}) N_t c_t + K_{t+1} = {} & \eta \mathscr{T}_t + \left(1 - \tau^{h}\right)(1 - \alpha)(1 - \tau^{\eta}) K_t^{\alpha} (A_t H_t)^{-\alpha} N_t h_t \\ & + \left[1 - \delta + \left(1 - \tau^{k}\right) \alpha (1 - \tau^{\eta}) K_t^{\alpha - 1} (A_t H_t)^{1-\alpha}\right] K_t.\end{aligned} \tag{A.8}$$

Definition 1. *The competitive equilibrium of this economy is a sequence of:*

I) a policy set $\Upsilon = \{\tau^{c}, \tau^{h}, \tau^{k}, \tau^{\eta}, \chi_t\}$ that includes taxes on consumption, hours worked, capital return and output, which is a function of the amount of corrupt bureaucrats in the economy (η) and the provision of public goods (χ_t), respectively;

II) a price system $Q = \{w_t, r_t\}$ of wages and interest rate; and

III) an allocation $X = \left\{Y_t, C_t, K_t, H_t, G_t, \{c_t^{i}, h_t^{i}\}_{i \in [0,1]}\right\}_{t \geq 0}$ such that, given the initial conditions and the constraints imposed by the problem, at the steady-state, the resulting optimal allocations satisfy:

(i) the household's maximization problem described in equations (A.6), (A.7) and (A.8);

(ii) the firm's maximization problem described by a production function, the law of motion of capital, and conditions (A.1) and (A.2);

(iii) the government budget constraint; and

(iv) the labor and goods market clear at any given time, respectively, as follows:

$$N_t h_t = H_t \tag{A.9}$$

$$N_t c_t + K_{t+1} + G_t = \left(1 - \tau^{\eta}\right) K_t^{\alpha} \left(A_t H_t\right)^{1-\alpha} + (1 - \delta) K_t \tag{A.10}$$

The competitive equilibrium outlined in the definition ensures that the economy operates efficiently under a given set of policy instruments, price systems, and optimal allocations. This structure guarantees that markets for labor and goods clear, and households and firms are optimizing given their respective constraints. However, while this equilibrium describes the allocation of resources at each point in time, it is essential to understand how the economy evolves over the long term, particularly in the context of growth.

In this regard, the concept of a Balanced Growth Path (BGP) becomes relevant. According to Acemoglu (2009), if the neoclassical growth model has (i) labor-augmenting technological progress growing at the rate μ; (ii) CRRA preferences; (iii) production function twice continuously differentiable in K and L, satisfying diminishing marginal products, and constant returns to scale and Inada conditions; then there exists a unique BGP with normalized capital to effective labor ratio and output per capita and consumption per capita grow at the same rate μ.

The BGP equilibrium for variables such as consumption (c), capital (K), labor (h), wages (w), interest rates (r), output (Y), and government spending (G) will now be derived. The growth of variable μ in the BGP is denoted as x_μ.

For example, from equation (A.6) and using market clearing conditions:

$$x_c := \frac{c_{t+1}}{c_t} = \beta\left[1-\delta+\left(1-\tau^k\right)\alpha\left(1-\tau^\eta\right)K_{t+1}^{\alpha-1}\left(A_{t+1}N_{t+1}h_{t+1}\right)^{1-\alpha}\right] \tag{A.11}$$

Dividing the above expression by itself in the t period and using the fact that $x_A := A_{t+1}/A_t = (1+\gamma)$, $x_N := N_{t+1}/N_t = (1+\zeta)$, and $x_h := h_{t+1}/h_t = 1$ since (1) satisfies the Inada Conditions, where γ is the technology growth rate, while ζ is the population growth rate:

$$\frac{c_{t+1}}{c_t}\bigg/\frac{c_t}{c_{t-1}} = 1 \Leftrightarrow x_K := \frac{K_{t+1}}{K_t} = \frac{A_{t+1}}{A_t}\frac{N_{t+1}}{N_t}\frac{h_{t+1}}{h_t} = (1+\gamma)(1+\zeta) \tag{A.12}$$

Repeating the same steps for the production function, interest rate, wage rate, and assuming that government spending grows at the same rate as output:

$$x_Y = x_G = (1+\gamma)(1+\zeta), \quad x_c = x_w = (1+\gamma), \quad x_r = 1 \tag{A.13}$$

Since "effective" or efficiency units of labor are given by $A(t)N(t)$, and Y exhibits constant returns to scale in its two arguments, we now define $\tilde{k}_t$ ($\tilde{y}_t$, $\tilde{g}_t$) as the effective capital (output, government spending)-labor ratio, i.e., capital divided by efficiency units of labor,

$$\tilde{k}_t = \frac{K_t}{A_tN_t}, \quad \tilde{y}_t = \frac{Y_t}{A_tN_t}, \quad \tilde{g}_t = \frac{G_t}{A_tN_t} \tag{A.14}$$

The same strategy above is used for the output and government spending. On the other hand, for consumption, hours worked, interest rate and wages, consider the following transformations:

$$\tilde{c}_t = \frac{c_t}{A_t}, \quad \tilde{h}_t = h_t, \quad \tilde{r}_t = r_t, \quad \tilde{w}_t = \frac{w_t}{A_t} \tag{A.15}$$

Replacing the transformed variables in equation (A.6) and using market clearing conditions:

$$(1+\gamma)\tilde{c}_{t+1} = \beta\left[(1-\delta)+\alpha\left(1-\tau^k\right)\left(1-\tau^\eta\right)\tilde{k}_{t+1}^{\alpha-1}\tilde{h}_{t+1}^{1-\alpha}\right]\tilde{c}_t \tag{A.16}$$

On the other hand, for the government budget constraint and equations (A.7), (A.8), (A.1) and

(A.2) and market clearing conditions, see that:

$$\frac{\theta \tilde{c}_t}{1-\tilde{h}_t} = \frac{(1-\alpha)\left(1-\tau^h\right)(1-\tau^\eta)\,\tilde{k}_t^\alpha \tilde{h}_t^{-\alpha}}{1+\tau^c} \tag{A.17}$$

$$\tilde{c}_t\,(1+\tau^c) = \eta \tilde{\mathfrak{t}}_t + \left[1-\alpha\tau^k-(1-\alpha)\tau^h\right](1-\tau^\eta)\,\tilde{k}_t^\alpha \tilde{h}_t^{1-\alpha} - \xi \tilde{k}_t \tag{A.18}$$

$$\tilde{g}_t = (1-\eta)\tilde{\mathfrak{t}}_t \tag{A.19}$$

$$(1-\tau^\eta)\,\tilde{k}_t^\alpha \tilde{h}_t^{1-\alpha} = \tilde{c}_t + \tilde{k}_{t+1}(1+\gamma)(1+\zeta) - (1-\delta)\tilde{k}_t + \tilde{g}_t \tag{A.20}$$

$$\tilde{w}_t = (1-\alpha)(1-\tau^\eta)\,\tilde{k}_t^\alpha \tilde{h}_t^{-\alpha} \tag{A.21}$$

$$\tilde{r}_t = \alpha(1-\tau^\eta)\,\tilde{k}_t^{\alpha-1}\tilde{h}_t^{1-\alpha} \tag{A.22}$$

where $\xi = \delta+\gamma+\zeta+\gamma\zeta$ and $\tilde{\mathfrak{t}}_t = \tau^c\tilde{c}_t + (1-\alpha)\tau^h(1-\tau^\eta)\,\tilde{k}_t^\alpha \tilde{h}_t^{1-\alpha} + \alpha\tau^k(1-\tau^\eta)\,\tilde{k}_t^\alpha \tilde{h}_t^{1-\alpha}$.

Equations (A.16) to (A.22) allow for the full characterization of the steady state for $\tilde{c}$, $\tilde{k}$, $\tilde{h}$, $\tilde{y}$, $\tilde{g}$, $\tilde{w}$, and $\tilde{r}$. In this context, as steady-state variables remain constant over time, the time subscript is omitted when referring to this equilibrium.

$$\tilde{k}^* = \frac{\dfrac{(1-\alpha)\left(1-\tau^h\right)(1-\tau^\eta)\,\phi^{-\alpha}}{\theta} - \eta\tilde{\mathfrak{t}}}{\dfrac{(1-\alpha)\left(1-\tau^h\right)(1-\tau^\eta)\,\phi^{1-\alpha}}{\theta} + \left[1-\alpha\tau^k-(1-\alpha)\tau^h\right](1-\tau^\eta)\,\phi^{1-\alpha} - \xi} \tag{A.23}$$

where $\phi = \left[\frac{\alpha\beta\left(1-\tau^k\right)(1-\tau^\eta)}{(1+\gamma)-\beta(1-\delta)}\right]^{-\frac{1}{1-\alpha}}$.

From equation (A.23), it can be seen that the capital stock is expressed only as a function of exogenous parameters, so that it is possible to study the behavior of the former for variations in the latter set. However, it is important to highlight that the equation contains several non-linear terms, particularly those associated with corruption (η) and its interactions with other variables, such as taxes and the inefficiency caused by bureaucratic corruption (τ_η). These non-linearities make it difficult to derive clear-cut analytical solutions or predictions regarding the capital stock's sensitivity to changes in key parameters. For instance, the relationship between corruption and capital accumulation is not straightforward, as the magnitude of η interacts with tax policies and public expenditures in a complex manner. Therefore, to better understand the dynamics at play and accurately capture the potential economic impacts, the model will be simulated under a range of plausible parameter values, enabling a more detailed exploration of how corruption influence the capital stock and overall economic performance.

A.3 Calibration and Parameterization

FIESP (2010) suggests that if Brazil's Corruption Perception Index (CPI) had been closer to a group of countries with higher CPI scores, Brazil's per capita GDP would have seen significant growth, amounting to an estimated annual loss of 1.38% of GDP due to corruption, equivalent to approximately R$ 41.5 billion at current 2008 prices. This figure provides a conservative estimate, reflecting a scenario in which Brazil's level of perceived corruption aligns more closely with coun-

Table A.1: Basic statistics, Brazilian and baseline economy

	Brazilian economy	Benchmark model
Share of consumption in output (%)	58.44	57.13
Share of investment in output (%)	20.03	20.58
Share of gov spending in output (%)	21.89	22.29
Capital to output ratio	3.2	3.27
Interest rate (%)	13.16	13.13
Share of currupt bureaucrats (%)	4.88	5.25

Sources: Office of the Comptroller General (2023), Paes and Bugarin (2006), Penn World Table (PWT) 9.1 and Central Bank of Brazil.

Notes: The first three variables are, respectively, csh_c, csh_i, and csh_g, from PWT 9.1 (1995-2010 averages). The interest rate, on the other hand, was obtained from the Central Bank of Brazil (monthly average in 1995-2010).

tries exhibiting higher control over corruption. The same study, however, indicates that under less controlled conditions, the economic loss due to corruption could rise as high as 2.3% of GDP. By focusing on the 1.38% estimate, this analysis adopts a more cautious and restrained benchmark to ensure a balanced evaluation of corruption's economic impact, without overstating its effects. In calibrating the model, an additional parameter (ι) is introduced so that counterfactual simulations, where corruption is vanished, reflect GDP gains consistent with this 1.38% estimate. This ensures that the analysis is aligned with empirically grounded projections, without overstating the impact of corruption. This value is calibrated at 6.385. To estimate the proportion of corrupt officials, we merged the CGU data with employment records from the Ministry of Labor and Employment's Annual Social Information Report (RAIS) for 2010. The RAIS data is identifiable, providing the name of the employer within a specific municipality. This allowed us to compare the number of implicated public workers to the total employment in these institutions. The results indicate that approximately 4.88% of public officials are involved in corruption, with the analysis focusing on ministries, which account for more than 97% of the cases flagged by the CGU.

With the construction of the model and its subsequent calibration, it becomes possible to deduce the proportion of corrupt bureaucrats. By multiplying both sides of $\psi_t = \mathscr{T}_t/(1-\upsilon)$ by $\eta(1-\upsilon)$ and $1\big/Y_t$ and incorporating the first-order conditions of firms and households, alongside the market clearing conditions, and aggregating household consumption ($N_t c_t = C_t$), the following expression emerges:

$$\frac{\mathscr{T}_t}{Y_t} = \tau^c \frac{C_t}{Y_t} + e^{(-\eta/\iota)} \left[\tau^h (1-\alpha) + \tau^k \alpha\right] \tag{A.24}$$

The LHS of equation (A.24) reflects the GDP share lost to corruption, established at 1.38%. Based on PWT 9.1 data (average 1995-2010), the consumption-to-output ratio is calibrated at 58.44%. By substituting the parameters outlined in Table I into the RHS of the same equation, and isolating η yields a plausible estimate for corrupt bureaucrats. The model estimates that 5.25% of public employees are involved in corruption, closely aligning with CGU data. With the model's parameters fully calibrated, the upper bound of the output penalty rate can be determined, approximately 14.96%, leading to the conclusion that $\tau^\eta \in [0, 0.1496]$.

A.3.1 Brazilian CPI and Corruption AR(2)

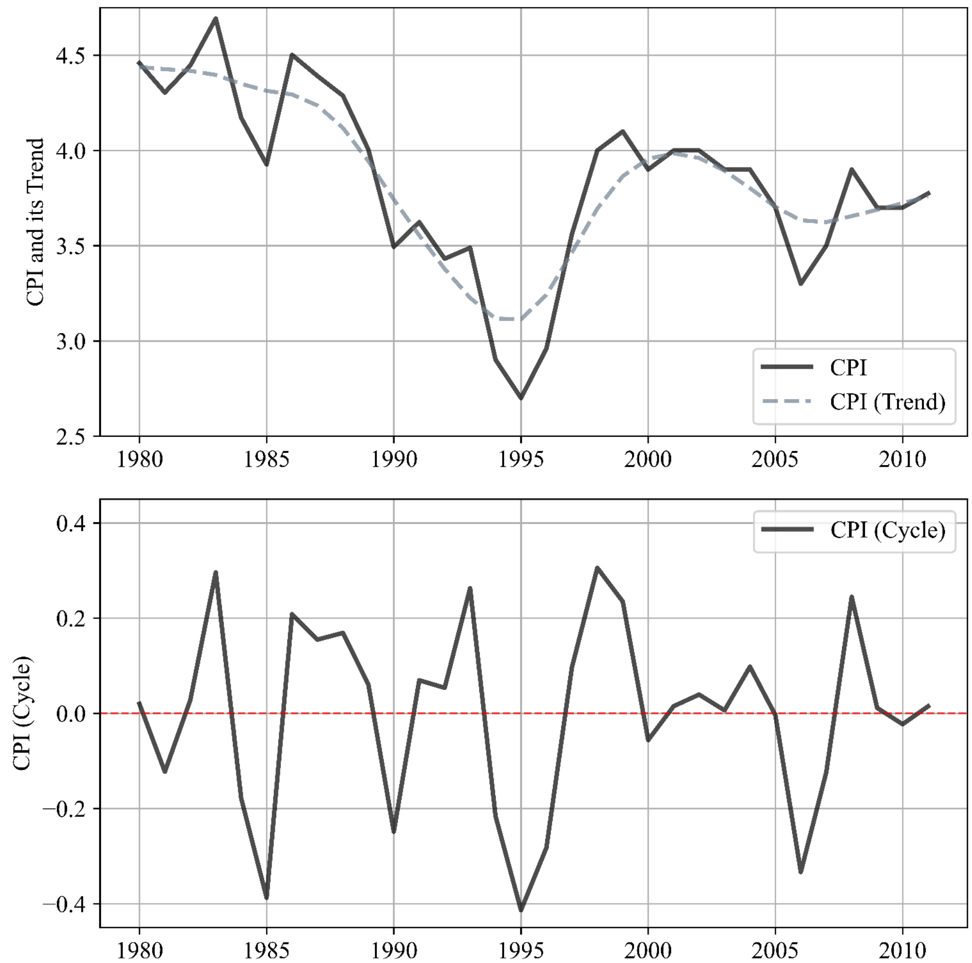

Figure A.1: CPI Dynamics, Brazil, 1980 - 2011 (HP filter, $\lambda = 6.25$). Sources: Castellacci and Natera (2011).

Table A.2: Corruption AR(2)

α	ϕ_1	ϕ_2
-0.0005	0.2782**	-0.4878***
(0.027)	(0.141)	(0.191)

Notes: ARIMA estimation, equation (5). The diagnostic tests show no significant issues with autocorrelation, non-normality, or heteroskedasticity in the residuals.
*: $p < 0.10$, **: $p < 0.05$, ***: $p < 0.01$.

A.3.2 Counterfactual analysis

Table A.3: Counterfactual analysis: variations in η

Variables	$\eta = 0$	$\eta^* - 0.01$	η^*	$\eta^* + 0.01$	$\eta = 0.1$	$\eta = 0.25$	$\eta = 0.5$	$\eta = 1$
% Variation relative to benchmark model								
y	1.38	0.26	0	-0.26	-1.18	-4.92	-10.94	-22.09
k	0.57	0.11	0	-0.11	-0.5	-2.16	-5.05	-11.16
h	-0.04	-0.01	0	0.01	0.04	0.15	0.34	0.66
c	0.34	0.06	0	-0.06	-0.28	-1.17	-2.52	-4.87
i	0.57	0.11	0	-0.11	-0.5	-2.16	-5.05	-11.16
g	6.45	1.19	0	-1.19	-5.47	-22.79	-50.22	-100
w	1.43	0.26	0	-0.26	-1.21	-5.07	-11.24	-22.6
r^1	0.11	0.02	0	-0.02	-0.09	-0.39	-0.85	-1.7
ω	-1.09	-0.2	0	0.2	0.94	3.95	8.89	18.27
Economic aggregates (%)								
C/Y	56.33	57.12	57.38	57.48	58.15	60.97	65.96	77.13
I/Y	19.9	20.03	20.07	20.09	20.2	20.64	21.39	22.87
G/Y	23.77	22.85	22.53	22.43	21.66	18.39	12.66	0

Notes: Results with * denote benchmark parameters. Each scenario varies η while keeping other parameters constant; (1) Only the interest rate variation is given in percentage points.

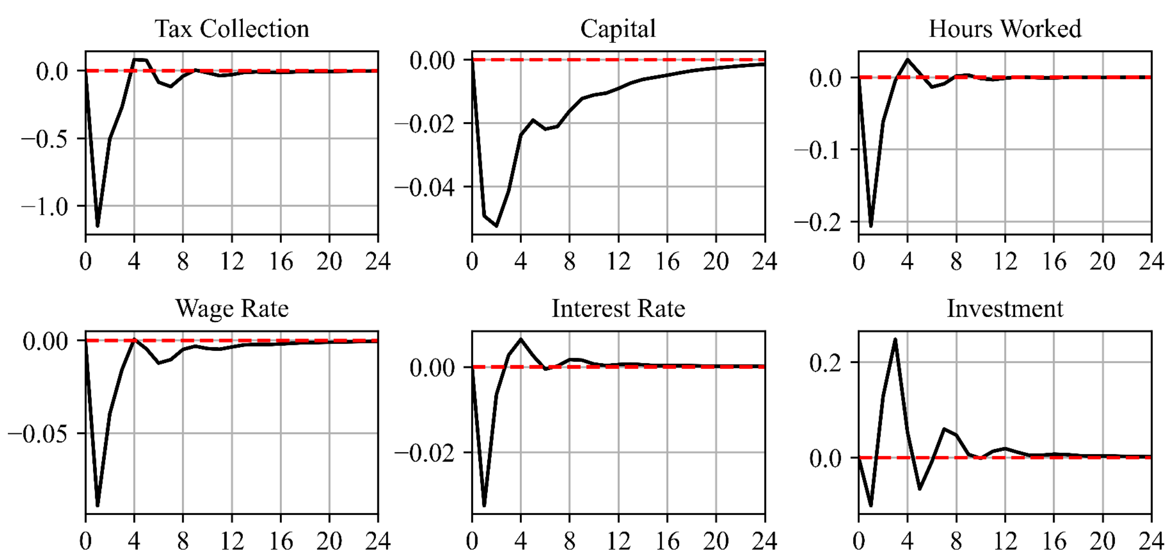

Figure A.2: Variable responses to a 1pp increase in corruption. Note: Variables are in log-deviations from the steady-state, and have been multiplied by 100.

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