Democracy, Rule of Law, Corruption Incentives, and Growth

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Abstract

We bridge the gap between the standard theory of growth and the mostly static theory of corruption. Some public investment can be diverted from its purpose by corrupt individuals. Voters determine the level of public investment subject to an incentive constraint equalizing the returns from productive and corrupt activities. We concentrate on two exogenous institutional parameters: the “technology of corruption” is the ease with which rent-seekers can capture a proportion of public spending. The “concentration of political power” is the extent to which rent-seekers have more political influence than other people. One theoretical prediction is that the effects of the two institutional parameters on income growth and equilibrium corruption are different according to the constraints that are binding at equilibrium. In particular, the effect of judicial quality on growth should be stronger when political power is concentrated. We estimate a system of equations where both corruption and income growth are determined simultaneously and show that income growth is more affected by our proxies for legal and political institutions in countries where political rights and judicial institutions, respectively, are limited.

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1. Introduction

The concern of international organizations for fighting corruption is supported by a large volume of empirical research measuring its devastating effect on economic performance and growth. These studies were made possible by the increasing number and quality of measures of corruption (see the indicators of the World Bank and the International Country Risk Guide, as well as the corruption perceptions index from Transparency International, to mention aggregate measures only). They highlight various channels through which corruption may hamper growth, either directly (Poirson 1998, Leite and Weidmann 1999, Meon and Sekkat 2005) or indirectly through lower private investment (Mauro 1995, Knack and Keefer 1995) or lower efficiency of public investment (Tanzi and Davoodi 1997, Gupta, Davoodi, and Tiongson 2001).

The way corruption is modeled in theory is, however, not yet firmly established. Two different strategies have been followed in the literature. Most of the theory of corruption has been developed in a static context and focuses on incentives, information, and enforcement determining corrupt practices, mainly due to market failures (Shleifer and Vishny 1993, Banerjee 1997, Acemoglu and Verdier 2000). A key element in this literature is that individuals face a choice between different activities, including productive and rent-seeking activities. A minor strand of the literature is devoted to the dynamics and growth aspects of corruption activities, using dynamic general equilibrium modeling. In most of these studies, corruption is either exogenous, or a by-product of another activity, and households are not subject to incentive constraints. For example in Le Van and Maurel (2006), corruption is identical to an (exogenous) productivity parameter, whose consequences for catching-up and convergence are analyzed. Ehrlich and Lui (1999) build a growth model with thresholds in human capital, generating two equilibria, one with corruption and one without. Corruption is a direct product of government size, which is set arbitrarily. Another endogenous growth model is proposed by Mohtadi and Roe (2003). In this model, the equilibrium size of the rent-seeking sector depends on the "state of democracy" which is related to the flow of information and access to the government. Eicher, García-Peñalosa, and van Ypersele (2009) postulate two exogenous types of politicians, honest and dishonest ones to, and include the possibility for the dishonest ones to imitate the honest ones if certain incentives are available.[1]

[1] Further references are Long and Sorger (2006) where corruption is possible because its revenues can be held abroad, and Magee, Brock, and Young (1989) who propose in their appendix (pp. 294–299) one of the first dynamic model with corruption (wealth redistribution) but in which its level is simply exogenous. Finally, in Dalgic and Long (2006) corruption consists in extortionary fees decided by a local government which can be hidden from a central government at some exogenous quadratic cost. The equilibrium is a game between the two levels of government; too much extortion in equilibrium will go hand in hand with a poverty trap.

One paper though has the three following elements: dynamic general equilibrium, incentive constraint, and endogenous corruption. In Barreto (2000), corruption is defined as a monopoly rent that public servants enjoy when selling the publicly produced good. This rent is endogenous and depends on various parameters such as the detection technology. Another nice feature of the Barreto model is that the product of corruption is not lost for the economy but is an income for public servants. Corruption therefore entails redistribution from private to public agents. Unfortunately, Barreto model does not provide analytical results, there is no explicit condition under which corruption prevails in equilibrium, and the solution needs to be found numerically.

In this paper, we explicitly introduce an incentive constraint into a simple dynamic optimization program. In doing so we bridge the gap between the standard neo-classical theory of growth and the mostly static theory of corruption. This way of setting the problem has important consequences both in theory and for the empirical analysis. A key implication is to distinguish the prevailing level of corruption, which is an endogenous variable determined at equilibrium, from its institutional factors. Here, we focus on two institutional parameters. We use the term "technology of corruption" ν to denote the ease with which rent-seekers can capture part of public spending; it depends on the legal framework and its enforcement. The "concentration of political power" θ is defined as the extent to which rent-seekers have more political influence than other people.

A prediction of our theory is that the effects of the two institutional parameters on income growth and equilibrium corruption are different according to the constraints that hold at equilibrium. In other words, the model displays several regimes with different properties. The combination of failing legal and political institutions (high ν and θ) should have more detrimental effects on income growth. Indeed, corruption is made possible by a failing judicial and legal system. A concentrated political power leads to a diversion of public investment, which is detrimental to growth.

To test this theoretical prediction, we need to estimate a system of equations where both corruption and income growth are determined simultaneously by the quality of institutions and other exogenous factors. This leads us to have a singular empirical approach of the link between the level of corruption and income growth, both determined by institutional components. In most studies, the empirical test of this link consists in estimating the direct impact of the level of corruption on the growth rate (Poirson 1998, Knack and Keefer 1995, Meon and Sekkat 2005 show this impact is significant and negative). This paper suggests that this empirical approach suffers from an omitted variable bias since both corruption level and income growth are determined by institutional components. By distinguishing between the institutional setting and the level of corruption, the latter being endogenous, we provide refined empirical results on the link between institutions, corruption, and growth.

In particular, we show that a failing legal system and a high concentration of power favor corruption and that income growth is slower when legal and political institutions are both weak due to a diversion of public investment.

The paper is organized as follows. Section 2 introduces the structure of the model, solves the dynamic problem, and characterizes the different regimes. In Section 3, we report empirical estimations of the main implications of the model, including the description of data, instruments, and tests. Section 4 presents robustness tests. Section 5 concludes.

2. Technology, Preferences, and Voting Equilibrium

2.1. The Model

The model is set up in discrete time. The economy is populated by a mass of identical households of measure N_t growing at rate n. Households choose between working either in the productive sector or in the rent-seeking activity (in this paper we treat rent-seeking and corruption as synonymous). We denote by $1 - x_t$ the share of the population in the productive sector, and by x_t the share in the rent-seeking sector. The model can also be interpreted as if each household was allocating its time optimally between the two activities.

2.1.1. Technology

Public capital K_t is the only stock of capital in this economy. Investment spending is denoted as I_t. Corruption acts as a tax on investment I_t. Rent-seekers are able to extract some of the public investment I_t, which is proportional to their fraction of population. Only a fraction $1 - \nu x_t$ of investment spending is effectively invested while $\nu x_t I_t$ accrues as income for rent-seekers. The parameter $\nu > 1$ reflects the corruption technology of the economy. It is positively related to the ease with which rent-seekers can divert resources. The value $1/\nu$ should be interpreted as the proportion of rent-seekers "needed" to divert 100% of investment. The law of motion of capital is:

$$K_{t+1} = (1 - \delta)K_t + (1 - \nu x_t)I_t$$

with parameter δ being the depreciation rate ($\delta \in (0, 1)$). Denoting the per-capita variables as $k_t = K_t/N_t$ and $i_t = I_t/N_t$, the law of motion of capital can be rewritten as:

$$(1 + n)k_{t+1} = (1 - \delta)k_t + (1 - \nu x_t)i_t. \tag{1}$$

There is one physical good which is used for consumption and investment. Total production Q_t depends positively on labor input $N_t(1 - x_t)$ and on services from capital. The production function is a Cobb–Douglas with constant return to scale:

$$Q_t = (N_t(1 - x_t))^{1-\eta} K_t^{\eta}$$

with $\eta \in (0, 1)$. As in Arrow and Kurz (1970) and Barro (1990), public capital enters the production function directly. As the production function is homogenous of degree one, output per person $q_t = Q_t/N_t$ can be written as

$$q_t = (1 - x_t)^{1-\eta} k_t^{\eta}.$$

Public investment spending is financed by a lump-sum tax T_t paid by every citizen[2]

$$N_t T_t = I_t \Rightarrow T_t = i_t.$$

An alternative would be to tax only people in the productive sector which would introduce an additional channel through which corruption could play a role, i.e., by reducing the fiscal base of the government. To keep the model as simple as possible we abstract from other types of public spending and from public debt.

2.1.2. Preferences and incentives

At each date, households consume their income, which includes either the product of corruption or the return from the productive activity. Their preferences are represented by a CIES utility function $u[\cdot]$ with inter-temporal elasticity of substitution σ. The utility of working in the productive sector U_t is equal to the utility of the income in this sector. We assume that firms operating in this sector are owned by the workers, or, in other words, everybody is self-employed. Workers are thus paid the average product:

$$\frac{Q_t}{N_t(1 - x_t)} = \left(\frac{k_t}{1 - x_t}\right)^{\eta}.$$

They also pay taxes lump sum T_t. Net income per person is thus

$$y_t = \left(\frac{k_t}{1 - x_t}\right)^{\eta} - T_t = \left(\frac{k_t}{1 - x_t}\right)^{\eta} - i_t.$$

The utility in the productive sector is given by:

$$U_t = u[y_t]. \tag{2}$$

The utility from the productive sector U_t is a positive function of x_t, because of marginal decreasing returns to labor.

The utility in the rent-seeking sector V_t is the utility associated with the income from corruption, net of taxes. Since total income from corruption is $\nu x_t I_t$, the income per rent seeker is $\nu x_t I_t/(x_t N_t) = \nu i_t$. If $x_t = 1/\nu$, all spending i_t is diverted by rent-seekers, and there is no incentive for the marginal person to move into rent-seeking. Then,

$$V_t = u\left[\nu i_t - i_t\right] \text{ if } x_t \leq 1/\nu,$$

[2] Note that in the absence of consumption-leisure choice, lump-sum taxation is the same as consumption taxation (e.g., Value Added Tax).

$V_t = u[0]$ otherwise. The individual utility from corruption V_t does not depend on the proportion of the population which is corrupt for $x_t \leq 1/\nu$ but decreases to 0 as soon as x_t is larger than $1/\nu$.

As individuals are identical in terms of preferences and ability, equilibrium corruption x_t is positive only if returns on the two possible activities are equalized. We distinguish three possible cases.

In the first case, the return in the rent-seeking sector is dominated by that in the productive sector for any x_t. In this case, we have

$$x_t^* = 0$$

and

$$\nu i_t < k_t^\eta. \tag{3}$$

In such a situation, corruption does not exist at all. Condition 3 can be understood as a condition on the parameter ν relative to the parameter $1 - \eta$. If ν is large enough, i.e., if the corruption technology is efficient enough, this corner situation will never prevail.

In the second case, there is a value $x_t^\star \in (0, 1/\nu)$ for which the utility from the two activities is equal at equilibrium. The following constraint holds:

$$U_t = V_t \;\Rightarrow\; \left(\frac{k_t}{1 - x_t}\right)^\eta = \nu i_t. \tag{4}$$

Condition (4) states that, at equilibrium, there is a relationship between the share of the population in the rent-seeking sector (x_t) and public capital (k_t), the effectiveness of corruption technology (ν), and the amount of public spending subject to corruption (i_t). This relation, which describes the choice of activity by households, will act as a constraint for the political economy problem and makes the level of corruption endogenous.

In the third case, the income possibilities from rent-seeking are exhausted: $x_t^* = 1/\nu$. In this case we have

$$\nu i_t = \left(\frac{k_t}{1 - 1/\nu}\right)^\eta. \tag{5}$$

In this case, investment i is entirely diverted, implying that the stock of capital k shrinks. If this situation persists over time, income in the productive sector tends to zero, which cannot be an equilibrium solution. Hence, this corner case can only appear temporarily. In the following sections we will assume that $x_t < 1/\nu$ at equilibrium, i.e., we will rule out the possibility of maximum corruption because it is unrealistic and cannot be a long-run equilibrium.

2.1.3. Political economy equilibrium

The levels of public investment i_t and taxes T_t are chosen through probabilistic voting. Assume that there are two political parties, a and b. Each one proposes a policy vector $s^a = (i_t^a, T_t^a)_{t\geq 0}$ and $s^b = (i_t^b, T_t^b)_{t\geq 0}$. The probability that voter i votes for party a is a smooth function of the utility gain associated with the implementation of policy a, given by:

$$F_i(u_i|_{s^a} - u_i|_{s^b}),$$

where $F_i()$ is a continuous cumulative distribution function. As opposed to the median voter model, here the probability that an individual votes for party a is not equal to one every time party a's policy gives him/her higher utility but it increases gradually as the party's platform becomes more attractive. This reflects the fact that voters do not only care about the specific policy measure at hand but also about ideology, which makes the political choice less predictable. Assume now that people in the rent-seeking sector are more responsive to changes in utility than people working in the productive sector. Their responsiveness is given by $F_r(\cdot)$ and $F_p(\cdot)$, respectively, with $F_r'(0) > F_p'(0)$. In a static context, party a maximizes its expected vote share: $(1 - x_t)F_p(\cdot) + x_tF_r(\cdot)$. Party b acts symmetrically, and, at equilibrium, the two proposed policies coincide $s = s^a = s^b$. The chosen policy satisfies the following first-order condition:

$$(1 - x_t)F_p'(0)\,u_p' + x_tF_r'(0)\,u_r' = 0.$$

Hence, the maximization program of each party implements the maximum of a weighted social welfare function (this was first shown by Coughlin and Nitzan (1981)).

In a dynamic context, each party maximizes the discounted sum of its vote share:

$$\max \sum_{t=0}^{\infty} \rho^t((1 - x_t)F_p(\cdot) + x_tF_r(\cdot))$$

with ρ representing its rate of time preference. The weighted social welfare function is:

$$\max \sum_{t=0}^{\infty} \rho^t\,((1 - x_t)\,U_t + (1 + \theta)\,x_t\,V_t) \text{ subject to (1), (6), and } K_0 \text{ given,}$$

$$\text{with} \qquad \nu i_t \leq \left(\frac{k_t}{1 - x_t}\right)^{\eta}. \tag{6}$$

The parameter θ is the additional weight attached to the people in the rent-seeking sector. From above, it is equal to the relative responsiveness of rent seekers to changes in utility:

$$1 + \theta = F_r'(0)/F_p'(0).$$

More generally, it is interpreted as *political power of rent seekers*. If $\theta = 0$ the problem can be interpreted as that of a benevolent social planner giving equal weight to all citizens; if $\theta = \infty$, the social planner is the kleptocratic government envisioned by Kanczuk (1998), maximizing the discounted flow of income from corruption.

2.2. Solution Characteristics

To solve the voting problem we can write the following infinite Lagrangian:

$$\sum_{t=0}^{\infty} \rho^t \Bigg\{ ((1-x_t)U_t + (1+\theta)x_t V_t) + \rho\mu_{t+1}\,[(1-\delta)k_t$$
$$+ (1-\nu x_t)i_t - (1+n)k_{t+1}] + \phi_t \left[\left(\frac{k_t}{1-x_t}\right)^{\eta} - \nu i_t\right] + \omega_t x_t \Bigg\}.$$

The variable μ_t is the Lagrange multiplier associated with the equality constraint (1). The variables ϕ_t and ω_t are the Kuhn–Tucker multipliers associated with the constraints:

$$\nu i_t \le \left(\frac{k_t}{1-x_t}\right)^{\eta}$$
$$0 \le x_t.$$

The multiplier ϕ_t associated with the incentive constraint is the shadow price of corruption, reflecting the idea that the outcome of the vote has an effect on the type of activity chosen by households. For example, if voters decide to increase the amount of public investment, more households will work in the rent-seeking sector.

At each date, three cases are possible, depending on which constraint holds. The optimality conditions are derived in Appendix A for the three possible regimes.[3] From these conditions we can analyze how the standard Keynes–Ramsey rule is modified by the presence of corruption. In the next section we consider the different regimes in turn.

2.2.1. Benchmark regime

We start with the regime where Equation (3) holds, so that the incentive constraint is not binding. There is no corruption and public investment is not diverted. We label this case without corruption the *benchmark regime* because it can be seen as a benchmark against which we can evaluate the cases with corruption. From the first-order conditions analyzed in Appendix A we

[3] Note that these cases stand for three regimes at a same equilibrium, and not for three different equilibria. They correspond to different values of the parameters.

derive the following "Keynes-Ramsey" rule:

$$\frac{u'[y_t]}{u'[y_{t+1}]} = \left(\frac{y_{t+1}}{y_t}\right)^{\frac{1}{\sigma}} = \frac{\rho\left(1-\delta+\eta k_t^{\eta-1}\right)}{1+n}, \tag{7}$$

i.e., the higher the net marginal product of capital $1-\delta+\eta k_t^{\eta-1}$, the more it pays to depress the current level of income to enjoy higher income in the future.

The benchmark case arises if condition (3) holds. This condition can be interpreted as an upper bound on the corruption technology ν. There is another condition for this regime to prevail, which is derived in the Appendix from the positivity of the Kuhn–Tucker multiplier ω_t associated with $x_t \geq 0$. This condition is written as

$$1+\theta < \frac{u[y_t] + u'[y_t]\left(\nu i_t - \eta k_t^{\eta}\right)}{u[\nu i_t - i_t]}. \tag{8}$$

It requires θ not to be too large. For a given corruption technology ν, if θ is large, rent-seekers have much more political weight than productive workers, and it is less likely that the equilibrium without corruption could prevail.

Balanced growth path
In the long-run, variables K_t, I_t, and Y_t all grow at the same rate n. All the per capita variables converge to a constant level. The following proposition establishes the essential properties of the equilibrium without corruption and the conditions for reaching it.

PROPOSITION 1: *Let the Modified Golden Rule stock of capital k_ρ be given by:*

$$1-\delta+\eta k_\rho^{\eta-1} = \frac{1+n}{\rho}. \tag{9}$$

If there exists a balanced growth path solution to the voting problem which satisfies

$$\nu < \frac{k_\rho^{\eta-1}}{n+\delta} = \frac{(1+n)/\rho - (1-\delta)}{(n+\delta)\eta} \tag{10}$$

and

$$1+\theta < \frac{u[y_\rho] + u'[y_\rho]\left(\nu(n+\delta)k_\rho - \eta k_\rho^{\eta}\right)}{u[(\nu-1)(n+\delta)k_\rho]}, \tag{11}$$

with $y_\rho = k_\rho^{\eta} - (n+\delta)k_\rho$, then there is no corruption, i.e., $x=0$, and in the long-run $k = k_\rho$.

In Equation (9) the marginal productivity of capital is equal to the growth factor of the population divided by the discount factor ρ. According to conditions (10) and (11), it will prevail if the corruption technology is not too efficient, and if the political weight of rent-seekers is not too high.

The threshold on θ depends on ν. If corruption technology is weak enough (say ν close to 1), θ can be very large.

2.2.2. Lower investment without corruption

In this regime, the incentive constraint holds with equality at $x_t = 0$. Intuitively, the government will have to lower investment i_t in order to deter households from rent-seeking. There is less capital k in the economy as a consequence of the drop in investment i necessary to deter corruption. Corruption acts like a negative externality which can be limited at a certain cost. In Appendix A we compute a modified Keynes–Ramsey rule:

$$\frac{u'[y_{t-1}]}{u'[y_t]} = \frac{\rho\left(\eta k_t^{\eta-1} + 1 - \delta\right)}{1+n} + \frac{\rho\left(\eta k_t^{\eta-1} + 1 - \delta\right)}{1+n}\frac{\phi_t}{u'[y_t]} - \nu\,\frac{\phi_{t-1}}{u'[y_t]}.$$

Compared to Equation (7), the last two terms on the right-hand side are new and reflect the depressing effect of potential corruption on investment. The interpretation is easier when we look at the rule at steady state, which leads to a modified "Modified Golden Rule" that incorporates corruption:

$$1 - \delta + \eta k_t^{\eta-1} = \frac{1+n}{\rho}\frac{u'[y]}{u'[y]+\phi} + \nu\,\frac{\rho}{(1+n)}\frac{\phi}{u'[y]+\phi}.$$

Compared to the benchmark regime there are two modifications. The discounted growth rate of the population is now multiplied by a factor smaller than one: $u'[y]/(u'[y]+\phi)$. And the net marginal productivity of capital is equal to the sum of this discounted growth rate of population with a positive term depending on the shadow price of corruption. Comparing this sum on the right-hand side to the simpler term $(1+n)/\rho$ of the benchmark model, we see that

$$\frac{1+n}{\rho}\frac{u'[y]}{u'[y]+\phi} + \nu\,\frac{\rho}{(1+n)}\frac{\phi}{u'[y]+\phi} > \frac{1+n}{\rho} \Leftrightarrow \nu > \left(\frac{1+n}{\rho}\right)^2.$$

Hence, if ν is large enough, i.e., if potential corruption is sufficiently high, the incentive constraint has a negative impact on investment in k, which allows corruption to be kept out of the economy.

2.2.3. Interior regime

In this case, Constraint (4) holds. Two forces work in opposite directions: the interest of having households working in the productive sector against the additional utility drawn from the presence of rent-seekers.

To better understand the role of the incentive constraint, we look at the optimal value of the corresponding multiplier, ϕ_t, the shadow price of corruption. From the optimality conditions of Appendix A, we obtain:

$$\phi_t = \frac{-\theta u[y_t] - u'[y_t]\eta(1-x_t)^{-\eta}k_t^{\eta} + \nu\rho\mu_{t+1}i_t}{\eta(1-x_t)^{-\eta-1}k_t^{\eta}} > 0.$$

The shadow price of corruption is the sum of three terms. The first term $-\theta u[y_t]$ is the direct effect of x_t on the objective function. For a correct interpretation of this term, we need to assume that the utility function is positive which requires $\sigma > 1$ with the CIES functional form. Everything else being kept constant, when corrupt people carry more weight ($\theta > 0$), the cost of the constraint is decreased. The second term is negative too: if there is more corruption, fewer people work in the productive sector, but their individual productivity is higher because of decreasing marginal returns to labor. The third term $\nu\rho\mu_{t+1}i_t$ is positive. It involves the shadow price of capital μ_{t+1} and reflects the loss of investment and future capital because of corruption. If one needs to have a measure of the level of corruption in the model, this term provides one, as being the product of the extent of corruption $\nu\xi$ with its implicit cost in terms of future capital μ_{t+1} (discounted by ρ).

We computed the Modified Golden Rule in Appendix A. Unfortunately, the computations are very involved and make it impossible to derive clear-cut results as we did for the other regimes.

2.3. Numerical Illustration

To illustrate Proposition 1 as well as the properties of the different long-run regimes, we run a numerical example. The technology parameter is set at $\eta = 1/4$. Considering that one model period is equivalent to 1 year, we assume population growth at rate $n = 0.005$, a discount factor of 0.96, and depreciation rate $\delta = 0.04$. To ensure $u[.] > 0$ we set the intertemporal elasticity of substitution at $\sigma = 2$.[4]

The benchmark regime arises when ν and θ are small. Conditions (10) and (11) can be written explicitly as:

$$\begin{aligned} \nu &< 7.722 \\ 1+\theta &< \frac{1.165(0.166\nu + 1.906)}{\sqrt{\nu - 1}}. \end{aligned}$$

The shaded area in Figure 1 represents the surface in the plane $\{\nu, \theta\}$ satisfying this system of inequalities and for which the benchmark regime arises. Although we have no formal conditions on the parameters to delimit the two other regimes, the regime with lower investment but no corruption arises when θ is low and ν is high, while the interior regime arises when both parameters are high. Finally, when θ is high and ν is low (dictatorship but rule

[4] Macroeconometric estimates of this parameter based on regressions of consumption growth rates on real rates of return tend toward a value lower than one; on the contrary, micro estimates based on cross-individual differences in after-tax real interest rates that derive from arguably exogenous differences in capital tax rates yield to estimates around 2 (see Gruber 2006).

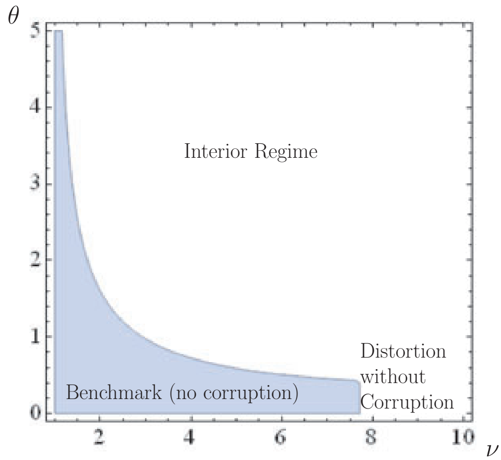

Figure 1: Regimes in the $\{\nu, \theta\}$ plane.

Table 1: Steady-state comparisons

	ν	θ	**Regime**	ϕ	x	$\rho\,\mu\,\nu\,x$	i	k	q
A	3	1/4	Benchmark	0	0	0	0.184	4.093	1.422
A′	4	1/4	Benchmark	0	0	0	0.184	4.093	1.422
B	9	1/4	Lower invest	0.019	0	0	0.150	3.337	1.351
C	3	3/2	Interior	0.394	0.27	2.167	0.406	1.597	1.218
C′	4	3/2	Interior	0.331	0.19	2.171	0.288	1.422	1.153

of law), one can either be in the benchmark regime or be in the interior regime depending on whether the second inequality holds.

Table 1 gives five examples of steady states. Examples A and A’ describe a benchmark regime where ν and θ satisfy the system above. There is no corruption ($x = 0$), the shadow price of corruption is zero too ($\phi = 0$) and the stock of capital is determined by the Modified Golden Rule (9). In Example B, we assume the same low political weight attached to rent-seekers ($\theta = 1/4$) but increase the efficiency of the corruption technology ν to $\nu = 9$. The economy switches to a regime where corruption is still absent, but its possibility imposes a reduction in public investment. This is reflected by the fact that the shadow price of corruption is now positive and public investment is reduced. The capital stock and output are slightly reduced, compared to the benchmark. Examples C and C’ are cases of interior regimes, which arise for high values of θ. In this case the rent-seekers have such a high political weight ($\theta = 3/2$) that public investment is encouraged. At C, for example, households spend 19% of their time on corruption activities. Notice that investment i is very high but a large fraction ($\nu x = 4 \times 0.19 = 0.76$) is diverted, implying that the stock of capital k is low. Looking at output in the

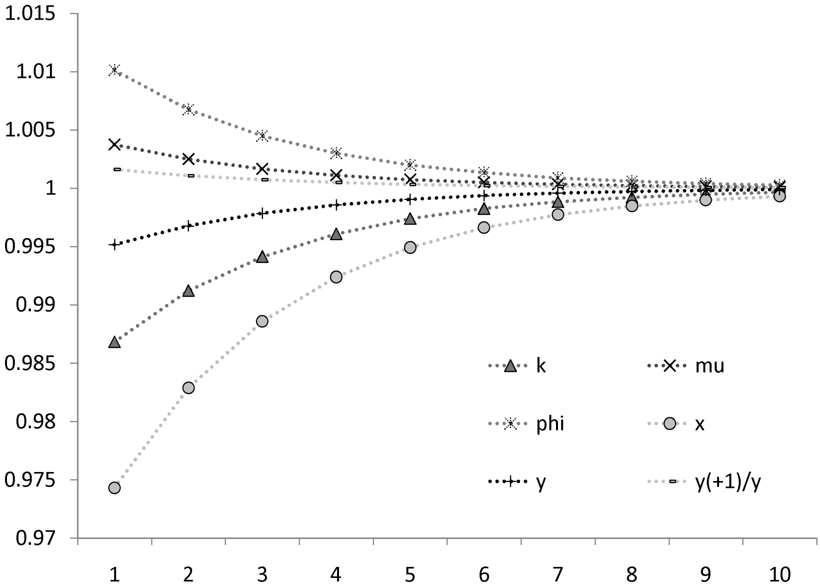

Figure 2: Convergence to the steady state in the interior regime (% deviation from steady state).

five examples, we observe large differences across regimes, and small differences within regimes. A, A' and B are associated with relatively high income y, while examples C and C' describe a poorer economy with high corruption ρ μ ν x. The empirical analysis of the next section will be based on this across regime variation.

In order to illustrate the dynamic behavior of the model, we have simulated the convergence path to the interior steady-state C' starting from below (with a low initial capital stock). The eigenvalues of the linearized system are equal to 0.6672 and 1.561, reflecting that, with one eigenvalue smaller than one for one predetermined variable (capital), the Blanchard and Kahn (1980) conditions for a saddle path are met. In addition, as in any one-sector neo-classical growth model, dynamics are monotonic (at least, as long as there is no regime shift in the transition). The simulation results are displayed in Figure 2. We observe that corruption x increases as the capital stock approaches its steady-state level from below. This can be understood by considering Equation (4). A higher stock of capital requires more replacement investment i_t which gives "more food" to the rent-seekers (right-hand side of Equation (4)); this effect dominates the one according to which the productive sector also benefits from higher capital but with decreasing returns (left-hand side of Equation (4)).

3. Empirical Analysis

3.1. Theoretical Predictions and Empirical Strategy

Our theoretical model is a neo-classical growth model with usual long-run properties according to which all variables in level (Y_t, I_t, K_t) grow at a constant exogenous rate n and per-capita variables converge to a steady-state level determined by parameters ν, θ, A, n, and ρ. Along the dynamic path, the growth rate of income per capita depends on the distance between income per capita and its steady-state value. Hence, keeping income per capita constant, any increase in a parameter influencing positively the steady state will also temporarily raise the growth rate.

What is unique in our set-up, compared to a standard neo-classical growth model, is not only that corruption is endogenous, but also that the relation between the parameters and the dependent variables differs according to the regime. The benchmark regime and the regime with lower investment but no corruption correspond to countries with controlled corruption and a high growth rate, which have a low value of θ and a low or a high value of ν, respectively. The interior regime is more likely to correspond to countries with high ν and θ, a low level of income growth and widespread corruption.

Hence, the model leads us to predict that the effects of parameters ν and θ on growth should be weaker in countries with low θ and ν, respectively.

In what follows, we present the data used to measure first the two dependent variables and then the parameters affecting them. We will introduce interaction terms between the variables measuring ν and θ in order to test the key predictions highlighted above. We present the empirical model and the estimation method before discussing the instrumental variables. Then, we present and interpret the empirical results.

3.2. Data, Model, and Method

The two indices used to approximate the level of corruption and the growth rate are described below.

- **Corrup**: The extent of corruption is represented in the model by $\mu\nu x$, the share of spending which is diverted from its aim evaluated with the shadow price of capital. As a proxy for $\mu\nu x$, we use the "Control of Corruption" index ($Corrup_{WB}$) provided by the World Bank and presented by Kaufmann, Kraay, and Mastruzzi (2009). $Corrup = 2.5 - Corrup_{WB}$ where $Corrup_{WB}$ is an aggregate of the results of several survey questions, some of them on the ease of getting involved in corruption ν (e.g. "How well would you say the current government is handling the fight against corruption in the government?"), some others on the level of corruption x (e.g. "How many government officials do you think are involved in corruption?"). Hence, *Corrup* is a measure of the interaction term νx. Contrary to Transparency International's corruption perceptions index, the World Bank index makes it possible to conduct intertemporal as well as cross-country comparisons.[5]

- **Growth**: This index measures the logarithm of constant PPP GDP per capita growth on 10 years, based on the constant PPP GDP per capita index provided by the WDI database. Using *Growth* as a dependent variable and regressing it on a set of explanatory variables including $\ln Y_0$ is equivalent to regressing $\ln Y$ on the same set of variables.

Parameters are measured with the following variables.

1. **Techcor**: ν is measured by the World Bank *Rule of Law* index (GRICS). This index is an aggregate of perceptions of the quality of contract enforcement and property rights, the likelihood of crime, and the effectiveness and predictability of the judiciary (Kaufmann, Kraay, and Mastruzzi 2009). We use the following transformation: *Techcor* = 2.5 − *RuleofLaw*, so that the lower the variable *Rule of Law*, the lower is the probability of a corrupt public agent being caught and punished, and the more efficient the technology of corruption (*Techcor*).
2. **Polbias**: As a proxy for θ, that is the political weight given to rent-seekers in the objective function, we use an indicator of the lack of political rights taken from Freedom House. Limited political rights for the population indicate a strong concentration of power in the hands of very few people who, in the context of vote-buying mentioned above, are presumably rent-seekers. We subtract 1 from the original index in order to obtain a variable ranging from 0 (if the country provides very extended political rights to its citizens) to 7 (if the citizens have no political rights). Figure B1 in Appendix B represents the countries in the plane $\{\nu, \theta\}$.
3. **Patience**: This variable indicates the number of years the party of the chief executive has been in office, taken from Beck et al. (2001). It is used as a proxy for the discount factor ρ. A "forward-looking" variable

[5] However, measurement errors demand that we proceed with great caution. In the following subsection, we make explicit the method we use to deal with the endogeneity implied by measurement errors. Although it confuses the extent and the level of corruption, this index has the advantage of measuring mainly public corruption and, within public corruption, mainly political corruption. We use the World Bank's measure of corruption based on perception surveys, although it suffers measurement problems. To our knowledge, quantitative indices of political public corruption, not based on perceptions, do not allow international comparisons since they are only available for Italy: Golden and Picci (2005) approximate the level of corruption in a given region by calculating the difference between the amounts of physical public capital and the amounts of investment cumulatively allocated for these public works. Other indices used to measure public corruption (e.g. from Business International (Ehrlich and Lui 1999) or Political Risk Services (Mauro 1997)) have the same disadvantages. But the World Bank index reduces each source-specific bias by combining them.

indicating in how many years the next elections will take place would have fitted better with the discount factor but, to the best of our knowledge, this is not available. Here, we assume that political groups can predict their term of office relatively well. Thus, if the political group has been in power for a long time, which was expected, the group is more patient and values the future more than parties which expect to be in power for a shorter period.[6]

4. **Pop**: The rate of growth of the total population, taken from the World Development Indicators (WDI) database, gives us n.
5. **Productivity**: Total factor productivity is normalized to one in the theoretical model. In the empirical exercise, we use two dummy variables to control for geographic conditions affecting productivity: **Tropic** which is equal to 1 if the country is located between the tropic of Cancer and the tropic of Capricorn, 0 otherwise; and **Ldlock** equal to 1 for landlocked countries, and to 0 otherwise.

We also introduce the logarithm of the 10-year-lagged constant PPP GDP per capita, $\ln \mathbf{Y_0}$. This is provided by the WDI database. Measurement errors, simultaneity and omission of variables are potential sources of endogeneity. We present the instruments we use to control for endogeneity below.

In the benchmark regime, the endogenous variables are not affected by small variations in ν and θ. As mentioned above, countries in such a situation also have more extended political rights and rule of law, respectively. To control for this possibility, we add an interaction term $Techcor * Polbias$ in the list of regressors.

We estimate a restricted form system of two equations where each endogenous variable is a function of the measured parameters and initial conditions:

$$\begin{cases} Corrup_{it} = \beta_1 + \beta_2 Techcor_{it} + \beta_3 Polbias_{it} + \beta_4 Techcor * Polbias_{it} \\ \qquad + \beta_5 Patience_{it} + \beta_6 Pop_{it} + \beta_7 Tropic_{it} + \beta_8 Ldlock_{it} + \beta_9 \ln Y_{0it} + \rho_{it} \\ Growth_{it} = \gamma_1 + \gamma_2 Techcor_{it} + \gamma_3 Polbias_{it} + \gamma_4 Techcor * Polbias_{it} \\ \qquad + \gamma_5 Patience_{it} + \gamma_6 Pop_{it} + \gamma_7 Tropic_{it} + \gamma_8 Ldlock_{it} + \gamma_9 \ln Y_{0it} + \varsigma_{it}. \end{cases}$$

Estimates are run on even-year data for the period 1996 to 2004 on 62 countries using a three-stage least-squares (3SLS) procedure. We first estimate an unrestricted model (see Table B1 in Appendix B). At each step, we perform a Wald test that the least significant parameter of each equation is null. If the p-value of a coefficient is above 0.15, we reject the coefficient at

[6] This does not imply that dictators should be considered more patient. Dictatorships do not necessarily last longer than democracies. For instance, Zimbabwe or Madagascar have very short-term governments compared to Botswana. More than by the time they last, dictatorships are characterized by a high concentration of power, which is captured by *Polbias*.

the following step. Hence, at the end of the procedure, we retain a restricted model for which all the coefficients have a low p-value (below 0.15).

The three-stage least-squares method has several advantages. First, it reduces simultaneity biases. If there is a correlation between the regressors and the error terms, 3SLS estimators are still consistent, unlike ordinary least-squares estimators. Secondly, 3SLS provide estimators correcting not only for the residuals' heteroskedasticity (residuals' variance depends on the technology of corruption and the extent of political rights because these partly reflect the quality of political and legal institutions) but also for the correlation between the residuals of two distinct equations in the system. Indeed, the correlation between the residuals of the regressions of corruption and growth is equal to -0.25 and significant at the 1% level: some omitted explanatory variables are common to the three equations. By taking into account such a correlation between the residuals of different equations, 3SLS yields more efficient estimators than equation-by-equation 2SLS or classical estimations of panel data. Finally, 3SLS estimation is also preferable to fixed effects insofar as it preserves transversal information contained in the data and since our variables, in particular those of corruption, are quite stable over time.

As mentioned above, the variables $Techcor$, $Polbias$, and $Patience$ suffer from measurement errors with respect to the actual technology of corruption, the lack of political rights, and the discount factor. For reinforcing the treatment of endogeneity, we introduce the following instrumental variables in the first stage of the procedure:

- **antiq** is an index of the depth of experience of state-level institutions, or state antiquity, as developed by Bockstette, Chanda, and Putterman (2002). We use it here as an instrument for political and legal infrastructure. Bockstette, Chanda, and Putterman (2002)'s paper documents how the state antiquity index is an appropriate instrument for institutional quality, and in particular for social infrastructure as measured by Hall and Jones (1999).
- **legsoc**, **legfr**, and **legbr** are dummies equal to 1 if the country's legal system has a socialist, a French, or a British origin, respectively. Using the legal origin as an instrument for the rule of law follows La Porta et al. (1998), who show the greater capacity of British common law systems to protect property rights.
- **polbiaslag** is the 10-year lagged index of political rights.
- **poplag** is the 10-year lagged index of the growth rate of the population.

We also tried to include the percentage of natural resources exports in GDP in the set of instruments. This index is often used as an instrument for the level of corruption since abundant natural resources create strong incentives to rent-seeking, and hence to corruption (Leite and Weidmann

1999). These exports being given as a percentage of GDP, we suspect this instrument of being too endogenous. Adding this variable does not change the main results but worsens the instrument validity tests.

We perform two tests for evaluating the validity of using instrumented estimations. The Sargan overidentification test and the Cragg–Donald (CD) F statistic (see Cragg and Donald 1993, Stock and Yogo 2002, and Stock, Wright, and Yogo 2002). These two tests are presented at the bottom of Table 2. They both suggest that the instruments are valid. We also report the first-stage regressions in Appendix B (see Table B2). They suggest a few points. First, state antiquity reinforces a lack of democracy. At the same time, states which became independent more recently tend to have weaker legal systems—favoring corruption—and to be weaker democracies. When

Table 2: Estimation of the restricted model of two simultaneous equations

Model	**3**	
	Dependent Variables	
Explanatory Variables	***Corrup***	***Growth***
Techcor	1.21***	−0.03
	(0.08)	(0.09)
Polbias	0.45**	0.10
	(0.20)	(0.12)
Techcor ∗ *Polbias*	−0.14**	−0.10*
	(0.07)	(0.05)
Patience.10^{-1}	−0.14***	0.24***
	(0.05)	(0.05)
Ldlock	0.13*	−0.16**
	(0.07)	(0.07)
Tropic		−0.30***
		(0.08)
$\ln Y_0$		−0.30***
		(0.08)
Pop.10^{-1}	−1.94**	
	(0.90)	
Observations	304	
Instruments	***legbr legsoc legfr antiq poplag polbiaslag Tropic Ldlock*ln Y_0**	
Sargan test	0.77	1.47
p-value	(0.86)	(0.48)
CD F stat.	1.32	2.66

Notes: Standard errors in parentheses: ***, **, and * denote coefficients significantly different from zero at the 1%, 5%, and 10% level, respectively.

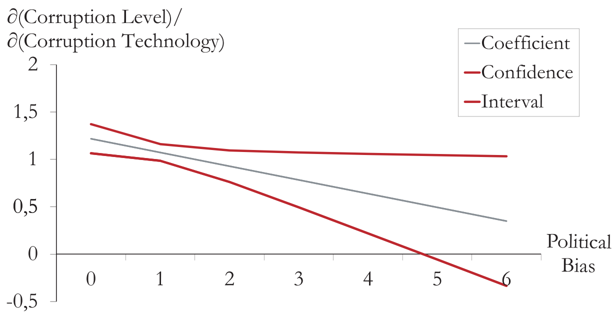

Figure 3: Partial effect of ν on the level of corruption.

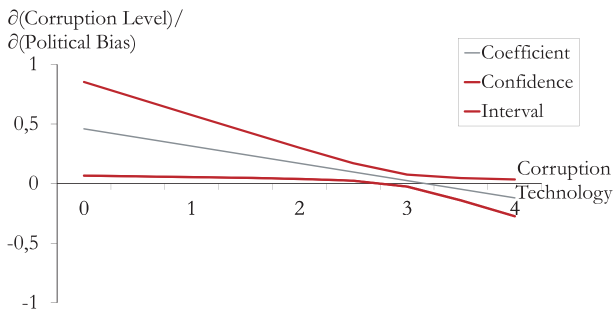

Figure 4: Partial effect of θ on the level of corruption.

the country was colonized for a long time, a deeper experience of state-level institutions may strengthen mechanisms for circumventing the legal system as efficiently as authoritarian regimes which deny political rights to their citizens. But a longer experience of independent statehood and autonomy helps to build a stronger political and legal system. Regarding the origin of the legal system, our results are in line with legal-origins theories comparing the effects of common law and civil law (La Porta et al. 1998, Beck and Levine 2003). Indeed, legal systems with a French or socialist origin prove less efficient to protect property rights than those of British origin.

3.3. Results

The results of our main estimation (Model 3) are presented in Table 2. As mentioned above, two tests were run to check that the instruments we used were valid. The coefficients associated with the explanatory variables indicate their marginal effects on the dependent variables. However, because we use an interaction term *Techcor* $*$ *Polbias*, the partial effects of *Techcor* and *Polbias* have to be calculated. The marginal effect of *Polbias* on the level of corruption is given by $\beta_3 + \beta_4$*Techcor* for each country i. Figure 4 represents such an effect according to the quality of the legal system.

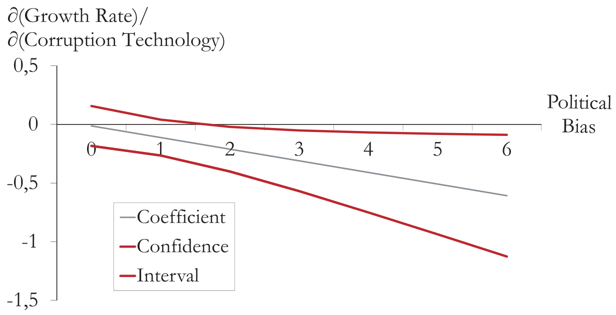

Figure 5: Partial effect of ν on GDP growth.

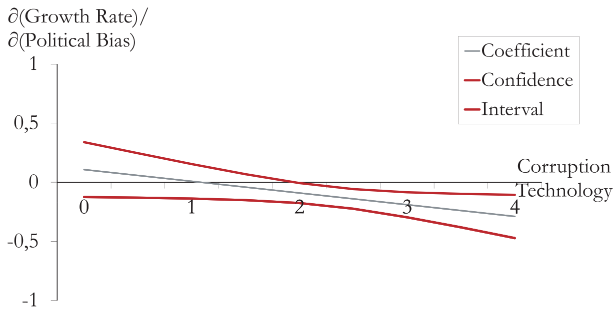

Figure 6: Partial effect of θ on GDP growth.

Similarly, the marginal effects of *Techcor* and *Polbias* on GDP growth are equal to $\gamma_2 + \gamma_4 Polbias$ and $\gamma_3 + \gamma_4 Techcor$, respectively. These effects are shown in Figures 5 and 6.

As expected, the *technology of corruption* (ν) appears to have a positive impact on the **level of corruption** and its coefficient is significant at the 1% level. When the judiciary does not manage to implement the law, corruption is made easier and less condemned, and the interior regime is more likely to prevail. A failing legal system reinforces corruption but this effect gets lower as political power is increasingly concentrated (see Figure 3). This is in line with Mohtadi and Roe (2003): when political rights are extended, a weak judicial system combined with easier entry in public affairs is more favorable to the expansion of rent-seeking activities at first. In the same way, the *lack of political rights* (θ) is linked to higher levels of corruption as well, but it enhances the level of corruption significantly only in countries where the technology of corruption is poor, as shown in Figure 4. In weak or non-democratic regimes, political power is unevenly distributed, and it is likely that rent-seekers have more political weight, which makes the rent-seeking activity more attractive. Then, the level of corruption depends on the quality of both the legal and political systems. But it seems that both determinants are substitutes rather than complements: a good technology of corruption, proxied by a weak rule of law, facilitates corruption all the more in a context of large political rights. This result suggests that the indicator used to approximate the level of corruption might measure not only effective corruption but also potential corruption. Counterfactual calculations show, for example, that if Burundi's technology of corruption in 2000 had been equal to that of the United States, its level of corruption would decrease from 3.77 to 2.76. Similarly, if Zimbabwe experimented the same technology of corruption as Denmark in 2004 (0.59 instead of 3.04, that is divided by 5), the level of corruption in Zimbabwe would drop from 3.24 to 1.56 (divided by 2) – as a comparison, the level of corruption in Denmark in 2004 was equal to 0.12.

In the regression of **growth**, $Techcor$, standing for ν, has a negative and significant coefficient: whatever the extent of political rights in a country, the *technology of corruption* slows growth down. But the more political power is concentrated, the more the absence of rule of law (easy access to corruption) hampers growth (see Figure 5). Countries in this situation stand in the interior regime described above (with high values of ν and θ). On the opposite, small values of θ correspond to the regime with lower investment but no corruption: a good predatory technology means a high potential corruption which leads voters to reduce public investment in order to deter corruption. This is also harmful to growth but less than an increase in public investment aiming at "feeding rent-seekers," which occurs in the interior regime.

Similarly, as Figure 6 shows, the lack of political rights damages growth all the more as the legal system is less developed. At one extreme, in countries where the predatory technology is weak, there is neither potential nor effective corruption. So, even if the political power is highly concentrated, public investment is not distorted and the extent of political rights has no incidence on growth, as in the benchmark regime (left panel of Figure 6). At the opposite extreme, if the predatory technology is well developed, corruption is potentially high. When rent-seekers concentrate political power in their hands, corruption is effective and public investment is increased, which weakens growth, as in the interior regime (right panel of Figure 6).

Simulating GDP per capita growth in Burundi, Ethiopia, and Zimbabwe with the values of the United States, Norway, and Denmark, respectively, have higher effects if the value being simulated is ν rather than θ. If Burundi's extent of political rights were equal to those in the United States, then Burundi's growth rate in 2000 would increase from 0.68% to 2.15 compared to 3.86% if it had the same technology of corruption. If the technology of corruption in Zimbabwe were as weak as in Denmark, its growth rate would rise from 1.05% to 2.72%, compared to only 1.87% if its political power was similarly distributed. Hence, an interesting result of our estimation is that improving the quality of the judicial system reduces corruption and favors growth more than extending political rights. This is perfectly in line with the result of Rigobon and Rodrik (2005) according to which democracy and the rule of law are both good for economic performance, but the latter has a much stronger impact on incomes.

The growth rate decreases significantly when *initial GDP per capita* is higher, capturing a catch-up effect. Then, all other things being equal, the *population growth rate* has a negative and significant impact on the level of corruption. As for *patience*, approximated by the number of years the party of the chief executive has been in office, it appears to have a positive and significant impact on the growth rate but a negative one on the level of corruption: the more impatient the government, the more extensive the level of public corruption and embezzlement and the weaker the growth rate, reflecting a will to plunder resources intensely while in office. The two dummies controlling for *geographic conditions* have significant coefficients in the regression of growth rate. As expected, hard climatic conditions and being landlocked threaten growth.

4. Robustness Estimations

In this section, we provide robustness estimations so as to check that the results and mechanisms presented in the previous section are still valid with another set of instruments and with other specifications of the model. Results are reported in Table 3.

We first modify the panel of instruments by introducing the logarithm of the number of years of independence of the state: **yrind**. It is meant to capture the autonomy of the political and legal system and its capacity to influence or resist foreign influence. Results of the estimation based on this set of instruments are presented in model 3.1. The significance and signs of explanatory variables are not altered. The global marginal effects of $Techcor$ and $Polbias$ on the level of corruption and on the growth rate are very similar to those obtained through our main estimation (model 3).

Then, in model 4, yearly dummies are added to the list of regressors to capture specific effects due to time variations. 1996 is the excluded yearly dummy variable. The yearly dummies are significant only in the regression of corruption. Their negative signs reveal that the level of corruption steadily declines after 1996. However, taking into account such a gap in the index of corruption after 1996 does not have any incidence on the main results commented above. Finally, model 4.1 combines the new specification including year dummies and the new set of instruments including $yrind$: results are not altered by such changes either.

Finally, in order to check that standard errors of the estimated coefficients were not artificially reduced by a large number of similar data points (corruption data are relatively persistent over time), we estimated the same system for every year separately. In a majority of cases, the effects of ν and θ on corruption and income growth remain significant, at least at the 10%-level.

Table 3: Robustness estimations

Model	**3.1**		**4**		**4.1**	
Explanatory variables	**Dependent variables**					
	Corrup	***Growth***	***Corrup***	***Growth***	***Corrup***	***Growth***
Techcor	1.22***	−0.01	1.22***	−0.04	1.22***	−0.02
	(0.08)	(0.09)	(0.08)	(0.09)	(0.08)	(0.09)
Polbias	0.46**	0.11	0.46**	0.09	0.47**	0.10
	(0.20)	(0.12)	(0.20)	(0.12)	(0.20)	(0.12)
$Techcor * Polbias$	−0.14**	−0.10**	−0.15**	−0.09*	−0.15**	−0.10**
	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)
$Patience.10^{-1}$	−0.14***	0.25***	−0.14***	0.24***	−0.14**	0.24***
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Ldlock	0.13*	−0.15**	0.14**	−0.16**	0.14**	−0.15**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Tropic		−0.31***		−0.29***		−0.31***
		(0.08)		(0.08)		(0.08)
$\ln Y_0$		−0.29***		−0.31***		−0.29***
		(0.08)		(0.08)		(0.08)
$Pop.10^{-1}$	−1.98**		−1.90**		−1.95**	
	(0.89)		(0.89)		(0.88)	
Year 1998			−0.14**	0.01	−0.14**	0.01
			(0.07)	(0.06)	(0.07)	(0.06)
Year 2000			−0.16**	0.05	−0.16**	0.05
			(0.07)	(0.06)	(0.07)	(0.06)
Year 2002			−0.19***	0.03	−0.19***	0.03
			(0.07)	(0.06)	(0.07)	(0.06)
Year 2004			−0.22***	0.06	−0.22***	0.06
			(0.07)	(0.06)	(0.07)	(0.06)
Observations	304		304		304	
Instruments	***yrind legbr legsoc legfr antiq poplag polbiaslag Tropic Ldlock* ln Y_0**		***legbr legsoc legfr antiq poplag polbiaslag Tropic Ldlock* ln Y_0**		***yrind legbr legsoc legfr antiq poplag polbiaslag Tropic Ldlock* ln Y_0**	
Sargan test	0.84	1.73	0.76	1.57	0.82	1.82
p-value	(0.93)	(0.63)	(0.86)	(0.46)	(0.94)	(0.61)
CD *F* stat.	1.20	2.28	1.29	2.65	1.18	2.28

Notes: Standard errors in parentheses: ***, **, and * denote coefficients significantly different from zero at the 1%, 5%, and 10% level, respectively.
"CD" stands for "Cragg–Donald."

5. Conclusion

Most of the theory of corruption focuses on incentives, information, and enforcement determining corrupt practices, mainly due to market failures in a static context. The main contribution of our model is to bridge the gap between this mostly static theory of corruption and the standard theory of growth. In particular, we show how rent-seekers' political power and corruption technology affect the level of corruption at equilibrium as well as classical relationships such as the Modified Golden Rule. In addition to developing a dynamic general equilibrium model of corruption and growth, we distinguish two different aspects of corruption: the level of corruption, which is determined endogenously at equilibrium; and the predatory technology (an exogenous variable in the theory and instrumented in the econometrics) which indicates the ease with which resources can be captured.

One key prediction of the model is that several regimes may prevail according to the values of the institutional parameters. One of these regimes is unique in the literature. When the technology of corruption is high but the concentration of political power is low, the government lowers its investment to discourage rent-seeking activities. In this situation, there is no corruption in equilibrium, but the possibility of corruption distorts the policy compared to the first best.

We examine empirically to what extent these regimes apply to different countries. We estimate that both the poor quality of the legal system and the lack of political rights favor corruption. Then, we show that the detrimental effect of an easy access to corruption on the growth rate is higher in countries where political power is strongly concentrated.

Two quantitative findings are worth stressing. First, the effects of predatory technology and political weight of rent-seekers (approximated by the lack of political rights) on the level of corruption and GDP per capita are large. If Zimbabwe had Denmark's rule of law and democracy levels, its annual income growth would double and the level of corruption would decrease from 3.2 to 0.2, inferior to the Norwegian level. Second, improving the quality of the legal and judicial system seems critical to fight corruption and its detrimental effect on growth.

The paper shows that the effect of corruption on policy is not straightforward and depends on both the predatory technology and the concentration of political power. In another paper, we consider an extension of the present set-up to investigate whether corruption not only affects the level of public investment but also its composition (de la Croix and Delavallade 2009).

Appendix A: Solution to the Maximization Problem

We follow de la Croix and Michel (2002) and use the Lagrangian of period t $\mathcal{L}_t$, which is composed of the terms of the infinite Lagrangian which depends on k_t, i_t, and x_t. Replacing U_t by its value from (2) and $V_t = u[\nu i_t - i_t]$, we obtain:

$$\begin{aligned}\mathcal{L}_t = {} & (1-x_t)\,u\left[\left(\frac{k_t}{1-x_t}\right)^{\eta} - i_t\right] \\ & + (1+\theta)\,x_t u[\nu i_t - i_t] + \rho\mu_{t+1}\left[(1-\delta)k_t + (1-\nu x_t)\,i_t\right] \\ & - \mu_t(1+n)k_t + \phi_t\left(\left(\frac{k_t}{1-x_t}\right)^{\eta} - \nu i_t\right) + \omega_t x_t. \end{aligned} \tag{A1}$$

It is equal to the instantaneous utility plus the increase in the value of the capital stock, $\rho\mu_{t+1}k_{t+1} - \mu_t(1+n)k_t$ minus the cost of the inequality constraints. For an optimal solution, the derivatives of $\mathcal{L}_t$ with respect to k_t, i_t, and x_t are equal to zero:

$$\frac{\partial\mathcal{L}_t}{\partial k_t} = \big((1-x_t)\,u'[y_t] + \phi_t\big)\,\eta\left(\tfrac{k_t}{1-x_t}\right)^{\eta} k_t^{-1} + \rho(1-\delta)\mu_{t+1} - (1+n)\mu_t = 0 \tag{A2}$$

$$\begin{aligned}\frac{\partial\mathcal{L}_t}{\partial i_t} = {} & -(1-x_t)\,u'[y_t] + (1+\theta)(\nu-1)\,x_t u'[\nu i_t - i_t] + \rho\mu_{t+1}(1-\nu x_t) \\ & - \phi_t\nu = 0 \end{aligned} \tag{A3}$$

$$\begin{aligned}\frac{\partial\mathcal{L}_t}{\partial x_t} = {} & -u[y_t] + (1+\theta)\,u[\nu i_t - i_t] - \nu\rho\mu_{t+1}i_t - \big((1-x_t)\,u'[y_t] + \phi_t\big) \\ & \times((-\eta)\,k_t^{\eta}(1-x_t)^{-\eta-1} + \omega_t = 0 \end{aligned} \tag{A4}$$

with $y_t = (\frac{k_t}{1-x_t})^{\eta} - i_t$. The multipliers of the inequality constraints should satisfy:

$$\begin{aligned} \phi_t &\geq 0 \\ \phi_t\left(\left(\frac{k_t}{1-x_t}\right)^{\eta} - \nu i_t\right) &= 0 \\ \nu i_t &\leq \left(\frac{k_t}{1-x_t}\right)^{\eta} \\ \omega_t &\geq 0 \\ \omega_t x_t &= 0 \\ -x_t &\leq 0. \end{aligned}$$

The transversality condition is:

$$\lim_{t\to\infty} \rho^t \mu_t k_t = 0. \tag{A5}$$

At each date, four possible cases are *a priori* possible, depending on which constraint is binding. Let us consider these cases in turn, which we label by the sign of the vector (ϕ_t, ω_t).

1. (0, +) This is the regime where Equation (3) holds, so that the incentive constraint is not binding. There is no corruption and public investment is not distorted.
2. (+, +) This case corresponds to a situation without corruption, but where Equation (3) does not hold. The incentive constraint holds with equality at $x_t = 0$.
3. (+, 0) This is the interior regime with $0 < x_t$.
4. (0, 0) This case is not possible because $\omega_t = 0 \rightarrow x_t > 0$ which implies that the incentive constraint should be binding, and thus $\phi_t > 0$.

A.1. Benchmark Regime

We first consider the regime where $x_t = 0$, $\phi_t = 0$, and $\omega_t > 0$. The first-order conditions become

$$\frac{\partial \mathcal{L}_t}{\partial k_t} = u'[y_t]\eta k_t^{\eta-1} + \rho(1-\delta)\mu_{t+1} - (1+n)\mu_t = 0$$

$$\frac{\partial \mathcal{L}_t}{\partial i_t} = -u'[y_t] + \rho\mu_{t+1} = 0$$

$$\frac{\partial \mathcal{L}_t}{\partial x_t} = -u[y_t] + (1+\theta)u[\nu i_t - i_t] - \nu\rho\mu_{t+1}i_t - u'[y_t](-\eta)k_t^{\eta} + \omega_t = 0.$$

The Keynes–Ramsey rule can be derived by replacing μ_t and μ_{t+1} in the first equation by their value computed from the second equation.

$$\mu_{t+1} = u'[y_t]/\rho \qquad \rightarrow$$

$$\frac{u'[y_{t-1}]}{u'[y_t]} = \frac{\rho\left(\eta k_t^{\eta-1} + 1 - \delta\right)}{1+n}.$$

The last equation can be used to derive an expression for the multiplier ω_t:

$$\omega_t = u[y_t] - (1+\theta)u[\nu i_t - i_t] + \nu\rho\mu_{t+1}i_t + u'[y_t](-\eta)k_t^{\eta}.$$

Imposing $\omega_t > 0$ on it gives an upper bound on the parameter θ:

$$1+\theta < \frac{u[y_t] + \nu\rho\mu_{t+1}i_t + u'[y_t](-\eta)k_t^{\eta}}{u[\nu i_t - i_t]},$$

which, after substituting the value of μ_{t+1} given by $\mu_{t+1} = u'[y_t]/\rho$, leads to Equation (8) of the main text.

A.2. Lower Investment without Corruption

This is the regime where $x_t = 0$, $\phi_t > 0$, and $\omega_t > 0$. When the incentive constraint holds with equality, $-u[y_t] + (1+\theta)u[\nu i_t - i_t]$ simplifies into $\theta u[y_t]$. The first-order conditions are:

$$\frac{\partial \mathcal{L}_t}{\partial k_t} = \big(u'[y_t] + \phi_t\big)\eta k_t^{\eta-1} + \rho(1-\delta)\mu_{t+1} - (1+n)\mu_t = 0$$
$$\frac{\partial \mathcal{L}_t}{\partial i_t} = -u'[y_t] + \rho\mu_{t+1} - \phi_t\nu = 0$$
$$\frac{\partial \mathcal{L}_t}{\partial x_t} = \theta u[y_t] - \nu\rho\mu_{t+1}i_t - (u'[y_t] + \phi_t)(-\eta)k_t^{\eta} + \omega_t = 0.$$

A modified Keynes–Ramsey rule can be derived by replacing μ_t and μ_{t+1} in the first equation by their value computed from the second equation.

$$\mu_{t+1} = \frac{u'[y_t] + \nu\phi_t}{\rho} \qquad \rightarrow$$

$$\frac{u'[y_{t-1}]}{u'[y_t]} = \frac{\rho\big(\eta k_t^{\eta-1} + 1 - \delta\big)}{1+n} + \frac{\rho\big(\eta k_t^{\eta-1} + 1 - \delta\big)}{1+n}\frac{\phi_t}{u'[y_t]} - \nu\,\frac{\phi_{t-1}}{u'[y_t]}.$$

A.3. Interior Regime: $0 > x_t > 1$ and $\phi_t \neq 0$

This is the interior regime with $0 < x_t < 1/\nu$. The multiplier $\phi_t > 0$, but $\omega_t = 0$. When the incentive constraint holds with equality, $-(1 - x_t)u'[y_t] + (1+\theta)(\nu - 1)x_t u'[\nu i_t - i_t]$ simplifies into $(\nu x_t(1+\theta) - (1+\theta x_t))u'[y_t]$, and $u'[y_t] = u'[\nu i_t - i_t]$. The first-order conditions are:

$$\frac{\partial \mathcal{L}_t}{\partial k_t} = ((1-x_t)u'[y_t] + \phi_t)\eta\left(\frac{1}{1-x_t}\right)^{\eta} k_t^{\eta-1} + \rho(1-\delta)\mu_{t+1} - (1+n)\mu_t = 0$$
$$\frac{\partial \mathcal{L}_t}{\partial i_t} = (\nu x_t(1+\theta) - (1+\theta x_t))u'[y_t] + \rho\mu_{t+1}(1-\nu x_t) - \phi_t\nu = 0$$
$$\frac{\partial \mathcal{L}_t}{\partial x_t} = \theta u[y_t] - \nu\rho\mu_{t+1}i_t - ((1-x_t)u'[y_t] + \phi_t)(-\eta)k_t^{\eta}(1-x_t)^{-\eta-1} = 0.$$

The shadow price of corruption can be computed by solving the third equation for ϕ_t:

$$\phi_t = \frac{\theta u[y_t] - \nu\rho\mu_{t+1}i_t - (1-x_t)u'[y_t](-\eta)k_t^{\eta}(1-x_t)^{-\eta-1}}{(-\eta)k_t^{\eta}(1-x_t)^{-\eta-1}}.$$

The Keynes–Ramsey rule can be derived by replacing μ_t and μ_{t+1} in the first equation by their value computed from the second equation.

$$\mu_{t+1} = \frac{(1+\theta x_t)\, u'[y_t] - (1+\theta)\,\nu x_t + \nu\phi_t}{\rho(1-\nu x_t)} \qquad \rightarrow$$

$$\begin{aligned}
\frac{u'[y_{t-1}]}{u'[y_t]} &= \frac{\rho(1-\nu x_{t-1})}{(1+n)(1+\theta x_{t-1})}\left((1-x_t)\eta\left(\frac{1}{1-x_t}\right)^{\eta} k_t^{\eta-1} + (1-\delta)\frac{(1+\theta x_t)}{(1-\nu x_t)}\right) \\
&\quad + \frac{\rho(1-\nu x_{t-1})}{(1+n)(1+\theta x_{t-1})}\,\frac{\phi_t}{u'[y_t]}\eta\left(\frac{1}{1-x_t}\right)^{\eta} k_t^{\eta-1} \\
&\quad + (1-\delta)\,\frac{\nu\phi_t - (1+\theta)\,\nu x_t}{(1-\nu x_t)\, u'[y_t]}\,\frac{\rho(1-\nu x_{t-1})}{(1+n)(1+\theta x_{t-1})} \\
&\quad - \frac{\nu\phi_{t-1} - (1+\theta)\,\nu x_{t-1}}{(1+\theta x_{t-1})\, u'[y_t]}.
\end{aligned}$$

Appendix B: Data

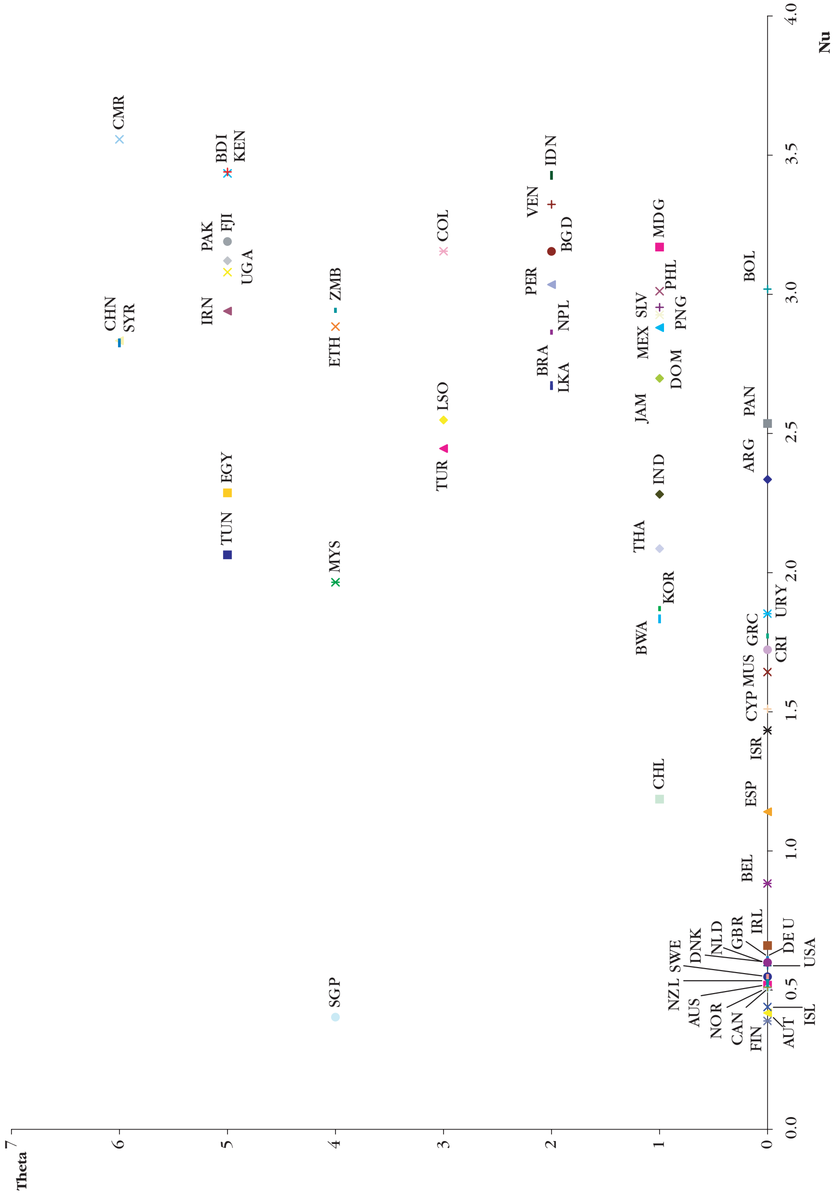

Figure B1: Countries' legal and political institutions

Table B1: From the unrestricted to the restricted model

Model	**1**		**2**		**3**	
Explanatory variables	**Dependent variables**					
	Corrup	***Growth***	***Corrup***	***Growth***	***Corrup***	***Growth***
Techcor	1.23***	0.01	1.23***	−0.04	1.21***	−0.03
	(0.12)	(0.10)	(0.10)	(0.10)	(0.08)	(0.09)
Polbias	0.41**	0.26	0.44**	0.09	0.45**	0.10
	(0.20)	(0.17)	(0.20)	(0.12)	(0.20)	(0.12)
Techcor ∗ *Polbias*	−0.13*	−0.14**	−0.14**	−0.09*	−0.14**	−0.10*
	(0.07)	(0.06)	(0.07)	(0.05)	(0.07)	(0.05)
$Patience.10^{-1}$	−0.12	0.19***	−0.13*	0.24***	−0.14***	0.24***
	(0.08)	(0.07)	(0.07)	(0.05)	(0.05)	(0.05)
Ldlock	0.13	−0.12*	0.13*	−0.16**	0.13*	−0.16**
	(0.09)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Tropic	−0.04	−0.25***	−0.03	−0.29***		−0.30***
	(0.10)	(0.08)	(0.10)	(0.08)		(0.08)
$\ln Y_0$	0.01	−0.29***		−0.31***		−0.30***
	(0.10)	(0.08)		(0.08)		(0.08)
$Pop.10^{-1}$	−1.58	−1.04	−1.78*		−1.94**	
	(0.98)	(0.80)	(0.94)		(0.90)	
Observations	304		304		304	
Exp. Var.	***Ldlock***	$\boldsymbol{Pop.10^{-1}}$	***Tropical***			
$\boldsymbol{P(coeff.=0)}$	**0.90**	**0.20**	**0.73**			
	legbr legsoc legfr					
Instruments			***antiq poplag polbiaslag Tropic Ldlock*** $\boldsymbol{\ln Y_0}$			
Sargan test	0.61	0.05	0.63	1.47	0.77	1.47
p-value	(0.44)	(0.82)	(0.73)	(0.48)	(0.86)	(0.48)
CD F stat.	1.70	1.70	1.48	2.66	1.32	2.66

Notes: Standard errors in parentheses: ***, **, and * denote coefficients which differ significantly from zero at the 1%, 5%, and 10% level, respectively.

Table B2: Relevance test: do the instruments predict the endogenous regressors well?

	Techcor	*Polbias*	*Techcor* ∗ *Polbias*	*Patience*.10^{-1}	*Pop*
antiq	0.21	1.52***	2.93***	1.00***	−0.01
	(1.63)	(4.93)	(2.94)	(3.35)	(−0.05)
yrind	−0.15***	−0.39***	−0.99***	−0.25***	−0.06*
	(−3.97)	(−4.37)	(−3.41)	(−2.88)	(−1.75)
legfr	0.64***	0.69***	1.42*	0.52**	0.23**
	(6.28)	(2.85)	(1.82)	(2.21)	(2.33)
legbr	0.13	0.41*	0.01	0.40*	0.28***
	(1.27)	(1.78)	(0.99)	(1.75)	(2.91)
legsoc.10	0.09***	0.36***	0.90***	0.49***	−0.02
	(3.32)	(5.72)	(4.44)	(7.98)	(−0.84)
poplag	0.03	0.56***	1.23***	0.22**	0.44***
	(0.87)	(6.22)	(4.22)	(2.52)	(11.83)
polbiaslag	−0.04*	0.47***	1.17***	0.26***	−0.01
	(−1.82)	(9.58)	(7.37)	(5.50)	(−0.53)
Ldlock	−0.22**	−0.11	−0.17	0.47**	−0.23***
	(−2.50)	(−0.53)	(−0.67)	(2.34)	(−2.67)
Tropic	0.32***	−0.01	−0.57	0.86***	0.09
	(4.63)	(−0.04)	(−1.08)	(5.48)	(1.36)
ln Y_0	−0.72***	−0.12	−1.33 ∗ **	0.76***	−0.20***
	(−16.52)	(−1.18)	(−4.04)	(7.62)	(−4.62)
Observations	304	304	304	304	304

Notes: T-statistics in parentheses: ***, **, and * denote coefficients which differ significantly from zero at the 1%, 5%, and 10% level, respectively.

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