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19 August 2010

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August 19, 2010

Abstract

Corruption in the public sector is manifested both in collusive and noncollusive forms. Collusive corruption erodes tax compliance and leads to higher tax evasion. Noncollusive corruption stems from abuse of the public position by corrupt public officials to extort bribes from the private agents, thus, reduces their income. Importantly, in both types of interaction with the public sector the private agents are bound to face uncertainty with respect to their disposable incomes, as neither bribes paid nor gains from tax evasion are deterministic. To analyze effects of corruption by accounting for the uncertainty caused by it, a stochastic dynamic growth model is considered. The model also incorporates possibility of nonlinear impact of corruption on production, which implies that corruption deteriorates the growth potential by preventing producers to enter high productive sectors. Most importantly, it is demonstrated that the rise of corruption, by increasing uncertainty, exerts adverse effects on capital accumulation, thus leads to lower growth rates. Hence, this paper resolves the theoretical ambiguity with regards to the overall growth effect of corruption obtained in previous studies.

*I thank Keith Blackburn, Been-Lon Chen, and Yew-Kwang Ng for the valuable comments on the paper.

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1 Introduction

Corruption is defined as a use of public position to create and capture private rents. This opportunism of bureaucracy impacts the economy through various channels.[1] This paper investigates how corruption affects growth by extending the existing models that focused on income redistribution and public sector inefficiencies in two aspects. Namely, the model used in the paper allows for a nonlinear impact of corruption on firms depending on their productivity, and takes into account income uncertainty caused by interactions between corrupt bureaucracy and firms. Importantly, the paper shows that by accounting for these effects one can avoid the existing theoretical ambiguity about the overall effect of corruption on growth. Thus, the paper reconciles the theory with the empirical evidence that finds the overall effect of corruption on economic growth is unambiguously negative.

There is a large body of literature that presents the analysis of the economic impact of corruption, which still appears controversial. The so called "the sand on the wheels" literature recognizes that corruption has a substantial adverse effect on economic growth by creating a tremendous burden on the private sector.[2] However, the literature dubbed as "the grease on the wheel" suggests that corruption can be efficiency improving.[3] In this literature corruption is viewed as an optimal response to market distortions that lessens the burden of regulations, and thus, improves efficiency. Due to these opposing impacts,

[1]See Pellegrini and Gerlagh (2004), Bardhan (1997), Aidt (2003), Alam (1989) for details.

[2]For example see: Barelli and Pessoa (2002); Mauro (2004); Rivera-Baitiz (2002); Rose-Ackerman (2004), Alesina and Angeletos (2005), Aidt (2003), Ali and Isse (2003), Tanzi (2000), Tanzi et al. (2000), Bardhan (1997), Knack and Keefer (1995), Keefer and Knack (1997), Alam (1989), Abed and Gupta (2002).

[3]For example, Leff (1964) suggests that corruption that decreases red tape can be beneficial for economic growth. Similar views are shared by Huntington (1968) and Liu (1985, 1996). Analyzing enforcement of property rights by corrupt bureaucrats Acemoglu and Verdier (1998), and analyzing the officials' actions that involve the exercise of discretion and cannot be monitored perfectly, Klitgaard (1988) have shown theoretically the possibility of the positive output-maximizing level of corruption. Dreher and Gassebner (2007), Meon and Weill (2006) empirically show corruption can be efficiency-enhancing. In line with this reasoning, interestingly, Sepulveda and Mendez (2006) find that the growth-maximizing level of corruption is, in fact, positive.

it appears that overall effects of corruption on economic growth are ambiguous. For example, the results obtained by Mauro (1995) and Barreto (2000) show that the effect of corruption on growth is not straightforward as it may have both efficiency improving and deteriorating characteristics simultaneously.

Unlike the theory, the empirical studies find that corruption is always bad for growth (Mauro, 1995; Meon and Weill, 2006; Mo, 2001; Pellegrini and Gerlagh, 2004). One reason for the theoretical ambiguity of the overall economic effects of corruption, not shared by the empirical studies, might be that not all impacts of corruption are accounted for in the analysis. Along these lines, this paper maintains that the uncertainty created by corruption and the nonlinear impact of corruption on firms depending on their productivity are the important factors that help explain better the relationship between corruption and growth. To accomplish this task the paper synthesizes the ideas developed in the literature that discussed below.

To this end, the possibility of nonlinear effect of corruption has been revealed by several empirical studies. For example, Coppier and Michetti (2006) argue that the relationship between corruption and production have a nonlinear nature. Corroborating them, Barelli and Pessoa (2002) and Svensson (2003) find that corruption redistributes income to bureaucrats through extraction of output from productive firms, thus, decreases net returns to capital in productive sectors, as well as creates entry barriers. Broadman and Recanatini (1999), Djankov et al. (2002), and Svensson (2005) find a strong correlation between higher barriers to market entry and the level of corruption. Mocan (2004) and Svensson (2003) demonstrate that the agents with high income levels pay also more bribes.

Surprisingly, the literature on corruption has largely neglected the growth impact of the uncertainty created by corruption. However, that corruption and income volatility may be related has been well noticed. For example, Denizer et al. (2000) state that corruption can be an important factor contributing to income volatility. One reason for this relationship is that in the environment with corrupt bureaucracy, the allocation of government permits and licenses is unpredictable. Consequently, the private firm's output depending on such permits and licenses is also subject to uncertainty. Moreover, in the environment with a highly corrupt and predatory bureaucracy, there is always a risk that a private agent can be framed and extorted bribes by the public officials, which may be a stochastic process itself. According to Polinsky and Shavell (2001), the extortion outcomes for the private agents, depending on the regulation and enforcement structure and attitudes to risk, may vary quite significantly. In addition, this income volatility might be burdensome, too: the idea that the secrecy stemming out of the illegal nature of corruption imposes an additional burden on the economy has been indicated by Shleifer and Vishny (1993). Campos (2001) argues that predictability of corruption is important and plays significant role in determining its growth impact.

To fill this gap in the literature, this paper formally incorporates the uncertainty stemming from interactions with corrupt bureaucracy and its nonlinear effect on production into a neoclassical growth model. It is done by extending the models used in the literature that maintains that corruption strongly affects economic growth by decreasing the productive input provided by the public sector and imposing a burden on the firms by extorting bribes[4]. Importantly, in the model, there is no *ad hoc* assumption that corruption *a priori* adversely or beneficially impacts economy. Instead, the model allows for both "the sand on the wheel" and "the grease on the wheel" effects of corruption. In such an environment, the agents' disposable income depends on the random outcomes of various interactions with the bureaucrats,[5] and indirectly depends on the productive input provided by the public sector.

[4]For example, Blackburn et al. (2005), Keefer and Knack (2002), Del Monte and Papagni (2001), Barreto (2000) find that the corrupt rent-seeking misallocates public resources from productive use, hence, decrease capital productivity in the economy.

[5]Lin and Yang (2001) used a similar approach to analyze tax evasion.

The main results of the paper are as follows. To reflect the empirical findings that corrupt bureaucracy extort more income from highly profitable firms[6], it is assumed that in the model economy there two sectors: low and high-productivity. Corruption creates entry barriers into the high-productive sector both through extortion of bribes and the associated increase in income uncertainty. The marginal product of capital used in the high-productive sector depends on the infrastructure and services provided by the public sector. Since, corruption reduces the public productive input through increased tax evasion and inefficiency of the government, with an increase in corruption, returns on investment in the high-productive sector are decreased. This outcome further reduces capital accumulation in the high-productive sector and hinders overall economic growth.

The structure of the paper is as follows: first, the setup of the basic model is described, then the implications based on the optimal solution obtained are analyzed.

2 The Model

2.1 Background

The literature classifies corruption as *ex ante* or noncollusive and *ex post* or collusive. In provision of public services that requires red tape we have noncollusive corruption. In this case, corrupt bureaucracy bundles the public services with excessive red tape or the private agents are framed directly. This corrupt behavior coerces private agents to pay bribes to the bureaucrat involved. The extent of such extortion depends on the strength of the rule of law and the judicial system in the economy. This type of corruption leads to bottlenecks (long queues) and shortages of public goods and services.[7] Thus, only those who find it beneficial pay bribes and obtain the service effectively at a higher price. For

[6] See Mocan (2004), Svensson (2003).

[7] See e.g. Shleifer and Vishny, (1993).

example, Svensson (2003) finds that the firms with higher profits also pay more bribes. Mocan (2004) also finds that individuals with higher income and education levels are more likely to be asked for bribes. Hunt (2004) examines how bribes are paid using data from 34 countries, and also finds that rich people pay the most bribes while the poor the least. Thus, the impact of corruption on firms is nonlinear, as while extorting bribes bureaucrats discriminate low productivity agents from high productivity ones.

Collusive corruption happens only after an interaction between the private and public agents occurred. It usually involves the situation when the public agent obtains some information about the private agent's failure in abiding by law or regulation. Consequently, to avoid the penalty for the infringement the private agent is willing to pay bribes to the public agent. A corrupt public agent chooses bribes and conceals the infringement. Thus, a corrupt deal occurs only if it is beneficial for both public and private agents. This situation may arise in relation with costly compliance to regulations, such as taxation.[8]

In both types of corrupt deals the outcomes are random as depends on the private bargaining between the public and private agents, and hence, not known to the private agent beforehand.[9] Therefore, after accounting for both types of corruption stemming from public sector activites, and the income uncertainty caused by them, we summarize that corruption is manifested as: i) corrupt tax inspectors concealing tax evasion for the bribes paid by detected tax evaders; ii) corrupt public officials abusing the authority given to them by attaching excessive red tape to the public services to coerce the private agents to pay bribes; iii) income uncertainty, because in both types of corruption, the outcome for the private agent is random; iv) high-productive firms paying more bribes. Now, given

[8]See Yitzhaki (1974), Lin and Yang (2001), Chen (2003) more on tax evasion.

[9]Some may argue that corruption actually decreases uncertainty as the firms by paying bribes get the service they want right away and do not have to wait in unawareness. The problem with this reasoning is that corrupt deals are not openly conducted and there is no public price list available for the firms to use in their planning. Even if the bribe rates were a common knowledge, it is an illegal transaction, hence, the secrecy (mentioned by Shleifer and Vishny, 1993) makes the outcomes or bargaining uncertain for the private agents.

these main features of corruption, I proceed to the discussion of the environment where corruption occurs.

2.2 The Environment

Let us consider a closed economy with ex-ante identical infinitely-lived agents with zero population growth. Each agent has a measure of utility defined by a function on private consumption c. The instantaneous utility function is given by

$$u(c) = \ln(c). \tag{1}$$

Assume that the agents maximize their expected utility

$$U(0) = \mathbb{E}_0 \left\{ \int_0^\infty \ln(c(t)) \exp(-\rho t) dt \right\}, \tag{2}$$

where ρ is the constant rate of time preference. Further, when it does not distort the underlying idea we omit the time argument.

Assume that there are two types of production technology: low-productivity and high-productivity. In the low-productivity case the production function is given as:

$$y_1 = Ak_1, \tag{3}$$

where, A is the technology coefficient assumed to be exogenous. In case of high-productivity technology, the production function has the following form:

$$y_2 = B(g)k_2. \tag{4}$$

Here y_1 and y_2 are output per capita, k_1 and k_2 is per worker capital, g is per worker public input, which leads to a higher productivity in the second sector: $B(g) > A$.[10] It is also assumed that the production functions are stationary within the planning horizon. The government imposes an income tax at a flat rate τ and uses the revenues to produce productive government services, g. In general, I model with this tax all direct costs caused by the government regulations. Therefore, tax evasion in this model captures general non-compliance to costly regulations. To capture the inefficiency in the public sector, the public input can be expressed as:

$$g = \eta \tau y,$$

where $0 < \eta \leq 1$ is the efficiency coefficient. Thus, it is implicitly assumed that due to corruption (institutional weakness in general) the amount and quality of public services fall.[11]

It is assumed that both types of corruption occurs in this economy. Collusive corruption takes place when the bureaucrats and taxpayers collude to conceal the fact of tax evasion. Non-collusive corruption occurs when the private agents wish to enter the high-productivity sector, which enables them to obtain public services and infrastructure, but also makes them a subject to extortion by the predatory bureaucrats. Optimizing agent may not put all her capital stock into high productive production but rather divide the capital into two parts and engage in production in both sectors. Assume, that $k_1 = (1-n)k$ is the capital employed in the low-productive sector, while $k_2 = nk$ is the capital used in the high-productive sector, where $0 < n < 1$ is the share of capital stock used in the high-productivity sector.

[10] Barro (1990), Futagami et al. (1993), Turnovsky (1996), Tsoukis and Miller (2003), and Chen (2006) show importance of the public sector in economic growth. Although, the model in this paper does not explicitly capture how the public input affects productivity.

[11] As in Del Monte and Papagni (2001), and Blackburn et al. (2005)

2.3 Collusive corruption

To increase their disposable income the agents evade taxes by under-reporting their true income. We assume that the agent reports only $(1-e)y$ of his total income y in per capita terms. To combat tax evasion the government audits taxpayers randomly. The joint probability of being audited and detected is given exogenously by p. The detected evader pays back the due tax liability and some additional fine. This penalty is determined by a penalty rate $\theta = 1 + s$, which includes the tax evaded and a surcharge, s.

An individual taxpayer treats the tax rate, tax audit probability, and penalty rate as given. We assume that a tax inspector can be corruptible with probability p_1. The extent of corruptibility depends on the quality of the institutions or specifically on their effectiveness in controlling corruption. Assuming that corruption exists implies the probability of the tax inspector being corrupt satisfies $0 < p_1 < 1$. Thus we ignore the trivial $p_1 = 0$ case.

Due to corruption the penalty rate becomes random, as when audited and detected a taxpayer may pay bribes instead of the tax penalty. In other words, the effective penalty rate should be adjusted to the following:

$$\theta_1 = \begin{cases} \theta \text{ with probability } q_1 = 1 - p_1, \\ b \text{ with probability } p_1, \end{cases} \tag{5}$$

where $b < \theta$ is the bribe rate, so tax evasion costs the bribe paid instead of the penalty, if the inspector is corrupt.

In general the bribe rate depends on the bargaining power of the involved private agents, which again depends on the institutional arrangements. The less the risk for the tax inspector to be caught and punished the more bargaining power he wields.

The expected value of the random penalty rate then is given by

$$E[\theta_1] \equiv \bar{\theta} = p_1 b + q_1 \theta. \tag{6}$$

Since $0 < p_1 < 1$, the expected penalty rate is lower than it is when the tax inspectors are not corrupt.

Given the context, for an individual taxpayer being audited and getting a corrupt deal is random. Thus, disposable income after taxes and audit is also a random variable given by,

$$y_d = \begin{cases} (1-\tau)y + (1-\bar{\theta})\tau e y, \text{with probability } p, \\ (1-\tau)y + \tau e y \text{ with probability } 1-p. \end{cases} \tag{7}$$

Then the random return on a unit of evaded tax is determined as $x_1 = 1$ with probability $(1-p)$, and $x_1 = -(\bar{\theta}-1)$ with probability p. The expected return on a unit of evaded tax is given by $\bar{x}_1 = 1 - p\bar{\theta}$. Tax evasion is possible only if $\bar{x}_1 > 0$, which implies that $p\bar{\theta} < 1$. This condition is assumed to hold to allow for tax evasion in the model.

It is known that this type of binomial process converges to some limiting normal distribution with the mean equal to $\bar{x}_1$ and the variance of the return on tax evasion is given by:[12]

$$\sigma_1^2 = pq\bar{\theta}^2. \tag{8}$$

Therefore, the random income generated through tax evasion is given by:

$$dx_1 = \bar{x}\tau e y + (\sigma_1 \tau e y) dz_1. \tag{9}$$

[12]See Appendix A1 for derivation, and see Dixit (1993) for details.

2.4 Noncollusive corruption

Private agents are subjected to noncollusive corruption, when they enter the high-productivity sector. This essentially means extortion of bribes by bureaucrats from the private agent involved in the high-productive sector through abuse of their power to license and audit. The rationale here is that the high-productivity may mean organization of production at urban centers with developed infrastructure, and frequently it also may mean a larger size of the enterprises. All these make the producer easily detectable and create motivation for government regulation and red tape. As we discussed earlier, corruption in public good provision occurs through creation of red tape, which is used to extract rents from the private agents.

This interaction is again can be viewed as a stochastic income shock to the private agent. Since, the private agent involved in the high-productivity sector has to deal with corrupt bureaucracy, we assume that the agent pays bribes with some probability. It is clear that there may be a myriad of different ways in which the bureaucrats can extort bribes from the private agents. However, for the sake of tractability, I assume that the bureaucrat extorts 0 bribes with probability, $q_2 = 1 - p_2$, and b_h bribes with probability, p_2, where $0 < b_h$. This binomial process can be viewed, similar to the case of collusive corruption, converging to some limiting normal distribution with the following parameters:

$$\bar{x}_2 = b_h p_2 \tag{10}$$

and

$$\sigma_2 = p_2 q_2 b_h^2. \tag{11}$$

One also may note that as a distribution of bribe payments becomes more symmetric (i.e. $p_2 = q_2$), the uncertainty caused by this corruption grows. Thus, in the environment where corruption is widespread and accepted as a norm, the probability of paying bribes becomes close to unity. This eliminates uncertainty stemming from noncollusive corruption, and hence, decreases the negative effect of corruption. It is clear that under such conditions noncollusive corruption becomes just a type of illegal taxation. In a related study, Shleifer and Vishny (1993) have explained intuitively why centralized corruption results in lower burden for the private agents than it is under decentralized corruption. Our discussion complements their results by indicating that under decentralized corruption the burden of uncertainty is also greater.

Now, we are ready to formulate the impact of noncollusive corruption on private agent's income. Quite intuitively, the bribes extorted are positively related to the income level of the private agent. Thus, similar to the case with taxation, we can write this random income shock caused by noncollusive corruption as:

$$dx_2 = \bar{x}_2 y_2 dt + \sigma_2 y dz_2. \tag{12}$$

Here the first term is the deterministic part of the extorted rents and the second term is its stochastic part.

Based on the above discussions the following proposition is stated.

Proposition 2.1 *An increase of the burden of both types of corruption raises income uncertainty.*

Proof From (6), it is verified that an increase in corruption expressed as an increase in the bribe rate, b, raises directly $\bar{\theta}$. Observing (8), one can establish that this leads to an increase in the variance, σ_1^2.

From (11) it is clear that for any given distribution of outcomes for bribes, and an increase in the levels of bribe rate, b_h, raises uncertainty, measured by σ_2^2. ■

2.5 Overall random income process

By incorporating the both random income shocks to the initial income of the agent, we write the budget equation as:

$$dk = [(1 - \tau + \bar{x}_1 \tau e)y - \bar{x}_2 y_2 - c]dt + \sigma_1 \tau e y dz_1 - \sigma_2 y_2 dz_2 \tag{13}$$

where the first term is the expected part of this random income, the second term is the stochastic part, which depends on the success in tax evasion. Incorporating effects of both types of corruption, disposable income is found as a sum of two stochastic processes: i) tax evasion, ii) and income extortion by corrupt officials.

For the ease of notation I introduce:

$$dv = y\sigma_1 \tau e dz_1 + y_2 \sigma_2 dz_2. \tag{14}$$

This implies that the variance of the summary shock is given by:

$$\sigma^2 = (y\tau e\sigma_1)^2 - 2yy_2\tau e\sigma_{12} + y_2^2\sigma_2^2.$$

We can assume that there is no correlation between the two income shocks, as taxation and other red tape related regulations are implemented by different bureaucrats. Thus, $\sigma_{12} = 0$, and hence, $\sigma^2 = (y\tau e\sigma_1)^2 + (y_2\sigma_2)^2$. This also allows to write the budget equation as:

$$dk = [(1 - \tau + \bar{x}_1 \tau e)y - \bar{x}_2 y_2 - c]dt + \sigma dv.$$

Now, we are ready to consider a household's optimization problem.

2.6 The household's optimization

An individual household maximizes its expected overall utility by choosing the consumption level c, the tax evasion rate e, and the share of capital in the high-productive sector n, subject to the budget constraint:

$$\max_{c,e,n} U = \int_0^\infty \ln(c)\exp(-\rho t)dt, \tag{15}$$

$$s.t.\, dk = [(1-\tau+\bar{x}_1\tau e)y - \bar{x}_2 y_2 - c]dt + \sigma dv, \tag{16}$$

$$0 \leq c \leq (1-\tau+\bar{x}_1\tau e)y - \bar{x}_2 y_2, 0 \leq k, k(0) = k_0, \tag{17}$$

$$0 \leq e \leq 1. \tag{18}$$

This problem is solved by satisfying the following Bellman equation, where I made the following substitutions $y = [A(1-n)+Bn]k$ and $y_2 = Bnk$:

$$\rho I(k) = \max_{c,e,n}\{\ln(c(t)) + I'(k)([1-\tau+\bar{x}_1\tau e][B(1-n)+Kn]k - \bar{x}_2 BnK - c) + \\ +\frac{1}{2}I''(k)[(A(1-n)+Bn)^2k^2(\sigma_1 e\tau)^2 + \sigma_2^2(Bnk)^2]\}, \tag{19}$$

where $I(k) = \max_{c,e} \mathbb{E}_0\left\{\int_0^\infty \ln(c)\exp(-\rho t)dt\right\}$ s.t. (16),(17), (18), is the value function, $\mathbb{E}_0$ is the conditional expectation operator for the given initial value of capital, $k(0) = k_0$.

The FOC of the Bellman equation (19) leads to

$$c(t) = \frac{1}{I'(k)}, \tag{20}$$

$$e(t) = -\frac{I'(k)\bar{r}}{I''(k)\tau\sigma^2[A(1-n)+Bn]k}, \tag{21}$$

$$n = -\frac{I'(k)[\sigma_1 e\tau k]^2 A + kI'(k)[(1-\tau+\bar{x}_1\tau e)(B-A) - \bar{x}_2]}{k^2 I''(k)[(\sigma_1 e\tau(B-A))^2 + (\sigma_2 B)^2]}. \tag{22}$$

A general solution of this differential equation can be expressed in the following form, $I(k) = \frac{ln(k)+C}{\rho}$. A substitution for $I(k)$ in (20),(21),and (22) leads to:

$$c(t) = \rho k, \tag{23}$$

$$e(t) = \frac{\bar{x}_1}{\tau\sigma_1^2[A(1-n)+Bn]}, \tag{24}$$

$$n = \frac{(1-\tau+\bar{x}_1\tau e)(B-A) - \bar{x}_2 - [\sigma_1 e\tau]^2 A}{[(\sigma_1 e\tau(B-A)]^2 + (\sigma_2 B)^2]}. \tag{25}$$

Since, only consumption is a function of capital, we insert back (21) into (19), and obtain:

$$\begin{aligned}
&\rho I(k) = \ln\left({}^{1}/_{I'(k)}\right) + I'(k)\left[(1-\tau+\bar{x}_1\tau e)\left(A(1-n)+Bn)k\right) - \bar{x}_2 Bnk - \left({}^{1}/_{I'(k)}\right)\right] \\
&+\frac{1}{2}I''(k)\left[(A(1-n)+Bn)^2(k\sigma_1 e\tau)^2 + (Bnk\sigma_2)^2\right] = \\
&= \ln(\rho k) - 1 + \frac{(1-\tau+\bar{x}_1)\tilde{A} - \bar{x}_2 Bn}{\rho} - \frac{(\tilde{A}\sigma_1 e\tau)^2 + (Bn\sigma_2)^2}{2\ \rho}
\end{aligned} \tag{26}$$

Here, for ease of notation we use $\tilde{A} = A(1-n)+Bn$. Now, we can confirm that the value function has the assumed functional form and given by:

$$I(k) = \frac{1}{\rho}\left[\ln(\rho k) - 1 + \frac{(1-\tau+\bar{x}_1)\tilde{A} - \bar{x}_2 Bn}{\rho} - \frac{(\tilde{A}\sigma_1 e\tau)^2 + (Bn\sigma_2)^2}{2\ \rho}\right]. \tag{27}$$

This confirms that the assumed functional form for the value function is correct.

2.7 Equilibrium Analysis

Productive sector

Using the equilibrium expressions for the evasion rate and the capital share in the high-productivity sector, we can conduct comparative statics analysis. Taking the first-order derivatives of the share of the productive sector, n with regards to the measures of both types of corruption (the bribe rate b and the mean value of extorted income $\bar{x}_2$), and the measures of uncertainty (σ_1 and σ_2) the following proposition is formulated.

Proposition 2.2 *An increase of the burden of both types of corruption, as well as the uncertainty caused by them decreases share of capital in the high-productivity sector.*

Proof One can verify that following results hold:

$$\begin{aligned} &\frac{\partial n}{\partial \bar{b}} < 0, \quad \frac{\partial n}{\partial \bar{x}_2} < 0, \\ &\frac{\partial n}{\partial \sigma_2} < 0, \quad \frac{\partial n}{\partial \sigma_1} < 0. \end{aligned} \tag{28}$$

■

The indirect effect of uncertainty

The uncertainty caused by corruption not only directly impacts the economy, but also there is an indirect channel through which it inflicts losses to productivity. This conclusion is based on the following corollary.

Corollary 2.3 *Corruption indirectly affects productivity through increase in uncertainty.*

Proof Recall from Proposition 2.1 that an increase of the burden of both types of corruption raises the income uncertainty, therefore, Proposition 2.2 implies that an increase of the burden of corruption by raising uncertainty has an indirect adverse effect on the overall productivity through a decrease in the productive sector share, n. ■

Since an increase of the burden of corruption decreases the share of the high-productive sector, overall productivity of the economy diminishes. More generally, we can state that the adverse economic effect of corruption is not limited to the income redistribution and inefficiencies in the public sector, but also corruption affects the saving and investment decisions by increasing the uncertainty related to capital income.

The effect on tax evasion

Our model reveals a quite interesting relationship between productivity (measured as a share of the productive sector) and tax evasion. This relationship is stated as the following proposition.

Proposition 2.4 *Tax evasion falls with the increase of the high productivity sector size,* n.

Proof It is straightforward to verify that $\frac{\partial e}{\partial n} < 0$ by differentiating (25). ■

This result gives some explanation why corruption is persistent. It is because that when the share of the productive sector is low (that is the country is poor), tax evasion is high which further decreases productive input to the high productivity sector, thus making it even less attractive for investment. This also implies that with corrupt bureaucracy tax evasion is higher, at least because the share of the high-productive sector is lower.

Overall growth effects

Based on (13), we can find the per capita growth rate is given as:

$$\gamma = E\left(\frac{dk}{k}\right) = (1-\tau)\,(1-n)A + \frac{\bar{x}_1^2}{\sigma_1^2} + (1-\tau-\bar{x}_2)Bn - \rho \tag{29}$$

It can be verified that an increase of corruption manifested as an increase in the burden of both types of corruption unambiguously decreases growth rate. This results is stated as the following proposition.

Proposition 2.5 *An increase of corruption, measured by its burden, unambiguously reduces economic growth rate.*

Proof Recall that an increase in the bribes rates in collusive corruption, b, decreases the gain from collusion, $\bar{x}_1$, and increase the uncertainty related to it, σ_1. This implies that

$$\frac{\partial}{\partial n}\left(\frac{\bar{x}_1}{\sigma_1^2}\right) < 0.$$

Thus, the value of the second term decreases on the RHS in(29). Further, recall that an increase in noncollusive corruption raises $\bar{x}_2$, and hence, the contribution of the productive sector to overall growth diminishes. Moreover, as the results stated above confirm, an increase in corruption reduces the share of the productive sector, n, and therefore, production shifts to low-productive sector. For profit maximizing firms, at the margin $(1-\tau)A \approx (1-\tau-\bar{x}_2)B$ should hold. Then the following condition holds:

$$\frac{\partial \gamma}{\partial n} = (1-\tau)A - (1-\tau-\bar{x}_2)B - abs\left[\frac{\partial}{\partial n}\left(\frac{\bar{x}_1}{\sigma_1^2}\right)\right] < 0.$$

■

3 Conclusions

The model used in the paper allows for a nonlinear impact of corruption on firms depending on their productivity, and takes into account income uncertainty caused by interactions between corrupt bureaucracy and firms. Importantly, the paper shows that by accounting for these effects one can avoid the existing theoretical ambiguity about the overall effect of corruption on growth. Thus, the paper reconciles the theory with the empirical evidence that states that corruption always has a negative overall effect on economic growth.

The main results of the paper are as follows. Corruption creates higher entry barriers into the high-productive sector both through extortion of bribes and the associated increase in income uncertainty. As the marginal product of capital used in the high-productive sector depends on the infrastructure and services provided by the public sector. Since, corruption reduces this public sector productive input through increased tax evasion and inefficiency of the government, with an increase in corruption returns on investment in the high-productive sector is decreased. This outcome further reduces capital accumulation in high-productive sector and hinders overall economic growth. The analysis also shows that an increase in the share of high-productive sector leads to lower tax evasion.

Appendix

A1. Derivation of the variance

We denote the return on tax evasion by x. The variance of the return on tax evasion is then determined by

$$var(x) = E[(x)^2] - (E[x])^2 \tag{30}$$

where E is the expectation operator. The first term is determined as $E[(x)^2] = p(-s\tau)^2 + (1-p)\tau^2 = \tau^2[1 - p(1 - s^2)]$. Then the variance of this random variable is given by

$$\begin{aligned} var(x) &= E[(x)^2] - (E[x])^2 = \tau^2[1 - p(1 - s^2)] - [(1 - p(1 + s))\tau]^2 \\ &= \tau^2[1 - p(1 - s^2)] - [1 - 2p(1 + s) + p^2(1 + s)^2] \\ &= \tau^2[p - p^2](1 + s)^2 = p(1 - p)(\theta\tau)^2 \end{aligned} \tag{31}$$

By denoting the variance of the return on tax evasion by σ^2 and obtain the following:

$$\sigma^2 = pq\theta^2\tau^2 \tag{32}$$

References

Abed, G. T. and e. Gupta, Sanjeev (2002). *Governance, corruption, and economic performance*. Washington, D.C: International Monetary Fund. *American Economic Review 98*(1), 267–293.

Acemoglu, D. and T. Verdier (1998). Property rights, corruption and the allocation of talent: A general equilibrium approach. *Economic Journal 108*(450), 1381–1403.

Aidt, T. S. (2003). Economic analysis of corruption: a survey. *The Economic Journal 113*, F632–F652.

Alam, S. (1989). Anatomy of corruption: An approach to the political economy of underdevelopment. *American Journal of Economics and Sociology 48*(4), 441–456.

Alesina, A. and G.-M. Angeletos (2005). Corruption, inequality, and fairness. *Journal of Monetary Economics 52*(7), 1227–44.

Ali, A. M. and H. S. Isse (2003). Determinants of economic corruption: A cross-country comparison. *Cato Journal 22*(3), 449–466.

Bardhan, P. (1997). Corruption and development: a review of issues. *Journal of Economic Literature 35*(3), 1320–1347.

Barelli, P. and S. d. A. Pessoa (2002). *A model of Capital Accumulation and Rent seeking*. CARESS Working Paper No. 02-06. Available at SSRN: http://ssrn.com/abstract=317239.

Barreto, R. A. (2000). Endogenous corruption in a neoclassical growth model. *European Economic Review 44*(1), 35–60.

Blackburn, K., N. Bose, and M. E. Haque (2005). *Public Expenditures, Bureaucratic Corruption and Economic Development.*. The University of Manchester, Centre for Growth and Business Cycle Research, DPS 053.

Broadman, H.G. and F. Recanatini (2002). Corruption and Policy: Back to the Roots. *Journal of Policy Reform 5*, 37–49.

Campos, J. E. L. (2001). *Corruption : the boom and bust of East Asia*. Quezon City: Ateneo de Manila University Press.

Chen, B. L. (2003). Tax evasion in a model of endogenous growth. *Review of Economic Dynamics 6*(2), 381–403.

Chen, B. L. (2006). Economic growth with an optimal public spending composition. *Oxford Economic Papers 58*, 123–136.

Coppier,R. and E. Michetti (2006). Corruption vs production. A non-linear relationship. *Economic Modelling 23*, 622–637.

Delavallade, C. (2006). Corruption and Distribution of Public Spending in Developing Countries. *Journal of Economics and Finance 30*(2), 222–239.

Del Monte, A. and E. Papagni (2001). Public expenditure, corruption, and economic growth: the case of Italy. *European Journal of POlitical Economy 170*, 12–16.

Denizer, C., M. Iyugun, and A. Owen (2000). *Finance and Macroeconomic Volatility.* World Bank Policy Research Paper No. 2487.

Djankov, S., R. La Porta, F.Lopez-De-Silanes, A. Shleifer (2002). The regulation of entry. *Quarterly Journal of Economics 117*, 1–37.

Dreher, A. and M. Gassebner (2007). Greasing the wheels of entrepreneurship? The impact of regulations and corruption on firm entry. CESifo Working Paper Series CESifo Working Paper No. 2013, CESifo GmbH.

Futagami, K., Y. Morita, and A. Shibata (1993). Dynamic analysis of an endogenous growth model with public capital. *Scandinavian Journal of Economics 95*, 525–607.

Huntington, S. P. (1968). *Political Order in Changing Societies.* New Haven, CT: Yale University Press.

Jain, A. K. (2000). *Corruption and Business: A Review*. Spellbound Publications.

Keefer, P. and S. Knack (1997). Why don't poor countries catch up? a cross-national test of institutional explanation. *Economic Inquiry 35*, 590–602.

Klitgaard, R. (1988). *Controlling Corruption.* University of California Press, Berkeley.

Knack, S. and P. Keefer (1995). Institutions and economic performance: cross-country test using alternative institutional measures. *Economics and Politics 7*, 207–227.

Leff, N. (1964). Economic development through bureaucratic corruption. *American Behavioral Scientist 8*(3), 8–14.

Lin, W.-Z. and C.-C. Yang (2001). A dynamic portfolio choice model of tax evasion: Comparative statics of tax rates and its implication for economic growth. *Journal of Economic Dynamics and Control 25*, 1827–184.

Liu, F. T. (1985). An equilibrium queuing model of bribery. *Journal of Political Economy 93*, 760–781.

Liu, F. T. (1996). Three aspects of corruption. *Contemporary Economic Policy 14*(3), 26–29.

Mauro, P. (1995). Corruption and growth. *Quarterly Journal of Economics 110*, 681–712.

Mauro, P. (2004). The persistence of corruption and slow economic growth. *Imf Staff Papers 51*(1), 1–18.

Meon, P.-G. and L. Weill (2006). Is corruption an efficient grease? a cross-country aggregate analysis. In *Public Choice Conference 2006,*, Amsterdam.

Mo, P. H. (2001). Corruption and economic growth. *Journal of Comparative Economics 29*(1), 66–79.

Pellegrini, L. and R. Gerlagh (2004). Corruption's effect on growth and its transmission channels. *KYKLOS 57*(3), 429–456.

Polinsky, A. M. and S. Shavell (2001). Corruption and optimal law enforcement. *Journal of Public Economics 81*, 1–24.

Rivera-Baitiz, F. L. (2002). Governance, and economic growth: Theory and evidence. *Review of Development Economics 6*(2), 225–247.

Rose-Ackerman, S. (2004). *Corruption*. Kluwer Academic.

Sepulveda, F. and F. Mendez (2006). Corruption, growth and political regimes: Cross country evidence. *European Journal of Political Economy 22*(1), 82–98.

Shleifer, A. and R. W. Vishny (1993). Corruption. *The Quarterly Journal of Economics 108*(3), 599–617.

Svensson, J. (2005). *Eight Questions about Corruption, Journal of Economic Perspectives 19*(3), 19–42.

Tanzi, V. (2000). *Policies, institutions and the dark side of economics*. Cheltenham, UK ; Northampton, Mass., USA: E. Elgar.

Tanzi, V., H. R. Davoodi, and I. M. F. F. A. Dept. (2000). *Corruption, growth, and public finances*. IMF working paper ; WP/00/182. Washington, D.C.: International Monetary Fund, Fiscal Affairs Department.

Tsoukis, C. and N. J. Miller (2003). Public services and endogenous growth. *Journal of Policy Modeling 25*, 297–307.

Turnovsky, S. J. (1996). Fiscal policy, adjustment costs and endogenous growth. *Oxford Economic Papers 48*, 361–381.

Yitzhaki, S. (1974, May). A note on income tax evasion: Theoretical analysis. *Journal of Public Economics 3*(2), 201–202.