What do we talk about when we talk about corruption?

Fabio Méndez
University of Arkansas
Department of Economics
Business Building Room 402
Fayetteville, AR, 72701
fmendez@uark.edu

Facundo Sepúlveda
Depto. de Gestión y Políticas Públicas.
Universidad de Santiago de Chile
Santiago, Chile

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Abstract

In this paper we analyze the behavior of three objective measures of corruption. We present a theoretical model of bribery and investment, in which three measures of corruption typically found in the literature are defined and compared. We then study how each one of these measures changes when key parameters in the model change and show that, under identical circumstances, the behavior of a particular corruption measure can differ completely from the behavior of other corruption measures. Furthermore, we find that changes in any particular corruption measure are different when the economy exhibits a "low corruption" equilibrium than when it exhibits a "high corruption" equilibrium.

1 Introduction

Is it fair to say that a government official who accepts a $100 bribe from a private agent is more (or less) corrupt than another one who accepts ten bribes of $10 each for the same purpose? More importantly, can we label both officials as "corrupt" and study the causes and consequences of their behavior as if they were no different? The answers to these and other related questions may be vital for the understanding of economic decisions in a corrupt environment. However, the literature addressing such issues has been disappointingly vague about what is to be understood by "corruption" and about whether the definition adopted for the analysis could alter the conclusions.

The emergence of alternative measures that are not based on perception indices are now well received among economists, for they allow one to conduct more specific policy evaluations and more rigorous theoretical testings (see, for example, Donchev and Ujhelyi (2006) and Olken (2006)). But when faced with the problem of choosing an objective measure, different people define corruption in different ways. Some people think about the number of corrupt transactions that take place or their relative frequency. Others look at the amount of money that changes hands as part of those transactions. Others look at the percentage of government officials that are willing to accept a bribe[1].

This is true for those who model corruption theoretically, as is the case with Cadot (1987), Shleifer and Vishny (1993), Guriev (2004), and Çule and Fulton (2005); but is also true for those who study corruption empirically. Authors like Svensson (2003) and Clarke and Colin (2004), for example, used firm-level data to study the incidence (*how often*) and the level (*how much*) of bribes paid by private firms in connection with regulations, licenses, public utilities, etc. Gorodnichenko and Sabirianova (2006) assessed the *total monetary*

[1] See Bardhan (2006) for a similar evaluation of the literature

compensation received by dishonest officials to evaluate the extent of corruption in Ukraine. Olken (2007) used the *difference between total expenditures reported and total estimated expenses* to measure the extent of corruption; and Wolfers (2006) looks at the *number* of games for which evidence of "point-shaving" can be found to expose corruption in american collegial basketball.

A priori, there is no reason to prefer one definition over another. A posteriori, however, would the conclusions obtained by those studies have changed if another corruption measure had been chosen in the first place? Or in other words, does it really matter for policy analysis which criteria is used to quantify corruption? If it does, then the findings and policy prescriptions that apply for any particular measure of corruption may not apply when other measures are used instead. As more researchers adopt newer and more specific measures of corruption based on micro-surveys, these questions are becoming increasingly relevant. It is precisely this issue that we address in this paper.

Specifically, in this paper we present a theoretical model of bribery and investment, in which three alternative measures of corruption are defined and compared. We then study how each one of these measures changes when key parameters in the model change. These parameters are thought to be the target of typical anti-corruption policies; namely: the proportion of dishonest public officials and the costs of the bureaucratic regulations necessary for investment. We consider this particular theoretical framework and these two specific policy targets because they constitute some of the most visited topics and most frequently used frameworks in the literature, respectively (see, for example, Cadot (1987), Shleifer and Vishny (1993), Djankov et al. (2002), or Damania et al. (2004)). The main intuition provided by our results, however, could apply to many other situations where the scope and reach of corruption extends.

After the policy experiments are implemented and studied, the results of the paper show that the concept used to quantify corruption is capable of altering the conclusions of the analysis. That is to say that, the same policy, under identical circumstances, can generate an effect on a particular corruption measure that differs completely from the effect it produces on other corruption measures. Thus, the paper warns against the over-simplification of policy analysis and points out that, although related, different measures of corruption are not necessarily consistent with each other.

Furthermore, the results of the model suggest that the multiple separating equilibrium nature found in many influential models of corruption (see, for example Andvig and Moene (1990), Johnson, Kaufman and Shleifer (1997) or Alesina and Angeletos (2005)) plays an important role for the analysis. In the paper, the changes in any particular corruption measure are different when the economy exhibits a "low corruption" equilibrium than when it exhibits a "high corruption" equilibrium; regardless of the particular definition used.

As in previous studies (see Choi and Thum (2005) or Guriev (2004)), in our model the government imposes regulations on investment and public officials issue a certification of compliance for these regulations. Some officials are honest and provide the certification only when regulations are followed. Others are dishonest and are willing to take bribes in exchange for the certification. Agents in this economy, then, must decide whether to become investors and, if they do, whether to follow the government regulations. In contrast to previous contributions, however, in this paper we model the interaction between investors and officials as a search and bargain process.

The remaining of the paper is organized as follows: the next section displays a model of corruption where decisions regarding investment, compliance with government regulations and bribery are taken simultaneously. Section 3 presents the alternative definitions of corruption and tracks their reaction to typical anti-corruption policies as discussed in previous literature. Finally, section 4 offers some concluding remarks and perspectives for future research.

2 A search model of investment, regulation and bribery

We study an economy with a continuum of infinitely lived agents of size one. Each agent is endowed with a level of entrepreneurial ability R_i, drawn from a distribution with c.d.f. $G(R)$ and frequency function $G' = g$. According to the most simple production function, ability is transferred one to one into earnings. If an agent decides to become an entrepreneur, she incurs in an investment cost i, and must have the project certified for regulations compliance by government officials[2]. Such regulations, if followed, impose an additional cost α on investors.

When the time comes to obtain certifications for their projects, investors get a random draw of a government official. Officials are of two types. A proportion $1 - p$ of them is honest, and verify that regulations have been followed. If they have not, the certification is simply not given. The remaining p officials are corrupt and ask for a bribe β in exchange of the certification. We assume that each official reviews one project.

By taking the fraction p as exogenous, we are abstracting from all those elements that influence the public servant's decision on whether to behave honestly. Such elements include the public servant's compensation, his level of risk aversion, the penalties imposed on those found to accept a bribe, the penalties imposed on those found to pay a bribe, the moral disposition of public servants, and others (see Mookherjee and Png (1995) for a study of the determinants of public official's behavior). Thus, instead of looking at the specific public policies, we concentrate on the expected consequences of this policies.

When faced with either type of official, investors may also decide to keep searching for a

[2]Because entrepreneurs are heterogeneous in their ability R_i, which determines the rate of return of their projects, it is reasonable to normalize the cost of the project to i, as we have done.

different type (or to withdraw from the process altogether, but we disregard this possibility as it is never chosen in equilibrium). Thus, in choosing whether to follow the regulations, the entrepreneur chooses the compliance policy that solves

$$v = -i + \max\{v_s(0), -\alpha + v_s(1)\} \tag{1}$$

Where $v_s(1_{[\alpha]})$ is the expected value of searching for an official and the argument in $v_s(.)$ is an indicator that takes the value of one when the regulations have been followed and zero when they have not. A solution to (1) is a policy function $\Lambda : \mathbb{R}^+ \rightarrow \{0, 1\}$ that maps values of R to a decision of whether to comply (1) or not (0) with the regulations.

In turn, the function v_s is defined as

$$v_s(0) = pv_c(0) + (1-p)v_h(0) \tag{2}$$

$$v_s(1) = pv_c(1) + (1-p)v_h(1) \tag{3}$$

Where v_c and v_h represent the value functions for the agents when facing a corrupt official (v_c) or an honest official (v_h) respectively. They are solutions to the following Bellman equations:

$$v_c(0) = \max\{R_i - \beta + \delta v, \delta v_s(0)\} \tag{4}$$

$$v_c(1) = \max\{R_i - \beta + \delta v, \delta v_s(1)\} \tag{5}$$

$$v_h(0) = \delta v_s(0) \tag{6}$$

$$v_h(1) = \max\{R_i + \delta v, \delta v_s(1)\} \tag{7}$$

In expressions 4 to 7 we impose the equilibrium result that $\frac{1}{1+r_t} = \delta$, where r_t is the interest rate and δ is a discount factor. In expressions 4 and 6 we also impose the equilibrium feature that, if no compliance was optimal at time zero, it will remain the optimal choice regardless of the history of draws [3]. Equilibrium search costs are then constant over time and proportional to δ.

We briefly discuss Bellman equations 4 to 7. Equations 4 and 5 represent the choice between accepting to pay the bribe and refusing to pay the bribe and search for another official. In the first case, the payoff is the instant gain of $R_i - \beta$ plus the continuation value of δv. In the second case the payoff is given by the discounted value of searching δv_s. As will become clear in what follows, both the bribe and the value of searching are different for investors who followed the regulations versus those who did not. In equation 7 the investor faces an honest official, and must decide whether to accept the certification and obtain $R_i + \delta v$, or keep on searching. Clearly searching will not be optimal in this case. Finally, in equation 6 the investor did not follow the regulations, and faces an honest official who gives her no choice but to keep on searching.

The solution to $\{v_c, v_h\}$ in (4) to (7) is a pair of policy functions $s_{c,h} : \{1, 0\} \times \mathbb{R}^+ \rightarrow \{accept, search\}$ that map a value of R and a compliance choice Λ to a decision of whether to accept the official's offer (*accept*) or keep searching for a different official (*search*). Note that the decision to accept the offer involves paying a bribe if the official is corrupt, and simply accepting the certification if it is honest.

When the investor draws a corrupt official, the bribe is determined by Nash bargaining, where the bargaining power of the official is θ, the reservation value for the corrupt official is zero, and the reservation value for the investor is the discounted value of searching (δv_s). The bribe is then determined by solving

$$\max_{\beta} (\beta)^{\theta} (R_i - \beta + \delta v - \delta v_s)^{1-\theta} \tag{8}$$

The solution for the bribe follows a simple rule of surplus sharing between corrupt officials

[3] Otherwise we would substitute $\delta v_s(0)$ for the equivalent, but more cumbersome $\delta \max\{v_s(0), -\alpha + v_s(1)\}$.

and investors; where the equilibrium bribe is a function of the return of the project R_i, which is observable by the official:

$$\beta(R) = \theta(R_i + \delta(v - v_s)) \tag{9}$$

This environment may be seen as a repeated game between corrupt officials and entrepreneurs, with nature determining the type of official. It is natural in this case to impose subgame perfection on the equilibrium policies. In particular, when the bribe is determined we restrict the reservation value for the entrepreneur to be that which is derived from policies that are optimal in the subgame that starts from next period on (if the entrepreneur keeps on searching). We refer to this as the threat points being credible.

Agents choose compliance, and search policies that solve 1 to 7, taking α and β as given. The equilibrium objects for this economy are a set of Bellman equations for $\{v, v_c, v_h\}$, along with a bribe function $\beta : \mathbb{R}^+ \rightarrow \mathbb{R}^+$ that solves 8, a set of search policies for honest and corrupt officials contingent on R, and the compliance choice $\{s_h, s_c\} : \{0, 1\} \times \mathbb{R}^+ \rightarrow \{accept, search\}$ that solves 4 to 7, and a compliance rule $\Lambda : \mathbb{R}^+ \rightarrow \{0, 1\}$ that solves 1. Given the optimal choices, the value v in 1 represents the value of becoming an entrepreneur. Agents decide to become entrepreneurs if $v > 0$ and decide not to become entrepreneurs if $v < 0$.

2.1 Equilibrium

The solution of the model reveals that out of all the possible investment rules $\{\Lambda, s_h, s_c\}$ available for entrepreneurs, at most two of them would be used in equilibrium. The proof is in the appendix. For simplicity we will refer to them as plan 1: $\{1, accept, accept\}$ and plan 2: $\{0, search, accept\}$. For plan 1, the entrepreneur decides to *follow* the regulations, *accept* the certification when facing an honest official, and *accept* to pay a bribe when facing a corrupt official. For plan 2, the entrepreneur decides *not to follow* the regulations, *search* for an opportunity to bribe when facing an honest official, and *accept* to pay a bribe when facing a corrupt official.

Notice that searching when the agent draws a corrupt official cannot be optimal, as Nash bargaining by definition gives the agent a share of the surplus *above* the payoff from searching. Similarly, searching if an honest official is drawn is the only possibility when $\Lambda = 0$, and could not be optimal if $\Lambda = 1$, since accepting the certification is done at no marginal cost.

For entrepreneurs who follow plan 1, the payoffs from obtaining a certification are high enough that the expected costs of waiting until a corrupt official is drawn, plus the higher bribes to be paid in this case, would dominate the reduction in costs from not following the regulations. Agents who follow plan 2 effectively trade in lower investment costs, as they do not incur in the costs of complying with the regulations, for a lower probability (p) of being given a certification. This implies a reduced expected level of profits, which comes from two sources: First, the expected delay in implementing the project is now $\frac{1}{p}$, reducing the present value of profits. Second, the bribe to be paid is higher if the agent follows plan 2.

Whether some investors follow plan 1 while others follow plan 2, or whether either plan is followed exclusively by all investors cannot be determined a priory; as the equilibrium solution depends of the value of the exogenous parameters. Formally, the equilibrium solution of the model is described by the following proposition:

Proposition 1 *For any set of exogenous parameters* $\{i, \delta, \alpha, \theta\}$*, let* p^* *be the value of* p *that satisfies the condition* $\alpha(\frac{1-p\theta\delta}{1-p}) - \frac{i(1-\delta)}{p(1-\theta)} = 0$*; where* p^* *exists and is unique. The solution of the model is characterized by two types of equilibria, depending on the value of the exogenous parameters, as follows:*

Equilibrium 1 (Corruption Tolerant Economy) *For values of* $p < p^*$, *agents with* $R \in (0, R3)$ *will choose not to invest. Agents with* $R \in [R3, \infty)$ *will become entrepreneurs, abide by the regulations, and choose to pay bribes if they draw a corrupt official (follow plan 1).*

Equilibrium 2 (Corruption Reliant Economy) *For values of* $p > p^*$, *agents in* $R \in (0, R2)$ *will choose not to invest, agents with* $R \in [R2, R1)$ *will invest, not abide by the regulations, and search for a corrupt official (follow plan 2). Finally, agents with* $R \in [R1, \infty)$ *will follow the regulations, and pay the bribe if they draw a corrupt official (follow plan 1).*

Where $R1 = i\delta + \alpha\frac{1-p\theta\delta}{1-p}$, $R2 = i(\frac{1-\delta}{p(1-\theta)} + \delta)$, $R3 = (i + \alpha)\frac{1-p\theta\delta}{1-p\theta}$. The proof is in the appendix.

As stated in the proposition, there are two alternative equilibria for this economy: in the first equilibria all investors follow plan 1, government regulations are always followed and corruption is tolerated by those investors for whom declining to bribe an official is too costly. In the second equilibria some investors follow plan 1 while others follow plan 2, government regulations are sometimes disregarded and corruption becomes essential for some investment projects. In this second equilibria, an immediate consequence of there being two observed plans is that there will be two bribes (as functions of R), since the threat points δv_s -the value of searching- will be different for both plans.

All investment projects in the first equilibria become operational in the same period the investment takes place regardless of the type of official they draw. In the second equilibria, however, some of the investors do not comply with the regulations and their projects become operational only if the entrepreneur finds a corrupt official that can be bribed. That is, only a fraction p of the projects following plan 2 will become operational at any period. It is in this sense that we label this two potential equilibria as a "corruption tolerant" and "corruption reliant" economies respectively

A corruption-reliant economy will be observed in an equilibrium solution only when the condition $R1 > R2$ is satisfied and plan 2 dominates both, not investing and investing with plan 1, for some positive interval of R. Intuitively, that occurs in an environment where the costs of regulations α are high, the investment cost i is low, and the bargaining power of corrupt officials is low. That is, whenever the expected value of investing without complying with regulations exceeds the value of investing under government regulations for at least some levels of R.

The two equilibria have very different policy and welfare implications. The first equilibrium describes an economy where corruption has similar effects to those of a capital earnings tax. In the second equilibrium, in contrast, some investors are induced to engage in a form of rent seeking behavior. In this regard, as expected, entrepreneurs who follow plan 2 have lower ability than those who follow plan 1. Thus, the model provides a formal interpretation of the common observation that low and high corruption are associated with different types of deadweight losses.

3 A comparison of alternative corruption measures

We now use the equilibrium solution of the model to define and compare three alternative measures of corruption: Corruption Incidence (CI), Relative Corruption Incidence (RCI) and Total Corruption Rents (CR). Several papers found in the literature have used these measures when discussing corruption, either directly or indirectly (see, for example, Bliss and Di Tella (1997), Cadot (1987), Damania et al. (2004), Guriev (2004), Olken (2007)):

Measure 1 - Corruption Incidence (CI): Corruption incidence measures the number of times a corrupt deal is observed, or alternatively, the number of investment projects that become operational by paying a bribe. In the context of the model presented in the previous section, CI is defined as follows:

- In a corruption-tolerant economy $CI = p\int_{R3}^{\infty} g(R_i)dR_i = p[1 - G(R3)]$

- In a corruption-reliant economy $CI = p\int_{R2}^{R1} g(R_i)dR_i + p\int_{R1}^{\infty} g(R_i)dR_i = p[1 - G(R2)]$

Measure 2 - Relative Corruption Incidence (RCI): Relative corruption incidence measures the ratio of operational projects involving a bribe to the total amount of operational investment projects. In terms of the model, RCI is defined as follows:

-In a corruption-tolerant economy, $RCI = \frac{(1-G(R3))p}{(1-G(R3))} = p$

-In a corruption-reliant economy, $RCI = \frac{p[1-G(R2)]}{p\int_{R2}^{R1} g(R_i)dR_i + \int_{R1}^{\infty} g(R_i)dR_i} = \frac{p[1-G(R2)]}{1-pG(R2)-G(R1)(1-p)}$

Measure 3 - Total Corruption Rents (CR): Total corruption rents measures the total amount of rents collected by dishonest public officials in the form of bribes. In terms of the model, CR is defined as follows:

-In a corruption-tolerant economy, $CR = p\int_{R3}^{\infty} \theta[R_i - \delta(i+\alpha)] \cdot g(R_i)dRi$

-In a corruption-reliant economy,

$$CR = p\int_{R2}^{R1} \theta[R_i - \delta i]g(R_i)dRi + p\int_{R1}^{\infty} \theta[R_i - \delta(i+\alpha)]g(R_i)dRi$$

Although related, the alternative definitions need not to be consistent with one another. Changes in the bargaining power of corrupt officials (θ), for example, redistributes resources from the investor to the corrupt officials; but only the CR measure accounts for this redistribution directly. Similarly, changes in the fraction of corrupt officials (p) affect both the total number of corrupt deals and the total number of operational projects; but since the RCI is the only one expressed as a ratio of these two numbers, its reaction to changes in p

could differ from that one of either CI or CR.

Even the same definitions behave differently across equilibrium types. The CI measure, for example, is sensitive to changes in government regulations (α) in corruption-tolerant economies, as the higher costs reduce the pool of investors. In corruption-reliant economies, in contrast, the CI measure is not sensitive to changes in the cost of regulations α, because in those economies the value of α only determines the fraction of investment projects that comply with government regulations, but does not alter the total pool of investors and thus, the number of projects that encounter a corrupt official and pay a bribe.

As mentioned before, these and other differences across corruption measures may be relevant for both theoretical and empirical discussions. To better illustrate this point, we turn to the analysis of some of the most frequently discussed anti-corruption policies. As shown below, whether these policies achieve its goal of reducing corruption might depend of the specific meaning attached to the word "corruption" and the type of economy studied.

3.1 Do more honest bureaucracies lead to more or less corruption?

This question has capture a great deal of attention within the economics literature. Higher wages, heavier punishments, and greater meritocracy among others have been argued to produce more honest bureaucrats; and more honest bureaucrats, in turn, have been argued to reduce the incidence and persistence of corruption (see, for example, Acemoglu and Verdier (1998), Damania et al.(2004), Treisman (2000)). The implicit assumption is that a more honest bureaucracy translates into a less corrupt economy. As we show next, however, the answer to this question is highly sensitive to both, the definition of corruption and the degree of corruption prevalent in the economy (that is, whether one studies a corruption-tolerant or a corruption-reliant equilibrium).

In order to obtain an answer within the model, we proceed by taking the derivative of corruption with respect to p for each corruption measure defined before. The results of this exercise are summarized in Table 1. A separate analysis for each corruption measure follows after that.

Table 1. Do more honest bureaucracies lead to more or less corruption?

	CI	**CRI**	**CR**
Corruption-Tolerant Economy	Either	Less	Either
Corruption-Reliant Economy	Less	Either	Less

As shown, the answer to whether a more honest bureaucracy leads to more or less corruption depends both on the definition of corruption and the type of equilibrium studied. In a corrupt tolerant economy, the answer is "less" only for the CRI measure but "either" for the other two. Notice also that using the same measure of corruption does not yield consistent answers across equilibrium types. This results reflects the importance of taking into account the specific characteristics represented in the two equilibriums. The effects of an economic policy are different across equilibrium types because the role of corruption is different in these alternative economies and, more importantly, not directly comparable. Next, we scrutinize the results for each measure separately.

3.1.1 Corruption measured by CI

In a corruption-tolerant economy, the change in CI (number of corrupt deals) that is generated by a change in p is described by the following equation:

$$\frac{\partial CI}{\partial p} = [1 - G(R3)] - p[G'(R3) \cdot \frac{\partial R3}{\partial p}].$$

Where $\frac{\partial R3}{\partial p} = \frac{\theta(1-\delta)(i+\alpha)}{(1-p\theta)^2} > 0$ and thus, the expression can take on both positive and negative values depending on the specific distribution function $G(R)$.

Intuitively, the change in p generates two opposing effects. On the one hand, as the number of dishonest officials increases, it is more likely that a corrupt transaction takes place in association with investment. On the other hand, as the probability of facing a corrupt official (p) increases, the amount of individuals who decide to become entrepreneurs diminishes because the possibility of added bribing costs makes investments less profitable. The resulting balance between these two forces, then, may yield undetermined answers for the question at hand.

In turn, the corresponding expression for the comparative statics in a corruption-reliant economy can be described as follows:

$$\frac{\partial CI}{\partial p} = [1 - G(R2)] - p[G'(R2) \cdot \frac{\partial R2}{\partial p}].$$

Where $\frac{\partial R2}{\partial p} = \frac{-i(1-\delta)}{(1-\theta)p^2} < 0$ and the expression takes on positive values only, so that an increase in the fraction of honest officials always generates a decrease in corruption as measured by CI.

The difference in this case is that an increase in the proportion of dishonest officials (p) increases the total amount of investment projects. In a corruption-reliant economy increases in p makes investments less profitable, but those entrepreneurs whose investment project is no longer profitable do not abandon their investment plans; instead they shift their strategy from plan 1 to plan 2 and continue with their investment but without complying with regulations. At the same time, increases in p increase the expected payoffs of investing with plan 2 with respect to not investing. Thus, an increase in p generates more investments projects overall and a greater measure for CI.

3.1.2 Corruption measured by CRI

We proceed similarly with the CRI corruption measure (ratio of operational projects involving a bribe to the total amount of operational investment projects). For the case of a corruption-tolerant equilibrium, the expression for changes in CRI as p changes is simple: $\frac{\partial CRI}{\partial p} = 1$. Intuitively, in a corruption tolerant equilibria, the number of investment projects that pay a bribe equal the fraction of the investment projects that encounter a corrupt official; since all projects follow plan 1, this fraction is constant and equal to p.

In contrast, for corruption-reliant equilibria the CRI can either increase or decrease as the result of changes in p. The specific form of the expression is presented below. Notice how the expression cannot be simplified further without making explicit assumptions about $G(R)$: $\frac{\partial CRI}{\partial p} = \frac{(1-G(R2))-pG'(R2)\frac{\partial R2}{\partial p}}{1-G(R1)+p(G(R1)-G(R2))} - \frac{p[1-G(R2)][G(R1)-G(R2)-pG'(R2)\frac{\partial R2}{\partial p}-G'(R1)\frac{\partial R1}{\partial p}(1-p)}{[1-G(R1)+p(G(R1)-G(R2))]^2}$. Where $\frac{\partial R1}{\partial p} = \frac{\alpha(1-\theta\delta)}{(1-p)^2} > 0$ and $\frac{\partial R2}{\partial p} < 0$ as stated before.

In this case, it is easier to study the changes in CRI by looking at the changes of both the numerator and the denominator. The numerator of the CRI is a positive function of p; this was shown to be the case in the previous paragraphs. The denominator, in turn, can either increase or decrease: On the one hand the number of investors that follow plan 1 decreases. On the other hand, the number of investors that follows plan 2 increases; but since only a fraction p of those projects become operational, it is impossible to tell whether the total number of operational projects increase or decrease without making additional assumption about the form of the distribution function $G(R)$.

3.1.3 Corruption measured by CR

For the corruption-tolerant equilibrium, the derivative of CR with respect to p cannot be signed. When the fraction of corrupt officials (p) increases the number of agents that decide to become entrepreneurs diminishes; but those who remain are willing to pay greater bribes and will pay them more often than before since the likelihood of encountering a corrupt official has increased. Again, whether the total rents collected by corrupt officials (CR) increases or decreases depends of the distribution function G(R). If G is very sensitive to changes in R then CR would decrease; if G is not sensitive then CR would increase. The expression for the change in CR follows:

$$\frac{\partial CR}{\partial p} = \theta \int_{R3}^{\infty} R_i \cdot g(R_i) dR_i + pG'(R3) \frac{\partial R3}{\partial p} [\theta\delta(i+\alpha) - \theta R3] - \theta\delta(i+\alpha)[1 - G(R3].$$

In contrast, in the case of a corruption-reliant economy the measure CR will certainly increase as p increases. Bribes collected increase for two reasons. First, as p increases, the pool of total investors gets bigger and therefore, more bribes are paid in total. Second, since at the margin the bribes paid by plan 2 followers are greater than the bribes paid by plan 1 followers, as agents flip from plan1 to plan 2 the total rents collected increase as well. The algebraic expression for the derivative is stated below:

$$\frac{\partial CR}{\partial p} = \int_{R2}^{\infty} \theta[R_i - \delta i] g(R_i) dR_i - \theta\delta\alpha[1 - G(R1)] - p\theta(R2 - \delta i)G'(R2)\frac{\partial R2}{\partial p} + pG'(R1)\frac{\partial R1}{\partial p} > 0.$$

Notice in this case that although the total amount of corruption rents is increasing, the rent collected per investment project might not. Thus, if one was to measure corruption as rents collected per project, the answer once again is likely to change.

3.2 Do greater and costlier government regulations lead to more or less corruption?

Many influential studies such as De Soto (1990), Nye (1969) or Huntington (1968) have portrayed corruption as the consequence of regulations. According to this argument, the costs imposed by governmental regulations, regardless of whether they are justified, generate incentives for corrupt deals that allow some investments projects, that would not become operational otherwise, to become operational. Several empirical studies have found support for this argument in reporting a positive correlation between the level of corruption and the extent and costs of government regulations (see, for example, Treisman (2000), or Kaufmann and Wei (2000)).

In our model, this question refers to the effects that regulation costs α have on the equilibrium corruption levels. Thus, as before, we proceed by taking the derivative of corruption with respect to the parameter α for each one of the corruption measures defined. Also, as before, the results of the comparative statics are summarized in Table 2, and a separate analysis for each measure is provided afterwards.

Table 2. Do greater regulations lead to more or less corruption?

	CI	**CRI**	**CR**
Corruption-Tolerant Economy	Less	no effect	Less
Corruption-Reliant Economy	no effect	More	Either

As shown in Table 2, the answer to the question of the effects of regulations on corruption varies greatly across definitions and across equilibria. For a corruption-reliant economy, for example, all measures yield different answers. In the same manner, the answer provided changed when the equilibrium solution changed for all corruption measures. Thus, the results presented in Table 2 are somehow surprising, as only in one instance it is found that costlier regulations lead to more corruption. In this environment, however, it is possible that the amount of regulations have an additional impact on the fraction p that is not accounted for in the model.

3.2.1 Corruption measured by CI

In a corruption-tolerant economy, an increase in α generates a smaller incentive to become an entrepreneur through smaller expected returns on investment. Thus, as the number of investment projects diminishes and the pool of public officials remains unchanged, the total number of corrupt deals (CI) decreases. This explanation follows the algebraic expression for the comparative statics: $\frac{\partial CI}{\partial \alpha} = -pG'(R3) \cdot \frac{\partial R3}{\partial \alpha}$; which is negative for all parameter values since $\frac{\partial R3}{\partial \alpha} = \frac{1-p\theta\delta}{1-p\theta} > 1$.

In a corruption-reliant economy, in contrast, an increase in α will not change the value CI; that is, $\frac{\partial CI}{\partial \alpha} = 0$. In this case, when the regulations costs α increase, a fraction of the investment projects (those following plan 1) become less profitable. For these entrepreneurs, however, the next best alternative is not to stop production but to bypass the costs of regulation by shifting to plan 2. Thus, in this type of equilibrium, an increase in α does not affect the total number of investment projects, but will only affect proportion of investors that comply with regulations.

3.2.2 Corruption measured by CRI

Using CRI (ratio of operational projects involving a bribe to the total amount of operational investment projects) as a corruption measure instead, generates an interesting contrast. In a corruption-tolerant economy a change in the costs of regulations α has no effect on the measure CRI ($\frac{\partial CRI}{\partial \alpha} = 0$); whereas in a corruption-reliant economy an increase in α generates an increase in corruption as measured by the CRI. This last claim is easily verified by looking at the derivative of CRI with respect to α:

$$\frac{\partial CRI}{\partial \alpha} = \frac{p[1 - G(R2)][(1-p)G'(R1)\frac{\partial R1}{\partial \alpha}]}{[1 - pG(R2) - G(R1)(1-p)]^2} > 0.$$

In the corruption-tolerant economy, a change in α decreases the number of agents that decide to become entrepreneurs and the total number of bribes generated. Out of those agents that decide to become entrepreneurs, however, a fraction p of them still must face a corrupt official, and thus, a change in α does not alter the equilibrium value of CRI. For a corruption-reliant economy, in contrast, while the number of agents that become entrepreneurs (using either plan1 or plan2) does not change, the number of total operational projects diminishes due to the increased fraction of non-compliant projects that get caught by honest officials; thus generating an increase in CRI

3.2.3 Corruption measured by CR

In a corruption-tolerant economy, when CR is used to measure corruption, an increase in the cost of regulations α will always generate a decrease in the total rents collected through bribes (CR). Intuitively, as the cost α increases the number of investment projects decreases as expected profits shrink. Simultaneously, since all investors follow plan 1 and have already paid the cost of regulations, as α increases the gains obtained through the bargaining process become smaller and the bribe per investment project also decrease. As a result of these two effects, the total rents collected must decrease. Taking the derivative of CR with respect to α, one obtains

$$\frac{\partial CR}{\partial \alpha} = p\theta\{-\delta[1 - G(R3)] - G'(R3)[R3 - \delta(i + a)][\frac{1 - p\theta\delta}{1 - p\theta}]\};$$

which is negative since $R3 > \delta(i + a)$.

In turn, for the corruption-reliant economy one obtains the following expression:

$$\frac{CR}{\partial \alpha} = p\theta\delta[G(R1) + \alpha G'(R1)\frac{\partial R1}{\partial \alpha} - 1];$$

which can be either positive or negative, but can be positive only for big values of α. In this equilibrium, changes in α have multiple effects on the total corruption rents. First, as explained above, for all those investors who comply with regulations, an increase in α leads to smaller bribes. Second, an increase in α generates a shift towards more investment projects that do not comply with regulations and since projects that do not comply pay greater bribes than those that do, the total effect of changes in α on CR cannot be determined a priory.

4 Conclusions

The nature of corruption prevents us from using simple one-dimensional measures since it corresponds to a complicated mix of incentives and behaviors. In this regard, this paper warns economists about the dangers of settling on any one particular measure and shows how the results of public policy analysis might be altered by choosing a different criteria for quantifying corruption.

This potential danger is illustrated here by using two specific examples of anti-corruption policies, but it is disregarded in general by both theoretical and empirical contributions that typically adhere to one conceptual definition of corruption and attempt to draw conclusions using that definition only. Whether the conclusions of these studies would change if another criteria was used to measure corruption, however, cannot be inferred from this study.

The work presented in this paper can be expanded and modified to analyze the role of corruption in a series of settings. Of special interest are the links between the effects of corruption and the distribution G(R); as this function can be related to the distribution of income or ability, and to changes in technology. Additionally, since the function G(R) ultimately determines the segmentation of the population into different groups that use corruption in different ways, the function G(R) appears as a potential determinant of the overall attitudes towards corruption.

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5 Appendix: Solution of the Model

To characterize the optimal strategies, we proceed by backwards induction; first deriving the optimal choices and payoffs of an agent who chose to invest and then deriving the conditions under which this decision is optimal. We begin by noting that, because of the recursive nature of the problem, we can focus on time invariant plans.

LEMMA 1: For entrepreneurs, at most two plans are used in equilibrium

$$\{\Lambda, s_h, s_c\} \in \{\{1, accept, accept\}, \{0, search, accept\}\} \tag{10}$$

Proof of Lemma 1:

The list of possible plans $\{\Lambda, s_h, s_c\}$ is: 1.$\{1, accept, accept\}$, 2. $\{0, search, accept\}$, 3. $\{1, search, accept\}$, 4. $\{1, accept, search\}$, 5. $\{1, search, search\}$, 6. $\{0, search, search\}$. Plans 5 and 6 can be eliminated, since they lead to negative profits of $-i-\alpha$ and $-i$ respectively, which are dominated by not investing. Thus, we derive the payoffs for plans 1 to 4 only.

- Plan 1: $\{1, accept, accept\}$

  The value functions take the form

$$\begin{aligned} v_c(1) &= R - \beta + \delta v && (11)\\ v_h(1) &= R + \delta v && (12)\\ v_s(1) &= p v_c + (1-p) v_h && (13)\\ v &= -i - \alpha + v_s(1) && (14) \end{aligned}$$

  Substitution of v_c and v_h in v_s, and v_s in v yields

$$v(R) = \frac{1}{1-\delta}(R - i - \alpha - p\beta) \tag{15}$$

For the bribe, the problem is

$$\max_{\beta} \beta^{\theta}(R - \beta + \delta v - \delta v_s)^{1-\theta} \tag{16}$$

Which yields

$$\beta = \theta(R + \delta(v - v_s)) \tag{17}$$

Since $v_e - v_s = -i - \alpha$, we have

$$\beta = \theta(R - \delta(i + \alpha)) \tag{18}$$

and

$$v(R) = R\frac{1 - p\theta}{1 - \delta} - (i + \alpha)\frac{1 - p\theta\delta}{1 - \delta} \tag{19}$$

- Plan 2: $\{0, search, accept\}$

The value functions take the form

$$v_c(0) = R_i - \beta + \delta v \tag{20}$$

$$v_h(0) = \delta v_s(0) \tag{21}$$

$$v_s(0) = p v_c + (1 - p) v_h \tag{22}$$

$$v = -i + v_s(0) \tag{23}$$

The bribe is

$$\beta = \theta(R - \delta i) \tag{24}$$

Substitution of v_c and v_h in v_s yields

$$v_s = \frac{p}{1 - \delta(1 - p)}(R - \beta + \delta v) \tag{25}$$

Substitution of β in v_s and v_s in v yields

$$v(R) = R\frac{p(1 - \theta)}{1 - \delta} - i(1 + \frac{\delta p(1 - \theta)}{1 - \delta}) \tag{26}$$

- Plan 3: $\{1, search, accept\}$

  The value functions take the form

$$\begin{aligned} v_c(1) &= R_i - \beta + \delta v & (27) \\ v_h(1) &= \delta v_s(1) & (28) \\ v_s(1) &= pv_c + (1-p)v_h & (29) \\ v &= -i - \alpha + v_s(1) & (30) \end{aligned}$$

  The bribe is

$$\beta = \theta(R + \delta(i + \delta)) \qquad (31)$$

  which implies

$$v(R) = R\frac{p(1-\theta)}{1-\delta} - (i+\alpha)(1 + \frac{\delta p(1-\theta)}{1-\delta}) \qquad (32)$$

- Plan 4: $\{1, accept, search\}$

  The value functions take the form

$$\begin{aligned} v_c(1) &= \delta v_s & (33) \\ v_h(1) &= R + \delta v & (34) \\ v_s(1) &= pv_c + (1-p)v_h & (35) \\ v &= -i - \alpha + v_s(1) & (36) \end{aligned}$$

  The bribe offered is

$$\beta = \theta(R + \delta(i + \delta)) \qquad (37)$$

  and we have

$$v_s(1) = \frac{1-p}{1-\delta p}[R + \delta v] \qquad (38)$$

which implies

$$v_e(R) = R\frac{1-p}{1-\delta} - (i+\alpha)\frac{1-\delta p}{1-\delta} \tag{39}$$

Note that plan 3 is dominated by plan 2:

$$v_e(plan\ 2) - v_e(plan\ 3) = \alpha(1 + \frac{\delta p(1-\theta)}{1-\delta})$$

Plan 4 is dominated by plan 1 for all R such that investing is the dominant choice. Plan 1 dominates plan 4 for all $R > \delta(i+\alpha)$. In turn, under the following condition investing under plan 4 dominates not investing:

$$\begin{aligned} R(1-p) - (i+\alpha)(1-p\delta) &> 0 && (40)\\ R &> (i+\alpha)\frac{1-p\delta}{1-p} && (41)\\ &> i+\alpha && (42)\\ &> \delta(i+\alpha) && (43) \end{aligned}$$

So plan 4 dominates plan 1 only for R such that not investing is the dominant plan. Q.E.D.

To complete the characterization of the optimal choices by investors and non-investors, we need to map the values of R to a choice of plan. Because of the linear structure of the model, the optimal choices between pairs of plans can be simply characterized in terms of cutoff points in R. The following lemma formally defines this cutoff points:

LEMMA 2 : There are three levels of R, $\{R1, R2, R3\}$, such that

Lemma 2 *1. Strategy 1 is preferred to strategy 2 for all* $R_i > R1$ *with*

$$R1 = i\delta + \alpha\frac{1-p\theta\delta}{1-p} \tag{44}$$

2. Strategy 2 is preferred to not investing for all $R_i > R2$, with

$$R2 = i(\frac{1-\delta}{p(1-\theta)} + \delta) \tag{45}$$

3. Strategy 1 is preferred to not investing for all $R_i > R3$, with

$$R3 = (i+\alpha)\frac{1-p\theta\delta}{1-p\theta} \tag{46}$$

Proof of Lemma 2:

The payoffs are: For following strategy 1,

$$\begin{aligned} v &= -\frac{1-p\theta\delta}{1-\delta}(i+\alpha) + \frac{1-p\theta}{1-\delta}R \\ &\equiv a_1 + a_2 R_i \end{aligned} \tag{47}$$

From following strategy 2,

$$\begin{aligned} v &= -i(1+\delta p\frac{1-\theta}{1-\delta}) + \frac{p(1-\theta)}{1-\delta}R \\ &\equiv d_1 + d_2 R_i \end{aligned} \tag{48}$$

For 1, note that $a_1 < d_1$ and $a_2 > d_2$. Since $R \in \mathbb{R}^+$, there is a cutoff point such that strategy 1 is preferred to strategy 2 for all R that are higher. Simple algebra shows that this point is $R1$. For 2, note that $d_1 < 1$ and $d_2 > 0$, so a cutoff point for the choice between strategy 2 and not investing exists. Again simple algebra shows that it is $R2$. For 3, a similar argument to 2 applies. Q.E.D.

Proof of Proposition 1: Since R is unbounded and strategy 1 is optimal for all $R > \max\{R1, R3\}$, strategy 1 will always be observed in equilibrium. In turn, strategy 2 would also be observed iff R1>R2. The condition R1>R2 implies $\alpha(\frac{1-p\theta\delta}{1-p^*}) - \frac{i(1-\delta)}{p(1-\theta)} > 0$.This condition can be re-written as $p\left[i(1-\delta)+\alpha(1-\theta)\right] - p^2\left[\theta\delta\alpha(1-\theta)\right] - i(1-\delta) > 0$.

Evaluating this condition at $p=0$ yields a negative value. Evaluating this condition at $p=1$ yields a positive value. Furthermore, the expression is either strictly increasing in p or it is increasing at low values of p and decreasing at high values of p but achieving a maximum for $p \leq 1$. In either case there must exist one and only one value of p, namely p^*, such that for $p>p^*$ the condition $R1>R2$ holds and for $p<p^*$ the condition $R1>R2$ does not hold. QED