BRIBERY, CORRUPTION DEPTH, AND STRATEGIC GOVERNMENT POLICY

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Abstract

We develop a general economic framework for corruption and policy evaluation. The depth of corruption and the bribe are endogenously determined by the strategic interaction of the parties. We study the overall effects of changes in various parameters embodying measures of efficiency, punishment, and willingness-to-pay. A mere change in the officer's salary does not affect the depth of corruption. We propose a taxonomy of corruption that offers some benchmarks for the management of anticorruption policy and the variability of the bribe.

Keywords: The bribe, the depth of corruption, anticorruption policy, the "ability-to-pay," government's efficiency, the costs of breaking the law.

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1. Introduction

In this paper we are concerned with economic mechanisms reshaping the value of the bribe, the depth or incidence of corruption, and strategic government policies. We develop a general economic framework for corruption where the bribe values, the government's investment in the anticorruption measure, and the extent of corruption are endogenously determined by the strategic interaction of various forces. Several considerations motivate this research. First, there is a shortage of models that consider the general equilibrium effects of anticorruption measures and the bribe from changes in parameter values, while this seems critical for policy management and evaluation. Our model will cast light on these effects from the interaction between the government attempting to prevent corruption and an external party (the donor) bribing the officer. The model could be extended in various dimensions,[1] but the basic mechanisms determining corruption should prevail in related environments; in turn, our analysis can be of guidance for those simplified models used in empirical work. Second, heterogeneity pervades studies of corruption. As detailed below, empirical findings most often face a diverse set of factors involving various elements of economic activity, characteristics of companies and consumers, and the legal environment across economic sectors and countries. We propose a parsimonious approach to comparative statics (i.e., perturbation of parameter values) based on the public cost of corruption (or "ability-to-pay" of the government) and the profitability (or "ability-to-pay") of the donor, which can be useful to evaluate changes in the depth of corruption and the bribe over these different factors. And third, we compare our results with other models and competing theories. Some partial equilibrium approaches turn out to be very simplistic, and hence quite misleading for policy evaluation. Our rich economic framework includes several parameters embodying measures of efficiency and willingness-to-pay, and deals explicitly with the strategic interaction of the various parties. The variability of the bribe arises from some fundamental forces rather than from price discrimination. Moreover, we can appeal to some properties of the bribe schedule to characterize how the division of the surplus from bribing can be shared between the donor and the officer.

Technically, we are considering a full-blown, simultaneous-move game in which the government invests in anticorruption, while the donor offers a side payment b to pursue the officer to deviate from the government's mandate. The government pays a fixed salary, w, to the officer and may devote a certain amount of expenditure, q, to deter the officer from accepting the bribe and deviating from the government's stipulated duty. We refer to q as the investment value in the anticorruption measure, and b as the value of the bribe. We search for an equilibrium in the strategy space (q, b). We identify conditions under which

[1] As discussed in the concluding section, an important extension of our work appears to be the case of public procurement for multiple private contractors bidding for related projects.

the equilibrium is unique. As an added benefit of this approach, we can also compute the depth of corruption, $h(q, b)$; i.e., the equilibrium probability that the officer will accept the bribe and deviate from the government's mandate. We then perturb the model in several directions to understand the various factors and policy measures influencing our equilibrium quantities $(q, b, h(q, b))$. We also provide a numerical example that can attest for the behavior of q and b to perturbations of parameter values.

The large variability of the depth of corruption and the value of the bribe over various data sets has not been systematically studied, but should be at the heart of theories of corruption. Central to our analysis, we establish a fundamental asymmetry between the effects of the "ability-to-pay" of the government and the donor. An increase in the government's "ability-to-pay" will push up q and lower b, and hence will decrease the depth of corruption, while an increase in the donor's "ability-to-pay" will push up q and b, and so the effect on the depth of corruption will be indeterminate. Furthermore, our model exemplifies that an increase in the government's efficiency to fight corruption would be isomorphic to an increase in the government's "ability-to-pay," and an exogenous lowering of the probability of detection would amount to a scaling up of the "ability-to-pay" of the donor. Then, without loss of generality we suggest a taxonomy of corruption (Table 1) that centers upon the "ability-to-pay" of both the government and the donor relative to the government's marginal efficiency to fight corruption and the officer's marginal disutility of breaking the law. Grand corruption (i.e., a high "ability-to-pay" of the donor V^d) may prevail in high-efficient economies because the donor is ready to offer a high bribe—even though the government will respond with high investment in anticorruption. For public procurement there is usually a high "ability-to-pay" of the government V^g since bribing may result in substantially lower budgets and diminished quality. There are, however, other instances of grand corruption (loosely refer as "white-collar" crimes) which are not related to the provision of public goods and services, and V^g may be lower from this perspective. Then, our model predicts that the bribe value would go up (while the depth of corruption can be indeterminate). Petty corruption (a small "ability-to-pay" of the donor V^d) may only occur in environments in which the government's efficiency to fight corruption and disutility of breaking the law may be rather low; hence, some forms of petty corruption can be absent in advanced economies. Petty corruption, however, can be associated with a high "ability-to-pay" of the government V^g because of overlooked collateral effects, especially in some poor countries. Small bribes for essential services and unqualified hires can have severe outcomes, causing fatalities through poor healthcare quality and unsafe infrastructure. Therefore, the "ability-to-pay" of the government V^g can be overshadowed by their low efficiency to fight corruption.

Early theoretical work on corruption centered on the officer's individual rationality *(IR)* constraint (e.g., Becker & Stigler, 1974; Acemoglu, 1995; Andvig & Moene, 1990; Aidt, 2003,

Table 1. A TAXONOMY OF CORRUPTION.

	V^g	V^g
V^d	High High	High Low
V^d	Low High	Low Low

Mookherjee & Png, 1992, 1995). Most of the literature uses a partial equilibrium framework, and hence it fails to capture unintended consequences of the interaction between the government's anticorruption efforts and the donor's bribery attempts. Some other influential work has looked at corruption using a second-best welfare-optimization framework for the allocation of resources in society. These studies are not directly concerned with the depth of corruption and the value of the bribe. The officer enjoys some monopoly power and will try to extract the maximum surplus from the private sector subject to some screening and monitoring restrictions of the government. In Bliss & Di Tella (1997) and Shleifer & Vishny (1993) the role of the government is not explicitly modeled, and the officer's monopoly power may heavily impact the allocation of resources. Acemoglu & Verdier (2000) consider a general equilibrium model of the economy in which pay to public officials is a defining instrument for the allocation of talent in the public sector—loosening the officer's IR constraint. In Banerjee (1997), the officer may resort to red tape as a typical screening device under adverse selection over the various types of consumers. In our paper, red tape can be imposed by the government to the officer as an extra fixed cost while the officer deviates from the stipulated duty.

In a rather different setting from ours, Mookherjee & Png (1995) study delegated enforcement with asymmetric information, and emphasize that the relation between compensation policy and corruption may be quite complex. In particular, an increase in the penalty on the inspector for corruption may raise the bribe rather than reduce corruption, and it will take a sufficiently large, discrete increase in the penalty to eradicate bribery. Hence, their paper illustrates some unintended consequences from strategic interactions. As a matter of fact, in our model there could be some anticorruption measures and legal hurdles to avoid corruption, which may just raise bribe values with relatively little effect on the depth of corruption. In particular, a mere change in the officer's salary can be counterbalanced by a compensatory bribe, and so the lack of response of the threshold level of corruption to the officer's salary comes from general equilibrium considerations. Inadequate wages in developing countries are often cited as main cause of bureaucratic corruption. The theoretical literature has identified some channels for bureaucratic pay to affect corruption (Besley & Mclaren, 1993), but the empirical evidence in this regard is not so clear. Foltz & Opoku-Agyemang (2015) discuss a political experiment where the Ghana government doubled its police officers' salaries in 2010 in part to mitigate petty corruption on its roads. Contrary to its intended effect, the salary policy significantly increased the value of the bribe given by truck drivers to policemen.

While we mostly refer to empirical evidence based on a literature of isolated cases from court rulings and other documents, in a final section we explore the observed cross-country variability of the depth of corruption and the bribe. Perhaps, the most intriguing empirical evidence has been the negative correlation between the value of the bribe and per-capita GDP across countries. We collect data from the Global Competitiveness Report (GCR) and the World Justice Project (WJP) to construct an indicator for the government's efficiency to fight corruption. We then present various stylized facts on corruption which are in line with microeconomic studies: (i) *Grand Corruption*: The depth of grand corruption varies inversely with the government's efficiency to fight corruption. Grand corruption could be entrenched even in high-efficiency economies. (ii) *Petty Corruption*: The depth or prevalence of petty corruption varies inversely with the government's efficiency to fight corruption. Some types of petty corruption are quite uncommon in high-efficiency economies. (iii) *The Bribe*: The value of the bribe varies inversely with the government's efficiency to fight corruption. Besides, the bribe varies across income groups for a given type of crime. (iv) *Officers' Salaries*: Mere changes in officers' salaries (without additional supplementary measures) do not seem to affect the depth of corruption, either grand corruption or petty corruption. (v) *Investment in Anticorruption Policies*: Overall public investment in anticorruption is only slightly negatively correlated with the government's efficiency to fight corruption.

Section 2 lays out the corruption game, while Section 3 presents our main analytical results on the existence of a unique equilibrium. Then, in Section 4 we perform some comparative statics exercises over the equilibrium solution. Based on this comparative analysis, Section 5 goes over the above taxonomy of corruption. Section 6 proposes a simple extension in which the officer could be replaced by a committee proceeding under majority voting. If the depth of corruption is low, then a committee may be more desirable than a representative officer to fight corruption; and if the depth of corruption is high, then a representative officer may be more desirable than a committee to fight corruption. Section 7 discusses the aforementioned stylized facts from cross-country data. Finally, Section 8 ends with some concluding remarks. Proofs of our results illustrating these general equilibrium effects, and data sources, are gathered in the Appendix.

2. The Model

An *officer* must perform a formally *stipulated duty*, $\bar{x} \subset \mathbb{R}$. Bribery happens when the officer accepts a side payment $b \in \mathbb{R}_+$ by an external party (i.e., the *donor*) and deviates from $\bar{x}$ by choosing to undertake some less desirable task, $y \subset \mathbb{R}$. The *government* spends $q \in \mathbb{R}_+$ to implement $\bar{x}$ and so to deter the officer from accepting payment b in exchange for performing y, as requested by the donor. We refer to b as *the value of the bribe*, and to q as the government's *investment value in the anticorruption measure.*

The officer will suffer a utility loss from deviating from their stipulated duty. Besides a positive probability of punishment, there could be some non-pecuniary costs from breaking the law; say that these costs may come from the denial of social and ethical postulates, and the embarrassment associated with job separation and punishment. The stipulated duty $\bar{x}$ could be a discrete choice (voting, granting a permit, selection of a high-quality vendor in a procurement process) or a continuous action towards the achievement of a certain task (a given amount of time devoted to auditing and supervision, or a preparatory report for the operation of a public work). The anticorruption measure q can be thought of as the aggregate government's investment through the various anticorruption channels. The probability that the bribe is accepted, $\hat{h}(q, b)$, will be referred to as the *depth of corruption.*

2.1. **The Officer.** There is but a single officer with a preference type or "identity" h. The set of preference types is uniformly distributed over the unit interval $h \in [0, 1]$. The preference type h is private information—known to the agent but not observed by others. We can think of h as a measure of the attitude of the officer towards accepting the bribe based on legal, social, and personal considerations.

Let $\bar{u}^h(\bar{x}^h, q, w)$ for all h be the utility of the officer while performing the stipulated duty (i.e., being honest), $\bar{x}^h$, for anticorruption value q and salary w. The anticorruption measure may affect the officer's utility while performing $\bar{x}^h$ since it may impose compliance with certain regulatory and legal procedures. Moreover, $\bar{u}^h(y, q, w) < \bar{u}^h(\bar{x}^h, q, w)$, since the officer h will suffer some utility loss from taking a "wrong" action, y.

Let $I = w + b$. Then, an officer of preference type h will accept the bribe if

$$u^h(y, q, I) \geq \bar{u}^h(\bar{x}^h, q, w). \tag{1}$$

For simplicity, b enters u^h as a perfect substitute for w. We could consider some general functional forms for the utility of the bribe.

Assumption 1. • *$u^h(y, \cdot, \cdot)$ is twice continuously differentiable.*
• *$u^h(y, \cdot, I)$ is decreasing and strongly convex.*
• *$u^h(y, q, \cdot)$ is increasing and strongly concave.*
• *The second-order cross-partial derivative $u^h_{I,q}(y, q, I) < 0$ for all (y, q, I).*

As discussed below, these assumptions are entirely standard. Observe that $u^h_{I,q}(y, q, I) < 0$ means that the marginal utility of b decreases with q.

Let us temporarily fix (q, w) so that $\bar{u}^h(\bar{x}^h, q, w) = \bar{u}^h$. Then, for an officer with preference type h, we can define the reservation or compensatory bribe $b^h > 0$ as:

$$u^h(y, q, w + b^h) \equiv \bar{u}^h. \tag{2}$$

We shall impose the following natural ordering in the space of bribes: $b^h > b^{h'}$ for $h > h'$ for all (y, q, w). This is a rather mild restriction. Note that the smallest compensatory bribe $b^0 > 0$ corresponds to preference type $h = 0$, and sets up a lower bound for the bribe. It follows that for given (q, b), there is at most one preference type $\hat{h}(q, b)$ such that $u^{\hat{h}}(y, q, w + b) = \bar{u}^{\hat{h}}$. All preference types $h > \hat{h}$ will not accept the bribe, and all preference types $h < \hat{h}$ will accept the bribe. Then, $\hat{h}(q, b)$ is the probability that the bribe b is accepted; i.e., the depth of corruption.

For technical reasons and to avoid repeated use of the index h, we need some simplifying assumptions. First, we assume a common utility function u such that $u^h(y, q, I) = u(q, I)$ for all h. And second, we assume that function $\bar{u}^h(\bar{x}^h, q, w)$ is affine and additively separable with respect to h.

Assumption 2. • *A common utility function $u(q, I)$: For all h, function $u^h(y, q, I) = u(q, I)$, all (q, I).*
• *A simplified IR constraint: $u(q, I) = \bar{u}^h$. The reservation utility $\bar{u}^h$ is an increasing and affine function in h.*

From an economic point of view, these simplifying assumptions do not seem overly restrictive, and can be weakened. We should remark that further non-linearities will not change our results on existence and uniqueness of equilibrium as long as we can preserve the convexity properties of function u over the *IR* constraint. Our comparative statics exercises below will offer a neat characterization of changes in $(q, b, \hat{h})$ over parameter values. These benchmark effects will be blurred under more general assumptions.

2.2. **The Government.** In order to fix ideas, suppose that the government relies on the expertise of the officer to select a project. Let H be the right choice and R some other inferior choice, e.g., to build a hospital as opposed to a shopping mall. Let V_H^g and V_R^g be the government's valuations for H and R, respectively. Hence, $V^g = V_H^g - V_R^g > 0$ is the government's value of the corruption distortion. The government spends q to deter the officer from deviating, and will gain V^g if the officer is not bribed. Then, we can write the government's payoff or expected benefit as:

$$\pi_g(q, b) = (1 - \hat{h}(q, b))V^g - q.$$

The government's optimal choice $q(b)$ is obtained from the maximization problem:

$$\max \pi_g(q, b), \;\; s.t. \; q \geq 0. \tag{3}$$

Note that $q = 0$ implies $\pi_g(q, b) = (1 - \hat{h}(q, b))V^g \geq 0$. It follows that $q(b) \leq V^g$. That is, to fight corruption the government would not surpass the threshold of the corruption distortion.

2.3. **The Donor.** Similarly, $V^d = V_R^d - V_H^d > 0$, where V_H^d and V_R^d are the donor's valuations for choices H and R, respectively. Accordingly, we can write the donor's payoff or expected benefit as:

$$\pi_d(q,b) = \hat{h}(q,b)V^d - b, \ \ s.t.\ b \geq 0.$$

The donor's optimal choice $b(q)$ is obtained from the maximization problem:

$$\max \pi_d(q,b), \ \ s.t.\ b \geq 0. \tag{4}$$

Again, $b(q) \leq V^d$.

A few clarifications might be useful at this point. Both the government and the donor are risk neutral, which would seem appropriate if both q and b are relatively small as compared to V^g and V^d. Further, q and b are modeled as fixed costs regardless of the officer's decision. This represents commitment on the part of the government and the donor, respectively. It would be reasonable to suppose that b is only expended if the officer has accepted the bribe, but this would raise enforcement considerations that unduly complicate the analysis without adding economic substance.

To avoid some degenerate cases, we will focus on interior solutions, $q \geq 0, b > 0$. This interiority condition is not very restrictive since we have a continuum of preference types, and hence the depth of corruption $\hat{h}$ can be arbitrarily low or arbitrarily high.

Assumption 3. • *For all* $q \geq 0$ *there exists* $b \in [0, V^d]$ *such that* $\pi_d(q,b) > 0$.
• *For all* $b \geq 0$ *there exists* $q \in [0, V^g]$ *such that* $\pi_g(q,b) > 0$.

The first part of this assumption implies that the donor is always able to bribe some preference types, while the second part rules out the possibility of being able to bribe the whole continuum of preference types. Hence, $0 < \hat{h} < 1$ with $b > 0$.

Let us proceed to discuss some simple properties of the depth of corruption $\hat{h}$, the probability that the bribe b is accepted.

Lemma 1. *Under Assumptions 1-2 we have:*
- $\hat{h}(\cdot,\cdot)$ *is twice continuously differentiable.*
- $\hat{h}(\cdot,q)$ *is increasing and strongly concave for* $b \geq b^0$.
- $\hat{h}(b,\cdot)$ *is decreasing and strongly convex.*
- *The second-order cross-partial derivative* $\hat{h}_{bq}(q,b) < 0$ *for all* (q,b).

Corollary 1. *Under Assumptions 1-3 we have:*
- *First-Order Optimality Condition for the Government:* $-\hat{h}_q(q,b) \leq \frac{1}{V^g}$.
- *First-Order Optimality Condition for the Donor:* $\hat{h}_b(q,b) = \frac{1}{V^d}$.

3. Nash Equilibrium

3.1. **Existence.** We establish existence of a unique Nash equilibrium in the strategy space (q, b). Technically, the proof of existence must deal with a jump in the compensatory bribe from the officer's binary decision of breaking or not breaking the law. More formally, for an officer of preference type h the reservation bribe b^h equals zero when performing the stipulated duty, and $b^h \geq b^0$ otherwise.

Let $q(b)$ be the optimal solution to the maximization problem (**??**) for given b, and $b(q)$ the optimal solution to the maximization problem (**??**) for given q. Under the above standard assumptions, these functions are well defined and satisfy some monotonicity properties.

Lemma 2. *Under Assumptions 1-3, we have:*
- *For all $b \in [0, V^d]$, the mapping $q(b)$ is non-decreasing and continuously differentiable; $q(b) = 0$ for $b \leq b^0$.*
- *For all $q \in [0, V^g]$, the mapping $b(q) > 0$ is decreasing and continuously differentiable.*

This lemma points to the following asymmetry. As $q(b)$ is non-decreasing, a higher bribe b triggers a greater anticorruption measure q. As $b(q) > 0$ is decreasing, a higher anticorruption measure q will lower the bribe b. These results are essential for the existence of a unique equilibrium solution, and will play a key role in our comparative statics exercises below.

We define the Nash equilibrium as follows:

Definition 1. *A Nash equilibrium is a pair (q^*, b^*) such that $b^* = b(q^*)$ and $q^* = q(b^*)$.*

Proposition 1. *Under Assumptions 1-3, there exists a unique Nash equilibrium (q^*, b^*).*

We now restate some interiority properties of the unique equilibrium.

Corollary 2. *The following must hold:*
- *$q^* \geq 0$, $b^* > 0$.*
- *The Depth of Corruption: $0 < \hat{h}(q^*, b^*) < 1$.*
- *Payoffs: $\pi_g(q^*, b^*) > 0$ and $\pi_d(q^*, b^*) > 0$.*

Let us assume that government's inaction is never optimal.

Corollary 3. *Suppose that for all $b > b^0$ there exists $q > 0$, such that $\pi_g(q, b) > \pi_g(0, b) \geq 0$. Then, $q^* > 0$, $b^* > 0$.*

4. Comparative Statics

4.1. **Heterogeneity.** Corruption is commonplace in society, and most often is blamed to happen from lack of appropriate regulations and enforcement, together with the underlying characteristics of economic agents and the nature of the economic activity. Hence, heterogeneity pervades studies of corruption, and a fundamental question is how the various changes in the environment can reshape the value of the bribe and the depth of corruption. These issues frequently crop up in the literature,[2] and need to be supported by sound economic theories.

Large companies are usually subject to internal stringent auditing procedures and due diligence, and may face added reputational costs. Also, it may matter if a company is national, or operating abroad. Deviations by high-ranking officials may be much harder to detect, while some officers face a lower cost of dismissal at the end of their professional careers. Consumers are generally ranked by income or purchasing power and education. Public procurement and contracting are usually highly regulated [Bosio *et al*. (2022)]. Banking transactions, import duties, and taxation are exposed to close government monitoring. Other economic activities operate with greater opacity, evading public scrutiny. Unregulated sectors may allow for less oversight. Therefore, policy evaluation requires a good understanding of the economic mechanisms driving corruption.

4.2. **A Parsimonious Approach to Comparative Statics.** We now introduce certain functional forms to analyze some general equilibrium effects on corruption from various factors such as changes in the probabilities of detection and punishment, the officer's cost of breaking the law, the loss of government revenues or "ability-to-pay," and the donor's "ability-to-pay". Our main goal in this exercise is to trace back the equilibrium effects on $(q, b, \hat{h})$ from various parameters. The simplicity of our results hinges on some separability assumptions on the officer's utility function together with the linearity of the payoff functions for the government and the donor.

Although there are a host of factors to consider, we find that changes in these economic variables can be grouped into three categories; i.e., their effects turn out to be isomorphic within each group. First, there is the category of government or public policy variables which in our model will lower the value of the bribe and the depth of corruption. Hence, similar qualitative effects are found from increasing government's efficiency for detection and punishment, increasing the costs of punishment, and increasing the government's "ability-to-pay." Certainly, the optimal policy mix will depend on some considerations external to our model such as the underlying cost of each policy measure, and surrounding ethical values related to punishment. Second, increasing the donor's "ability-to-pay" has the same qualitative effect as an exogenous lowering the probability of detection and punishment. For these changes in the second group of economic variables, the value of the bribe will go up, but the depth of corruption will be indeterminate; i.e., there could be a further government's response in the anticorruption measure. And third, a mere change in the wage for performing

[2]In the sequel, we shall rely on some micro evidence from court documents by Cheung, Rau, and Stouraitis (2020), D'Souza and Kaufmann (2013), Karpoff, Lee, and Martin (2014), some OECD reports, e.g. OECD (2014), as well as Bosio *et al*. (2022).

a stipulated duty—without variation in the foregone outside opportunity—will not affect the depth of corruption, since such a change could be counterbalanced by a compensatory bribe of a risk-neutral donor. Moreover, some regulatory measures and protocols enhancing social norms, compliance and transparency, and auditing may translate into further fixed costs to the officer while deviating from the government's mandate. These fixed costs may lower the depth of corruption, but in our model will leave the marginal conditions for the bribe unchanged.

A systematic analysis of these general equilibrium effects is missing in the literature. We now proceed to explain these effects in more detail.

4.3. **Model's Parameters.** • $\bar{u}^h$: *The officer's bargaining power or reservation utility for preference type h.* We shall write: $\bar{u}^h = \bar{u} + \hat{u}^h$, where $\bar{u}$ is a constant term and $\hat{u}^h = \lambda h$. Hence, the slope λ is our measure of the information friction for the hidden type.[3]

• w: *The officer's salary.*

• V^g: *The government's value of the corruption distortion or "ability-to-pay".*

• V^d: *The donor's benefit from bribing the officer or "ability-to-pay".*

• α: *An added efficiency term for the anticorruption measure.* We shall write: $\alpha(q) = a + \bar{\alpha}q$, where a is a constant term and $\bar{\alpha}$ is the slope or marginal efficiency of q.

• γ: *The value of punishment.* A fixed parameter value.

Let p be the probability of detection and punishment, which most often will be referred as the probability of punishment, and which depends on the anticorruption measure, q. Following Becker and Stigler (1974), let us suppose that the *IR* constraint (**??**) takes the form:

$$(1 - p(q))v(w + b) - \alpha(q) - p(q)\gamma \geq \bar{u}^h. \tag{5}$$

Becker and Stigler (1974) assume that $\bar{u}^h$ is the cost of dismissal; that is, the present value of the excess income stream that would be forgone.

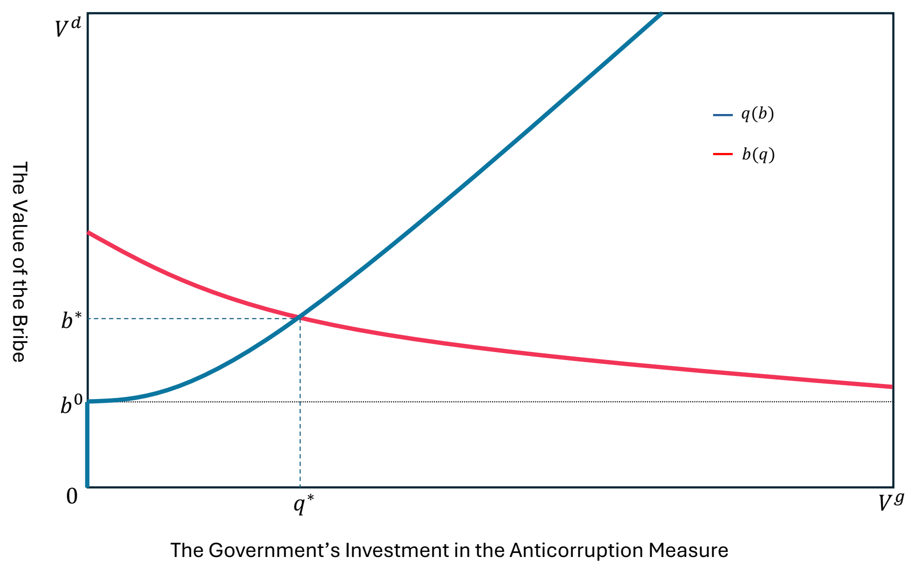
Observe that all the left-hand side terms in (**??**) can be lumped into an aggregate utility function, $u(q, I)$, for $I = w + b$; see Assumption **??**. Morevoer, Assumption **??** is satisfied if functions p, v and α are increasingly monotone and strongly concave. The cross-partial derivative $u_{I,q}(y, q, I)$ in Assumption **??** is negative since the expected marginal utility of income diminishes as we increase the probability of punishment, p. As before, concerning income the wage w and the bribe b are assumed to be perfect substitutes. We introduce $\alpha(q)$ to assess changes in the efficiency of the anticorruption measure q. Also, $\alpha(q)$ could include extra utility costs associated with performing the stipulated duty under q stemming from further compliance requirements, auditing, and social pressures, which may force the

[3]In this context, parameter λ would reflect the sensitivity or attachment to certain values over hidden identity types. Dissimilar behavioral patterns may be enhanced by income and education (e.g., transformed attitudes may be more prevalent in rich societies), ingrained social norms, and compliance to the law.

officer to take more costly actions to circumvent the law; e.g., a vastly cheaper road transport option is now bound to fail and the officer must use air freight shipping. And γ represents the cost of punishment.

4.4. **Results.** Figure 1 portrays the reaction functions $q(b)$ and $b(q)$ leading to the Nash equilibrium (q^*, b^*). Observe that $q(b)$ is non-decreasing and $b(q)$ is decreasing. From the first-order conditions as stated in Corollary **??**, we now discuss how perturbations of the various terms of the *IR* constraint (**??**) will shift reaction functions $q(b)$ and $b(q)$. Some parameters can be viewed as fixed costs to the officer, and will affect $\hat{h}(q^*, b^*)$, but have no influence on (q^*, b^*). From the first-order conditions (Corollary **??**), the "ability-to-pay" parameter V^g will affect reaction function $q(b)$, whereas V^d will affect $b(q)$. Similarly, a change in the marginal efficiency of the anticorruption measure, $\bar{\alpha}$, will be isomorphic to a change in V^g, whereas a change in the slope λ of u^h will equally affect both first-order conditions and so it will amount to a symmetric scaling down of both V^g and V^d.

FIGURE 1. NASH EQUILIBRIUM (q^*, b^*).

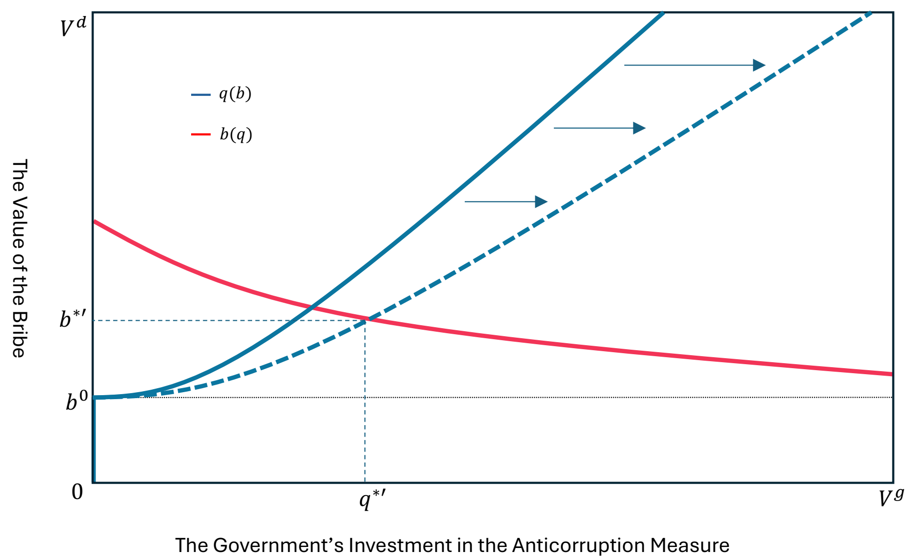


• *Changes in the officer's bargaining power or reservation utility, $\bar{u}^h$*: We assume $\bar{u}^h = \bar{u} + \hat{u}^h$, for $\hat{u}^h = \lambda h$. An increase in $\bar{u}$ does not affect the first-order optimality conditions for the government and the donor as stated in Corollary **??**. Hence, (q^*, b^*) remains unaltered, but $\hat{h}(q^*, b^*)$ will decrease. A change in the adverse selection coefficient λ amounts to an even scaling down of V^g and V^d, since all these terms appear in the first-order conditions of Corollary **??** as multiplying constants. Hence, the relevant terns are V^g/λ and V^d/λ.

• *Changes in the officer's wage, w*: Changes in w prompt an inverse move in the compensatory bribe b so that total income $I = w + b$ remains the same. In our model, the salary w and the bribe b are perfect substitutes, and the donor is risk neutral. Hence, $\hat{h}(q^*, b^*)$ remains unchanged as we vary w. This benchmark prediction highlights some general equilibrium effects not present in related corruption models.

- *Changes in the government's value of the corruption distortion,* V^g: From the government's first-order condition (Corollary **??**), an increase in V^g will shift out the government's reaction function $q(b)$, while the donor's reaction function $b(q)$ remains unchanged. Since $q(b)$ is non-decreasing, and $b(q)$ is decreasing, the new crossing point happens at a higher q and a lower b as illustrated in Figure 2. Therefore, $\hat{h}$ decreases with V^g.

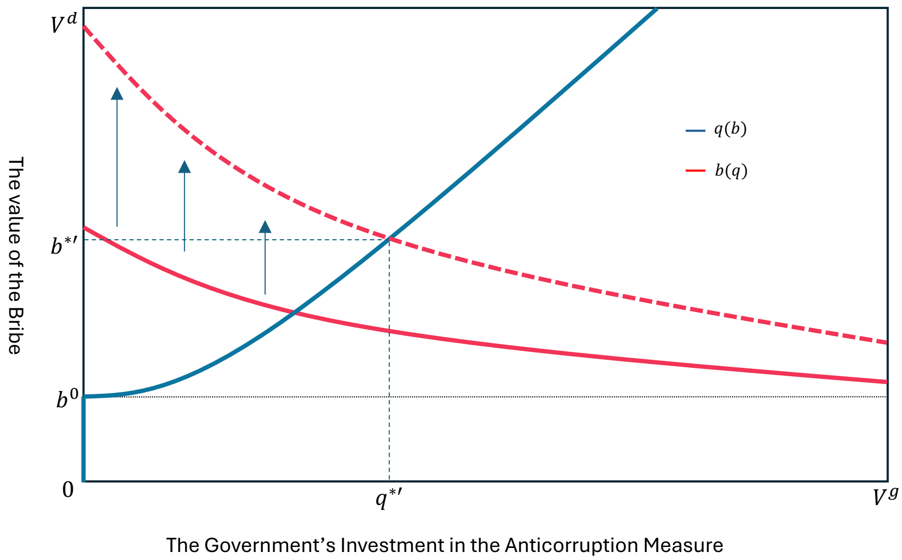
FIGURE 2. NEW NASH EQUILIBRIUM $(q^{*'}, b^{*'})$ FROM A POSITIVE SHIFT IN $q(b)$.



- *Changes in the donor's benefit from bribing the officer,* V^d: From the donor's first-order condition (Corollary **??**), an increase in V^d will shift up the donor's reaction function $b(q)$, while the government's reaction function $q(b)$ remains unchanged. Since $q(b)$ is non-decreasing, and $b(q)$ is decreasing, the new crossing point happens at both higher q and b as illustrated in Figure 3. Some examples not reported here confirm that $\hat{h}$ cannot be signed as we increase V^d.
- *Changes in the efficiency of the anticorruption measure,* α: Let $\alpha(q) = a + \bar{\alpha}q$. From the government's first-order condition (Corollary **??**), an increase in coefficient $\bar{\alpha}$ is isomorphic to an increase in V^g.
- *Changes in the value of punishment,* γ: As one can see from the *IR* constraint (**??**), an increase in the value of punishment has similar effects to an increase in the efficiency of the anticorruption measure, $\bar{\alpha}$.

Let us now formally state these results:

FIGURE 3. NEW NASH EQUILIBRIUM $(q^{*'}, b^{*'})$ FROM AN UPWARD SHIFT IN $b(q)$.



PROPOSITION 2. *Let* (q^*, b^*) *be the unique Nash equilibrium with* $q^* > 0$ *and* $b^* > 0$. *Let* $\hat{h}^* = \hat{h}(q^*, b^*)$. *Then,*

- *Changes in* $\bar{u}$: $\frac{\partial q^*}{\partial \bar{u}} = 0$, $\frac{\partial b^*}{\partial \bar{u}} = 0$, *and* $\frac{\partial \hat{h}^*}{\partial \bar{u}} < 0$.
- *Changes in* λ : $\frac{\partial q^*}{\partial \lambda} < 0$, *and* $\frac{\partial b^*}{\partial \lambda}$ *and* $\frac{\partial \hat{h}^*}{\partial \lambda}$ *cannot be signed.*
- *Changes in* w: $\frac{\partial q^*}{\partial w} = 0$, $\frac{\partial b^*}{\partial w} = -1$, *and* $\frac{\partial \hat{h}^*}{\partial w} = 0$.
- *Changes in* V^g: $\frac{\partial q^*}{\partial V^g} > 0$, $\frac{\partial b^*}{\partial V^g} < 0$, *and* $\frac{\partial \hat{h}^*}{\partial V^g} < 0$.
- *Changes in* V^d : $\frac{\partial q^*}{\partial V^d} > 0$, $\frac{\partial b^*}{\partial V^d} > 0$, *and* $\frac{\partial \hat{h}^*}{\partial V^d}$ *cannot be signed.*
- *Changes in* $\bar{\alpha}$: $\frac{\partial q^*}{\partial \bar{\alpha}} > 0$, $\frac{\partial b^*}{\partial \bar{\alpha}} < 0$, *and* $\frac{\partial \hat{h}^*}{\partial \bar{\alpha}} < 0$.
- *Changes in* γ: $\frac{\partial q^*}{\partial \gamma} > 0$, $\frac{\partial b^*}{\partial \gamma} < 0$, *and* $\frac{\partial \hat{h}^*}{\partial \gamma} < 0$.

4.5. **An Example.** Let $p(q) = \frac{q}{1+q}$. Let $v(w+b) = (w+b)^{1/2}$ be the utility function, and $\lambda h > 0$ be the disutility of breaking the law. Let $\bar{u} > 0$ be the reservation utility. We can then calculate the depth of corruption $\hat{h}$ form the *IR* constraint:

$$(1 - p(q))v(w+b) - \lambda \hat{h} = \bar{u}. \tag{6}$$

Therefore,

$$\hat{h}(q,b) = \frac{(1 - \frac{q}{1+q})(w+b)^{1/2} - \bar{u}}{\lambda}. \tag{7}$$

The government solves the optimization problem:

$$\max \quad (1 - \frac{(1-\frac{q}{1+q})(w+b)^{1/2} - \bar{u}}{\lambda})V^g - q$$
$$s.t.\ 0 \le q \le V^g. \tag{8}$$

From the first-order condition:

$$\frac{V^g(w+b)^{1/2}}{\lambda(1+q)^2} = 1, \tag{9}$$

we get the reaction function:

$$q(b) = (w+b)^{1/4}\left(\frac{V^g}{\lambda}\right)^{1/2} - 1. \tag{10}$$

Similarly, the donor solves the optimization problem:

$$\begin{aligned} \max \quad & \tfrac{(1-\frac{q}{1+q})(w+b)^{1/2}-\bar{u}}{\lambda}V^d - b \\ & s.t.\ 0 \le b \le V^d. \end{aligned} \tag{11}$$

From the first-order condition:

$$\frac{V^d(w+b)^{-1/2}}{2\lambda(1+q)} = 1, \tag{12}$$

we can also derive the reaction function $b(q)$, even though it does not have such a simple form because of the aforementioned discontinuity in the compensatory bribe. From (**??**) and (**??**), we compute the unique Nash equilibrium as:

$$q^* = \left(\frac{1}{2}\right)^{1/3}\left(\frac{V^d}{\lambda}\right)^{1/3}\left(\frac{V^g}{\lambda}\right)^{1/3} - 1, \tag{13}$$

and

$$b^* = \left(\frac{1}{2}\right)^{4/3}\left(\frac{V^d}{\lambda}\right)^{4/3}\left(\frac{V^g}{\lambda}\right)^{-2/3} - w. \tag{14}$$

Then, plugging (**??**) and (**??**) into (**??**), we can obtain the depth of corruption:

$$\hat{h}(q^*, b^*) = \frac{2^{-1/3}(\frac{V^d}{\lambda})^{1/3}(\frac{V^g}{\lambda})^{-2/3} - \bar{u}}{\lambda}. \tag{15}$$

Several important observations are apparent from (**??**)-(**??**). First,

$$\frac{\partial \hat{h}^*}{\partial w} = 0. \tag{16}$$

Second, the "ability-to-pay" parameters, V^g and V^d, and the costs of breaking the law, λ and $\bar{u}$, determine q^*, b^*, and $\hat{h}^*$. Moreover, the depth of corruption decreases with V^g and increases with V^d:

$$\frac{\partial \hat{h}^*}{\partial V^g} = -\frac{2^{2/3}\lambda^{-2/3}(V^d)^{1/3}(V^g)^{-5/3}}{3} < 0, \tag{17}$$

and

$$\frac{\partial \hat{h}^*}{\partial V^d} = \frac{2^{-1/3}\lambda^{-2/3}(V^d)^{-2/3}(V^g)^{-2/3}}{3} > 0. \tag{18}$$

Third, parameters λ, V^g, and V^d enter as $\frac{V^g}{\lambda}$ and $\frac{V^d}{\lambda}$ in (??)-(??). And fourth, both c and $\bar{u}$ are fixed terms that wash out in the first-order conditions, and hence only affect the depth of corruption $\hat{h}$.

5. A Taxonomy of Corruption and the Variability of the Bribe

Our model of bribery captures the simultaneous interaction of the three parties involved: the officer, the government, and the donor. The equilibrium quantities $(q, b, \hat{h}(q, b))$ are determined by the "ability-to-pay" of both the government and the donor, the government's efficiency to fight corruption, and the willingness of the officer to break the law. Moreover, an increase in the marginal efficiency of the anticorruption measure, as represented by parameter $\bar{\alpha}$, will be isomorphic to an increase in the "ability-to-pay" of the government V^g. Along these lines, an exogenous lowering of the probability of punishment p will be isomorphic to an increase in the "ability-to-pay" of the donor V^d. And an increase in the information friction, as represented by parameter λ, will be isomorphic to a scaling down of the "ability-to-pay" of both the government and the donor, V^g and V^d. Hence, without loss of generality we propose a taxonomy of corruption based on the "ability-to-pay" of both parties to trace down predicted changes in $(q, b, \hat{h}(q, b))$.

5.1. A Taxonomy of Corruption Based on the "Ability-to-Pay" of the Donor and the Government.

Table 1 contemplates four prototypical scenarios of corruption.

• *High V^d and high V^g.* A high bribe should certainly be expected if the donor is endowed with a high "ability-to-pay" even if the government is quite motivated to fight corruption. Our model predicts that a higher government's efficiency to fight corruption will result in greater expenditure in the anticorruption measures and lower bribe values. Hence, the depth of corruption and the value of the bribe are expected to be lower in developed economies. According to the World Bank Group (and related sources), public procurement may comprise between 15 and 20 percent of GDP, and could be about 50 percent of international bribing. Kenny (2009) reports that for a sample of developing countries, bribes in infrastructure projects may generally range between 5 and 20 percent of construction costs. These figures are confirmed by many other sources; see footnote 2. Obviously, the size of the bribe varies; but in some other sectors the bribe ranges between 2 to 10 percent of the total contract value, while a corrupt officer may extract between 15 to 30 percent of the total profit. As already pointed out, large companies and foreign companies may be more constrained to bribe. Evidence from survey data suggests that about one third of the involved companies may engage into bribing, and over 10 percent of these companies feel that they have lost contracts to corrupt competitors. The 2014 OECD report provides a breakdown of corruption based on the delivery of infrastructure projects, large purchasing orders of military and medical supplies, manufacturing, utilities, and subcontracting of services.

- *High V^d and low V^d.* Unlike public procurement, some highly lucrative corruption cases are less apparent and harder to detect. Bribing may just favor one citizen or company over another without higher cost and diminished quality of the public good or service, and hence V^g can be rather low from this perspective. In this scenario, we can refer to some "white-collar" crimes: securities fraud, insider trading, embezzlement, money laundering, cybercrime, identity theft, unverifiable product quality, and even drug-trafficking (deeply-rooted in some countries). For an increase in V^d, our model predicts that the bribe will go up. The government may nevertheless respond with a higher investment in the anticorruption measure, and hence the total change in the depth of corruption cannot be signed. As pointed out above, parameters $V^g, \bar{\alpha}, \lambda$ are interchangeable. Hence, rather than low V^g we may also think of low marginal efficiency to fight corruption $\bar{\alpha}$. The 2014 OECD report focuses on a large fraction of cases in "customs clearance," "preferential tax treatments," and "other preferential cases." It has been claimed that about 90 percent of those cases may go unreported. For more concrete examples, say that the Central Bank is undecided as to the right interest rate target; that is, suppose that there are two equally good interest rates, but a hike in the interest rate may greatly benefit one particular bank. Another example is the delivery of medical services, in which the government may be fairly indifferent as to which patient gets the treatment, while being concerned with a right and fair protocol for resource allocation. Bribery rates for the delivery of medical services—together with personal connections—can be of the order of 10 percent in advanced economies. With the Covid-19 outbreak, the bribery risk[4] peaked to about 33 percent—highlighting the donor's "ability-to-pay" under emergency conditions and supply shortages (*triage*).
- *Low V^d and low V^g.* Minor infringements and petty corruption; e.g., infractions and misdemeanors, minor offenses, and traffic violations. For low V^d, and a sufficiently high probability of punishment, our model would predict a corner solution (i.e., no bribing). In most poor countries, bribery rates are highest for *traffic officials* followed by *police officers*, but such bribery risk is much less common in advanced economies.[5] Roughly, for some countries in Africa, estimates of bribery risk for traffic officials could be of the order of 50 percent; for some CIS (Commonwealth Independent States) countries, bribery risk could be over 30 percent; by and large, for Latin America bribery risk hovers around 27 percent; for some Eastern-European countries more recently joining the European Union, bribery risk

[4] *Global Corruption Barometer–EU 2021.*

[5] Here, we just report some averages from the *tenth edition of the Global Corruption Barometer.* For other data sources of bribery see, for instance, the *Organized Crime and Corruption Reporting Project (OCCRP).*

hovers around 20 percent; whereas for some advanced countries in the European Union, bribery for traffic officials is usually reported to be below 5 percent.

• *Low V^d and high V^g.* Certainly, this is a extreme case of petty corruption. Again, rather than high V^g the government may be endowed with a high marginal efficiency $\bar{\alpha}$ to fight corruption together with imposing harsh punishments for breaking the law, or vice versa. A high q will push down b, and the depth of corruption $\hat{h}(q, b)$ is expected to be fairly low. Licensing officers in developing nations can accept small bribes, while jeopardizing safety by issuing licenses to unqualified or illicit individuals (criminals, terrorists, undocumented migrants), creating security risks and enabling crime (e.g., financial fraud); see Glynn (2022) and HURU (2025). Acquiring a driver's license without the necessary training may result in fatalities. Bertand *et al*. (2007) report on the corruption in driving licensing in Dehli, India. The World Health Organization Report (2008) informs on mortality rates due to poisoning per 100,000 children by region and country income level. In some poor nations the frequency could be 20 times greater than in the U.S. and Western Europe. The United Nations Report (2017) informs on severe abuses associated with chemical-intensive agriculture, and claims that 99 percent of the victims reside in the global South, where environmental, health, and safety regulations are often the weakest.

In summary, the first two scenarios involve a high "ability-to-pay" of the donor, and can be identified with grand corruption. Corruption in public procurement may prevail in high-efficient economies because the donor is ready to offer a high bribe—even though the government will respond with high investment in anticorruption. In the second scenario that we loosely refer as "white-collar" crimes, the probability of detection can be rather low because within a population of economic agents it could be hard to assess who is deviating. In some hard-to-monitor cases (e.g., cybercrime) the probability of detection may be much higher in advanced economies but the "ability-to-pay" of the donor could also be higher. Hence, for "white-collar" crimes the government may want to target some groups based on certain relevant attributes. Likewise, we consider two scenarios with petty corruption (a small "ability-to-pay" of the donor). First, we should note that in advanced economics some forms of petty corruption can be absent; i.e., for a given probability of punishment, the value of the bribe may not compensate for the costs of breaking the law. And second, small bribes in some poor nations can critically impact education, morbidity and public safety, and can fuel larger crimes such as financial fraud and security risks in infrastructure. Therefore, the high "ability-to-pay" of the government can be overshadowed by their low efficiency to fight corruption. As discussed below, national security policies may be legislated and voted by large committees.

5.2. **Variability of the Bribe.** We now discuss some determinants of the bribe as related to our model and the empirics of corruption.

Price Discrimination and the Behavior of the Bribe across Countries: Most of the corruption literature suggests that public officials may act as price discriminators. The contention is that officers in highly-corrupted countries may enjoy more monopoly power. Hence, third-degree price discrimination may underlie the observed variability of the bribe. Nonetheless, third-degree price discrimination would imply that relatively higher bribes will tend to occur in high-income countries, which is not usually supported in empirical studies. All in all, the probability of punishment is highly overlooked in the empirics of corruption, perhaps because of data availability, but such probability is a driving factor in our model.

Rather than price discrimination, we purport different mechanisms to account for the variability of the bribe based upon the government's efficiency to fight corruption and the "ability-to-pay." Then, the value of the bribe is determined by the strategic interaction of the parties. Consequently, in our model the government's efficiency to fight corruption is inversely correlated with the depth of corruption and the bribe value. For petty corruption, we have argued that the costs of breaking the law are relatively higher in advanced economies because of a higher probability of detection. Indeed, such costs are often enhanced by established protocols for surveillance together with democratic procedures for accountability, transparency laws, and projections on social media. Grand corruption can be hard to root out, even in developed nations. Among other considerations, grand corruption can be more involved between a company and the government, and can also become notorious in poor countries. The government may be unable to judge product quality and other subtleties, and must rely on outside experts' critical assessments; while the donor's "ability-to-pay" may remain quite high across all countries.

Herrera et al. (2007) find that larger firms appear to pay more in total bribes and also pay bribes more frequently than smaller firms. Hence, for a given type of crime the bribe may vary across income groups. This accords with a change of the "ability-to-pay" V^d in our model. They also claim that the incidence and total cost of bribes is lower for firms operating in countries with high quality infrastructure and security, and where the courts and regulatory system are rated highly. Svensson (2003) shows a positive correlation between company's "ability-to-pay" and bribes across graft-reporting firms in Ugandan industries facing similar regulations. Using a dataset on bribery of Peruvian public officials, Hunt & Laszlo (2005) find that both bribery incidence and value are increasing in household income. Rich households—who possibly have more complex businesses—pay more frequent and larger bribes than poor households. About 65% of the relation between bribery incidence and income is explained by greater use of more corrupt types of officials by high-income households.

The Division of the Surplus from Corruption between the Officer and the Donor: Observed bribe values may vary because of a host of heterogenous factors that can determine the extent of corruption. Nonetheless, a ballpark figure (see references in footnote 2) for the average value of the bribe can be around 8 percent of the total contract revenue, ranging between 2 and 10 percent, which can represent about 15 to 30 percent of profit. It is undeniable that such figures can provide a sense of the average profitability of bribing, which can further be associated with the probability of detection and the costs of breaking the law. However, as stressed in the introductory section, the bribe schedule can be quite complex. Indeed, in our model there is an initial fixed cost (or sudden disutility) to pursue the officer to break the law. Hence, the "ability-to-pay" of the donor V^d must be sufficiently high. Besides, there is also an upper bound to the bribe dictated by the cost of dismissal. Certainly, other factors external to our model can influence the bribe as a function of V^d. For instance, the probability of detection p can be itself a function of the bribe value b; and greater competition in the sector or economic activity (rival interests among various donors) may translate into higher bribing.

Therefore, as is well understood from the theory of moral hazard, linear contracts can only be generated under rather restrictive assumptions. Indeed, our framework embeds various measures of efficiency and willingness-to-pay, under the strategic interaction of various entities. As we plot the bribe value against the probability of detection and punishment, the lower bound of the bribe is dictated by the initial cost or disutility of breaking the law, and the upper bound of the bribe is dictated by the whole cost of dismissal. Both bounds would be positively correlated with the probability of detection. On the other hand, a lower probability of detection motivates the donor to offer a higher bribe. These countervailing forces may configure a highly non-linear bribe schedule.

5.3. **Some Evidence on Anticorruption Measures and the Costs of Breaking the Law.** It is generally accepted that agents respond to incentives [e.g., Becker (1968, 1993)]. But because of the paucity of data and inherent difficulties to run controlled experiments, it is usually not possible to perform full-scale, direct tests of models of corruption. Most empirical evidence is marred by heterogeneity and (poor) data quality. Since corruption deals with illegal activities, misreporting may be quite common in cross-country data. On the other hand, micro data may suffer from selection bias and other side effects from agents' repeated learning and long-term reactions to the new regulations (e.g., Olken & Pande, 2012). Moreover, Bosio *et al.* (2022) find that there is a poor correlation between laws and practices to corruption outcomes. Hence, their study exemplifies that empirical work would benefit from a better understanding of the underlying mechanisms generating corruption. Fisman & Miguel (2007) study parking violations in New York for UN officials protected by diplomatic immunity, and find that diplomats from high-corruption countries accumulated significantly more unpaid parking violations. They emphasize that cultural norms and legal enforcement are both important determinants of corruption. As already stressed, our model rests on the Beckerian assumption that agents respond to incentives. Hence, the probability of detection p can be enhanced by democratic procedures for accountability, transparency, and social media, and may lead to boundary solutions for some corruption situations in advanced economies. For interior solutions in our model, changes in both V^d and V^g have a lower impact on b and q under higher λ, which would measure the sensitivity or attachment to social norms over hidden identity types; see footnote 3. Therefore, transformed attitudes in a society or to certain crimes diminish the weight of *both* V^d and V^g.

Several micro studies highlight the importance of transparency, and the costs of breaking the law. Olken (2007) concludes that traditional top-down monitoring can play an important role in reducing missing expenditures, while increasing grassroots participation in monitoring had little average impact. Djankov *et al*. (2010) find that public disclosure rules for information about parliament members will lower perceived corruption. Using Puerto Rican longitudinal data of municipal governments, Bobonis *et al*. (2016) find that corruption is considerably lower in municipalities with timely audits before elections although these effects may not be long lasting. Ferraz & Finan (2008) study the role of electoral sanctions and find important complementarity between audits and electoral accountability. Avis *et al*. (2018) study an anticorruption program in Brazil which randomly audits municipalities for their use of federal funds. They suggest that the reduction in corruption may basically come from non-electoral costs of engaging in corruption (e.g., legal actions).

As once could expect, there is also a lot of variability on the costs of breaking the law. The probability of detection is usually smaller for high-ranking officials. Ferraz & Finan (2011) estimate that corruption is on average 27 percent lower among mayors with re-election incentives than among mayors without re-election incentives. McMillan & Zoido (2004) report that the value of bribes can depend on the level of the party member.

6. A Committee: Collective Decisions under Majority Voting

In this section policy implementation will be delegated to a group of officers. This happens often in practice. Indeed, many problems of social choice take the form of voting by a committee. In this setting, rather than looking at individual incentives, we need to determine the probability of collectively bribing a group of officers conforming a minimal winning coalition, which may in turn be characterized by the odds of accepting the bribe by a pivotal member of the committee.

As before, we frame the corruption problem as a binary decision; say between two projects or between taking some specific action or not taking it. A committee with N people is formed to make a decision collectively, where $N = 2M + 1$ for some $M \in \mathbb{N}$. Each committee member with a preference type or "identity" h is drawn independently from the uniform distribution on $[0, 1]$, and proposes an element from $\{\bar{x}^h, y\}$. We assume that each committee member does not differ from the entire population when it comes to ethical standards and the likelihood of accepting the bribe.

Bribery occurs when some officers deviate from their stipulated duty $\bar{x}^h$, and propose y, in exchange for a monetary payoff. Decisions are made by simple majority voting.[6] Therefore, for bribing the committee, it is enough to bribe up to $M+1$ members. The donor offers a bribe bill $B \in \mathbb{R}_+$, but is oblivious as to the reservation bribe b^h of every officer for given (q, w) because of the inability to sort out preference types h. All officers move at once and each member may accept the bribe or not. Those officers who agree to participate in corruption share the bribe bill B evenly.

Again, we shall impose the following natural ordering in the space of bribes: $b^h > b^{h'}$ for $h > h'$. Let $b^{N^P} = \frac{B}{N^P}$ for $N^P = M+1$. Then, there is at most one preference type $\hat{h}(q, b^{N^P})$ such that $u^{\hat{h}}(y, q, w + b^{N^P}) = \bar{u}^{\hat{h}}$. All preference types $h > \hat{h}$ will not accept the bribe, and all preference types $h < \hat{h}$ will accept the bribe.

Observe that $\hat{h}(q, b)$ defines the probability that the bribe b is accepted by an individual officer, but it does not define the probability that the committee will be bribed or has been corrupted and will collectively propose the "wrong" action. More specifically, for given b^{N^P} each officer independently drawn from the uniform distribution of preference types $h \in [0, 1]$ has a probability $\hat{h}(q, b^{N^P})$ of accepting the bribe. Majority voting requires that at least $M+1$ members are willing to accept the bribe. Therefore, for a fixed bribe bill, B, the probability $\phi(\hat{h}(q, b^{N^P}))$ that the committee of $N = 2M+1$ members will be bribed can be computed as:

$$\phi(\hat{h}(q, b^{N^P})) = \sum_{k=0}^{M} C_{2M+1}^{k} \hat{h}(q, b^{N^P})^{2M+1-k} (1 - \hat{h}(q, b^{N^P}))^k, \tag{19}$$

where $b^{N^P} = \frac{B}{N^P}$, and $N^P = M+1$. This is the cumulative probability of a binomial distribution. By the central limit theorem, the binomial distribution converges in probability to a normal distribution as $M \to +\infty$.

Consider the impact of a change in $\hat{h}(q, b)$. By (**??**), we get the first-order derivative of $\phi(\hat{h})$ with respect to $\hat{h}$:

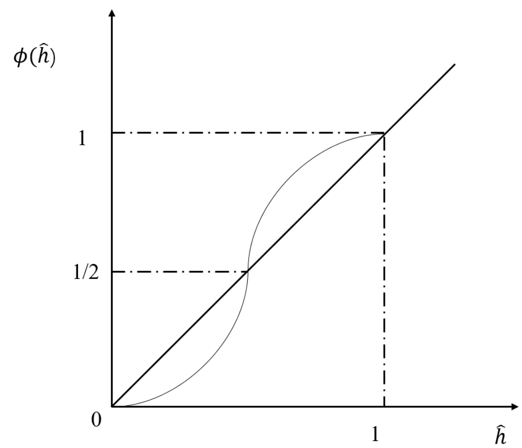
$$\phi'(\hat{h}) = \frac{d\phi(\hat{h}(q, b))}{d\hat{h}} = \frac{(2M+1)!}{M!M!} \hat{h}(q, b)^M (1 - \hat{h}(q, b))^M. \tag{20}$$

Hence, $\phi'(\hat{h}) > 0, \forall \hat{h} \in [0, 1)$. Intuitively, if each member has a higher probability of participating in corruption, then the committee is more likely to be corrupted. Moreover, in order to gain a more precise picture of $\phi(\hat{h}(q, b))$, we also calculate the second-order derivative: $\phi''(\hat{h}) = \frac{d^2\phi(\hat{h}(q,b))}{d\hat{h}^2} > 0$, if $\hat{h}(q, b) \in (0, 1/2)$; $\phi''(\hat{h}) = 0$, if $\hat{h}(q, b) = 1/2$; and $\phi''(\hat{h}) > 0$, if $\hat{h}(q, b) \in (1/2, 1)$. Hence, if the depth of corruption is less than $1/2$, the

[6] Qualified majorities and more general voting rules can also be embedded in this analysis.

probability of the committee being corrupted is represented by a convex function, and if the depth of corruption is greater than 1/2, the probability of the committee being corrupted is represented by a concave function (see Figure 4). As the committee gets sufficiently large, the slope of $\phi(\hat{h}(q,b))$ becomes unbounded at the mid-point, i.e., $\phi'(\hat{h}) \to +\infty$ at $\hat{h}(q,b) = 1/2$, as $M \to +\infty$.

FIGURE 4. FUNCTION $\phi(\hat{h})$.



Governments sometimes delegate power to an individual officer while other times they delegate power to a committee. There may be several reasons for this choice but one of them is the widespread belief that a committee involving several individuals would be harder to manipulate. Our setup has some immediate implications regarding the desirability of delegating implementation of policies to a committee under the possibility of bribery. If the depth of corruption is low, then a large committee is desirable because it decreases the probability of a majority of officers being bribed. However, if the depth of corruption is high, then the probability of being bribed is minimized with a solo-member committee. Clearly, as the committee gets arbitrarily large, the law of large numbers applies: the probability of a majority being bribed approaches zero if the depth of corruption is less than 1/2 and it converges to one if the depth of corruption is greater than 1/2.

Then, to prove the existence of a Nash equilibrium the objective functions of the government and the donor have to be redefined under $\phi(\hat{h}(q, b^{N^P}))$. That is, the probability that a committee of $N = 2M + 1$ members will be bribed is defined by (**??**). The following assumption imposes a restriction on the interaction of the distribution ϕ over $\hat{h}$:

ASSUMPTION 4. *For all q and $b \geq b^0$,*

$$\frac{\hat{h}_{bb}(q,b)}{[\hat{h}_b(q,b)]^2} < -\frac{\phi''}{\phi'} < \frac{\hat{h}_{qq}(q,b)}{[\hat{h}_q(q,b)]^2}.$$

As discussed above in the context of Assumption **??**, some type of regularity condition is necessary to preserve the convexity properties of the utility function $u(q, b)$ over the IR constraint. For a single officer ($M = 0$) Assumption **??** is automatically satisfied by Lemma **??**. If $\phi'' > 0$ the right-hand side inequality is satisfied, and if $\phi'' < 0$ the left-hand side inequality is satisfied. Hence, the assumption suggests that committees should not be too large to preserve the original convexity properties for the maximization problems of the government and the donor.

Under Assumption 4, we can now extend Lemma 1 above to the more general case of a committee making decisions by majority voting. Uniqueness of optimal solutions for the maximization problems of the government and the donor allows us to define the associated reaction functions $q(B)$ and $B(q)$.

Definition 2. *A Nash equilibrium is a pair (q^*, B^*) such that $q^* = q(B^*)$ and $B^* = B(q^*)$.*

Proposition 3. *Under Assumptions 1-4, there exists a unique Nash equilibrium (q^*, B^*).*

This proposition can be proved by following essentially the same strategy of Proposition 1 above.

For a representative sample of values of the depth of corruption $\hat{h}$, Table 4 tracks down the evolution of $\phi(\hat{h}(q, b^{N^P}))$, for $N = 3, 7, 13, 21, 29$. As one could expect from small-sample and asymptotic properties of the binomial distribution, for low values of $\hat{h}$ the gains of simple majority voting can be quite substantial even for relatively small committees. For instance, for $\hat{h} = 0.1$ the odds of being corrupted become negligible for a committee of $N = 3$ members, and for $\hat{h} = 0.3$ it takes a committee of $N = 21$ to reach similar values.

Table 2. EVOLUTION OF THE PROBABILITY OF CORRUPTING A COMMITTEE, $\phi(\hat{h}(q, b^{N^P}))$, FOR SIZE N.

$\hat{h}$	$N = 3$	$N = 7$	$N = 13$	$N = 21$	$N = 29$
0.1	0.028	0.003	0.000	0.000	0.000
0.2	0.104	0.033	0.007	0.001	0.000
0.3	0.216	0.126	0.062	0.026	0.012
0.4	0.352	0.290	0.229	0.174	0.136
0.5	0.500	0.500	0.500	0.500	0.500
0.6	0.648	0.710	0.771	0.826	0.864
0.7	0.784	0.874	0.938	0.974	0.988
0.8	0.896	0.967	0.993	0.999	1.000
0.9	0.972	0.997	1.000	1.000	1.000

Returning to our taxonomy of corruption, these results imply that corruption issues falling into the category of national security policies should be decided by committees since the depth of corruption could be rather low. In large public procurement projects and "white-collar" crimes, corruption may be hard to eliminate. Then, the monitoring of corruption may surprisingly need to rest on a single officer (e.g., a Chief Lawyer or Attorney General). Sometimes we can observe an elite group of top government officials *en petit comité* to decide on very delicate issues. Apart from other considerations, small working groups can circumvent the magnifying effects of high depths of corruption in large committees.

7. Empirical Evidence

So far, we have mostly referred to micro evidence from court documents stemming from various sources. Next, we collect data[7] for the depth of petty corruption (PC), the depth of grand corruption (GC), and the value of the bribe (VALUE), from the World Bank Enterprise Surveys (WBES). The Enterprise Surveys use a uniform methodology across countries and over time for a range of corruption indicators since 2005-2006. For the index of the government's efficiency to fight corruption (IEFC) we simply take the average over the corresponding indicators for the three anticorruption channels: detection, enforcement, and punishment. These measures for the anticorruption channels are taken from the Global Competitiveness Report (GCR) of the World Economic Forum (WEF) between 2007 and 2017, and the World Justice Project (WJP) between 2015 and 2022. Standard indicators of government expenditure and officers' salaries are taken from the Government Finance Statistics (GFS) by the IMF. For the index of government's investment in anticorruption measures (INVE), we take the general government's expenditure on public order and safety as a percentage of GDP.[8] We measure officers' salaries (SALARIES) from the general government's expenditure on compensation of employees (including wages and salaries, and employers' social contributions) as a percentage of GDP. Combining all these datasets, we come up with some empirical regularities on various types of corruption over a sample of 111 countries. Our data sources and the country list are detailed in Appendix B. Because of missing data, the country sample can vary slightly over the variables we are looking at.

Table 3 groups countries by the IEFC (high-efficiency, mid-efficiency, and low-efficiency). The table also includes the mean values of each group for both the Corruption Perceptions Index (CPI) of Transparency International and GDP per capita, PPP (constant 2017 international $, INCOME). As we can see, the mean values of the IEFC across the three groups increase together with the corresponding mean values for the CPI from low-efficiency to high-efficiency. Also, the IEFC is positively correlated with per capita income. That

[7]For definitions and data sources, see Appendix B.

[8]According to the Classification of the Functions of Government (COFOG), public order and safety includes military defense; civil defense; foreign military aid, R&D related to defense; defense n.e.c.; police services; fire-protection services; law courts; prisons; R&D related to public order and safety; public order and safety n.e.c.; see https://www.imf.org/external/pubs/ft/tnm/2013/tnm1301.pdf.

is, high-efficiency countries show a higher mean value for per capita income than the mid-efficiency group, while low-efficiency countries have the lowest mean value for per capita income. Appendix B.4 presents a more detailed account of the correlation among the three aggregates. IEFC is particularly suitable for our analysis, since it is not an expectations indicator and our model deals with various individual effects of the anticorruption channels on the depth of corruption and the value of the bribe.[9]

Table 3. MEAN VALUES FOR THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION (IEFC), THE CORRUPTION PERCEPTIONS INDEX (CPI), AND GDP PER CAPITA (INCOME).

	IEFC	CPI	INCOME
All countries	-.15	42.93	16303.76
	(.76)	(16.62)	(16794.18)
High-efficiency	.73	61.52	29396.43
	(.73)	(14.36)	(21579.1)
Mid-efficiency	-.31	38.02	11840.62
	(.17)	(5.30)	(8592.93)
Low-efficiency	-.87	28.85	7434.53
	(.24)	(5.00)	(6346.29)

Notes: For definitions and data sources, see Appendix B. Countries are grouped by the government's efficiency to fight corruption (IEFC). The number of observations for all countries is 111, evenly split within the three groups. Standard errors are reported within parentheses.

Table 4 displays mean values of our indicators of corruption and policy measures across countries over the three efficiency groups. The following facts about corruption become quite evident: (i) *The Depth of Petty Corruption:* PC varies inversely with the government's efficiency to fight corruption. Again, PC is smaller in high-efficiency economies, while the difference between mid-efficiency economies and low-efficiency economies is not so obvious. (ii) *The Depth of Grand Corruption:* GC varies inversely with the government's efficiency to fight corruption; over one-third of firms are expected to give gifts to secure a government contract in low-efficiency economies, while it is about one-sixteenth in high-efficiency economies. (iii) *The Value of the Bribe:* VALUE varies inversely with the government's efficiency to fight corruption, and ranges from a mean value of 0.11 percent over the total contract value in high-efficiency economies to 2.26 percent over the total contract value in low-efficiency economies. (iv) *Officers' Salaries:* SALARIES mean values (conditioned over GDP) do not present much variation in our data. While high-efficiency economies display a

[9]The degree of market and political competition can partially account for the cross-country variation of corruption [Svensson (2005)]. A large literature argues that the quality of institutions and economic development influence corruption. The literature is summarized in Ades & Di Tella, 1999; Djankov, *et al.*, 2002; Besley & Burgess, 2002; Brunetti & Weder, 2003; and Persson & Tabellini, 2004.

slightly higher share for such compensation to public employees, it is a bit surprising that mid-efficiency economies spend relatively less than low-efficiency economies. (v) *Government's Investment in Anticorruption Measures:* The observed INVE mean values are quite similar over the three efficiency groups. Therefore, there is no much variation for the share of expenditure on anticorruption (public order and safety).

Table 4. MEAN VALUES FOR OUR CORRUPTION INDICATORS AND POLICY MEASURES OVER EFFICIENCY GROUPS.

	PC	GC	VALUE	SALARIES	INVE
All countries	17.50	21.13	1.27	9.38	1.82
	(17.86)	(20.61)	(2.41)	(2.98)	(.66)
High-efficiency	6.09	6.40	.17	10.83	1.85
	(7.94)	(9.85)	(.51)	(2.89)	(.63)
Mid-efficiency	22.80	26.39	1.38	8.26	1.79
	(21.01)	(17.15)	(1.58)	(2.52)	(.51)
Low-efficiency	23.60	30.74	2.26	8.43	1.75
	(16.42)	(23.62)	(3.56)	(2.82)	(1.01)

Notes: For definitions and data sources, see the Appendix. Countries are grouped by the government's efficiency to fight corruption (IEFC). The number of observations for all countries is 111, evenly split into the three groups. Standard errors are within parentheses. PC: depth of petty corruption; GC: depth of grand corruption; VALUE: value of the bribe over the total contract value; SALARIES: share of salaries to public employees; and INVE: share of expenditure on anticorruption (public order and safety).

In conclusion, there is considerable variation for the mean values of PC, GC, and VALUE, over the efficiency groups; moreover, the standard errors within each group are quite sizable. There is, however, much less variation for SALARIES and INVE over these efficiency groups (both across groups and within groups). In Appendix B.5 we take a step further and estimate various fixed effects models that control for the three income groups: high-income, mid-income, and low-income. We can then attest for the strong negative correlation between PC over IEFC and GC over IEFC; indeed, both estimates are statistically significant at the 1% level. Also, the correlation between VALUE and IEFC, is statistically significant at the 5% level. There is no significant correlation between INVE and IEFC at the 10% level, and no significant correlation between SALARIES and each of the indicators for GC, PC, and VALUE. All in all, these correlations reveal that the government's efficiency to fight corruption—rather than salaries—has some explanatory power in trying to account for the cross-country variation in corruption. The large variation in the residuals for grand corruption seems to suggest that grand corruption could be quite entrenched in some advanced economies.

8. Concluding Remarks

There is a shortage of economic models to guide our thinking about corruption, and to evaluate the effectiveness of policy measures. We approach corruption from the "ability-to-pay" of both the government and the donor, the government's efficiency to fight corruption, and the officer's costs of breaking the law. The officer's identity type is unknown to the other two parties, and so both the depth of corruption and the bribe are endogenously determined. We highlight some general equilibrium effects from the interaction of the government spending to prevent corruption q and the value of the bribe b, which are missing in traditional models of corruption. Under certain standard conditions on the officer's utility function, the optimal q is increasing in b while the optimal b is decreasing in q. Then, we establish some definite predictions about the behavior of the depth of corruption and bribe values under perturbation of parameter values. Moreover, the model exemplifies that an increase in the government's efficiency to fight corruption would be isomorphic to an increase in the government's "ability-to-pay," and an exogenous lowering of the probability of punishment will be isomorphic to an increase in the donor's "ability-to-pay." Under these postulates, we propose a taxonomy of corruption based on the "ability-to-pay" of the donor and the government, which provides some benchmarks for anticorruption policy over the various considered scenarios.

Our analytical results translate into some basic testable propositions. When considering cross-country data, a higher government's efficiency to fight corruption will encourage further investments in anticorruption and will lower the bribe; hence, the depth of corruption will go down. This may explain why both the depth of corruption and the bribe are usually lower in the most developed countries. When considering various types of crime, a greater "ability-to-pay" of the average donor will drive up the bribe value, which will trigger investment in anticorruption; hence, the depth of corruption cannot be signed. This may explain why grand corruption may remain so entrenched even in some advanced countries. In contrast, many forms of petty corruption are just widely observed in developing countries. Finally, when considering income groups, a higher "ability-to-pay" of the donor will increase the value of the bribe. This may explain why most often the richest individuals in a society are most willing to engage into bribing, and may sometimes be most closely targeted.

There are several directions in which this work can be extended. In some situations, multiple donors with competing projects may try to bribe a single officer. Then, the value of the bribe could be considerably increased—commensurate to the significance of these projects. This may explain why in public procurement and related public contracts, some notorious bribes may be detached from the probability of punishment and the officer's cost of dismissal.

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Appendix A

A.1. **Proofs. Proof of Lemma ??**:

• By the definition of $\hat{h}$ along with Assumption **??**, we have:

$$u(y, q, w + b) \equiv \bar{u}^{\hat{h}(b,q)}.$$

By Assumption 1, it follows from the implicit function theorem that $\hat{h}(\cdot, \cdot)$ is twice continuously differentiable. • Differentiating the above identity with respect to b, we obtain:

$$\frac{\partial u}{\partial I}\frac{\partial I}{\partial b} = \frac{\partial \bar{u}}{\partial h}\frac{\partial \hat{h}}{\partial b}.$$

Therefore,

$$\frac{\partial \hat{h}}{\partial b} = \frac{\frac{\partial u}{\partial I}}{\frac{\partial \bar{u}}{\partial h}} > 0.$$

Differentiating once more this last equation we conclude that

$$\frac{\partial^2 \hat{h}}{\partial b^2} = \frac{\frac{\partial^2 u}{\partial I^2}}{\frac{\partial \bar{u}}{\partial h}} < 0.$$

• Now differentiating the above identity with respect to q, we obtain:

$$\frac{\partial \hat{h}}{\partial q} = \frac{\frac{\partial u}{\partial q}}{\frac{\partial \bar{u}}{\partial h}} < 0.$$

Differentiating once more this last equation we conclude that

$$\frac{\partial^2 \hat{h}}{\partial q^2} = \frac{\frac{\partial^2 u}{\partial q^2}}{\frac{\partial \bar{u}}{\partial h}} > 0.$$

• Finally, differentiating the above identity with respect to the variables b and q, we obtain:

$$\frac{\partial^2 \hat{h}}{\partial b \partial q} = \frac{\frac{\partial^2 u}{\partial I \partial q}}{\frac{\partial \bar{u}}{\partial h}} < 0.$$

□

Proof of Lemma ??:

• First, by Lemma **??** the government objective function is strictly concave, and so the solution $q(b)$ is single valued. If $q(b) > 0$ the optimality condition for the government's problem becomes $-\hat{h}_q(q(b), b) \equiv \frac{1}{V^g}$. Upon differentiation we have:

$$\frac{\partial q}{\partial b} = -\frac{\hat{h}_{qb}}{\hat{h}_{qq}} > 0,$$

where the sign is determined by Assumption **??** and Lemma **??**.

• By Assumption **??** the optimal solution to the donor's problem satisfies $b(q) \geq b^0 > 0$. By Lemma **??** the objective function of the donor is strictly concave, and so the solution $b(q)$ is single valued. Substituting the solution in the optimality condition for the donor's problem we obtain $\hat{h}_b(q(b), b) \equiv \frac{1}{V^d}$. Upon differentiation we have:

$$\frac{\partial b}{\partial q} = -\frac{\hat{h}_{qb}}{\hat{h}_{bb}} < 0,$$

where the sign is determined by Assumption **??** and Lemma **??**. □

Proof of Proposition 1:

Let us define $f_1 : [0, V^g] \times [0, V^d] \to [0, V^g]$ as follows:

$$f_1(q, b) = q(b), \forall b \in [0, V^d].$$

Also, let us define $f_2 : [0, V^g] \times [0, V^d] \to [0, V^d]$ as follows:

$$f_2(q, b) = b(q), \forall q \in [0, V^g].$$

The mapping $\Psi : [0, V^g] \times [0, V^d] \to [0, V^g] \times [0, V^d]$ given by $\Psi(q, b) = (f_1 \times f_2)(q, b)$ is continuous, single valued (i.e., convex valued), and maps a compact domain to itself. Hence, Ψ has a fixed point: $(q^*, b^*) = \Psi(q^*, b^*)$. That is,

$$q^* = f_1(q^*, b^*) = q(b^*), \tag{21}$$

$$b^* = f_2(q^*, b^*) = b(q^*). \tag{22}$$

Therefore, (q^*, b^*) is a Nash equilibrium.

Let $(q^{**}, b^{**}) \neq (q^*, b^*)$ be another Nash equilibrium. Without loss of generality, suppose that $q^* < q^{**}$. In this case, by Lemma **??** we have:

$$b^{**} = b(q^{**}) < b(q^*) = b^*.$$

Moreover, from the same lemma we can also conclude that

$$q^{**} = q(b^{**}) < q(b^*) = q^*,$$

which contradicts the hypothesis $q^* < q^{**}$. Therefore, the Nash equilibrium (q^*, b^*) is unique.
□

Proof of Proposition ??:

From Lemma **??**, for $q^* > 0$ and $b^* > 0$, we have:

$$\hat{h}_q(q^*, b^*)V^g + 1 \equiv 0, \tag{23}$$

and

$$\hat{h}_b(q^*, b^*)V^d - 1 \equiv 0. \tag{24}$$

• Changes in $\bar{u}$: Let $\hat{h}(q, b, \bar{u})$ be the solution to $u(y, q, w + b) = \bar{u}^h$. We can then write: $u(y, q, w + b) \equiv \bar{u}^{\hat{h}(q,b,\bar{u})}$. By Assumption **??**, we must have:

$$\frac{\partial \hat{h}(q, b, \bar{u})}{\partial \bar{u}} = -\frac{1}{\partial \bar{u}^h / \partial h} < 0, \tag{25}$$

and $\hat{h}_{q\bar{u}}(q, b, \bar{u}) = 0$, and $\hat{h}_{b\bar{u}}(q, b, \bar{u}) = 0$. Differentiating (**??**) and (**??**) with respect to $\bar{u}$, we obtain:

$$\hat{h}_{qq}(q, b, \bar{u})\frac{\partial q^*}{\partial \bar{u}} + \hat{h}_{qb}(q, b, \bar{u})\frac{\partial b^*}{\partial \bar{u}} + \hat{h}_{q\bar{u}}(q, b, \bar{u}) = 0, \tag{26}$$

and

$$\hat{h}_{bq}(q, b, \bar{u})\frac{\partial q^*}{\partial \bar{u}} + \hat{h}_{bb}(q, b, \bar{u})\frac{\partial b^*}{\partial \bar{u}} + \hat{h}_{b\bar{u}}(q, b, \bar{u}) = 0. \tag{27}$$

Solving (**??**) and (**??**), we get $\frac{\partial q^*}{\partial \bar{u}} = 0$, $\frac{\partial b^*}{\partial \bar{u}} = 0$, and $\frac{\partial \hat{h}^*}{\partial \bar{u}} = \frac{\partial \hat{h}(q,b,\bar{u})}{\partial \bar{u}} < 0$.

• Changes in λ: As already discussed, a change in λ can be seen as an inverse linear scaling up of V^g and V^d.

• Changes in w: Differentiating (**??**) and (**??**) with respect to w, we must have:

$$\frac{\partial q^*}{\partial w} = \frac{-\hat{h}_{qw}(b^*, q^*) - \hat{h}_{qb}(q^*, b^*) \cdot \frac{\partial b^*}{\partial w}}{\hat{h}_{qq}(q^*, b^*)}, \tag{28}$$

and

$$\frac{\partial b^*}{\partial w} = \frac{\hat{h}_{bq}(q^*, b^*)\hat{h}_{qw}(q^*, b^*) - \hat{h}_{qq}(q^*, b^*)\hat{h}_{bw}(q^*, b^*)}{\hat{h}_{bb}(q^*, b^*)\hat{h}_{qq}(q^*, b^*) - [\hat{h}_{qb}(q^*, b^*)]^2}. \tag{29}$$

Following the proof of Lemma **??**, we obtain $\hat{h}_{bb}(q^*, b^*) = \hat{h}_{bw}(q^*, b^*)$ and $\hat{h}_{bq}(q^*, b^*) = \hat{h}_{qw}(q^*, b^*)$. Then, solving (**??**) and (**??**), we get $\frac{\partial b^*}{\partial w} = -1$ and $\frac{\partial q^*}{\partial w} = 0$.
Recall that the following identity holds: $u^h(y, q, w + b^h(q, w)) \equiv \bar{u}^h$. Differentiating this identity, we obtain: $\frac{\partial u^h}{\partial I}\left(1 + \frac{\partial b_h}{\partial w}\right) = 0$. It follows that $\frac{\partial b_h}{\partial w} = -1$. From the definition of $\hat{h}(\cdot)$ we also have: $\forall b \geq 0, b\left(\hat{h}(b, w), w, q\right) \equiv b$. Differentiating this identity with respect to b,

$$\frac{\partial b}{\partial h}\frac{\partial \hat{h}}{\partial b} = 1.$$

Hence,

$$\frac{\partial \hat{h}}{\partial b} = \left(\frac{\partial b}{\partial h}\right)^{-1}.$$

Differentiating the same identity with respect to w,

$$\frac{\partial b}{\partial h}\frac{\partial \hat{h}}{\partial w} + \frac{\partial b}{\partial w} = 0.$$

Consequently,

$$\frac{\partial \hat{h}}{\partial w} = -\frac{\frac{\partial b}{\partial w}}{\frac{\partial b}{\partial h}} = \left(\frac{\partial b}{\partial h}\right)^{-1}$$

Therefore,

$$\frac{\partial \hat{h}}{\partial w} = \frac{\partial \hat{h}}{\partial b} \tag{30}$$

We finally obtain: $\frac{d\hat{h}(q^*,b^*)}{dw} = \frac{\partial \hat{h}(q^*,b^*)}{\partial b}\frac{\partial b^*}{\partial w} + \frac{\partial \hat{h}(q^*,b^*)}{\partial q}\frac{\partial q^*}{\partial w} + \frac{\partial \hat{h}(q^*,b^*)}{\partial w} = 0.$

- Changes in V^g: Differentiating (**??**) and (**??**) with respect to V^g,

$$[\hat{h}_{qq}(q^*,b^*)\frac{\partial q^*}{\partial V^g} + \hat{h}_{qb}(q^*,b^*)\frac{\partial b^*}{\partial V^g}]V^g + \hat{h}_q(q^*,b^*) = 0, \tag{31}$$

and

$$\hat{h}_{bb}(q^*,b^*)\frac{\partial b^*}{\partial V^g} + \hat{h}_{qb}(q^*,b^*)\frac{\partial q^*}{\partial V^g} = 0. \tag{32}$$

By (**??**),

$$\frac{\partial b^*}{\partial V^g} = -\frac{\hat{h}_{bq}(q^*,b^*)}{\hat{h}_{bb}(q^*,b^*)}\frac{\partial q^*}{\partial V^g}. \tag{33}$$

Inserting (**??**) into (**??**),

$$\frac{\partial q^*}{\partial V^g} = -\frac{\hat{h}_q(q^*,b^*)\hat{h}_{bb}(q^*,b^*)}{V^g\{\hat{h}_{qq}(q^*,b^*)\hat{h}_{bb}(q^*,b^*) - [\hat{h}_{qb}(q^*,b^*)]^2\}}. \tag{34}$$

Since $\hat{h}_{qq}(b^*,q^*) > 0$, $\hat{h}_{bb}(q^*,b^*) < 0$, and $\hat{h}_q(q^*,b^*) < 0$, we then get

$$\frac{\partial q^*}{\partial V^g} > 0.$$

Inserting (**??**) into (**??**),

$$\frac{\partial b^*}{\partial V^g} = \frac{\hat{h}_{qb}(q^*,b^*)\hat{h}_q(q^*,b^*)}{V^g\{\hat{h}_{qq}(q^*,b^*)\hat{h}_{bb}(q^*,b^*) - [\hat{h}_{qb}(q^*,b^*)]^2\}} < 0. \tag{35}$$

Therefore,

$$\frac{\partial \hat{h}(q^*, b^*)}{\partial V^g} < 0. \tag{36}$$

• Changes in V^d : Differentiating (??) and (??) with respect to V^d,

$$\hat{h}_{qq}(q^*, b^*)\frac{\partial q^*}{\partial V^d} + \hat{h}_{qb}(q^*, b^*)\frac{\partial b^*}{\partial V^d} = 0, \tag{37}$$

and

$$[\hat{h}_{bb}(q^*, b^*)\frac{\partial b^*}{\partial V^d} + \hat{h}_{qb}(q^*, b^*)\frac{\partial q^*}{\partial V^d}]V^d + \hat{h}_b(q^*, b^*) = 0. \tag{38}$$

Since $\hat{h}_{qq}(q^*, b^*) > 0$, $\hat{h}_{bb}(q^*, b^*) < 0$, and $\hat{h}_b(q^*, b^*) > 0$, solving (??) and (??), we obtain:

$$\frac{\partial b^*}{\partial V^d} = -\frac{\hat{h}_b(q^*, b^*)\hat{h}_{qq}(q^*, b^*)}{V^d\{\hat{h}_{qq}(q^*, b^*)\hat{h}_{bb}(q^*, b^*) - [\hat{h}_{qb}(q^*, b^*)]^2\}} > 0, \tag{39}$$

and

$$\frac{\partial q^*}{\partial V^d} = \frac{\hat{h}_b(q^*, b^*)\hat{h}_{qb}(q^*, b^*)}{V^d\{\hat{h}_{qq}(q^*, b^*)\hat{h}_{bb}(q^*, b^*) - [\hat{h}_{qb}(q^*, b^*)]^2\}} > 0. \tag{40}$$

Therefore, $\frac{\partial \hat{h}(q^*, b^*)}{\partial V^d}$ is undetermined.

• Changes in $\bar{\alpha}$: Let $\hat{h}(y, b, \bar{\alpha})$ be the solution to $u(y, q, w + b) = \bar{u}^h$. We can then write: $u(y, q, w + b) \equiv \bar{u}^{\hat{h}(q,b,\bar{\alpha})}$. Since $\bar{\alpha}$ is a constant coefficient multiplying q, we obtain

$$\frac{\partial \hat{h}(q, b, \bar{\alpha})}{\partial \bar{\alpha}} = -\frac{\partial u(q, b, \bar{\alpha})/\partial \bar{\alpha}}{\partial \bar{u}^h/\partial h} < 0. \tag{41}$$

Moreover, $\hat{h}_{q\bar{\alpha}}(q, b, \bar{\alpha}) = -\frac{\partial \alpha(q)/\partial q \partial \bar{\alpha}}{\partial \bar{u}^h/\partial h} < 0$, and $\hat{h}_{b\bar{\alpha}}(q, b, \bar{u}) = 0$. Differentiating (??) and (??) with respect to $\bar{\alpha}$, we get $\frac{\partial q^*}{\partial \bar{\alpha}} > 0$, $\frac{\partial b^*}{\partial \bar{\alpha}} < 0$, and $\frac{\partial \hat{h}^*}{\partial \bar{\alpha}} = \frac{\partial \hat{h}(q,b,\bar{u})}{\partial \bar{u}} < 0$.

• Changes in γ: This is quite similar to a change in $\bar{\alpha}$.

□

Appendix B. Cross-Country Data

B.1. **The World Bank Enterprise Surveys (WBES).** The Enterprise Surveys are conducted by the World Bank and its partners as an international firm-level survey of a representative sample of an economy's private sector. The universe of the Enterprise Surveys is consistently defined in all countries covering small, medium, and large companies—including the entire manufacturing sector, the services sector, and the transportation and construction sectors.

The depth of petty corruption (PC) is based on the following question from the WBES: It is said that establishments are sometimes required to make gifts or informal payments to public officials to "get things done" with regard to customs, taxes, licenses, regulations, services, etc. Then, "On average, what percent of total annual sales, or estimated total annual value, do establishments like this one pay in informal payments or gifts to public officials for this purpose?" Based on this answer, the Enterprise Surveys construct an indicator ranging between 0 and 100, which would measure the percentage of firms expected to give gifts to public officials (to get things done) with regard to customs, taxes, licenses, regulations, services, etc. We take the country's level of PC at the year when the latest survey is conducted in that country.

The depth of grand corruption (GC) is based on the following questions from the WBES: "Q.1. Over the last year, has the establishment secured or attempted to secure a government contract?" and "Q.2. When establishments like this one do business with the government, what percent of the contract value would be typically paid in informal payments or gifts to secure the contract?" The Enterprise Surveys construct an indicator from Q.1 and Q.2 ranging between 0 and 100, which would measure the percentage of firms expected to give gifts to secure a government contract. We take the country's level of GC at the year when the latest survey is conducted in that country. Meanwhile, the indicator of the value of the bribe (VALUE) is created from Q.2 to measure the percentage of the contract value of the gift intended to secure the government contract.[10] We take this relative value of the bribe at the year when the latest survey is conducted in that country.

B.2. **The Index of the Government's Efficiency to Fight Corruption (IEFC).** We collect data from the Global Competitiveness Report (GCR) and the World Justice Project (WJP) to construct the IEFC. This indicator is measured as the average value over the corresponding indicators for the three anticorruption channels: detection, enforcement, and

[10]For the Business Environment and Enterprise Performance Surveys (BEEPS) conducted prior to 2008, the second question was asked to all firms, regardless of whether or not the firm had secured or attempted to secure a government contract. Since 2008, only firms confirming to have secured or attempted to secure a government contract in the last 12 months were required to answer such question.

punishment. This aggregated measure is reported in the standard normal units,[11] ranging from approximately -2.5 to 2.5, with the higher value corresponding to the highest government's efficiency to fight corruption.

The index of detection aggregates three areas: (i) Strength of auditing and accounting standards (SAAS). The measurement of SARS is based on the following question from the GCR: "In your country, how strong are financial auditing and reporting standards?" The answers range from 1 for extremely week to 7 for extremely strong. (ii) Transparency of government policymaking (TGPM). We use a measure of TGPM based on the following question from the GCR: "In your country, how easy is it for companies to obtain information about changes in government policies and regulations affecting their activities?" The answers range from 1 for extremely difficult to 7 for extremely easy. (iii) Quality of democracy. We construct a democracy index (DI) as the average value of three measurements from the WJP: government powers are effectively limited by the legislature; government powers are effectively limited by the judiciary; transition of power is subject to the law. The answers range from 0 for extremely low to 1 for extremely high. We take the country's average level of the SAAS and TGPM over 2007 - 2017 and the country's average[12] level of DI during 2015 - 2022.

The index of enforcement aggregates two areas: (i) Judicial independence (JI). We use a measure of TGP based on the following question from the GCR: "In your country, how independent is the judicial system from influences of the government, individuals, or companies?" The answers range from 1 for not independent at all to 7 for entirely independent. (ii) Reliability of police services (PRS). We use a measure of TGP based on the following question from the GCR: "In your country, to what extent can police services be relied upon to enforce law and order?" The answers range from 1 for not at all to 7 for to a great extent. We take the country's average level of JI and RPS over the 2007 - 2017 period.

The index of punishment aggregates two areas: (i) Sanction for misconducted officials (SMO): We use data from WJP based on the indicator "government officials are sanctioned for misconduct". The answers range from 0 for extremely low to 1 for extremely high. (ii) The criminal justice index (CJI). We construct the CJI as the average value of three measurements from the WJP: criminal adjudication system is timely and effective; criminal justice system is impartial; due process of law and the rights of the accused. The answers range from 0 for extremely low to 1 for extremely high. We take the average country's level of the SMO and the CJI over the 2015-2022 period.

[11] A standardized variable has zero mean and unit standard deviation. To generate a standardized variable x^* from x, one just lets $x^* = (x - m)/sd$, where m is the mean of x and sd is the standard deviation of x.

[12] The WJP's survey instruments have remained relatively stable since 2015, and so comparisons can be made with more confidence from 2015 to 2022.

Table B.1. DESCRIPTIVE STATISTICS OVER THE THREE ANTICORRUPTION CHANNELS.

	Obs	Mean	Std. Dev.	Min	Max
Detection	111	-.11	.75	-1.64	1.91
Enforcement	111	-.21	.84	-2.05	2.01
Punishment	111	-.14	.82	-2.03	2.15

Table B.1 displays some descriptive statistics over the three channels in the construction of the IEFC.

B.3. **List of Countries:** Angola, Albania, Argentina, Austria, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bosnia and Herzegovina, Belize, Bolivia, Brazil, Barbados, Botswana, Cameroon, Chile, China, Cote d'Ivoire, Congo, Dem. Rep., Colombia, Costa Rica, Cyprus, Czech Rep., Germany, Denmark, Dominican Rep., Ecuador, Egypt, Arab Rep., Spain, Estonia, Ethiopia, Finland, France, Gabon, Georgia, Ghana, Guinea, Gambia, Greece, Guatemala, Guyana, Honduras, Croatia, Hungary, Indonesia, India, Ireland, Italy, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Rep., Cambodia, Lebanon, Liberia, Sri Lanka, Lithuania, Luxembourg, Latvia, Morocco, Moldova, Madagascar, Mexico, North Macedonia, Mali, Malta, Myanmar, Mongolia, Mozambique, Mauritania, Mauritius, Malawi, Malaysia, Namibia, Nigeria, Nicaragua, Netherlands, The, Nepal, Pakistan, Panama, Peru, Philippines, Poland, Portugal, Paraguay, Romania, Russian Federation, Rwanda, Senegal, Sierra Leone, El Salvador, Serbia, Suriname, Slovak Rep., Slovenia, Sweden, Thailand, Trinidad and Tobago, Tunisia, Turkey, Tanzania, Uganda, Ukraine, Uruguay, Venezuela, Vietnam, South Africa, Zambia, Zimbabwe.

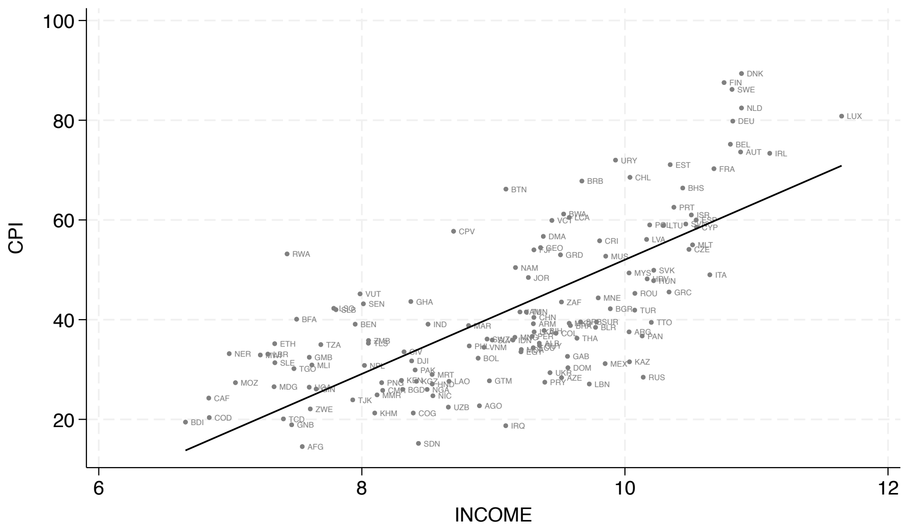
B.4. **The IEFC, CPI, and INCOME.** The Corruption Perceptions Index (CPI) from Transparency International measures perceptions of public sector corruption by expert assessments and opinion surveys. Countries are ranked on a scale from 100 (very clean) to 0 (highly corrupt). We take the country's average level of CPI over the 2012-2022 period to be consistent with the construction[13] of the IEFC. INCOME is measured as GDP per capita, based on purchasing power parity (PPP) (constant 2017 international $) taken from the World Bank for the year 2010.

Figure B.1 shows that the CPI is positively correlated with INCOME, and Figure B.2 shows that the IEFC is positiveiy correlated with income. However, both graphs for the CPI and IEFC make apparent the problem of the *middle-income trap;* i.e., most middle-income countries are below the fitted lines. Svensson (2005) argues that income and the quality of

[13]We should note that only CPI results from 2012 onwards can be compared because of an updating in the methodology used to calculate the CPI in 2012.

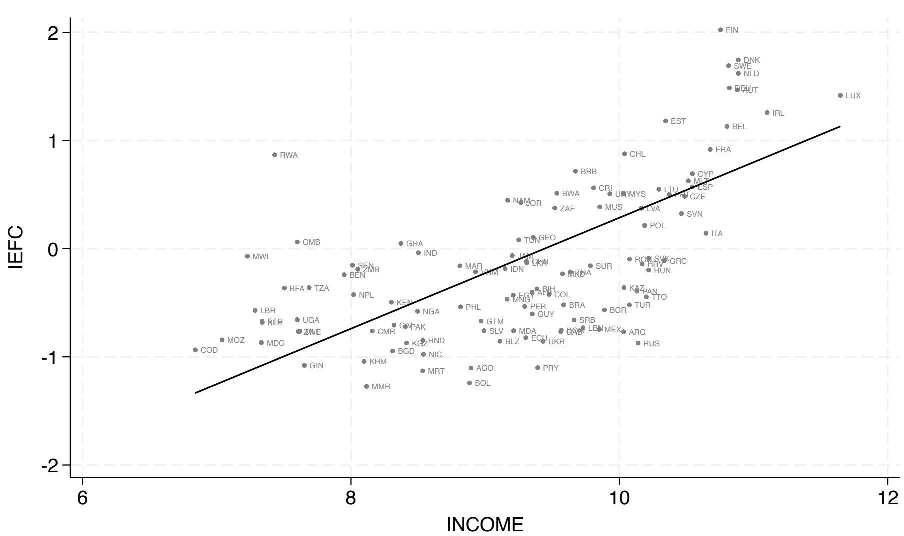
institution co-evolve. Economic development would create a demand for the improvements of the quality of institutions but institutions also influence economic development.

FIGURE B.1. CPI AND INCOME.



Sources: Income is measured by the (ln)GDP per capita, PPP (constant 2017 international $) taken from the World Bank for the year 2010. CPI is taken the country's average level of CPI over 2012-2022 from Transparency International.

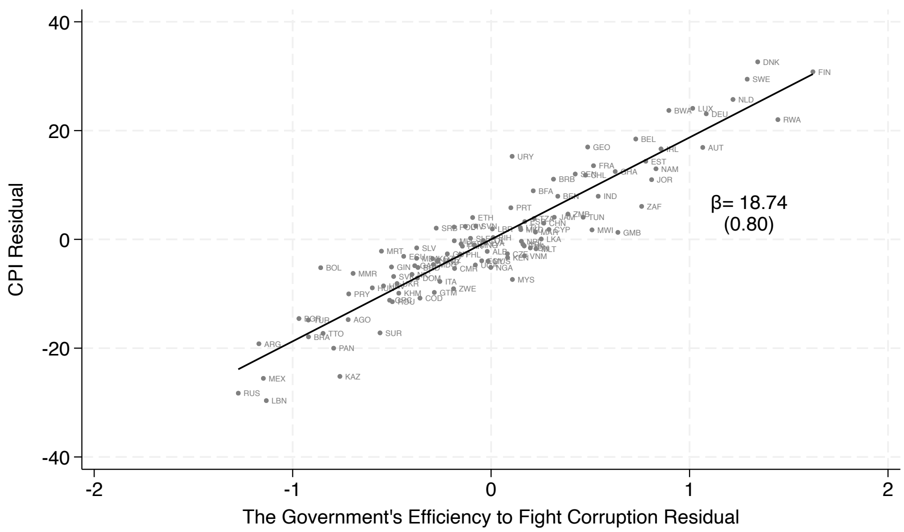
FIGURE B.2. THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION AND INCOME.



Sources: Global Competitiveness Report by World Economic Forum, World Justice Project, and the World Bank. Income is measured by the (ln) GDP per capita, PPP (constant 2017 international $) taken from the World Bank for the year 2010.

Figure B.3 projects the residuals of CPI against the residuals of the IEFC. The fixed effects model controls for the three income groups: high-income, mid-income, and low-income. The estimated values for the slope coefficients shows that the CPI is significantly positively correlated with the IEFC.

FIGURE B.3. THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION AND CPI.



Sources: Global Competitiveness Report by World Economic Forum, World Justice Project, and Transparency International. CPI is taken the country's average level of CPI over 2012-2022 from Transparency International. Income is measured by the (ln) GDP per capita, PPP (constant 2017 international $) taken from the World Bank for the year 2010. The residuals for CPI are calculated from regressions on GDP with grouped fixed effects, and the residuals for the government's efficiency to fight corruption are calculated from regressions on GDP with grouped fixed effects as well.

B.5. **Regression Equations with Fixed Effects to Control for Income.** In Table B.2 we take a step further by estimating various fixed effects models that control for the three income groups: high-income, mid-income, and low-income. Our country sample is evenly split among these groups. In Panel A, columns (1) and (2) attest for a strong negative correlation between PC over IEFC and GC over IEFC; indeed, with both estimates being statistically significant at the 1% level. Column (3) refers to the correlation between VALUE and IEFC, which is statistically significant at the 5% level. As expected, Column (4) confirms that there is no significant correlation between INVE and IEFC at the 10% level. Panel B presents the estimates for SALARIES over GC, PC, and VALUE, showing no statistically significant correlation between each of these indicators and salaries.

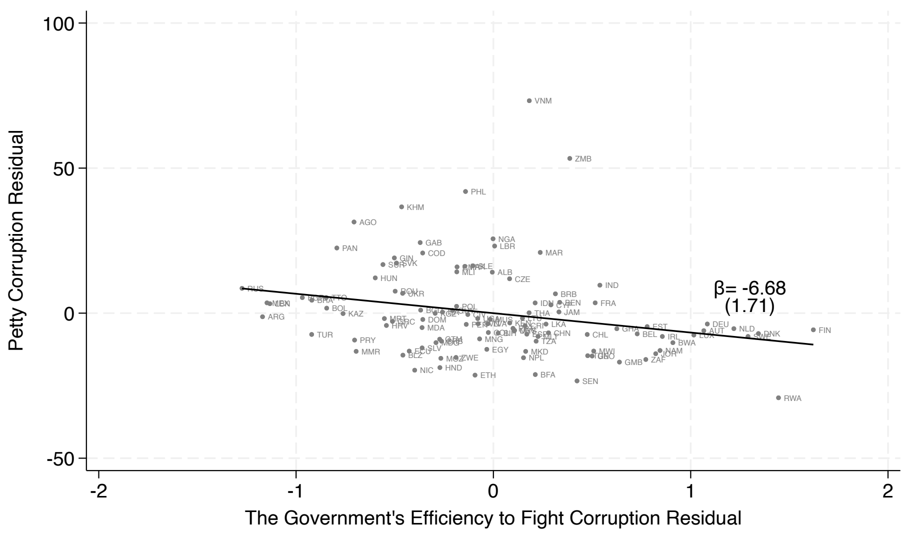
Table B.2. FIXED EFFECTS MODELS.

Panel A:		PC	GC	VALUE	INVE
		(1)	(2)	(3)	(4)
IEFC		-6.68***	-8.21***	-.52**	-.23*
		(1.71)	(2.13)	(.25)	(.13)
GDP per capita 2010q3					
	2	-10.98**	-12.11**	-1.43**	1.30***
		(4.63)	(4.77)	(.65)	(.45)
	3	-15.09***	-19.3***	-1.74***	1.24***
		(4.06)	(4.43)	(.59)	(.43)
Observations		110	109	109	45
R^2		.30	.37	.19	.28
Panel B:					
SALARIES		-.76	-.68	-.03	
		(.55)	(.62)	(.06)	
GDP per capita 2010q3					
	2	-3.59	-10.89	-.67	
		(5.29)	(6.78)	(.47)	
	3	-11.62***	-20.40***	-1.24***	
		(4.21)	(6.13)	(.43)	
Observations		83	83	83	
R^2		.16	.22	.14	

Notes: The fixed effects model is controlling for the three income groups: high-income, mid-income, and low-income. GDP per capita is PPP adjusted (constant 2017 international $) from the World Bank for the year 2010. Coefficients could be statistically different from 0 at the *** 1, ** 5, and * 10 % level. GC: depth of grand corruption; PC: depth of petty corruption; VALUE: value of the bribe over the total contract value; SALARIES: index of officers' salaries; INVE: index of investment in anticorruption measures; and IEFC: index of the government's efficiency to fight corruption.

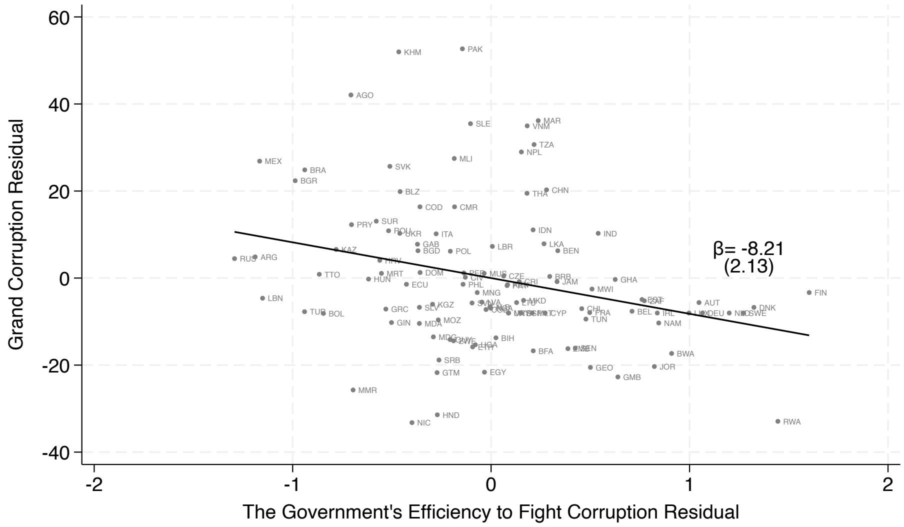
We complement this quantitative analysis with several graphical illustrations. After controlling for the income groups, Figure B.4 projects the residuals of PC against the residuals of IEFC, while Figure B.5 projects the residuals of GC against the residuals of IEFC. The estimated values for the slope coefficients are quite similar, but GC displays greater variation in these scatter plots. This suggests that GC could be quite entrenched in some countries, making the fight against GC quite complex. The negative correlation between VALUE and IEFC is evident from Figure B.6; again, some noticeable outliers are present. Figures B.7 and B.8 illustrate the effects of SALARIES on PC and GC, respectively. While salaries do not appear to have distinct effects on either PC or GC, the scatterplot for GC displays greater variation.

Figure B.4. PETTY CORRUPTION AND THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION.



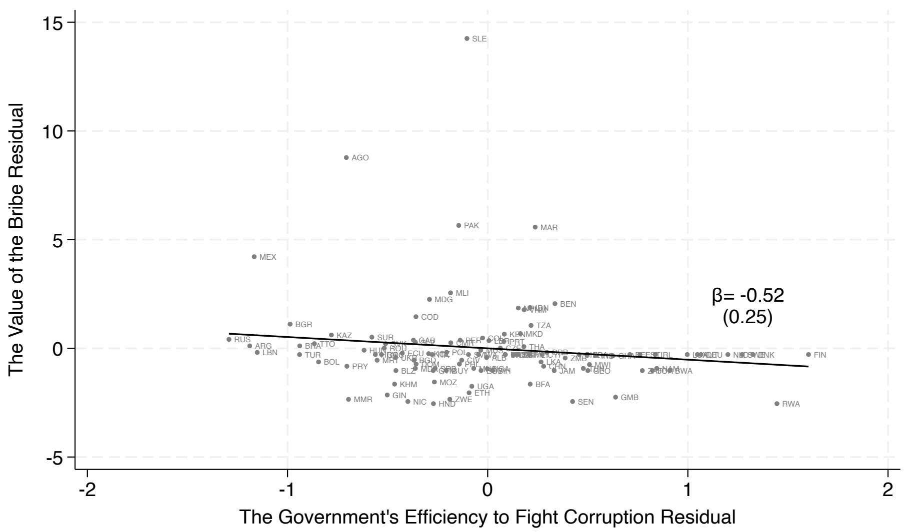
Notes: The residuals for petty corruption are calculated from regressions on GDP with grouped fixed effects, and the residuals for the government's efficiency to fight corruption are calculated from regressions on GDP with grouped fixed effects as well.

FIGURE B.5. GRAND CORRUPTION AND THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION.



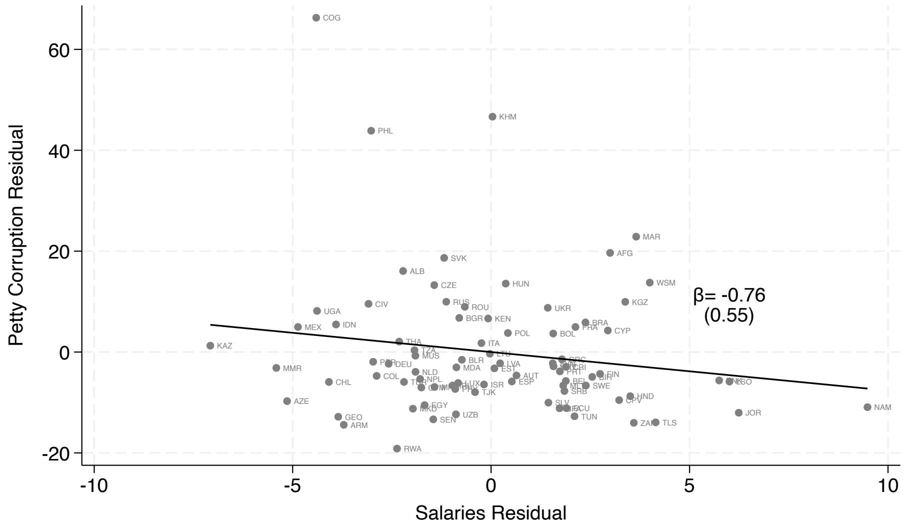
Notes: The residuals for grand corruption are calculated from regressions on GDP with grouped fixed effects, and the residuals for the government's efficiency to fight corruption are calculated from regressions on GDP with grouped fixed effects as well.

FIGURE B.6. THE VALUE OF THE BRIBE AND THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION.



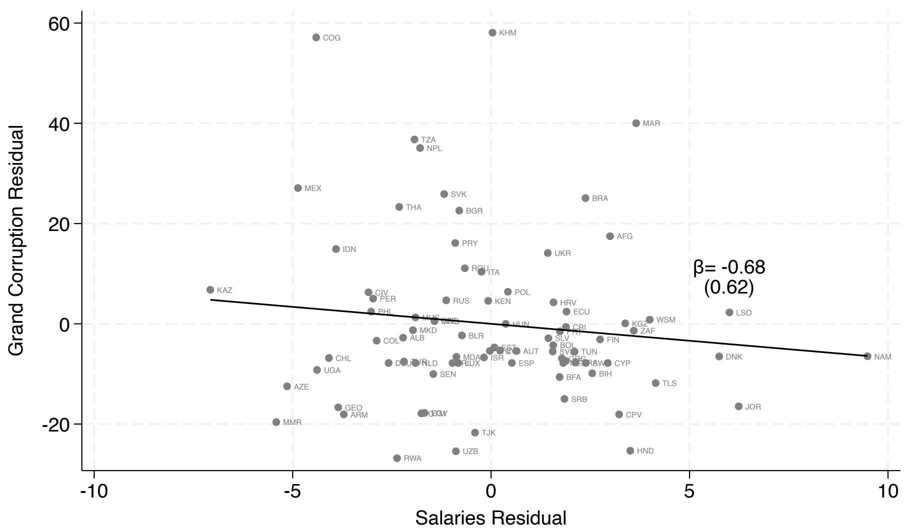
Notes: The residuals for the value of the bribe are calculated from regressions on GDP with grouped fixed effects, and the residuals for the government's efficiency to fight corruption are calculated from regressions on GDP with grouped fixed effects as well.

Figure B.7. PETTY CORRUPTION AND SALARIES.



Notes: The residuals for petty corruption are calculated from regressions on GDP with grouped fixed effects, and the residuals for salaries are calculated from regressions on GDP with grouped fixed effects as well.

Figure B.8. GRAND CORRUPTION AND SALARIES.



Notes: The residuals for grand corruption are calculated from regressions on GDP with grouped fixed effects, and the residuals for salaries are calculated from regressions on GDP with grouped fixed effects as well.