CORRUPTION, THE ABILITY TO PAY, AND THE COSTS OF BREAKING THE LAW

Leonidas Koutsougeras*, Manuel S. Santos†, Fei Xu‡

Abstract

We present a canonical model of corruption to account for some cross-country empirical regularities on the depth or prevalence of corruption, the variability of the bribe, officers' salaries, and investment in anticorruption measures. Under standard conditions the model has a unique equilibrium in which the depth of corruption and the bribe are endogenously determined. The analysis centers on the further effects on these equilibrium values from changes in the "ability-to-pay" of the parties involved, the government's efficiency to fight corruption, and the officer's costs of breaking the law. A mere change in the officer's salary does not affect the depth of corruption.

Keywords: The depth of corruption, the bribe, anticorruption measures, the "ability-to-pay", Nash equilibrium.

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*University of Manchester, School of Social Science, Department of Economics, Manchester M13 9PL, UK. E-mail: leonidas@manchester.ac.uk

†University of Miami, Miami Herbert Business School, Department of Economics, Coral Gables, FL 33124-6550. E-mail: m.santos2@miami.edu

‡Corresponding author. Umeå University, Umeå School of Business, Economics and Statistics, Department of Economics, SE- 901 87 Umeå, Sweden. Telephone number: +46(0)708806832. E-mail: fei.xu@umu.se

1. Introduction

Corruption distorts resource allocation, exacerbates income inequality, and represents a major barrier to economic development (Mauro, 1995; Bertrand et al., 2007). Several intergovernmental institutions (e.g., the International Monetary Fund, IMF, the World Bank, and the United Nations, UN) have long struggled to determine the nature and scope of corruption, and have outlined anticorruption policies for government officials in various matters (Olken & Pande, 2012). These initiatives to monitor corruption often lack a theoretical framework to guide policy evaluation.

The large variability of the depth of corruption and the value of the bribe over various data sets has not been systematically studied in the literature, but should be at the heart of theories of corruption.[1] We view corruption as an equilibrium outcome from various forces representing conflicts of interest. Hence, our main purpose here is to develop a model where the bribe values, the government's investment in the anticorruption measure, and the extent of corruption are determined endogenously from the interaction of several interest groups. In accomplishing this task, we are setting the following objectives. First, our model should be simple—yet sufficiently rich—to serve as a workhorse for the study of corruption. Second, with this framework in mind we intend to pool together many interesting elements scattered in the literature. And third, our model should reflect known and generally accepted stylized facts about corruption.

We first look at the observed cross-country variability of the depth of corruption and the bribe. 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: (i) *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. (ii) *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. (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,

[1]Perhaps, the most intriguing empirical evidence relates to the negative correlation between the value of the bribe and per-capita GDP across countries. In our analysis, this result stems from the strategic interaction of the parties involved—rather than from greater monopoly power of the officer and scarcity of public goods in developing countries. In our view, these latter approaches alone will not be able to account for the cross-country variability of the depth of corruption in some simple cases like traffic violations, as well as systemic cases of grand corruption in the most advanced economies. 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. This goes beyond the scope of this paper.

either grand corruption or petty corruption. (v) *Investment in Anticorruption Measures*: Overall public investment in anticorruption is only slightly negatively correlated with the government's efficiency to fight corruption.

To approach this empirical evidence, we present a canonical model of corruption which can be extended in various dimensions. The government will invest to prevent corruption and an external entity (the donor) will make a side payment to pursue an officer to deviate from the government's stipulated duty. Then, corruption arises as the interaction of the officer's individual incentives and the strategic behavior of the government and the donor. 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 assigned duty. We refer to q as the investment in the anticorruption measure. We refer to b as the value of the bribe. Technically, we are considering a full-blown, simultaneous-move game in which the government invests in anticorruption, while the donor tries to pursue the officer to deviate from the government's mandate.

We search for an equilibrium in the strategy space (q, b). We identify conditions under which 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 large variability of q and b.

In contrast, 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, Mookherjee & Png, 1992, 1995). Most of the literature uses a partial equilibrium framework, and hence it fails to capture the interaction between the government's anticorruption efforts and the donor's bribery attempts. The principal-agent setting provides a useful benchmark to illustrate the strong effects of monitoring and law enforcement on corruption. Becker (1968) emphasizes that close monitoring certainly helps reduce corruption as it increases the probability of corrupt officers getting caught red-handed.

Some other influential work has looked at corruption using a second-best welfare-optimization framework for the allocation of resources in society. 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.

Our analysis suggests a taxonomy of corruption 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. Lucrative forms of corruption 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. If the government’s “ability-to-pay” is relatively low, then the resulting low level of investment in anticorruption increases the incentive to bribe the officer as well as the depth of corruption. Still, petty corruption will mainly occur in environments in which the government’s efficiency to fight corruption and disutility of breaking the law may be rather low.

For interior solutions, a change in the officer’s salary can be counterbalanced by the equilibrium value of the bribe. Hence, the lack of response of the threshold level of corruption to the officer’s salary comes from general equilibrium considerations. 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. Some papers cite inadequate wages as the main cause of bureaucratic corruption, while in our model the wage has no effect on the depth of corruption. 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.

Section 2 goes over the aforementioned stylized facts on corruption. Section 3 sets out the corruption game, while Section 4 presents our main analytical results on the existence of a unique equilibrium. Then, in Section 5 we perform some comparative statics exercises over the equilibrium solution. Based on this comparative analysis, Section 6 provides a taxonomy of corruption over the “ability-to-pay” of the government and the donor. Section 7 contemplates 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. Finally, Section 8 concludes with an evaluation of our results. Data sources and proofs are gathered in the Appendix.

2. Some Stylized Facts

We collect data 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. As explained in the Appendix, 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.[2] 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. Finally, 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.[3] 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 A. Because of missing data, the country sample can vary slightly over the variables we are looking at.

Table 1 groups countries by the government's efficiency to fight corruption (high-efficiency, mid-efficiency, and low-efficiency). Besides this grouping over the IEFC, 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 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 A.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

[2]This arithmetic mean (or simple average) is reported in the standard normal units, ranging from approximately -2.5 to 2.5, with the higher value corresponding to the highest government's efficiency to fight corruption. 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.

[3]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.

various individual effects of the anticorruption channels on the depth of corruption and the value of the bribe.[4]

Table 1. 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 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 within the three groups. Standard errors are reported within parentheses.

Table 2 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 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

[4]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.

similar over the three efficiency groups. Therefore, there is no much variation for the share of expenditure on anticorruption (public order and safety).

Table 2. 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 A.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 countries, and the fight against grand corruption can be quite complex. As presently discussed, some forms of petty corruption are less common in developed countries.

Our above data set does not include poor countries (roughly, incomes per capita below $4000) in which corruption is generally considered to be rampant. Certainly, these countries can offer a wealth of empirical evidence which should prove valuable in economic studies of corruption. Our theoretical framework becomes most suitable to explain why grand corruption can be systemic even in high-efficiency economies and why some types of petty corruption are mostly observed in developing countries. In our setting, the officer's individual incentives are conformed by the strategic behavior of the government and the donor. The depth of corruption, government's anticorruption investment, and the value of the bribe are endogenously determined by the "ability-to-pay" of the government and the donor, the efficiency of the government to fight corruption, and the officer's costs of breaking the law.

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 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. In advanced economies, the depth of corruption may go down by the more pronounced officer's costs of breaking the law. Indeed, from several papers discussed in Section 6 below, such costs are often enhanced by established protocols for surveillance together with democratic procedures for accountability, transparency laws, and projections on social media. Further, our model suggests that the government's ability to fight corruption can be isomorphic to the government's "ability-to-pay" (i.e., the government's valuation of the option to be avoided). Hence, the depth of corruption should be much lower in advanced economies because of a higher government's valuation of the loss to society behind petty corruption and the costs of breaking the law.

For grand corruption, the officer's costs of breaking the law can be more commensurate across countries. Among other considerations, these crimes can also become notorious in poor countries; the government may be unable to judge product quality and must rely on outside experts' critical assessments; and the donor's "ability-to-pay" can be quite high across all countries. Consequently, grand corruption can be hard to root out in some situations. For instance, for the delivery of medical services, bribery rates—together with personal connections—can be of the order of 10 percent in advanced economies. With the Covid-19 outbreak, however, these bribery rates for the delivery of medical services[6] peaked to about 33 percent—highlighting the donor's "ability-to-pay" under emergency conditions and supply shortages (triage). Other areas with a high "ability-to-pay" of the donor—in which the government's ability to fight corruption becomes quite limited—include related cases of emergency laws backed by expedite procedures, state-of-the-art equipment technology,

[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)*.
[6] *Global Corruption Barometer–EU 2021.*

opaque military supplies, complex infrastructure projects, white-collar crimes to be discussed below, and extortion by highly organized groups.

3. 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 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.* For policy purposes it becomes of interest to study how (q, b) may change with perturbations of parameter values. Based on some simplifying assumptions, our analysis will cast light on the general equilibrium effects of the interaction between the government attempting to prevent corruption and the donor bribing the officer.

3.1. 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:

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

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. Common function $u(q, I)$ can be interpreted as picking up the effects of (q, w) on both the left- and the right-hand side of the *IR* constraint (2).

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.

3.2. **The Government.** 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.

3.3. **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.

4. Nash Equilibrium

4.1. **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 it is positive otherwise. 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 optimal solution in our setup starting with the depth of corruption $\hat{h}$.

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:* $\hat{h}_b(q, b) = \frac{1}{V^d}$.

Let $q(b)$ be the optimal solution to the maximization problem (3) for given b, and $b(q)$ the optimal solution to the maximization problem (4) 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, $q^* > 0$, $b^* > 0$.*

5. Comparative Statics

5.1. **Model's Parameters.** One main goal of this exercise is to trace back the equilibrium effects on $(q, b, \hat{h})$ from various parameters of the model. This is relevant for policy purposes. As already pointed out, 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. We establish that some changes in parameter values are isomorphic; i.e., they have the same qualitative effects on these equilibrium values.

- $\bar{u}^h$: *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.[7]
- 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 punishment, which depends on the anticorruption measure, q. Following Becker and Stigler (1974), let us suppose that the *IR* constraint (1) 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.

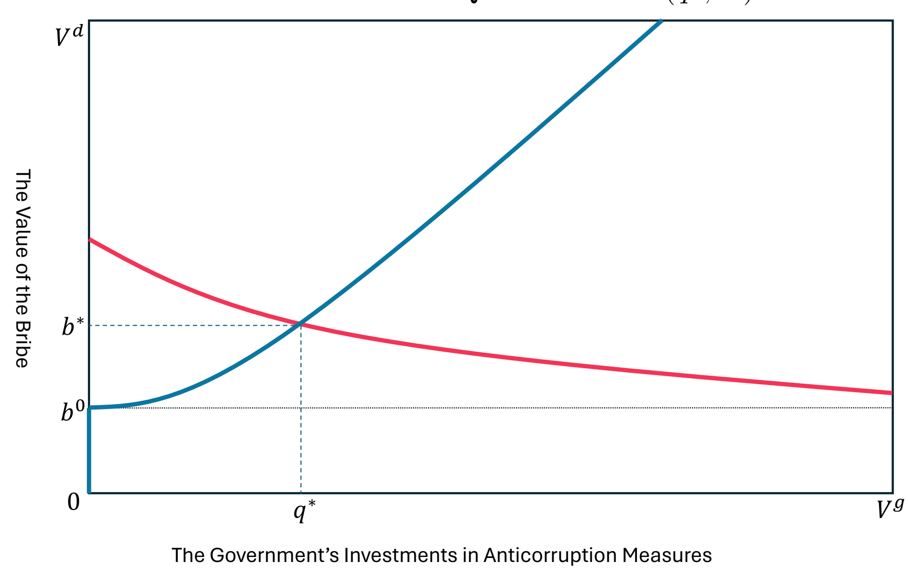
Observe that all the left-hand side terms in (5) can be lumped into an aggregate utility function, $u(q, I)$, for $I = w + b$; see Assumption 2. Morevoer, Assumption 1 is satisfied if functions p, v and α are increasingly monotone and strongly concave. The cross-partial derivative $u_{I,q}(y, q, I)$ in Assumption 1 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. As already

[7] 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. Likewise, some crimes (drug trafficking, extreme violence, sexual abuse) may be burdened by marked emotional, ethical, and social considerations with unequal reactions over a heterogeneous population of government officials.

discussed $\alpha(q)$ can encompass several terms in the left- and right-hand side of (5). On the left-hand side of the constraint, $\alpha(q)$ can serve to assess changes in the efficiency of the anticorruption measure q. While on the right-hand side of this constraint, $\alpha(q)$ we 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 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. Besides, the term γ represents the cost of punishment.

5.2. **Results.** In our model, the variability of the bribe and the depth of corruption originates from the endogenous interaction of various economic forces. 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 1, we now discuss how perturbations of the various terms of the IR constraint (5) 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^*). An increase in w, will not affect q^* and $\hat{h}(q^*, b^*)$. From the first-order conditions [Corollary 1], the "ability-to-pay" parameter V^g will affect directly function reactions function $q(b)$, whereas V^d will affect directly $b(q)$. 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^*).

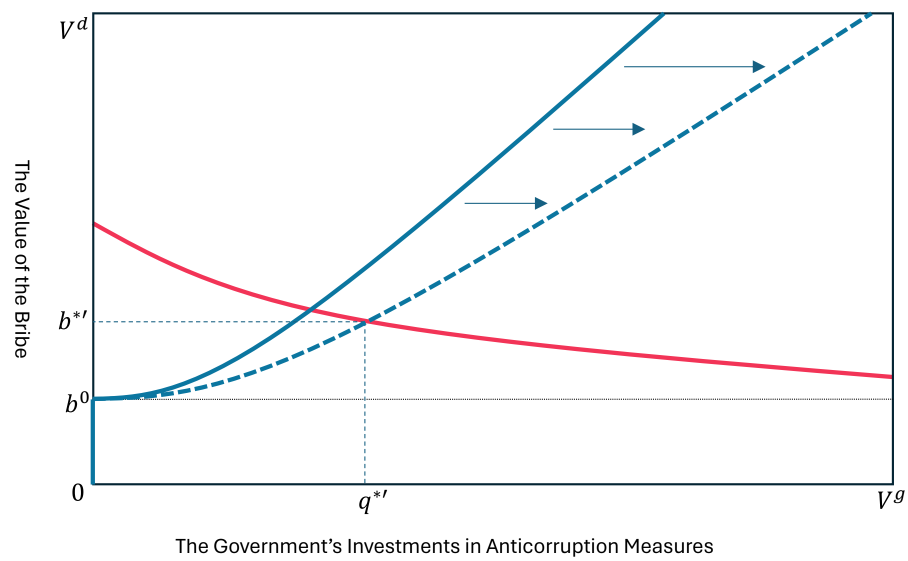


• *Changes in the officer's bargaining power or reservation utility,* $\bar{u}^h$: We assume $\bar{u}^h = \bar{u} + \hat{u}^h$, for $\hat{u}^h = \lambda h$. An increase in $\bar{u}$ does not affect the first-order optimality conditions for the government and the donor as stated in Corollary 1. Hence, (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 1 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.

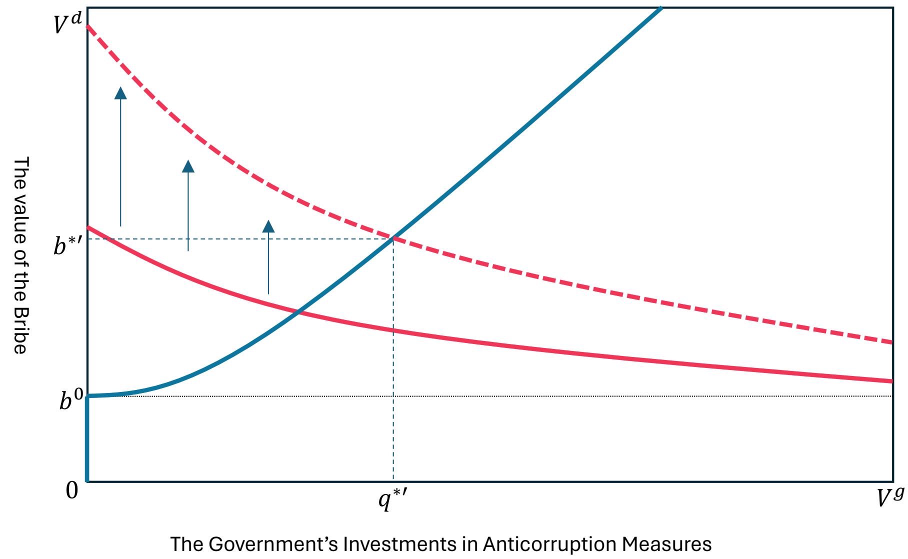
- *Changes in the government's value of the corruption distortion, V^g*: From the government's first-order condition [Corollary 1], an increase in V^g will shift out the government's reaction function $q(b)$, while the donor's reaction function $b(q)$ remains unchanged. Since $q(b)$ is non-decreasing, 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 1], 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.

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



• *Changes in the efficiency of the anticorruption measure,* α: Let $\alpha(q) = a + \bar{\alpha}q$. From the government's first-order condition [Corollary 1], 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 (5), 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 comparative statics results:

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* $\frac{\partial \hat{h}^*}{\partial \gamma} < 0$.

5.3. **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:

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

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:

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

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 (10) and (12), 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 (14) and (13) into (7), 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 (13)-(15). 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 (13)-(14). 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 $\hat{h}$.

6. A Taxonomy of Corruption

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. 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, see Table 3, based on the "ability-to-pay" of both parties to configure the equilibrium values $(q, b, \hat{h}(q, b))$ over some prototypical scenarios.

Table 3. A TAXONOMY OF CORRUPTION.

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

• *High V^g and high V^d.* This first scenario is especially relevant in those situations where both the government and the donor enjoy some bargaining power, e.g., public procurement and the delivery of infrastructure projects, large purchasing orders of military and medical equipment, global tax fraud and tax evasion, and even terrorist attacks. 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. 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. Campos et al. (2021) document the corruption case of Latin America's largest engineering and construction company, Odebrecht, which fetched a total of US $788 M to about 600 politicians and public servants in ten Latin American countries—generating about US $3,336 M in gross profits to Odebrecht via manipulation of subjective bid criteria, better terms in renegotiations, and multiple quid pro quos. For a dataset of over one million land transactions in China, Chen & Kai-sing Kung (2019) estimate that companies with political connections to members of China's supreme political elites may get price discounts between 55.4% to 59.9% of land prices as compared to companies without these connections. Following a corruption crackdown by President Xi Jingping in the targeted provinces, the depth of corruption went down between 42.6% and 31.5%. Both high q and high b should then be observed, which in turn have opposite effects on the depth of corruption, $\hat{h}(q, b)$.

• *Low V^g and high V^d.* Some lucrative corruption cases are less apparent and harder to determine: "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 a more concrete example, 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 the banking sector. 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 $\bar{\alpha}$. Again, we can think of many studies in the economics literature related to this scenario [e.g., Olken (2007) and Reinikka and Svensson (2004)]. As discussed below, for high depths of corruption a representative officer may be more desirable than a committee.

• *High V^g and low V^d.* For instance, acquiring a driver's license without the necessary training may result in fatalities. In the pharmaceutical sector, lowering production quality may endanger the health or security of a nation. 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. A high q will push down b, and the depth of corruption $\hat{h}(q, b)$ is expected to be fairly low. As discussed below, national security policies may be legislated and voted by large committees.

• *Low V^g and low V^d.* Minor infringements and petty corruption; e.g., infractions and misdemeanors, minor offenses, and traffic violations. In Olken & Barron (2009), on average truck drivers pay US $0.50 to $1 (in cash or in a pack or two of cigarettes) to police on their routes to and from the Indonesian province of Aceh. 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. From the empirical literature in this section below, the costs of breaking the law may be much higher in developed countries because of established protocols for monitoring government officials, the quality of democracy, transparency, and the possibility of being voiced in social media. In sum, developed countries command greater efficiency to fight corruption. Moreover, the information friction—as considered in our model—should be more pronounced in such countries because of high income and education levels, and solid institutions preserving social values and compliance to the law. Therefore, bribing becomes less attractive to the donor in advanced economies.

While it is generally accepted that agents respond to incentives [e.g., Becker (1968)], we still lack systematic studies on the general effects of of various economic policies on the different forms of corruption [e.g., Koutsougeras et al. (2024)]. Several micro-studies have identified substantial positive effects on the depth of corruption from close monitoring, public disclosure, auditing, and political turnover.[8] 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. Ferraz & Finan (2011) find that corruption is on average 27% lower among mayors with re-election incentives than among mayors without re-election incentives. In the Odebrecht case as documented by Campos et al. (2021), the company paid US $6 M to the president of the tender commission, US $5 M to a bribe intermediary, and US $3.8 M to the president and three board members of a government agency in charge of an airport. McMillan & Zoido (2004) report that the value of bribes would depend on the level of the party member and would range between US $3,000 to $50,000 per month. Bribes paid to control the media could be as much as US $1.5 M per month.

[8]Because corruption deals with illegal activities, misreporting may be quite common in cross-country data. There is also the problem of heterogeneous data quality across countries. In contrast, micro-evidence 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).

Svensson (2003) suggests that public officials may act as price discriminators, while Herrera et al. (2007) 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. These papers contend that officers in highly-corrupted countries may enjoy more monopoly power. We purport a different mechanism to account for the variability of the bribe based upon the "ability-to-pay" of both parties relative to the government's efficiency to fight corruption and an information friction about the officer's hidden type. Svensson (2003) argues that the company's "ability-to-pay" and "refusal power" can explain a large part of the variation in bribes across graft-reporting firms in Ugandan industries facing similar regulations. This study suggests that third-degree price discrimination may underlie the observed variability of the bribe. Third-degree price discrimination, however, would imply relatively higher bribes in high-income countries, which does not accord with the empirical evidence discussed below.

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. 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.

7. 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.[9] 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 (19), we get the first-order derivative of $\phi(\hat{h})$ with respect to $\hat{h}$:

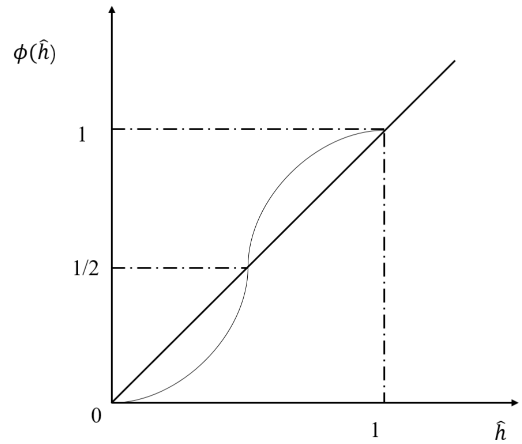
$$\phi'(\hat{h}) = \frac{d\phi(\hat{h}(q, b))}{d\hat{h}} = \frac{(2M+1)!}{M!M!} \hat{h}(q, b)^M (1 - \hat{h}(q, b))^M. \tag{20}$$

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 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

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

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 (19). 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 2, 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 4 is automatically satisfied by Lemma

1. 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 4. 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 comite* 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.

8. Concluding Remarks

There is a shortage of economic models to guide our thinking about corruption, and to evaluate the effectiveness of policy measures. Most attempts to combat corruption in developing countries have proven to be ineffective. 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. These basic pillars of our analysis should be at the forefront of theories of bribery and corruption, and can provide a useful benchmark to reassess the empirical evidence from data collection to hypothesis testing.

In our model, 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,[10] the slopes of the reaction functions of the government and the donor are unambiguously defined. The optimal q is increasing in b while the optimal b is decreasing in q. Then, there is a unique equilibrium. It follows that an increase in the government's "ability-to-pay" will increase q and reduce b, and hence will lower the depth of corruption. An increase in the donor's "ability-to-pay", however, will increase q and b, and so the effect on the depth of corruption will be indeterminate. 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 increase in the sensitivity of the information friction over the hidden type would amount to a scaling down of the "ability-to-pay" of the government and the donor. Based on these postulates, we propose a taxonomy of corruption that centers on the "ability-to-pay" of both the government and the donor, which bears on the structure of q and b.

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 investment in anticorruption and the bribe; 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

[10] From (5) above, the probability of getting caught $p(\cdot)$ and the utility function $v(\cdot)$ must be concave functions.

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.

In our model, a mere change in the wage for performing 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 bribe unchanged.

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 can explain why bribes may become so noticeable in the contracting of public works, and why some political leaders can have so much clout in society and accumulate large sums of wealth over their careers.

References

[1] ACEMOGLU, DARON (1995): "Reward Structures and the Allocation of Talent," *European Economic Review*, 39, 17-33.

[2] ACEMOGLU, DARON, AND THIERRY VERDIER (2000): "The Choice Between Market Failures and Corruption," *American Economic Review*, 90, 194-211.

[3] ADES, ALBERTO, AND RAFAEL DI TELLA (1999): "Rents, Competition, and Corruption," *American Economic Review*, 89 (4), 982-993.

[4] AIDT, STOKE (2003): "Economic Analysis of Corruption: A Survey," *Economic Journal*, 113, 632-652.

[5] ANDVIG, JENS CHR., AND KARL OVE MOENE (1990): "How Corruption May Corrupt?" *Journal of Economic Behavior and Organization*, 13, 63-76.

[6] AVIS, ERIC, CLAUDIO FERRAZ, AND FREDERICO FINAN (2018): "Do Government Audits Reduce Corruption? Estimating the Impacts of Exposing Corrupt Politicians," *Journal of Political Economy*, 126, 1912-1964.

[7] BANERJEE, ABHIJIT V. (1997): "A Theory of Misgovernance," *Quarterly Journal of Economics*, 112, 1289-1332.

[8] BECKER, GARY S. (1968): "Crime and Punishment: An Economic Approach," *Journal of Political Economy*, 76, 169-217.

[9] BECKER, GARY S., AND GEORGE J. STIGLER (1974): "Law Enforcement, Malfeasance and Compensation of Enforcers," *Journal of Legal Studies*, 3, 1-18.

[10] BERTRAND, MARIANNE, SIMEON DJANKOV, REMA HANNA, AND SENDHIL MULLAINATHAN (2007): "Obtaining a Driver's License in India: An Experimental Approach to Studying Corruption," *Quarterly Journal of Economics*, 122 (4), 1639-1676.

[11] BESLEY, TIMOTHY, AND JOHN MCLAREN (1993): "Taxes and Bribery: The Role of Wage Incentives," *Economic Journal,* 103 (416), 119-141.

[12] BESLEY, TIMOTHY, AND ROBIN BURGESS (2002): "The Political Economy of Government Responsiveness: Theory and Evidence from India," *Quarterly Journal of Economics*, 117 (4), 1415-1451.

[13] BLISS, CHRISTOPHER, AND RAFAEL DI TELLA (1997): "Does Competition Kill Corruption?" *Journal of Political Economy*, 105, 1001-1023.

[14] BOBONIS, GUSTAVO J., LUIS R. CÁMARA FUERTES, AND RAINER SCHWABE (2016): "Monitoring Corruptible Politicians," *American Economic Review*, 106 (8), 2371-2405.

[15] BRUNETTI, AYMO, AND BEATRICE WEDER (2003): "A Free Press is Bad News for Corruption," *Journal of Public Economics*, 87 (7-8), 1801-1824.

[16] CAMPOS, NICOLÁS, EDUARDO ENGEL, RONALD D. FISCHER, AND ALEXANDER GALETOVIC (2021): "The Ways of Corruption in Infrastructure: Lessons from the Odebrecht Case," *Journal of Economic Perspectives*, 35 (2), 171-190.

[17] CHEN, TING, AND JAMES KAI-SING KUNG (2019): "Busting the "Princelings": The Campaign Against Corruption in China's Primary Land Market,," *Quarterly Journal of Economics*, 134 (1), 185-226.

[18] DJANKOV, SIMEON, RAFAEL LA PORTA, FLORENCIO LOPEZ-DE-SILANES, AND ANDREI SHLEIFER (2002): "The Regulation of Entry," *Quarterly Journal of Economics*, 117 (1), 1-37.

[19] DJANKOV, SIMEON, RAFAEL LA PORTA, FLORENCIO LOPEZ-DE-SILANES, AND ANDREI SHLEIFER (2010): "Disclosure by Politicians," *American Economic Journal: Applied Economics*, 2 (2), 179-209.

[20] FERRAZ, CLAUDIO, AND FREDERICO FINAN (2008): "Exposing Corrupt Politicians: The Effects of Brazil's Publicly Released Audits on Electoral Outcomes," *Quarterly Journal of Economics*, 123 (2), 703-745.

[21] FERRAZ, CLAUDIO, AND FREDERICO FINAN (2011): "Electoral Accountability and Corruption: Evidence from the Audits of Local Governments," *American Economic Review*, 101 (4), 1274-1311.

[22] FISMAN RAYMOND, AND EDWARD MIGUEL (2007): "Corruption, Norms and Legal Enforcement: Evidence from Diplomatic Parking Tickets," *Journal of Political Economy*, 115, 1020-1048.

[23] FOLTZ, JEREMY D., AND KWEKU A. OPOKU-AGYEMANG (2015): "Do Higher Salaries Lower Petty Corruption? A Policy Experiment on West Africa's Highways," *International Growth Centre (IGC) working paper.*

[24] HERRERA ANA MARÍA, LEBOHANG LIJANE, AND PETER RODRIGUEZ (2007): "Bribery and the Nature of Corruption," *working paper.*

[25] HUNT, JENNIFER, AND SONIA LASZLO (2005): "Bribery: Who Pays, Who Refuses, What are the Payoffs?" *NBER working paper 11635.*

[26] KENNY, CHARLES (2009): "Measuring Corruption in Infrastructure: Evidence from Transition and Developing Countries," *Journal of Development Studies*, 45 (3), 314-332.

[27] KOUTSOUGERAS, LEONIDAS, MANUEL SANTOS, AND FEI XU (2024): "A Cross Country Study of the Determinants of Corruption," *Working paper.*

[28] MAURO, PAOLO (1995): "Corruption and Growth," *Quarterly Journal of Economics*, 110 (3), 681-712.

[29] MCMILLAN, JOHN, AND PABLO ZOIDO (2004): "How to Subvert Democracy: Montesinos in Peru," *Journal of Economic Perspectives*, 18 (4), 69-92.

[30] MOOKHERJEE, DILIP, AND I. P. L. PNG (1992): "Monitoring vis-à-vis Investigation in Enforcement of Law," *American Economic Review*, 82, 556-65.

[31] MOOKHERJEE, DILIP, AND I. P. L. PNG (1995): "Corruptible Law Enforcers: How Should They Be Compensated?" *The Economic Journal*, 105, 145-159.

[32] OLKEN BENJAMIN A. (2007): "Monitoring Corruption: Evidence from a Filed Experiment in Indonesia," *Journal of Political Economy*, 115, 200-249.

[33] OLKEN BENJAMIN A., AND PATRICK BARRON (2009): "The Simple Economics of Extortion: Evidence from Trucking in Aceh," *Journal of Political Economy*, 115, 200-249.

[34] OLKEN BENJAMIN A., AND ROHINI PANDE (2012): "Corruption in Developing Countries," *Annual Review of Economics*, 4, 479-509.

[35] ORGANIZED CRIME AND CORRUPTION REPORTING PROJECT (OCCRP) (2024): *https://www.occrp.org/en.*

[36] PERSSON, TORSTEN, AND GUIDO TABELLINI (2004): "Constitutional Rules and Fiscal Policy Outcomes," *American Economic Review*, 94 (1), 25-45.

[37] REINIKKA, RITVA, AND JAKOB SVENSSON (2004): "Local Capture: Evidence from a Central Government Transfer Program in Uganda," *Quarterly Journal of Economics*, 119 (2), 679-705.

[38] ROSE-ACKERMAN, SUSAN (1978): *Corruption: A Study in Political Economy.* New York: Academic Press.
[39] SHLEIFER, ANDREI, AND ROBERT W. VISHNY (1993): "Corruption," *Quarterly Journal of Economics*, 108 (3), 599-617.
[40] SVENSSON, JAKOB (2003): "Who Must Pay Bribes and How Much? Evidence from a Cross Section of Firms," *Quarterly Journal of Economics*, 118 (1), 207-230.
[41] SVENSSON, JAKOB (2005): "Eight Questions about Corruption," *Journal of Economic Perspectives*, 19 (3), 19-42.
[42] TRANSPARENCY INTERNATIONAL (2021): "The Global Corruption Barometer," *https://www.transparency.org/en/gcb*, tenth edition.
[43] TRANSPARENCY INTERNATIONAL (2021): "The Global Corruption Barometer–European Union," *https://www.transparency.org/en/gcb/eu/european-union-2021*, second edition.
[44] TREISMAN, DANIEL (2000): "The Causes of Corruption: A Cross-national Study," *Journal of Public Economics*, 76 (3), 399-457.

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Appendix A

A.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.[11] We take this relative value of the bribe at the year when the latest survey is conducted in that country.

A.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 punishment. This aggregated measure is reported in the standard normal units,[12] 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[13] 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

[11]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.

[12]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.

[13]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 A.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

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.

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

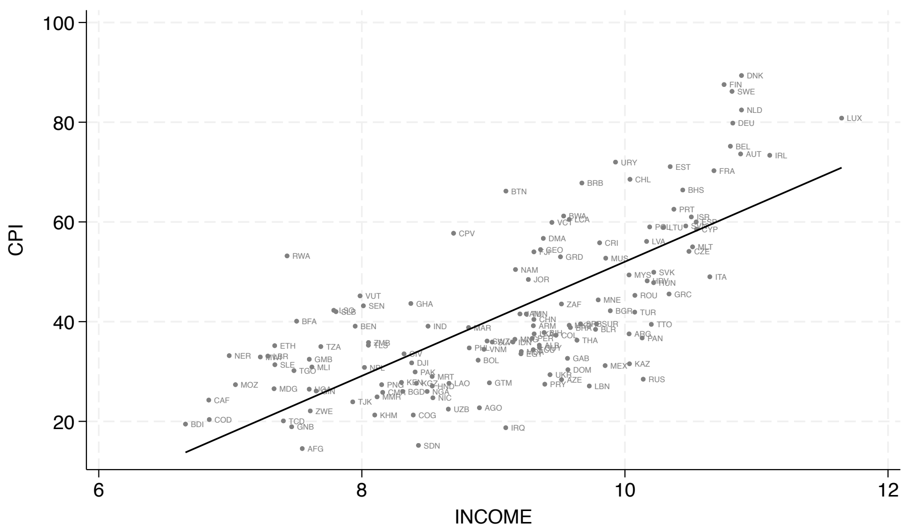
A.3. **The List of Countries:** Angola, Albania, Argentina, Austria, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bosnia and Herzegovina, Belize, Bolivia, Brazil, Barbados, Botswana, Chile, China, Cote d'Ivoire, Cameroon, Congo, Dem. Rep., Colombia, Costa Rica, Cyprus, Czech Rep., Germany, Denmark,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

A.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[14] 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 A.1 shows that the CPI is positively correlated with INCOME, and Figure A.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. La Porta, Lopez-de-Silanes and Shleifer (2004) suggest that per capita income could be a cause of corruption as higher income causes institutional development. Meanwhile, countries with higher income have more resources to invest in anticorruption measures (Treisman, 2000). But Svensson (2005) argues that income and the quality of institution co-evolve. Economic development would create a demand for the improvements of the quality of institutions but institutions also influence economic development.

FIGURE A.1. CPI AND INCOME.

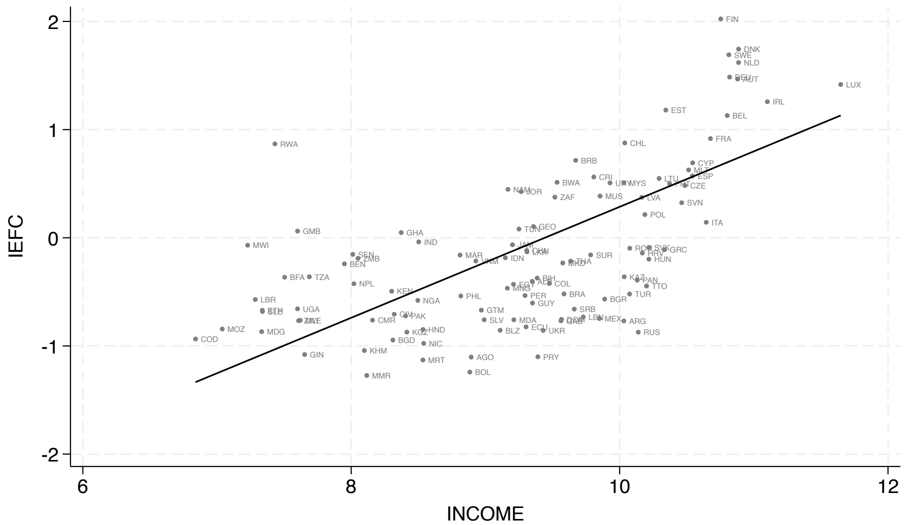


Sources: Income is measured by the (ln)GDP per capita, PPP (constant 2017 international $) taken from the World Bank for the year 2010. CPI is taken the country's average level of CPI over 2012-2022 from Transparency International.

Figure A.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.

[14] 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.

Figure A.2. THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION AND INCOME.

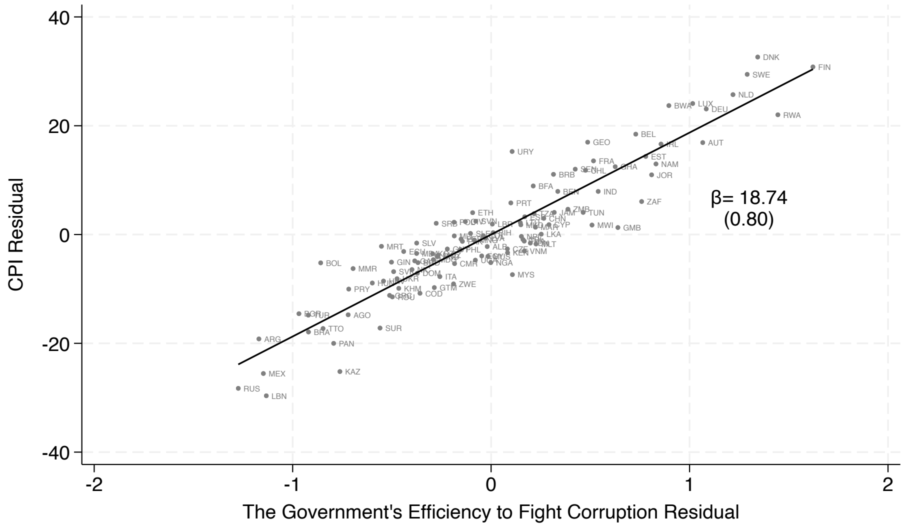


Sources: Global Competitiveness Report by World Economic Forum, World Justice Project, and the World Bank. Income is measured by the (ln) GDP per capita, PPP (constant 2017 international $) taken from the World Bank for the year 2010.

A.5. **Regression Equations with Fixed Effects to Control for Income.** In Table A.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.

We complement this quantitative analysis with several graphical illustrations. After controlling for the income groups, Figure A.4 projects the residuals of PC against the residuals of IEFC, while Figure A.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 A.6; again, some noticeable outliers are present. Figures A.7 and A.8 illustrate the effects of SALARIES on PC and GC, respectively. While salaries

FIGURE A.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.

do not appear to have distinct effects on either PC or GC, the scatterplot for GC displays greater variation.

APPENDIX B

B.1. **Proofs. Proof of Lemma 1**:

• By the definition of $\hat{h}$ along with Assumption 2, 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,

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

Table A.2. FIXED EFFECTS MODELS.

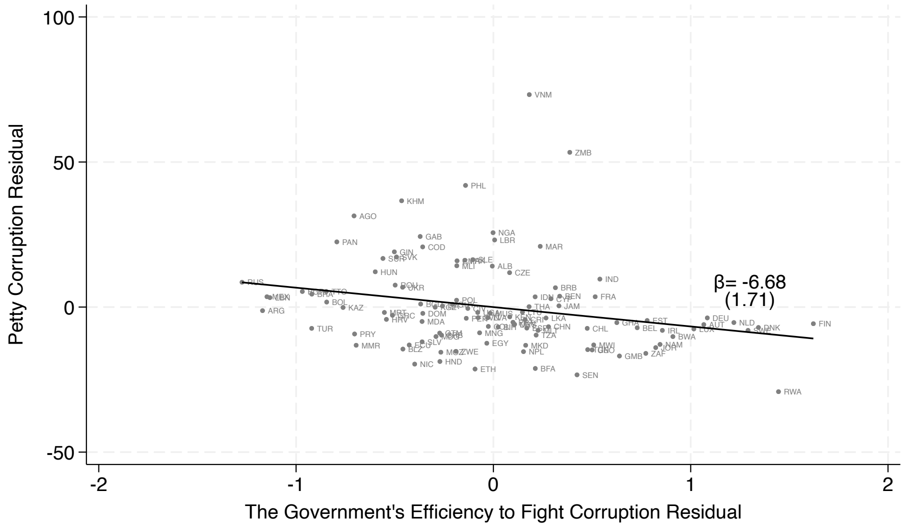
Panel A:		PC	GC	VALUE	INVE
		(1)	(2)	(3)	(4)
IEFC		-6.68***	-8.21***	-.52**	-.23*
		(1.71)	(2.13)	(.25)	(.13)
GDP per capita 2010q3					
	2	-10.98**	-12.11**	-1.43**	1.30***
		(4.63)	(4.77)	(.65)	(.45)
	3	-15.09***	-19.3***	-1.74***	1.24***
		(4.06)	(4.43)	(.59)	(.43)
Observations		110	109	109	45
R^2		.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: For definitions and data sources, see the Appendix. 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.

Differentiating once more this last equation we conclude that

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

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



Notes: For definitions and data sources, see the Appendix. 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.

• 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:

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

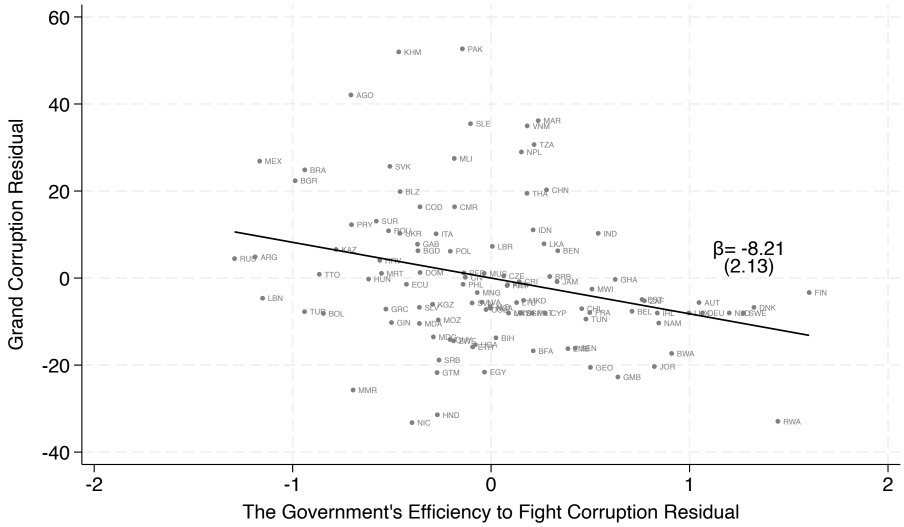
□

Proof of Lemma 2:

• First, by Lemma 1 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:

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

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



Notes: For definitions and data sources, see the Appendix. 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.

where the sign is determined by Assumption 2 and Lemma 1.

• By Assumption 3 the optimal solution to the donor's problem satisfies $b(q) \geq b^0 > 0$. By Lemma 1 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 2 and Lemma 1. □

Proof of Proposition 1:

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

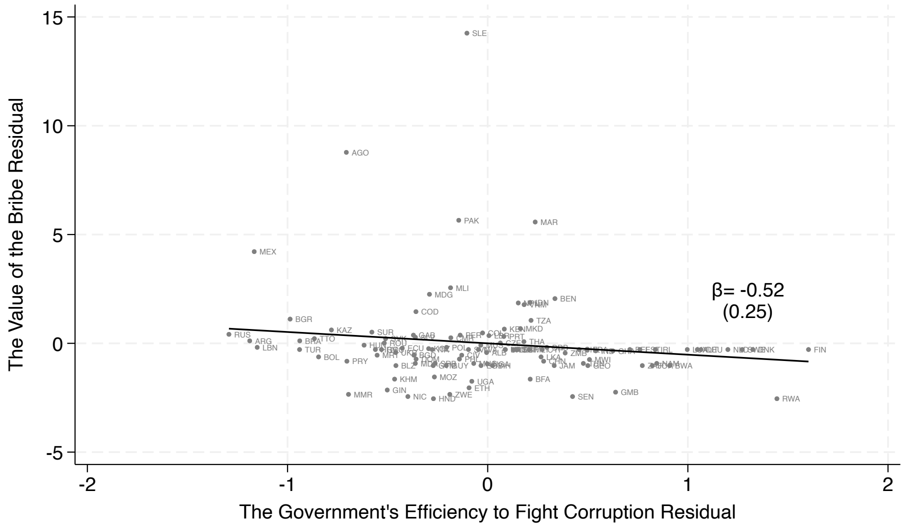
$$f_1(q, b) = q(b), \forall b \in [0, V^d].$$

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

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

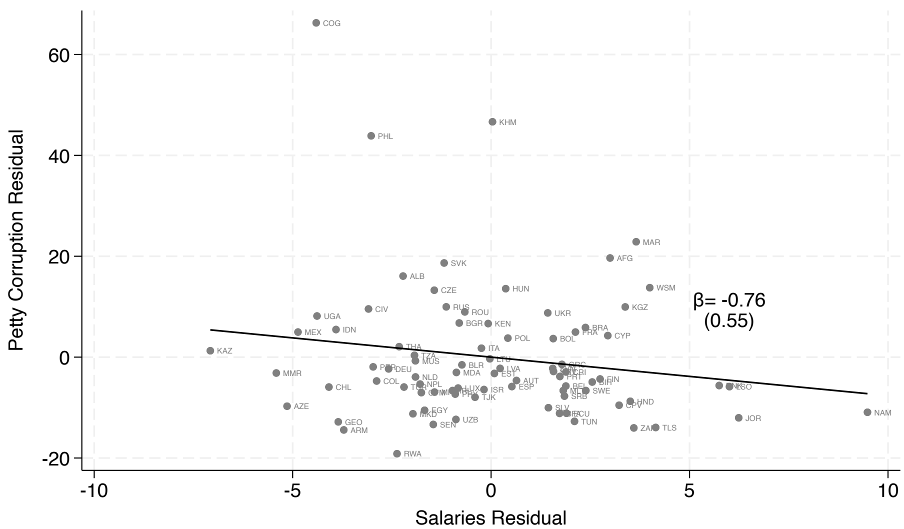
The mapping $\Psi : [0, V^g] \times [0, V^d] \to [0, V^g] \times [0, V^d]$ given by $\Psi(q, b) = (f_1 \times f_2)(q, b)$ is continuous, single valued (i.e., convex valued), and maps a compact domain to itself. Hence,

Figure A.6. THE VALUE OF THE BRIBE AND THE GOVERNMENT'S EFFICIENCY TO FIGHT CORRUPTION.



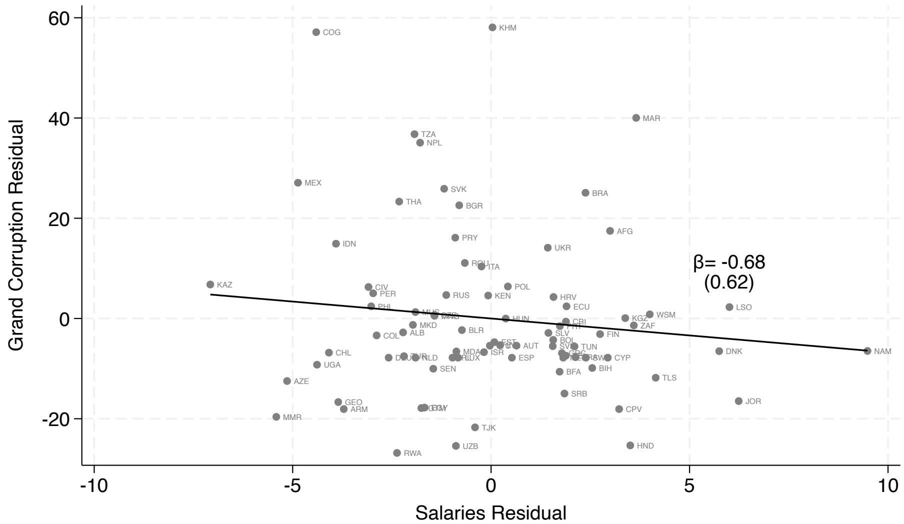
Notes: For definitions and data sources, see the Appendix. The residuals for the value of the bribe are calculated from regressions on GDP with grouped fixed effects, and the residuals for the government's efficiency to fight corruption are calculated from regressions on GDP with grouped fixed effects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

Figure A.7. PETTY CORRUPTION AND SALARIES.



Notes: For definitions and data sources, see the Appendix. 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 A.8. GRAND CORRUPTION AND SALARIES.



Notes: For definitions and data sources, see the Appendix. 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.

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 2 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 2:

From Lemma 2, 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 2, 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 (23) and (24) 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 (26) and (27), 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 (23) and (24) 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 1, 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 (28) and (29), 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 (23) and (24) 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 (32),

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

Inserting (33) into (31),

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

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 (34) into (32),

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

Therefore,

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

• Changes in V^d : Differentiating (23) and (24) 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 (37) and (38), 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 (23) and (24) 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 $\bar{\alpha}$.

□