

A model of theft and bribery

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Abstract

Two of the most pervasive kinds of public corruption are theft and bribery. I show how a simple common agency model can simultaneously depict both. In one setting, a public official (agent) who has discretion over government revenues can steal some of it and allocate the rest to public spending towards various sectors (principals), some of whom can pay bribes in exchange. I find that there is a threshold level of revenues at and below which the official obtains bribes but does not steal revenues. She only starts stealing revenues above the threshold. In another setting, there are two political candidates (agents), each promising to allocate public spending to various groups of voters (principals), some of whom can pay bribes in exchange. Each candidate then uses the bribes and any government revenues that she expects to steal in office to buy some votes. I find that the candidate who would steal less revenues in office will obtain larger bribes, and vice versa, which suggests that bribe money and stolen revenues are substitute sources of (illicit) campaign funds.

KEYWORDS

bribery, campaign finance, corruption, theft of government revenues

JEL CLASSIFICATION

D73; H2; H41

1 | INTRODUCTION

In a comprehensive survey of research on corruption in developing countries, Olken and Pande (2012), reveal that the reason why anti-corruption efforts can fail is that enforcing against some kinds of corrupt activities can induce perpetrators to switch to other kinds. Corrupt public officials simply find other ways to pursue rents. Yet current models of corruption do not take into account multiple sources of rents, and therefore cannot depict the possibility of switching between these sources. This paper is an attempt to fill the gap.

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I propose a common agency model that simultaneously depicts two kinds of public corruption: the theft (embezzlement) of government revenues, and bribe payments (kickbacks) from recipients of public spending contracts. Both types of corruption are ubiquitous, especially in the developing world. Two of the largest corruption scandals to date illustrate how government revenues can be siphoned off directly, or otherwise allocated to public projects that are implemented by firms from which public officials obtain bribes and kickbacks. Former Malaysian Prime Minister Najib Razak is currently on trial for his suspected involvement in the theft of over \$4.5 billion from the Malaysia state development fund 1MDB, out of which \$681 million were allegedly transferred to Mr Razak's personal bank account. The funds were apparently embezzled out of the country and spent on luxury properties and yachts, and even used to fund the 2013 Hollywood film 'The Wolf of Wall Street'. In Brazil, the Petrobras scandal illustrates large-scale corruption in the form of bribery, in which officials at the state-owned oil company Petroleo Brasileiro were alleged to have received bribes from construction companies in exchange for awarding contracts to the latter. The scandal is estimated to have amounted to \$9.5 billion in illicit payments, some of which were alleged to have been used in vote-buying schemes that benefited the Workers Party, including former Presidents Ignacio Lula Da Silva and Dilma Rousseff.¹

The OECD (2013). estimates that about 20–25% of government procurement budgets, equivalent to about \$2 trillion or 2% of global GDP, are lost annually to corruption, while the IMF (2016). suggests that such an amount captures the annual cost of bribery alone. The cost of theft is also likely to be large. Kar and Spanjers (2015). calculate that between 2004 and 2013, developing countries lost \$7.8 trillion from illicit financial outflows due to trade misinvoicing and leakages in the balance of payments. *The Independent* (Grice 2014) reports that about \$1 trillion a year is siphoned away from developing countries through money laundering, tax evasion and embezzlement.

Theft and bribery also occur at the local level—in some cases, local government officials embezzle public funds, while in other cases, they spend the funds on public projects in exchange for bribes. For instance, Olken (2006). shows that in Indonesia, about 18% of government-subsidized rice 'disappeared' and was not received by the intended households. Olken suggests that the rice was stolen by village officials who were in charge of distributing it. Similarly, Reinikka and Svensson (2004). show that 86% of Uganda's educational grants were not received by schools, while Neihaus and Sukhtankar (2013). estimate that 79% of public funds did not reach the intended recipients—employees through India's National Rural Employee Guarantee Scheme. Meanwhile, Batalla (2000). provides anecdotal evidence of how bribery from public spending occurs at the local level in the Philippines. Large public works projects that cover multiple jurisdictions are divided into smaller projects so that local governments can award them to their 'favoured' contractors. In exchange, local officials apparently earn kickbacks amounting to about 20–40% of the project. Other evidence of local-level bribery in developing countries includes Knutsen et al. (2017). for Africa, Brierley (2020). for Ghana, and Figueroa (2020). for Argentina.

Even developed countries are not immune to theft and bribery. Leeson and Sobel (2008). show that between 1990 and 1999, each \$100 of funds provided by the US Federal Emergency Management Agency (FEMA) to states for natural disaster relief increased the state's average number of convictions of corruption-related crimes by 102%. They suggest two ways by which state public officials benefit, namely theft and bribery. Citing Lakin (2004)., they note that officials in Buchanan county in Virginia solicited bribes from firms that have been awarded contracts for reconstruction projects. As an example of theft, they mention that in 2005, a public employee in Florida attempted to embezzle \$48,000 of FEMA relief after a hurricane in 1998.

With possibly only two exceptions—Martinelli (2022). and Desierto (2023).—most models of public corruption treat each of theft and bribery in isolation. In canonical models of the rent-seeking political agent (Barro 1973; Ferejohn 1986; Persson and Tabellini 2000; Bueno de Mesquita et al. 1999, 2003; Bueno de Mesquita and Smith 2010), the agent either spends government revenues on public goods or appropriates them for her own consumption and/or to

buy political support.² Corruption is thus tantamount to the theft of government revenues. On the other hand, there are common agency models of bribery (Bernheim and Whinston 1986a,b; Dixit et al. 1997; Grossman and Helpman 1994, 2001; Arteaga et al. 2024) in which groups or individuals from the private sector (principals) offer bribes to a public official (agent) in exchange for their preferred policy, such as the allocation of government revenues.

To construct a model that includes both theft and bribery, I modify Grossman and Helpman (2001). to allow for the possibility that the public official in charge of allocating government revenues may not be constrained to spend all of it on the principals. She then appropriates any unspent revenues. In one setting, she simply consumes what she appropriates, along with any bribes obtained from the principals. In another setting, she uses all illicit incomes that she obtains—stolen revenues and bribes—to buy votes in order to get elected into public office. I thus generate two sets of results.

In the first setting (Section 2), I show that there is a threshold level of government revenues at and below which the public official does not steal revenues but obtains illicit incomes only from bribe payments. To do so, she allocates all of the revenues towards public spending, but relatively more towards the principals who pay bribes than to those who do not. Above the threshold level of revenues, the public official obtains a fixed amount of bribes, and steals all revenues above the threshold. This is because stealing revenues is a direct way of obtaining illicit income, whereas bribes are obtained in exchange, or as ‘payment’, for the spending of those revenues. If there are diminishing marginal returns to public spending, then the marginal value of bribes will also diminish. At some point (i.e. at the threshold level of revenues), the public official would then prefer stealing revenues than spending them in exchange for more bribes. Thus if revenues are larger than the threshold level, then she spends exactly the threshold, thereby obtaining a fixed amount of bribes, and steals all the rest.

In the second setting (Section 3), I demonstrate that if political candidates can recover campaign funds spent in elections by stealing revenues when elected into public office, and in addition they can extract bribes from some groups of voters (principals) in exchange for future public spending, then the size of the bribes depends on how much the candidates would steal while in office. In equilibrium, larger bribes are paid to the candidate who would steal less. This is because this candidate needs more campaign funds in order to be elected, and is thus more willing to allocate more spending to the bribing principals in exchange for larger bribes. In contrast, a candidate who can steal more revenues would have less need for bribe money. In effect, bribes and stolen revenues are substitute sources of campaign funds.

Finally, I conclude (Section 4) by speculating on what the model implies about the effectiveness of anti-corruption policies. If public officials can choose how to obtain illicit money, whether by directly siphoning off revenues or spending the revenues to extract bribes, then enforcing solely against bribe-taking, or solely against theft, may be ineffective, as corrupt public officials can switch between these two types of corruption. It is also not as simple as *equally* enforcing against the two since, under certain conditions, one type of corruption may be more likely to occur than the other. The need to determine what these conditions are precisely warrants the simultaneous modelling of theft and bribery.

2 | THEFT AND BRIBERY IN PUBLIC SPENDING

Grossman and Helpman (2001). construct a common agency model in which a public official (agent) allocates government revenues towards public spending that benefit multiple groups (principals) in the private sector, from whom she can extract bribe payments. That is, the public official has to spend the revenues to obtain illicit income. But what if, instead of getting kickbacks, she can directly siphon off some of the revenues? I show how the model can accommodate the possibility of outright theft.

There are two groups, 1 and 2, whose common agent—a public official in charge of the government budget—decides how to use government revenues T . She can allocate some or all of it to public spending g_1 that benefits group 1, and some or all to public spending g_2 that benefits group 2. Specifically, public spending generates some value $V(g_i)$ to group $i = \{1, 2\}$, where V is twice-differentiable, with $V'(\cdot) > 0$, $V''(\cdot) < 0$, and therefore concave. That is, public spending targeted to any group is assumed to generate diminishing marginal returns.

Now suppose that group 1 is sufficiently organized such that it can influence the spending allocation. Specifically, it offers to pay the official bribe b in exchange for g_1 . Group 2, in contrast, cannot offer bribes and thus cannot influence public spending.

Faced with the bribe offer, the agent then chooses g_1 and g_2 . Total spending is thus $S = g_1 + g_2$. In Grossman and Helpman (2001), S is always equal to T —all government revenues are spent. In other words, the government budget constraint binds. I allow for the possibility that the public official may not be constrained to spend all the revenues, in which case, whatever she does not spend, she appropriates for herself. That is, the public official steals $T - g_1 - g_2$. She can then earn illicit money or rents equal to the amount of stolen revenues and bribes, that is, $R = T - g_1 - g_2 + b$, which she simply consumes. To stay in office, however, the public official also has to care, at least to some extent $\lambda \in (0, 1)$, about social welfare $\sum V(g_i)$. Her utility is thus given by

$$U = \lambda[V(g_1) + V(g_2)] + (1 - \lambda)(T - g_1 - g_2 + b),$$

where the closer λ is to zero, the more easily she can obtain illicit money in office. One can then think of λ as a parameter capturing the effectiveness of anti-corruption enforcement. By letting $\lambda < 1$, I assume that enforcement is always imperfect.

The public official chooses how much to allocate to groups 1 and 2, namely g_1 and g_2 , keeping any unspent revenues for herself. Meanwhile, group 1 chooses the bribe amount b to pay to the official in order to get as high an allocation as possible. Its net utility from g_1 is therefore $V(g_1) - b$. In equilibrium, the spending allocations and bribe payment are jointly efficient for the briber and the bribe-taker. That is, they are obtained by solving the following problem:

$$\max_{g_1, g_2, b} V(g_1) - b$$

subject to

- (i) $\lambda[V(g_1) + V(g_2)] + (1 - \lambda)(T - g_1 - g_2 + b) \geq \bar{U}$,
- (ii) $T - g_1 - g_2 \geq 0$,

where $\bar{U}$ is the public official's reservation utility—what she would obtain if she rejects the group 1 bribe offer. That is,

$$\bar{U} = \lambda[V(g_1^0) + V(g_2^0)] + (1 - \lambda)(T - g_1^0 - g_2^0),$$

where g_i^0 denotes what the public official would allocate to group i if she rejects the bribe offer. Thus (i) is her participation constraint. Meanwhile, constraint (ii) is her budget constraint, which captures the possibility of theft. If (ii) is binding, then there is no theft. If it is slack, then the unspent revenues $T - g_1 - g_2 > 0$ are appropriated or stolen by the public official.

I first characterize the equilibrium public spending allocation g_1^* to group 1, and g_2^* to group 2, and the bribe payment b^* when the government budget constraint is binding, and when it is slack.

Proposition 1.

- (i) If the budget constraint binds, then g_1^* and g_2^* increase with T , while b^* decreases (increases) with T if the marginal value of public spending is sufficiently high (low).
- (ii) If the budget constraint is slack, then none of g_1^* , g_2^* and b^* changes with T .

I relegate all proofs and details to the Appendix, but the intuition is the following. If the public official is constrained to spend all revenues, then an increase in revenues increases not only total spending, but spending to both groups. While the bribing principal (group 1) always obtains a higher allocation, the allocation to the non-bribing principal (group 2) is never zero. This is because with $\lambda > 0$, the public official has to be concerned with social welfare and therefore with the benefits accruing to both groups. Now the effect of revenues on the bribe amount is ambiguous and depends on the marginal value of public spending. If the latter is sufficiently high, then as revenues increase, group 1 would want g_1 to increase. It would thus offer larger bribes.

In contrast, if the budget constraint is non-binding, then the public official spends $\bar{S} = g_1^* + g_2^*$ and steals $T - \bar{S}$. Thus increasing revenues above $\bar{S}$ simply increases the amount that she steals. Group 1, therefore, does not increase its bribe offer, but just keeps it at b^* —the amount that buys exactly g_1^* .

A key question then is: when is the budget constraint binding, and when is it non-binding? Notice that the model does not have variables that explicitly determine whether the budget constraint is slack, nor does it specify the mechanism by which the public official steals the unspent revenues. A simpler result can be obtained. In particular, it can be shown that the budget constraint is binding at low levels of revenues and becomes slack when revenues become sufficiently large. That is, we have the following.

Proposition 2. *There exists a threshold level of revenues $\bar{T}$ such that if $T \leq \bar{T}$, then the budget constraint binds; if $T > \bar{T}$, then it is slack.*

Figure 1 depicts the effect of government revenues on public spending and corruption (bribes and stolen revenues), according to Propositions 1 and 2. There is a threshold amount of revenues $\bar{T}$ at and below which total spending is increasing, but beyond which it does not increase further. Since the budget constraint binds at and below the threshold, all revenues are spent. Total public spending $S = g_1 + g_2$ thus has slope 1 below $\bar{T}$, and 0 thereafter. Meanwhile, bribes may increase or decrease. Consider, then, bribe curves b_1 and b_2 which show different possibilities below $\bar{T}$, but which beyond $\bar{T}$ have slope 0. Finally, total illicit incomes below $\bar{T}$ are solely bribes (since there is no theft), in which case R_1 and R_2 coincide with b_1 and b_2 , respectively. Above $\bar{T}$, total illicit incomes consist of both bribes and stolen revenues, with the amount of bribes fixed at b_1 and b_2 , and all additional revenues are stolen since public spending is fixed. Thus above $\bar{T}$, R_1 and R_2 have as their y -intercepts their respective intersections with b_1 and b_2 , and slope 1.

The results are a direct consequence of the public official having, in effect, quasi-linear preferences over bribes and stolen revenues. Stolen revenues are directly appropriated and hence contribute $(1 - \lambda)(T - g_1 - g_2)$, therefore linearly, to the public official's utility. Bribes, however, are obtained in exchange for g_1 , and therefore depend on value $V(g_1)$, which is concave. Thus bribes contribute non-linearly (in concave fashion) to the public official's utility.³ In other words, the public official derives diminishing marginal utility from bribes, but constant marginal utility from stolen revenues. The natural consequence, then, is that initially (i.e. at lower revenues), bribes increase, but eventually, as revenues become sufficiently large, the marginal utility from stealing revenues surpasses that from extracting bribes, which induces the public official to concentrate all her illicit money-taking on the theft of revenues.

Note, then, how Figure 1 portrays a kind of revenue expansion path. Below threshold $\bar{T}$, all revenues are allocated in the pursuit of bribes, hence all revenues are spent, and stolen revenues are zero. Beyond the threshold, all revenues are allocated towards theft—in other words, all revenues above the threshold are stolen, which means that public spending does not change.⁴

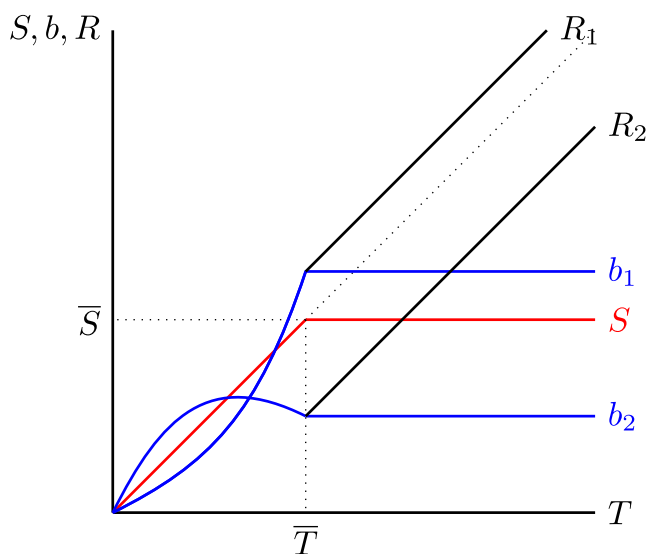


FIGURE 1 Effect of revenues on public spending and corruption. *Notes:* This figure depicts a threshold level of revenues $\bar{T}$ below which theft is not possible, in which case all revenues are spent, and the only illicit income is from bribes, which may increase or decrease with revenues. Above $\bar{T}$, all additional revenues are stolen, public-good spending remains constant, and total illicit income comes from a fixed amount of bribes and stolen revenues that are increasing at the same rate as revenues.

Thus the optimal mix of rents for the public official depends on $\bar{T}$. If revenues are below this threshold, then all rents come from bribes; at and above the threshold, rents come from a fixed amount of bribes (associated with $\bar{T}$) and, on top of that, stolen revenues $T - \bar{T}$.

It remains to note that λ —the effectiveness of anti-corruption efforts—has no effect on the size of threshold revenues $\bar{T}$.⁵ This is because such efforts do not distinguish between bribe-taking and theft. (Recall that the same weight $1 - \lambda$ is attached to bribe-rents and stolen revenues in the public official's utility function.) Thus when λ is close to 1, the public official is less able to extract rents in general, but how much of the rents are from bribes, and how much from stolen revenues, depends only on the size of the revenues relative to the threshold.

3 | THEFT AND BRIBERY IN ELECTIONS

Grossman and Helpman (2001). apply their common-agency model to bribe-taking in elections. I incorporate theft in a similar manner, that is, by allowing slackness of the budget constraint.

Suppose that there are two candidates (agents) vying for a public position that oversees the allocation of government revenues towards two groups of voters (principals). As before, assume that one group is sufficiently organized so as to be able to offer bribes to each of the candidates in exchange for a higher share in spending allocations once the candidate is in office. Each candidate then uses her bribe money to buy votes. Grossman and Helpman (2001). show that the candidate who is more likely to win the election would allocate less spending to the bribing principal, which induces the latter to offer a bribe amount that is larger than what it offers to the other candidate. That is, campaign money (bribes) follows the more popular candidate. I now consider the possibility that each candidate could steal government revenues if she is elected in office. What if these (anticipated) stolen revenues could also be used to buy votes? More concretely, what if the candidate could access other funds during the campaign that she would repay or replenish with stolen revenues once in office? I show then that the more popular candidate does not necessarily

obtain a larger bribe. Instead, the larger bribe goes to the candidate who would steal less revenue in office. In this manner, bribes substitute for stolen revenues, and vice versa.

To demonstrate, let principal $i = \{1, 2\}$ consist of a group of individuals who elect a candidate $k = \{A, B\}$ to be their agent in public office who would oversee the allocation of government revenues. Specifically, there are $N = N_1 + N_2$ voters, with $N_1 > 0$ voters belonging to group 1, and $N_2 > 0$ to group 2. Group 2 is an unorganized sector that is not capable of offering bribes, while group 1 is an organized sector that can offer bribes. A voter can either be strategic, in which case she votes according to the value of public spending that the candidate would allocate to her group once in office, or be impressionable, in which case her vote is influenced by the amount of campaign funds targeted towards her group.

To be precise, a strategic voter j in group i derives from candidate k utility $V(g_i^k) + v_{ji}^k$, where $V(g_i^k)$ is the utility that she obtains from public spending that k would allocate to group i , where, as before, V is twice-differentiable, with $V'(\cdot) > 0$, $V''(\cdot) < 0$, and therefore concave. Meanwhile, $v_{ji} = v_{ji}^B - v_{ji}^A$ is voter j 's (random) preference for B over A , which is uniformly distributed on the interval⁶

$$\left[\frac{2b-1}{2f}, \frac{2b+1}{2f} \right].$$

If voter j in group i is strategic, then she votes for A if $v_{ji} \leq V(g_i^A) - V(g_i^B)$, and for B otherwise. This implies that the fraction s_i^S of the strategic voters in group i who vote for A is $f[V(g_i^A) - V(g_i^B) - (2b-1)/(2f)]$, or

$$s_i^S = \frac{1}{2} - b + f[V(g_i^A) - V(g_i^B)].$$

With $\sum N_i s_i^S = s^S N$, the fraction of total strategic voters s^S who vote for A is

$$s^S = \frac{1}{2} - b + f \left[\frac{N_1}{N} [V(g_1^A) - V(g_1^B)] + \frac{N_2}{N} [V(g_2^A) - V(g_2^B)] \right].$$

As for impressionable voters, suppose that they vote for the candidate who spends more during the campaign. Candidate k 's campaign funds consist of bribe payment b^k from group 1 and government revenues that k would steal in office, which, as before, is equal to revenues less total spending, that is, $T - g_1^k - g_2^k$. Thus assuming some mapping from A 's campaign-fund advantage—the difference between the A and B campaign funds—to vote share, the vote share of A among impressionable voters is given by

$$\begin{aligned} s^I &= \frac{1}{2} - b + e(b^A - b^B + (T - g_1^A - g_2^A) - (T - g_1^B - g_2^B)) \\ &= \frac{1}{2} - b + e(b^A - b^B + g_1^B - g_1^A + g_2^B - g_2^A), \end{aligned}$$

where $e > 0$ is a parameter that captures how easily impressionable voters can be bought or influenced by campaign funds. That e is strictly greater than zero implies that some vote-buying always occurs.

Finally, assume that for each group i , there is a fraction μ of strategic voters, and a fraction $1 - \mu$ of impressionable voters. The total vote share of A is then

$$\begin{aligned} s &= \frac{1}{2} - b + \mu f \left[\frac{N_1}{N} [V(g_1^A) - V(g_1^B)] + \frac{N_2}{N} [V(g_2^A) - V(g_2^B)] \right] \\ &\quad + (1 - \mu)e(b^A - b^B + g_1^B - g_1^A + g_2^B - g_2^A), \end{aligned}$$

and that of B is $1 - s$. Maximizing s and $1 - s$, respectively, is equivalent to maximizing the following functions, which are therefore the respective utility functions of A and B :

$$U^A = \mu f \left[\frac{N_1}{N} V(g_1^A) + \frac{N_2}{N} V(g_2^A) \right] + (1 - \mu)e(b^A - g_1^A - g_2^A),$$

$$U^B = \mu f \left[\frac{N_1}{N} V(g_1^B) + \frac{N_2}{N} V(g_2^B) \right] + (1 - \mu)e(b^B - g_1^B - g_2^B).$$

Notice that U^k resembles the agent's (public official) utility in Section 2. Similar to λ , the parameters μ, f and e together determine the extent of corruption in elections. Larger values of μ and f , and a smaller value of e , mean that many voters cannot be bought, and therefore elections are relatively 'clean'.

The *ex ante* probability that A is elected is $F(\Delta)$, where

$$\Delta = U^A - U^B = \mu f \left[\frac{N_1}{N} [V(g_1^A) - V(g_1^B)] + \frac{N_2}{N} [V(g_2^A) - V(g_2^B)] \right] + (1 - \mu)e(b^A - b^B - (g_1^A + g_2^A) + (g_1^B + g_2^B)).$$

Thus the total value of public spending that the bribing principal (group 1) expects to be allocated to its members is $F(\Delta) N_1 V(g_1^A) + (1 - F(\Delta)) N_1 V(g_1^B)$ when the total bribes that it pays to candidates A and B is $\sum_k b_T^k$. As before, equilibrium public spending and bribes are jointly efficient for briber (group 1) and bribe-taker (candidate k). Thus they are obtained by solving, for each candidate k ,

$$\max_{g_i^k, b^k} F(\Delta) N_1 V(g_1^A) + (1 - F(\Delta)) N_1 V(g_1^B) - \sum_k b_T^k$$

subject to

$$(i) \quad \mu f \left[\frac{N_1}{N} V(g_1^k) + \frac{N_2}{N} V(g_2^k) \right] + (1 - \mu)e(b_T^k - g_1^k - g_2^k) \geq \overline{U}_T^k,$$

$$(ii) \quad g_1^k + g_2^k \leq T.$$

Constraint (i) is k 's participation constraint, with $\overline{U}_T^k$ her reservation utility, which, as before, is the utility that she gets if she rejects the bribe. That is,

$$\overline{U}_T^k = \mu f \left[\frac{N_1}{N} V(g_1^{k0}) + \frac{N_2}{N} V(g_2^{k0}) \right] - (1 - \mu)e(g_1^{k0} - g_2^{k0}),$$

where g_i^{k0} is what k would allocate to group i if she rejects the bribe. Constraint (ii) is the government budget constraint, which can be slack, in which case revenues can be stolen.

One can then compare the public spending allocations of the candidates, and the amount of bribes that they obtain from group 1.

First, it can be shown there is a threshold probability of winning for candidate A above which she would allocate less spending to the bribing principal than candidate B would. That is, we have the following.

Proposition 3. *Let*

$$w \equiv \left(\frac{\partial g_2^{A*}}{\partial g_1^{A*}} - 1 \right) \left(\frac{\partial g_2^{A*}}{\partial g_1^{A*}} - \frac{\partial g_2^{B*}}{\partial g_1^{B*}} \right).$$

Then

- (i) $F(\Delta) > w \iff g_1^{A^*} < g_1^{B^*}$
- (ii) $F(\Delta) < w \iff g_1^{A^*} > g_1^{B^*}$
- (iii) $F(\Delta) = w \iff g_1^{A^*} = g_1^{B^*}$.

Proposition 3 thus implies that the candidate that has a relatively higher probability of being elected is the one who spends relatively less on the bribing principal (group 1), and vice versa.⁷ The intuition is that the more popular candidate has less need for campaign funds to sway impressionable voters, and therefore has less need for bribes. She has less need to skew public spending allocation towards the bribing principal (group 1).

This, in turn, implies that the candidates do not necessarily receive the same amount of bribes. To see the difference in what they obtain from group 1, define as

$$x \equiv (T - g_1^{A^*} - g_2^{A^*}) - (T - g_1^{B^*} - g_2^{B^*})$$

the difference in revenues that would be stolen by A and by B , and define as

$$y \equiv \left[\frac{N_1}{N} V(g_1^{B^*}) + \frac{N_2}{N} V(g_2^{B^*}) \right] - \left[\frac{N_1}{N} V(g_1^{A^*}) + \frac{N_2}{N} V(g_2^{A^*}) \right]$$

the difference in the value of spending that the candidates would undertake.⁸ Then the following holds.

Proposition 4. *The difference in the amount of bribes paid to candidates A and B depends on their relative theft advantage. Specifically, let $\bar{\mu} \equiv \mu f / ((1 - \mu)e)$. Then*

- (i) $x < \bar{\mu}y \iff b_T^{A^*} > b_T^{B^*}$
- (ii) $x > \bar{\mu}y \iff b_T^{A^*} < b_T^{B^*}$
- (iii) $x = \bar{\mu}y \iff b_T^{A^*} = b_T^{B^*}$.

Thus by Proposition 4, the candidate that obtains larger bribes is either (i) one who is relatively worse both in stealing revenues and increasing social welfare (i.e. $x < 0$ and $y > 0$, or $x > 0$ and $y < 0$), or when one is relatively worse in one respect but better in the other (i.e. $x, y < 0$ or $x, y > 0$), or (ii) the candidate who is worse at stealing revenues provided that the relative disadvantage is sufficiently high (i.e. $x/y > \mu f / ((1 - \mu)e) \equiv \bar{\mu}$).⁹

It is therefore always the case that larger bribes are paid to the candidate with a sufficient theft disadvantage. That is, we have the following.

Corollary 1. *Let $x/y > \bar{\mu}$. Then candidate A (B) obtains larger bribes than B (A) if $x > 0$ ($x < 0$).*

The foregoing results can be shown graphically. Denote as $S^k \equiv g_1^k + g_2^k$ the total amount of revenues that k will spend in office. Figures 2 and 3 illustrate the public spending allocations of candidates A and B . By Proposition 3, the candidate with the higher probability of being elected allocates relatively less spending to group 1. Note, then, that the g_1^A curve lies below (above) the g_1^B curve at values of $F(\Delta)$ greater (less) than $\frac{1}{2}$, with the curves intersecting at $F(\Delta) = \frac{1}{2}$. Since theft is possible, the total amount of spent by k need not equal revenues T —the S^A and S^B curves can lie below T . Also, $g_1^A < g_1^B$ does not imply $g_2^A > g_2^B$ because the candidates may differ in the total amounts S^k that each would spend, and therefore in the amounts $T - S^k$ that each would steal.

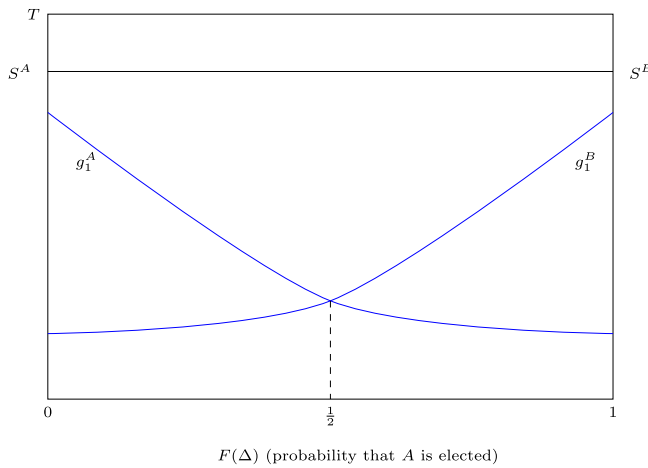
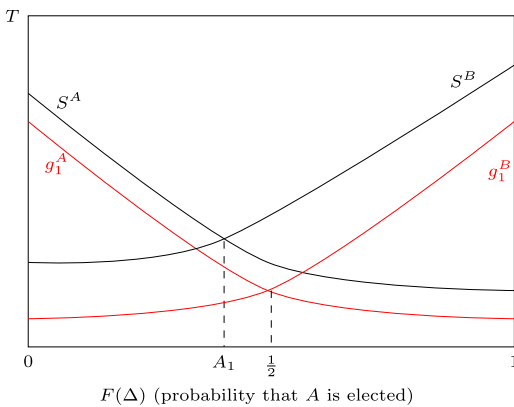
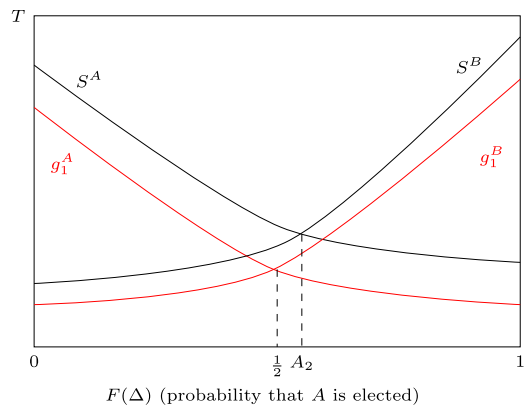


FIGURE 2 Public spending by candidates A and B , with A and B stealing the same amount of revenues. *Notes:* This figure plots the amount of public spending that each candidate A and B , if elected, would allocate to group 1 (respectively depicted by blue curves g_1^A and g_1^B) on the probability $F(\Delta)$ that A is elected, assuming that A and B would always spend the same total amount, i.e. the total spending curves $S^A \equiv g_1^A + g_2^A$ and $S^B \equiv g_1^B + g_2^B$ intersect at all values of $F(\Delta)$.



(a) Candidate A stealing at a higher rate than B



(b) Candidate B stealing at a higher rate than A

FIGURE 3 Public spending by candidates A and B , with A and B stealing at fixed rates. *Notes:* This figure plots the amount of public spending that each candidate A and B , if elected, would allocate to group 1 (respectively depicted by red curves g_1^A and g_1^B) on the probability $F(\Delta)$ that A is elected, assuming that each steals an amount that is a fixed proportion of their allocation to group 1. (a) A steals at a higher proportion than B , such that the candidates' respective total spending curves $S^A \equiv g_1^A + g_2^A$ and $S^B \equiv g_1^B + g_2^B$ intersect at $F(\Delta) = A_1 < \frac{1}{2}$. (b) B steals at a higher proportion than A ; the spending curves intersect at $F(\Delta) = A_2 > \frac{1}{2}$.

I depict two special cases. In Figure 2, the candidates always steal the same amount of revenues, in which case the spending curves S^A and S^B intersect at all values of $F(\Delta)$. Notice that a relatively higher allocation to group 1 implies a relatively lower allocation to group 2. Thus $F(\Delta) \leq \frac{1}{2} \iff g_1^A \geq g_1^B \iff g_2^A \leq g_2^B$. In Figure 3, the candidates each steal an amount that is a fixed proportion of their allocation to group 1, that is, $S^k \propto g_1^k$. In this case, S^A and S^B intersect at a unique point—Figure 3(a) shows them intersecting at the point at which $F(\Delta) = A_1$, with $A_1 \in [0, \frac{1}{2})$, while Figure 3(b) shows the intersection at $F(\Delta) = A_2$, with $A_2 \in (\frac{1}{2}, 1]$.¹⁰ Notice

that when the spending curves intersect at $F(\Delta) = A_1$, we have $g_1^A < g_2^B$ at all values of $F(\Delta)$. When they intersect at $F(\Delta) = A_2$, we have $g_2^A > g_2^B$ at all values of $F(\Delta)$. That is, the candidate that steals at a higher rate (i.e. for which the vertical distance between S^k and g_1^k is smaller) always allocates relatively less spending to group 2.

What about the equilibrium amount of bribes that group 1 would offer to candidates A and B ? When both candidates would steal the same amount of revenues, we have $S^A = S^B$, and at $F(\Delta) = \frac{1}{2}$, $g_1^A = g_1^B$ —recall Figure 2. By Proposition 4, group 1 offers the same amount of bribes to the candidates, that is, $b_T^A = b_T^B$.

The more interesting case is when the candidates would steal different amounts. Consider the case when each candidate steals a fixed proportion of her allocation to group 1. Then recall from Figure 3 that S^A is equal to S^B only at some unique value of $F(\Delta)$. It can be shown that provided that one candidate has sufficient theft advantage over the other (i.e. $x/y > \bar{\mu}$), the candidate that spends more, or steals less revenue, obtains larger bribes. That is, if A steals less (i.e. $S^A > S^B$), then $b_T^A > b_T^B$; if B steals less (i.e. $S^A < S^B$), then $b_T^A < b_T^B$.¹¹ This is generally true, whether A steals at a higher or lower proportion of her spending on group 1 than B does. That is, we have the following.

Corollary 2. *Let $S^A = S^B$ at $F(\Delta) = A_1$, where $A_1 \in \left[0, \frac{1}{2}\right)$. That is, candidate A steals at a higher proportion of her spending on group 1 than B does. Then:*

- (i) $0 \leq F(\Delta) < A_1 \iff g_1^A > g_1^B, S^A > S^B \iff b_T^A > b_T^B$
- (ii) $F(\Delta) = A_1 \iff g_1^A > g_1^B, S^A = S^B \iff b_T^A = b_T^B$
- (iii) $A_1 < F(\Delta) \leq \frac{1}{2} \iff g_1^A \geq g_1^B, S^A < S^B \iff b_T^A < b_T^B$
- (iv) $\frac{1}{2} < F(\Delta) \leq 1 \iff g_1^A < g_1^B, S^A < S^B \iff b_T^A \leq b_T^B$ if $x/y \geq \bar{\mu}$ (otherwise $b_T^A = b_T^B$).

Let $S^A = S^B$ at $F(\Delta) = A_2$, where $A_2 \in \left(\frac{1}{2}, 1\right]$. Then, by symmetry:

- (i) $0 \leq F(\Delta) < \frac{1}{2} \iff g_1^A > g_1^B, S^A > S^B \iff b_T^A \geq b_T^B$ if $x/y \geq \bar{\mu}$ (otherwise $b_T^A = b_T^B$)
- (ii) $\frac{1}{2} \leq F(\Delta) < A_2 \iff g_1^A \leq g_1^B, S^A > S^B \iff b_T^A > b_T^B$
- (iii) $F(\Delta) = A_2 \iff g_1^A < g_1^B, S^A = S^B \iff b_T^A = b_T^B$
- (iv) $A_2 < F(\Delta) \leq 1 \iff g_1^A < g_1^B, S^A < S^B \iff b_T^A < b_T^B$.

Figure 4 illustrates by plotting the relationship between the probability $F(\Delta)$ of A being elected and the bribes offered to A and B in cases in which S^A and S^B intersect (uniquely) at any value of $F(\Delta)$, that is, at A_1 or A_2 , where $A_1 \in \left[0, \frac{1}{2}\right)$ and $A_2 \in \left(\frac{1}{2}, 1\right]$, and when one candidate's theft advantage is sufficiently higher than the other candidate's (i.e. $x/y > \bar{\mu}$), and when it is not (i.e. $x/y < \bar{\mu}$).

Notice, then, that the candidate who is more likely to win does not always obtain larger bribes. In Figures 4(a) and 4(c), candidate A receives more bribes than B when $F(\Delta)$ is between 0 and A_1 , that is, when A has lower probability of being elected than B . Analogously, as seen in Figures 4(b) and 4(d), candidate B obtains larger bribes even if her probability of winning is less than $\frac{1}{2}$, that is, when $F(\Delta)$ is between A_2 and 1.

The results are a stark contrast to existing results (Grossman and Helpman 2001) in which the candidate that is more likely to be elected always obtains more bribes. This is not necessarily true when candidates can also use stolen revenues to sway impressionable voters. Larger bribes are given to the candidate who is either worse at both stealing revenues and improving social welfare (i.e. $x < 0, y > 0$ or $x > 0, y < 0$) or—if one candidate is relatively worse in one respect but better in the other—to the candidate who is relatively worse at stealing, provided that such theft

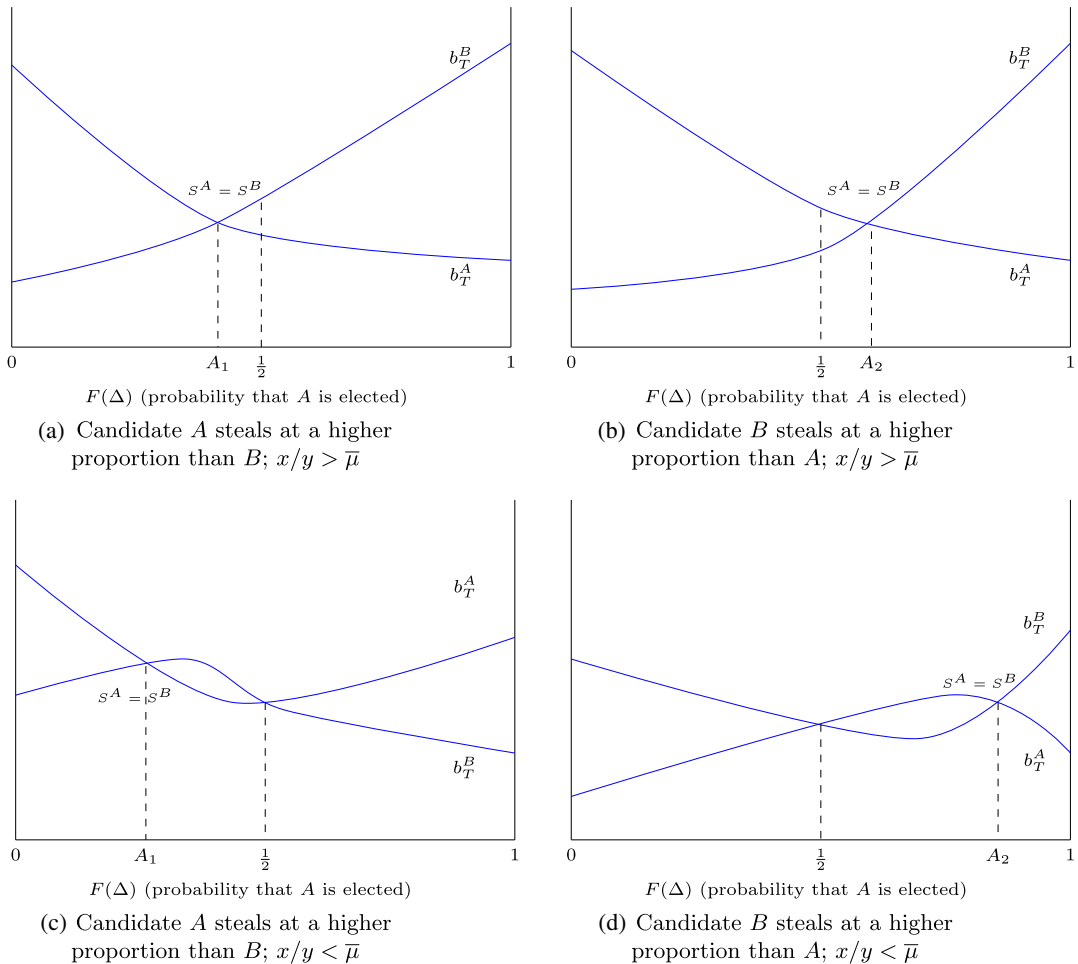


FIGURE 4 Bribe offers to candidates A and B . Notes: This figure plots the bribe offers of group 1 to each candidate A and B (respectively depicted by blue curves b_T^A and b_T^B) on the probability $F(\Delta)$ that A is elected, assuming that A and B each steal an amount of revenue that is a fixed proportion of their allocation to group 1.

disadvantage is sufficiently high (i.e. $x/y > \bar{\mu}$). This demonstrates that bribes and stolen revenues are substitute sources of illicit campaign funds.

4 | CONCLUSION

A corrupt public official who has discretionary power over government revenues can obtain illicit money in two ways—by siphoning off (stealing) some of the revenues, or allocating them towards sectors/groups in the private sector in exchange for bribes. These two types of corruption are substitutable to some extent, which allows the public official to switch between them depending on certain conditions.

For example, if the public official wants to obtain and consume illicit money while in office, then the optimal mix depends on the size of government revenues. When the latter are below some threshold, public spending still generates sufficiently large marginal returns, which induces the public official to keep spending the revenues and therefore not to steal them. She earns more and

more bribes in exchange for larger and larger spending. When revenues are above the threshold, the marginal returns to public spending have sufficiently diminished, which induces the public official to stop spending. She then earns a fixed amount of bribes from a fixed amount of spending, and steals the extra revenues.

Now if illicit money is instead spent in order to get candidate public officials elected, then one candidate will steal more than the other when elected if the former gets a smaller amount of bribes than the latter; conversely, she will receive relatively more bribes from the private sector if she will steal less than the other when elected into office. Thus the optimal mix between stolen revenues and bribe money depends on the 'theft' advantage of one candidate over the other.

There are important implications on the effectiveness of anti-corruption policies. Focusing on only one type of corruption (i.e. theft or bribery) may not necessarily work.¹² In the first example, enforcing only against theft when revenues are below the threshold is pointless when the public official would not want to steal revenues in the first place. Enforcing only against bribery when revenues are above the threshold would not decrease corruption, as the theft of revenues can occur on an even grander scale when revenues are very large. In the second example, enforcing solely against the theft of revenues simply increases the amount of bribes that candidates can extract during elections. Enforcing solely against the latter will only induce any candidate to steal more when elected.

Yet simultaneously enforcing against both theft and bribery requires some calibration. It may not be enough to enforce against them *equally*. When revenues are small, anti-corruption may be more effective if it is concentrated towards anti-bribery enforcement. When revenues are large, the returns from anti-theft enforcement may be larger than from anti-bribery. Also, corruption during electoral campaigns does not occur independently of corruption after elections. Small bribe-taking during elections may give rise to larger theft in public office. Thus elections that appear 'clean' may not be so—even if candidates do not extract bribes during elections, any one of them may still steal revenues once in office, in order to recover whatever campaign funds they have used.

Moreover, it may be harder to detect and prosecute cases of bribery than those of theft. As shown in Desierto (2023), a public official who obtains rents from bribes generates more public goods than one who obtains them through theft. Because citizens benefit more from the former, they may be less willing to report instances of bribe-taking. Even if such reports are made, the evidentiary requirements to *prove* bribery in court are also stricter, since a *quid pro quo* arrangement between the briber and the bribe-taker has to be established. Thus, for instance, receipt of money from a private firm or individual is not enough—it has to be shown that the money was given in consideration of a favour that the official purposely granted in exchange for the bribe. (See Desierto (2019). for the particular case of the Philippines.) This implies that enforcing against bribery may require larger investments, which, so as not to be wasteful, should also prevent public officials from switching to stealing government revenues.

While all these predictions are speculative, some empirical papers at least confirm the general proposition that corrupt public officials switch between different sources of rents. Desierto (2019). demonstrates that municipal mayors in the Philippines switch between bribe-taking and the theft of government revenues. Bologna-Pavlik and Desierto (2024). show that after enforcement of the US Foreign Corrupt Practices Act, public officials switch from taking bribes from legal markets to taking bribes from illegal markets. Burgess et al. (2012). reveal that officials in Indonesia switch from obtaining rents from oil and gas to obtaining rents from illegal logging. Olken (2007). provides evidence suggesting that when public officials suffer loss of rents from road projects in Indonesia due to audits, they make up for it by hiring their relatives to work on the projects, hence increasing nepotism.

The existence of ‘rent-switching’ in many settings necessitates more formal analyses of this phenomenon. This paper, I hope, invites subsequent endeavours.

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ENDNOTES

- Concerning the 1MDB and Petrobras scandals, see, for example, Bologna-Pavlik and Desierto (2024), and Desierto (2023).
- For applications to resource curse phenomena, see Brollo et al. (2013), Abdih et al. (2012), Ahmed (2012), Smith (2008), Robinson et al. (2006), and Desierto (2018a,b).
- For the precise expression for b , see equation (A2) in the Appendix.
- It follows that a similar result can be obtained for any other specification for the public official’s utility function, provided that it captures non-homothetic preferences over the sources of illicit incomes. Specifically, the result should hold whenever bribes are a kind of inferior good to the public official, while stolen revenues are a normal good. Initially, bribes and stolen revenues can both increase with revenues, but there will be some threshold at which bribes start to decrease while stolen revenues keep increasing.
- See Appendix Subsection A.4 for a proof.
- In Grossman and Helpman (2001), the strategic voter’s utility is $V_i(\mathbf{g}^k) + v_{ji}^k$, where $\mathbf{g}$ is the vector of policies, which in this case is $\mathbf{g} = (g_1, g_2)$. I simplify here by letting the first term be $V(g_1^k)$ —i.e. voter j cares only about the spending allocated to her own group, by assuming that V takes the same functional form across groups.
- To see this, note that $F(\Delta) \geq w \iff 1 - F(\Delta) \leq 1 - w$, while $F(\Delta) = w \iff 1 - F(\Delta) = 1 - w$. Now it must be that w is between 0 and 1. (Otherwise, if $w < 0$ or $w > 1$, then $1 - F(\Delta) > 1 - w$ and $F(\Delta) < w$ cannot both be true.) This implies that when $g_1^{A^*} = g_1^{B^*}$, for both $F(\Delta) = w$ and $1 - F(\Delta) = 1 - w$ to be true, it must be that $w = \frac{1}{2}$, which means that $F(\Delta) = \frac{1}{2} = 1 - F(\Delta)$. That is, candidates A and B have equal probability of being elected. Now, when $g_1^{A^*} > g_1^{B^*}$, for both $F(\Delta) < w$ and $1 - F(\Delta) > 1 - w$ to be true when $w \in (0, 1)$, it must be that $F(\Delta) < 1 - F(\Delta)$. Analogously, when $g_1^{A^*} < g_1^{B^*}$, for both $F(\Delta) > w$ and $1 - F(\Delta) < 1 - w$ to be true when $w \in (0, 1)$, it must be that $F(\Delta) > 1 - F(\Delta)$.
- I also make the natural assumption that in the absence of bribes, both candidates would allocate the same to group 1, i.e. $g_1^{A^0} = g_1^{B^0}$.
- To see this, note that if $x, y < 0$, then A is worse at stealing but better at improving social welfare. If $x/y > \bar{\mu}$, then $x < \bar{\mu}y$, and by Proposition 4, $b_T^A > b_T^B$ —i.e. A obtains higher bribes. If $x, y > 0$, then B is worse at stealing but better at improving social welfare. In this case, $x/y > \bar{\mu}$ implies $x > \bar{\mu}y$, which by Proposition 4 implies $b_T^A < b_T^B$ —i.e. B obtains higher bribes.
- There are many other equilibria, depending on how much revenue each candidate would steal at each value of $F(\Delta)$. The S^k curves may not intersect, or intersect at multiple points.
- Note that stealing at a higher proportion of spending on group 1 does not always mean stolen revenues are larger. Thus, even if A has a higher proportion of stealing, it could still be that $S^A > S^B$.
- I am unaware of policy or institutional design that intentionally takes into account the substitutability between theft and bribery. The US Foreign Corrupt Practices Act, for instance, enforces against firms and individuals that pay bribes to foreign officials. The OECD Anti-Bribery Convention likewise requires its signatory countries to make bribe payments to foreign officials illegal. On the other hand, government audits may be more indiscriminate, and can uncover many kinds of illicit activities. However, they can also pick up mismanagement of funds, which is not necessarily illicit. (See, for example, Avis et al. (2018), for the case of Brazil.)
- If k were to reject the bribe, then she would choose $g_1^{k^0}$ by solving

$$\max_{g_1^k, g_2^k} U_T^k = \mu f \left[\frac{N_1}{N} V(g_1^{k^0}) + \frac{N_2}{N} V(g_2^{k^0}) \right] - (1 - \mu)e(g_1^k + g_2^k)$$

subject to $g_1^{k^0} + g_2^{k^0} \leq T$ when the constraint is slack, which yields $V'(g_1^{k^0})/V'(g_2^{k^0}) = N_2/N_1$.

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APPENDIX A. PROOFS

A.1 Proof of Proposition 1(i)

Suppose that the budget constraint binds. Then $g_2 = T - g_1$ and the optimization problem becomes

$$\max_{g_1, b} V(g_1) - b$$

subject to

$$\lambda[V(g_1) + V(T - g_1)] + (1 - \lambda)b \geq \bar{U}.$$

In equilibrium, the above constraint binds with equality, allowing us to obtain the following expression for b :

$$b = \frac{1}{1 - \lambda} \left[\bar{U} - \lambda[V(g_1) + V(T - g_1)] \right], \quad (\text{A1})$$

which, when plugged into the maximand, transforms it into the unconstrained problem

$$\max_{g_1} V(g_1) - \frac{1}{1 - \lambda} \left[\bar{U} - \lambda[V(g_1) + V(T - g_1)] \right].$$

Equilibrium g_1^* thus satisfies the first-order condition

$$F = V'(g_1^*) + \frac{\lambda}{1 - \lambda} V'(g_1^*) - \frac{\lambda}{1 - \lambda} V'(T - g_1^*) = 0,$$

or

$$V'(g_1^*) = \lambda V'(T - g_1^*).$$

That is, the equilibrium allocation attaches more weight to the marginal benefit from spending of group 1, implying that $g_1^* > g_2^* = T - g_1^*$.

Meanwhile, the equation for b requires an expression for $\bar{U}$ —which is the utility that the public official would obtain if she rejected group 1's bribe offer. In this case, her utility would be given by $\lambda[V(g_1) + V(T - g_1)]$, which she could maximize by choosing the first-best, socially optimal level of spending, that is, g_1^0 . To see this, note that maximizing $\lambda[V(g_1) + V(T - g_1)]$ yields the first-order condition $V'(g_1^0) = V'(T - g_1^0)$, which implies an equal allocation of T between sectors, that is, $g_1^0 = (T - g_1^0) = T/2$. Thus if she rejects the bribe offer, then she gets $\bar{U} = \lambda[V(T/2) + V(T/2)] = 2\lambda V(T/2)$ which, when plugged into equation (A1), gives the equilibrium amount of bribes:

$$b^* = \frac{\lambda}{1 - \lambda} [2V(T/2) - V(g_1^*) - V(T - g_1^*)]. \quad (\text{A2})$$

Thus in equilibrium, the bribe compensates the public official for a fraction $\lambda/(1 - \lambda)$ of the loss in social welfare.

Lemmas 1 and 2 below together prove Proposition 1(i).

First, Lemma 1 establishes that revenues increase both g_1^* and $g_2^* = T - g_1^*$, and thus total public spending. However, the increase in g_1^* may be smaller or larger than the increase in g_2^* . In particular, if the ratio of the rates of decrease of the marginal utilities from g_1^* and from g_2^* is larger (smaller) than the weight λ that the public official attaches to social welfare, then an increase in revenues induces a smaller (larger) increase in g_1^* relative to g_2^* . That is, we have the following.

Lemma 1. *Let $x = V''(g_1^*)/V''(T - g_1^*)$. Then:*

- (i) *if $\lambda > x$, then $dg_1^*/dT > dg_2^*/dT > 0$*
- (ii) *if $\lambda < x$, then $dg_2^*/dT > dg_1^*/dT > 0$*
- (iii) *if $\lambda = x$, then $dg_2^*/dT = dg_1^*/dT > 0$.*

Proof. By the implicit function theorem,

$$\frac{dg_1^*}{dT} = -\frac{\partial F/\partial T}{\partial F/\partial g_1^*} = \frac{\lambda V''(T - g_1^*)}{V''(g_1^*) + \lambda V''(T - g_1^*)} > 0.$$

Since $g_1^* + g_2^* = T$, we have

$$\frac{dg_1^*}{dT} + \frac{dg_2^*}{dT} = 1,$$

which implies that

$$\frac{dg_2^*}{dT} = \frac{V''(g_1^*)}{V''(g_1^*) + \lambda V''(T - g_1^*)} > 0.$$

Thus (i), (ii) and (iii) are obtained by comparing

$$\frac{\lambda V''(T - g_1^*)}{V''(g_1^*) + \lambda V''(T - g_1^*)} \quad \text{and} \quad \frac{\lambda V''(g_1^*)}{V''(g_1^*) + \lambda V''(T - g_1^*)},$$

or, simplifying,

$$\lambda \quad \text{and} \quad \frac{V''(g_1^*)}{V'(T - g_1^*)}. \quad \blacksquare$$

Next, differentiating g_i^* with respect to T reveals that government revenues have an ambiguous effect on bribes. Specifically, we have the following.

Lemma 2. *Government revenues may increase or decrease corruption. Specifically, let*

$$y = \frac{V'(T/2) - V'(T - g_1^*)}{V'(g_1^*) - V'(T - g_1^*)}.$$

Then:

- (i) *if $dg_1^*/dT < y$, then $\partial b^*/\partial T > 0$*
- (ii) *if $dg_1^*/dT > y$, then $\partial b^*/\partial T < 0$*
- (iii) *if $dg_1^*/dT = y$, then $\partial b^*/\partial T = 0$.*

Proof. Differentiating equation (A2) with respect to T gives

$$\frac{\partial b^*}{\partial T} = \frac{\lambda}{1 - \lambda} \left[V'(T/2) - V'(g_1^*) \frac{dg_1^*}{dT} - V'(T - g_1^*) \left(1 - \frac{dg_1^*}{dT} \right) \right],$$

which is greater than zero if

$$V'(T/2) > V'(g_1^*) \frac{dg_1^*}{dT} + V'(T - g_1^*) \left(1 - \frac{dg_1^*}{dT}\right),$$

or, rearranging,

$$\frac{dg_1^*}{dT} < \frac{V'(T/2) - V'(T - g_1^*)}{V'(g_1^*) - V'(T - g_1^*)}.$$

Items (ii) and (iii) follow directly. ■

That is, if revenues increase, then group 1 will want to increase (decrease) the amount of the bribe if the public official will allocate the additional revenues towards group 1 at a rate that is below (above) some threshold γ . In turn, this threshold captures the marginal value of the spending on group 1, relative to the spending on group 2 (see the denominator of γ). Note that when the former is much larger than the latter, the threshold is smaller, which makes a decrease in corruption (case (ii)) more likely. Thus in an equilibrium in which the budget constraint binds, revenues decrease corruption if the marginal value of the public spending from which bribes are extracted is sufficiently high.

A.2 Proof of Proposition 1(ii)

When the budget constraint does not bind, and with the participation constraint binding in equality, the optimization problem can be written as

$$\max_{g_1, g_2} V(g_1) - \frac{1}{1 - \lambda} \left[\bar{U} - \lambda[V(g_1) + V(g_2)] \right] + T - g_1 - g_2$$

subject to

$$g_1 + g_2 - T \leq 0.$$

The necessary conditions for optimal g_1^*, g_2^*, γ^* are given by the following Kuhn–Tucker conditions:

$$V'(g_1^*) + \frac{\lambda}{1 - \lambda} V'(g_1^*) - 1 - \gamma^* = 0, \quad (\text{A3})$$

$$\frac{\lambda}{1 - \lambda} V'(g_2^*) - 1 - \gamma^* = 0, \quad (\text{A4})$$

$$\gamma^*(g_1^* + g_2^* - T) = 0, \quad (\text{A5})$$

where γ^* is the Lagrange multiplier. To solve for the equilibrium when the budget constraint is slack, one can set $\gamma^* = 0$.

Then, using the participation constraint, one can obtain the following expression for equilibrium bribes:

$$b^* = \frac{1}{1 - \lambda} \left[\bar{U} - \lambda[V(g_1^*) + V(g_2^*)] \right] + T - g_1^* - g_2^*.$$

To get the public official's reservation utility $\bar{U}$, note that if the agent rejects the bribe offer, then she will obtain utility from social welfare and stolen revenues, which she can maximize by choosing g_1^0, g_2^0 via the following optimization problem:

$$\max_{g_1, g_2} \lambda[V(g_1) + V(g_2)] + (1 - \lambda)(T - g_1 - g_2)$$

subject to

$$g_1 + g_2 - T \leq 0.$$

Necessary for g_1^0, g_2^0, γ^0 are the following Kuhn–Tucker conditions:

$$\lambda V'(g_1^0) - (1 - \lambda) - \gamma^0 = 0, \quad (\text{A6})$$

$$\lambda V'(g_2^0) - (1 - \lambda) - \gamma^0 = 0, \quad (\text{A7})$$

$$\gamma^0(g_1^0 + g_2^0 - T) = 0. \quad (\text{A8})$$

Thus if the public official rejects the bribe offer, then she obtains utility

$$\bar{U} = \lambda[V(g_1^0) + V(g_2^0)] + (1 - \lambda)(T - g_1^0 - g_2^0),$$

which, when plugged into the expression for b^* , gives the equilibrium amount of bribes:

$$b^* = \frac{\lambda}{1 - \lambda} [V(g_1^0) + V(g_2^0) - V(g_1^*) - V(g_2^*)] - (g_1^0 + g_2^0 - g_1^* - g_2^*). \quad (\text{A9})$$

Lemmas 3–5 below together prove Proposition 1(ii).

Lemma 3. *Government revenues have no effect on g_1^* or g_2^* , that is, $dg_1^*/dT = 0$ and $dg_2^*/dT = 0$.*

Proof. Applying Cramer's rule gives

$$\frac{dg_1^*}{dT} = -\frac{1}{\det A} \det \begin{pmatrix} V'(g_1^*) \frac{dg_1^*}{dT} \frac{1}{1-\lambda} - \frac{d\gamma^*}{dT} & 0 & -1 \\ V'(g_2^*) \frac{dg_2^*}{dT} \frac{1}{1-\lambda} - \frac{d\gamma^*}{dT} & \frac{\lambda}{1-\lambda} V''(g_2^*) & -1 \\ (g_1^* + g_2^* - T) \frac{d\gamma^*}{dT} - \gamma^* & \gamma^* & g_1^* + g_2^* - T \end{pmatrix}.$$

Now if theft occurs in equilibrium, $g_1^* + g_2^* < T$, which by equation (A5) implies $\gamma^* = 0$ and hence $d\gamma^*/dT = 0$. Imposing $\gamma^* = 0$ and $d\gamma^*/dT = 0$ gives

$$\frac{dg_1^*}{dT} = -\frac{1}{\det A} \left[(g_1^* + g_2^* - T) V'(g_1^*) \frac{dg_1^*}{dT} \frac{1}{1-\lambda} V''(g_2^*) \right],$$

or, simplifying, $dg_1^*/dT = 0$. Analogously,

$$\frac{dg_2^*}{dT} = -\frac{1}{\det A} \det \begin{pmatrix} V''(g_1^*) \frac{1}{1-\lambda} & V'(g_1^*) \frac{dg_1^*}{dT} \frac{1}{1-\lambda} - \frac{d\gamma^*}{dT} & -1 \\ 0 & V'(g_2^*) \frac{dg_2^*}{dT} \frac{1}{1-\lambda} - \frac{d\gamma^*}{dT} & -1 \\ \gamma^* & (g_1^* + g_2^* - T) \frac{d\gamma^*}{dT} - \gamma^* & g_1^* + g_2^* - T \end{pmatrix}.$$

Imposing $\gamma^* = 0$ and $d\gamma^*/dT = 0$ gives

$$\frac{dg_2^*}{dT} = -\frac{1}{\det A} \left[(g_1^* + g_2^* - T) V'(g_2^*) \frac{dg_2^*}{dT} \frac{1}{1-\lambda} V''(g_1^*) \right],$$

or, simplifying, $dg_2^*/dT = 0$. ■

Lemma 4. Government revenues have no effect on g_1^0 or g_2^0 , that is, $dg_1^0/dT = 0$ and $dg_2^0/dT = 0$.

Proof. I first show that $g_1^0, g_2^0 > 0$ by applying the implicit function theorem to the system of equations (A6), (A7) and (A8). That is, it is necessary that

$$\det B = \begin{vmatrix} \lambda V''(g_1^0) & 0 & -1 \\ 0 & \lambda V''(g_2^0) & -1 \\ \gamma^0 & \gamma^0 & g_1^0 + g_2^0 - T \end{vmatrix}$$

is non-zero. Imposing γ^0 and $d\gamma^0/dT = 0$, and evaluating, gives

$$\det B = (g_1^0 + g_2^0 - T) \lambda V''(g_1^0) \lambda V''(g_2^0),$$

which is less than zero, unless $g_1^0 = 0$ or $g_2^0 = 0$. That is, assuming that sufficiency conditions are met such that g_1^0, g_2^0, γ^0 exist, some spending still occurs, that is, $g_1^0, g_2^0 > 0$ even when there is theft (i.e. $\gamma^0 = 0$).

The proof of this lemma is then similar to the proof of Lemma 3. Applying Cramer's rule gives

$$\frac{dg_1^0}{dT} = -\frac{1}{\det B} \det \begin{vmatrix} \lambda V''(g_1^0) \frac{dg_1^0}{dT} & 0 & -1 \\ \lambda V''(g_2^0) \frac{dg_2^0}{dT} & \lambda V''(g_2^0) & -1 \\ 0 & 0 & g_1^0 + g_2^0 - T \end{vmatrix}.$$

Now if theft occurs in equilibrium, then $g_1^0 + g_2^0 < T$, which by equation (A8) implies $\gamma^0 = 0$, hence $d\gamma^0/dT = 0$. Imposing $\gamma^0 = 0$ and $d\gamma^0/dT = 0$ gives

$$\frac{dg_1^0}{dT} = -\frac{1}{\det B} \left[(g_1^0 + g_2^0 - T) \lambda V''(g_1^0) \frac{dg_1^0}{dT} \lambda V''(g_2^0) \right],$$

or, simplifying, $dg_1^0/dT = 0$. Analogously,

$$\frac{dg_2^0}{dT} = -\frac{1}{\det B} \det \begin{vmatrix} \lambda V''(g_1^0) & \lambda V''(g_1^0) \frac{dg_1^0}{dT} & -1 \\ 0 & \lambda V''(g_2^0) \frac{dg_2^0}{dT} & -1 \\ 0 & 0 & g_1^0 + g_2^0 - T \end{vmatrix}.$$

Imposing $\gamma^0 = 0$ and $d\gamma^0/dT = 0$ gives

$$\frac{dg_2^0}{dT} = -\frac{1}{\det B} \left[(g_1^0 + g_2^0 - T) \lambda V''(g_1^0) \lambda V''(g_2^0) \frac{dg_2^0}{dT} \right],$$

or, simplifying, $dg_2^0/dT = 0$. ■

Lemma 5. Government revenues have no effect on the equilibrium bribe, that is, $\partial b^*/\partial T = 0$.

Proof. Differentiating b^* (equation (A9)) with respect to T gives

$$\frac{\partial b^*}{\partial T} = \frac{\lambda}{1-\lambda} \left[V'(g_1^0) \frac{dg_1^0}{dT} + V'(g_2^0) \frac{dg_2^0}{dT} - V'(g_1^*) \frac{dg_1^*}{dT} - V'(g_2^*) \frac{dg_2^*}{dT} \right] - \frac{dg_1^0}{dT} - \frac{dg_2^0}{dT} + \frac{dg_1^*}{dT} + \frac{dg_2^*}{dT}.$$

By Lemma 4, $dg_1^0/dT = 0$ and $dg_2^0/dT = 0$, and by Lemma 3, dg_1^*/dT and $dg_2^*/dT = 0$. Thus $\partial b^*/\partial T = 0$. ■

A.3 Proof of Proposition 2

Lemma 6 below, together with Lemmas 1, 2, 3 and 5, prove Proposition 2.

Lemma 6 establishes that even if it is optimal for the public official to steal revenues, she does not steal all the revenues. That is, there is still some minimum amount of revenues that she spends on both groups 1 and 2. This implies that at and below this minimum amount, the budget constraint actually binds, in which case Lemmas 1 and 2 hold, while above the threshold, the constraint is slack, in which case Lemmas 3 and 5 hold.

Lemma 6. *There is a minimum amount of revenues $\bar{T}$ that the public official does not steal, but spends on groups 1 and 2. That is, $\bar{T} = g_1^* + g_2^* > 0$, where $g_1^*, g_2^* > 0$.*

Proof. I apply the implicit function theorem to the system of equations (A3), (A4) and (A5). Necessary for g_1^*, g_2^*, γ^* to exist is that the inverse of

$$A = \begin{pmatrix} V''(g_1^*) & \frac{\lambda}{1-\lambda} V''(g_2^*) & -1 \\ 0 & \frac{\lambda}{1-\lambda} V''(g_2^*) & -1 \\ \gamma^* & \gamma^* & g_1^* + g_2^* - T \end{pmatrix} \quad (\text{A10})$$

exists, or equivalently, that the determinant of A is non-zero. Note that

$$\det A = V''(g_1^*) \left[\frac{\lambda}{1-\lambda} V''(g_2^*) (g_1^* + g_2^* - T) + \gamma^* \right].$$

If theft occurs in equilibrium, then $g_1^* + g_2^* - T < 0$, which implies that $\gamma^* = 0$. Imposing $\gamma^* = 0$,

$$\det A = V''(g_1^*) \left[\frac{\lambda}{1-\lambda} V''(g_2^*) (g_1^* + g_2^* - T) \right],$$

which is less than zero, unless $g_1^* = 0$ or $g_2^* = 0$, in which case $\det A = 0$. Thus if sufficiency conditions are met such that g_1^*, g_2^*, γ^* exist, then it must be that when theft occurs such that $\gamma^* = 0$, some revenues are allocated to both groups, that is, $g_1^*, g_2^* > 0$. ■

A.4 Proof that λ has no effect on $\bar{T}$

By Lemma 6, one can write $\bar{T} = g_1^* + g_2^*$, so to prove that $d\bar{T}/d\lambda = 0$, one can show that $dg_1^*/d\lambda = dg_2^*/d\lambda = 0$.

Applying Cramer's rule on the Kuhn–Tucker conditions (equations (A3), (A4) and (A5)) gives

$$\frac{dg_1^*}{d\lambda} = -\frac{1}{\det A} \det \begin{pmatrix} V'(g_1^*) \frac{dg_1^*}{d\lambda} (1-\lambda)^2 & 0 & -1 \\ V'(g_2^*) \frac{dg_2^*}{d\lambda} (1-\lambda)^2 & \frac{\lambda}{1-\lambda} V'''(g_2^*) & -1 \\ (g_1^* + g_2^* - T) \frac{d\gamma^*}{d\lambda} + \gamma^* \left(\frac{dg_1^*}{d\lambda} + \frac{dg_2^*}{d\lambda} \right) & \gamma^* & g_1^* + g_2^* - T \end{pmatrix},$$

where A is given by equation (A10). When the budget constraint is slack, $\gamma^* = d\gamma^*/d\lambda = 0$. This means that

$$\frac{dg_1^*}{d\lambda} = -\frac{1}{\det A} \left[-\frac{\lambda}{1-\lambda} V'''(g_2^*) V'(g_1^*) \frac{dg_1^*}{d\lambda} (1-\lambda)^2 (g_1^* + g_2^* - T) \right],$$

which reduces to $dg_1^*/d\lambda = 0$.

An analogous procedure obtains $dg_2^*/d\lambda = 0$.

A.5 Proof of Proposition 3

One gets the following expression for bribes by letting the participation constraint bind with equality:

$$b_T^k = \frac{1}{(1-\mu)e} \left(\overline{U}_T^k - \mu f \left[\frac{N_1}{N} V(g_1^k) + \frac{N_2}{N} V(g_2^k) \right] \right) + g_1^k + g_2^k, \quad (\text{A11})$$

where the reservation utilities are given by

$$\overline{U}_T^k = \mu f \left[\frac{N_1}{N} V(g_1^{k0}) + \frac{N_2}{N} V(g_2^{k0}) \right] - (1-\mu)e(g_1^{k0} + g_2^{k0}),$$

that is, when bribes are rejected. Plugging this expression into the maximand, the problem then becomes

$$\begin{aligned} \max_{g_1^k, g_2^k} & F(\Delta) N_1 V(g_1^A) + (1-F(\Delta)) N_1 V(g_1^B) \\ & - \frac{1}{(1-\mu)e} \left((\overline{U}_T^A + \overline{U}_T^B) - \mu f \left[\frac{N_1}{N} (V(g_1^A) + V(g_1^B)) + \frac{N_2}{N} (V(g_2^A) + V(g_2^B)) \right] \right) \\ & - (g_1^A + g_2^A) - (g_1^B + g_2^B) \end{aligned}$$

subject to

$$g_1^A + g_2^A - T \leq 0, \quad g_1^B + g_2^B - T \leq 0.$$

The necessary (Kuhn–Tucker) conditions are

$$N_1 F(\Delta) V'(g_1^{A*}) + 1 - \lambda^{A*} - \frac{\partial \Delta}{\partial g_1^{A*}} \left[N_1 \frac{\partial F}{\partial \Delta} [V(g_1^{B*}) - V(g_1^{A*})] - \frac{1}{(1-\mu)e} \right] = 0, \quad (\text{A12})$$

$$1 - \lambda^{A*} - \frac{\partial \Delta}{\partial g_2^{A*}} \left[N_1 \frac{\partial F}{\partial \Delta} [V(g_1^{B*}) - V(g_1^{A*})] - \frac{1}{(1-\mu)e} \right] = 0, \quad (\text{A13})$$

$$N_1 (1-F(\Delta)) V'(g_1^{B*}) - 1 - \lambda^{B*} - \frac{\partial \Delta}{\partial g_1^{B*}} \left[N_1 \frac{\partial F}{\partial \Delta} [V(g_1^{B*}) - V(g_1^{A*})] + \frac{1}{(1-\mu)e} \right] = 0, \quad (\text{A14})$$

$$-1 - \lambda^{B*} - \frac{\partial \Delta}{\partial g_2^{B*}} \left[N_1 \frac{\partial F}{\partial \Delta} [V(g_1^{B*}) - V(g_1^{A*})] + \frac{1}{(1-\mu)e} \right] = 0, \quad (\text{A15})$$

$$\lambda^{A*} (g_1^{A*} + g_2^{A*} - T) = 0, \quad (\text{A16})$$

$$\lambda^{B*} (g_1^{B*} + g_2^{B*} - T) = 0, \quad (\text{A17})$$

where λ^{k*} are the Lagrange multipliers.

To obtain the equilibrium when the constraints are slack, thus theft occurs, one imposes $\lambda^{A*} = \lambda^{B*} = 0$. Condition (A16) then implies $g_1^{A*} + g_2^{A*} < T$, while conditions (A12) and (A13) imply

$$(i) \quad N_1 = \left(\frac{\partial g_2^{A*}}{\partial g_1^{A*}} - 1 \right) \frac{1}{V'(g_1^{A*}) F(\Delta)},$$

where

$$\frac{\partial g_2^{A*}}{\partial g_1^{A*}} = \frac{\partial \Delta}{\partial g_1^{A*}} \frac{\partial g_2^{A*}}{\partial \Delta} = \frac{\mu f(N_1/N) V'(g_1^{A*}) - (1 - \mu)e}{\mu f(N_2/N) V'(g_2^{A*}) - (1 - \mu)e}.$$

Meanwhile, condition (A17) implies $g_1^{B*} + g_2^{B*} < T$, while conditions (A14) and (A15) imply

$$(ii) \quad N_1 = \left(1 - \frac{\partial g_2^{B*}}{\partial g_1^{B*}} \right) \frac{1}{V'(g_1^{B*}) (1 - F(\Delta))},$$

where

$$\frac{\partial g_2^{B*}}{\partial g_1^{B*}} = \frac{\partial \Delta}{\partial g_1^{B*}} \frac{\partial g_2^{B*}}{\partial \Delta} = \frac{-\mu f(N_1/N) V'(g_1^{B*}) + (1 - \mu)e}{-\mu f(N_2/N) V'(g_2^{B*}) + (1 - \mu)e}.$$

Equating (i) and (ii) and rearranging, the equilibrium when theft occurs thus satisfies

$$\frac{V'(g_1^{A*})}{V'(g_1^{B*})} = \frac{(1 - F(\Delta))(\partial g_2^{A*}/\partial g_1^{A*} - 1)}{F(\Delta) (1 - (\partial g_2^{B*}/\partial g_1^{B*}))}.$$

Note that $g_1^{A*} \geq g_1^{B*} \iff V'(g_1^{A*}) \geq V'(g_1^{B*})$, and $g_1^{A*} = g_1^{B*} \iff V'(g_1^{A*}) = V'(g_1^{B*})$. By equation (A17),

$$V'(g_1^{A*}) \geq V'(g_1^{B*}) \iff (1 - F(\Delta)) \left(\frac{\partial g_2^{A*}}{\partial g_1^{A*}} - 1 \right) \geq F(\Delta) \left(1 - \frac{\partial g_2^{B*}}{\partial g_1^{B*}} \right),$$

or, rearranging,

$$F(\Delta) \leq \left(\frac{\partial g_2^{A*}}{\partial g_1^{A*}} - 1 \right) \left(\frac{\partial g_2^{A*}}{\partial g_1^{A*}} - \frac{\partial g_2^{B*}}{\partial g_1^{B*}} \right) \equiv w,$$

while $V'(g_1^{A*}) = V'(g_1^{B*}) \iff F(\Delta) = w$. □

A.6 Proof of Proposition 4

To compare the equilibrium bribe offers to candidates A and B , plug $\overline{U}_T^k$ into equation (A11) to get

$$b_T^{k*} = \frac{1}{(1 - \mu)e} \left(\mu f \left[\frac{N_1}{N} \left(V(g_1^{k^0}) - V(g_1^{k*}) \right) + \frac{N_2}{N} \left(V(g_2^{k^0}) - V(g_2^{k*}) \right) \right] \right) + g_1^{k*} + g_2^{k*} - (g_1^{k^0} + g_2^{k^0}).$$

One can then take the difference:

$$\begin{aligned} b_T^{A^*} - b_T^{B^*} &= \frac{1}{(1-\mu)e} \left(\mu f \left[\frac{N_1}{N} \left(V(g_1^{A^0}) - V(g_1^{A^*}) + V(g_1^{B^*}) - V(g_1^{B^0}) \right) \right. \right. \\ &\quad \left. \left. + \frac{N_2}{N} \left(V(g_2^{A^0}) - V(g_2^{A^*}) + V(g_2^{B^*}) - V(g_2^{B^0}) \right) \right] \right) \\ &\quad + (g_1^{A^*} + g_2^{A^*}) - (g_1^{A^0} + g_2^{A^0}) + (g_1^{B^0} + g_2^{B^0}) - (g_1^{B^*} + g_2^{B^*}). \end{aligned} \quad (\text{A18})$$

It is not always the case that $g_1^{A^0} = g_1^{B^0}$ and $g_2^{A^0} = g_2^{B^0}$, since $g_i^{k^0}$ only requires $V'(g_1^{k^0})/V'(g_2^{k^0}) = N_2/N_1$ for each $k = \{A, B\}$.¹³ However, the latter implies that if $g_1^{A^0} = g_1^{B^0}$, then $g_2^{A^0} = g_2^{B^0}$, and vice versa. Thus we assume that there would be no difference in the candidates' behaviour towards group 1 only if they were to reject the latter's offer, that is, $g_1^{A^0} = g_1^{B^0}$.

Now, for $V'(g_1^{k^0})/V'(g_2^{k^0}) = N_2/N_1$ to hold for each candidate A and B , it must be that $g_1^{A^0} = g_1^{B^0} \iff g_2^{A^0} = g_2^{B^0}$. In this case, the right-hand side of equation (A18) reduces to

$$\begin{aligned} &\frac{1}{(1-\mu)e} \left(\mu f \left[\frac{N_1}{N} (V(g_1^{B^*}) - V(g_1^{A^*})) + \frac{N_2}{N} (V(g_2^{B^*}) - V(g_2^{A^*})) \right] \right) \\ &\quad + g_1^{A^*} + g_2^{A^*} - (g_1^{B^*} + g_2^{B^*}). \end{aligned}$$

Thus $b_T^{A^*} \geq b_T^{B^*}$ if

$$\begin{aligned} &\frac{1}{(1-\mu)e} \left(\mu f \left[\frac{N_1}{N} (V(g_1^{B^*}) - V(g_1^{A^*})) + \frac{N_2}{N} (V(g_2^{B^*}) - V(g_2^{A^*})) \right] \right) \\ &\quad + g_1^{A^*} + g_2^{A^*} - (g_1^{B^*} + g_2^{B^*}) \geq 0, \end{aligned}$$

or, rearranging,

$$\begin{aligned} [(g_1^{B^*} + g_2^{B^*}) - (g_1^{A^*} + g_2^{A^*})] &\leq \frac{\mu f}{(1-\mu)e} \left[\frac{N_1}{N} V(g_1^{B^*}) + \frac{N_2}{N} V(g_2^{B^*}) \right] \\ &\quad - \left[\frac{N_1}{N} V(g_1^{A^*}) + \frac{N_2}{N} V(g_2^{A^*}) \right], \end{aligned}$$

or

$$x \leq \frac{\mu f}{(1-\mu)e} y.$$

A.7 Proof of Corollary 1

The proof is immediate, and can be seen in the text.

A.8 Proof of Corollary 2

Recall from Figure 3 that when S^A and S^B intersect at a value of $F(\Delta)$ less (greater) than $\frac{1}{2}$, then it is always the case that $g_2^A < g_2^B$ ($g_2^A > g_2^B$). Now in Figure 3(a), note that at $F(\Delta) \in [0, A_1)$, $S^A > S^B$, which means that $x < 0$. It is also the case that $g_1^A > g_1^B$. For $x < 0$ to hold, it must be that $g_1^B - g_1^A < g_2^A - g_2^B$, which, with $g_2^A < g_2^B$, implies that $y > 0$. Since $x < 0$ and $y > 0$, we have $b_T^A > b_T^B$ by Proposition 4. At $F(\Delta) = A_1$, $S^A = S^B$, which means that $x = 0$. It is still the case that $g_1^A > g_1^B$. For $x = 0$ to hold, it must be that $g_1^B - g_1^A = g_2^A - g_2^B$, which, with $g_2^A < g_2^B$, implies that $y = 0$. Thus $b_T^A = b_T^B$. At $F(\Delta) \in (A_1, \frac{1}{2})$, $S^A < S^B$, which means that $x > 0$. It is still the case

that $g_1^A > g_1^B$. For $x > 0$ to hold, it must be that $g_1^B - g_1^A > g_2^A - g_2^B$, which, with $g_2^A < g_2^B$, implies that $y < 0$. Thus $b_T^A < b_T^B$. Finally, at $F(\Delta) \in \left(\frac{1}{2}, 1\right]$, $S^A < S^B$, hence $x > 0$, which in turn requires $g_1^B - g_1^A > g_2^A - g_2^B$. However, it is now the case that $g_1^A < g_1^B$. Thus for $g_1^B - g_1^A > g_2^A - g_2^B$ to hold when $g_2^A < g_2^B$, it must be that $y > 0$. With $x, y > 0$, $b_T^A \leq b_T^B$ if $x/y \geq (\mu f)/((1 - \mu)e) \equiv \bar{\mu}$, while $b_T^A = b_T^B$ if $x/y = \bar{\mu}$.

By symmetry, the case when S^A and S^B intersect at A_2 (see Figure 3(b)) can be viewed from B 's perspective as the case when S^A and S^B intersect at A_1 .

The above discussion can then be summarized by the following, which is precisely Corollary 2.

Let $S^A = S^B$ at $F(\Delta) = A_1$, where $A_1 \in \left[0, \frac{1}{2}\right)$. That is, candidate A steals more than B . Then

$$\begin{aligned} 0 \leq F(\Delta) < A_1 &\iff g_1^A > g_1^B, \quad S^A > S^B \iff b_T^A > b_T^B, \\ F(\Delta) = A_1 &\iff g_1^A > g_1^B, \quad S^A = S^B \iff b_T^A = b_T^B, \\ A_1 < F(\Delta) \leq \frac{1}{2} &\iff g_1^A \geq g_1^B, \quad S^A < S^B \iff b_T^A < b_T^B, \\ \frac{1}{2} < F(\Delta) \leq 1 &\iff g_1^A < g_1^B, \quad S^A < S^B \iff b_T^A \leq b_T^B \text{ if } x/y \geq \bar{\mu} \text{ (otherwise } b_T^A = b_T^B). \end{aligned}$$

Let $S^A = S^B$ at $F(\Delta) = A_2$, where $A_2 \in \left(\frac{1}{2}, 1\right]$. Then, by symmetry,

$$\begin{aligned} 0 \leq F(\Delta) < \frac{1}{2} &\iff g_1^A > g_1^B, \quad S^A > S^B \iff b_T^A \geq b_T^B \text{ if } x/y \geq \bar{\mu} \text{ (otherwise } b_T^A = b_T^B), \\ \frac{1}{2} \leq F(\Delta) < A_2 &\iff g_1^A \leq g_1^B, \quad S^A > S^B \iff b_T^A > b_T^B, \\ F(\Delta) = A_2 &\iff g_1^A < g_1^B, \quad S^A = S^B \iff b_T^A = b_T^B, \\ A_2 < F(\Delta) \leq 1 &\iff g_1^A < g_1^B, \quad S^A < S^B \iff b_T^A < b_T^B. \end{aligned}$$