

1 Introduction

Petty corruption is widespread in the developing world and affects primarily the lowest levels of government, dealing directly with ordinary citizens and firms (e.g., tax collectors, environmental, and labor inspectors).¹ One of its most detrimental consequences is to undermine the enforcement of regulations designed to protect society from risks and hazards (e.g., pollution, accidents, etc.).

A major difficulty in the struggle against corruption is to provide low-ranking officials with the incentives to adequately perform their duty. Two issues, particularly salient in developing countries, give rise to this challenge. First, public officials are often given large discretionary power: little transparency surrounds the decisions they make. Second, officials are rarely held accountable for abusing their power (e.g., because the judicial system is weak, or because supervisors are corrupt). As previous literature has emphasized, given such difficulties, even perfectly benevolent governments may have no choice but to tolerate corruption (see, e.g., Tirole (1992), Hindriks et al. (1999), and Khalil et al. (2010)).

To overcome these limitations, several governments have recently introduced *citizen feedback schemes* that gather assessments from ordinary citizens at the receiving end of public services. Examples include Ghana's Whistleblower Act and Punjab's Citizen Feedback Model.² Despite the potential of these initiatives, the literature on corruption has largely neglected the question of how to optimally incorporate feedback in public officials' incentive schemes. We investigate this issue by developing a model of regulatory control in which officials benefit both from high discretionary power and low levels of accountability. We characterize a mechanism that, by tying officials' pay to citizen feedback, deters corruption. Its main virtue, we argue,

¹See Olken and Pande (2012) and Banerjee et al. (2012) for recent surveys.

²See Callen and Hasanain (2011) for a detailed description of the Punjab Model. Another example is the anti-corruption website recently created in Kenya (www.president.go.ke/en/category/corruption.php), where people can directly report cases of malfeasance. Less recent examples include hot-lines set up in countries such as Uganda, where the government promised rewards for citizens reporting corrupt tax officials. In the same vein, some NGOs have taken initiatives to facilitate reports of officials' misconduct (e.g., the "I paid a bribe" website in India). An obvious reason behind the growing interest in these schemes is that improvements in ICT have dramatically reduced the cost of filing, registering, and processing feedback. See, e.g., *The Economist* (September 24th, 2009).

is simplicity: neither does it require the intervention of internal/external monitors and courts, nor does the government need to verify the accuracy of the feedback received.

In our model, a population of entrepreneurs is required to comply with some regulation (e.g., environmental law) upon undertaking an activity (e.g., the production of a good). Compliance with regulation is privately costly, but avoids generating negative externalities (e.g., pollution). Government officials are matched with entrepreneurs to perform a screening function. They verify whether entrepreneurs comply with regulation, and either issue or deny the permit necessary to carry out the activity. The government observes whether an official grants a permit, but not the information upon which the decision is based. As a result, officials can engage in (i) *bribery*, by obtaining money from noncompliant entrepreneurs in exchange for granting the permit, and (ii) *extortion*, by forcing compliant entrepreneurs to pay a bribe to be issued the permit.

To capture the fact that officials operate under low levels of accountability, we assume that the expected sanctions they face are insufficient to deter corruption.³ Therefore, if it wishes to deter bribery, the government has to pay bonuses to officials who deny permits. However, in the absence of a feedback scheme, such a policy invites extortion: it makes systematically refusing permits in the officials' interest. The government cannot do better than offer low-powered incentives, and tolerate bribery in order to deter extortion.⁴ Without exploiting feedback, therefore, the enforcement of regulation is weak, because noncompliant entrepreneurs who bribe their way to a permit generate potentially large negative externalities.

We then introduce citizen feedback and obtain a simple mechanism that allows to deter both bribery and extortion. The main features of the mechanism are as follows. Entrepreneurs are asked to file a complaint if they disagree with the official's decision. Although the government never overturns an official's ruling, it promises a small reward to all entrepreneurs

³More precisely, in our model, limited liability protects officials; that is, the government cannot impose negative wages. However, officials face a small expected penalty when misbehaving. The fact that expected sanctions are limited captures the fact that, to convict corrupt officials, governments must follow legal procedures that are often ineffective and costly, especially in developing countries.

⁴Several previous studies, including Hindriks et al. (1999) and Khalil et al. (2010), arrived to similar conclusions.

who file a complaint. In addition, officials receive a bonus *when they deny permits without triggering a complaint*, and are paid a flat wage otherwise. Because feedback is solicited—and rewarded, officials know that arbitrarily denying a permit leads to a complaint. Entrepreneurs who comply with regulation can therefore obtain the permit without being victims of extortion. Moreover, the government ensures that officials deny permits to noncompliant entrepreneurs by setting the bonus at an appropriate level, by giving entrepreneurs the option to waive their right to file a complaint, and by empowering officials with the means to compensate noncompliant entrepreneurs who agree to waive this right.⁵

By deterring corruption, the feedback scheme we propose makes regulation more effective in curbing negative externalities. Nevertheless, adopting this mechanism is not always socially optimal. Because it entails the payment of bonuses to officials, the budget needed to maintain the administration is expanded. As a result, we find, for the adoption of the feedback scheme to be optimal, the cost of allocating the necessary resources must be relatively small compared to the external costs society can avoid by taming corruption.

The "citizen feedback" programs recently developed in several countries, such as Punjab's Feedback Model, inspire the mechanism we propose. However, in such programs, feedback is collected with the primary goals of guiding investigations against dishonest officials and administering sanctions. We explore a different, and possibly complementary, use of feedback. An important novelty of our proposal is to empower citizens with the ability to directly influence the pay of the officials they interact with. By exploiting complaints, the government is able to offer officials a high-powered incentive scheme that does not invite extortion. This feature of our scheme is particularly relevant, given that the lack of transparency regarding the officials' decisions often hampers the implementation of effective anti-corruption incentives (OECD (2013, p. 110)).⁶ An additional practical concern is that incentive systems may be

⁵The logic behind this incentive scheme is not unprecedented. For instance, several municipalities in the UK outsource enforcement of parking meters to private companies. To limit abuses, incentive contracts for enforcers stipulate bonuses tied to *uncontested* tickets. Furthermore, offenders who agree to settle early (effectively waving their right to complain) are often entitled to discounts on fines (<http://www.economist.com/node/16847086/print>, retrieved June 2015).

⁶Several scholars have argued in favor of linking officials' rewards (either monetary or non-monetary) to

ineffective if they provide broad discretion to higher-level supervisors (for instance, by requiring them to assess complaints). However, one strength of our scheme is precisely that it is not necessary to distinguish between fair and opportunistic complaints, so that the administrators in charge of implementing it are left with little discretion to exercise. Finally, because of their limited informational content, complaints can consist of very simple and inexpensive actions (e.g., sending an SMS).

In the second part of the paper, along with other extensions, we introduce bureaucracy intermediaries (e.g., paralegals, brokers, facilitators, etc.). Intermediaries specialize in assisting individuals who must deal with administrations to obtain a government service (e.g., a permit), and, according to evidence (Fredriksson (2014)), are common in developing countries. We focus on their ability to facilitate bribery: by developing stable relationships with officials, intermediaries guarantee a preferential treatment for their customers, thereby weakening the incentives entrepreneurs have to comply with regulation. Our results suggest the pervasiveness of intermediaries is a by-product of the low-powered incentives provided to officials. We also show that, if properly exploited, the feedback scheme may allow the government to deter officials from dealing with intermediaries, thereby strengthening the enforcement of regulation.

Related Literature. A vast literature exists on corruption in public administrations (see, e.g., Aidt (2009), Banerjee et al. (2012), and Olken and Pande (2012) for surveys). A large strand of this literature studies the optimal design of officials' incentives in environments of low accountability.⁷ A common finding is that a strong tension exists when trying to induce officials to enforce rules and, at the same time, prevent them from abusing their discretionary power (e.g., Hindriks et al. (1999), Polinsky and Shavell (2000), Khalil et al. (2010)). This

their performance in order to deter corruption (see, e.g., Polinsky and Shavell (2000)). Albeit limited, empirical evidence on the effectiveness of this kind of measures suggests that they can be effective if carefully designed (Olken and Pande (2012)). Kahn et al. (2001) studied an incentive program for tax collectors in Brazil, finding evidence of reduction in the extent of bribery.

⁷This issue has been investigated in different settings, such as law enforcement (e.g., Polinsky and Shavell (2000), Mishra and Mookherjee (2013), Burlando and Motta (2014)) and tax collection (e.g., Hindriks, et al. (1999)).

tension can be so strong that tolerating some forms of corruption in order to deter others is often optimal. A contribution of our paper is to show how the government can deter both forms of corruption if it exploits complaints from individuals dealing directly with officials. To the best of our knowledge, the only other paper investigating such complaints is Atsu Amegashie (forthcoming). However, in his model, citizens do not need to comply with rules to be entitled to the government service.⁸

The literature on collusion in hierarchies has extensively investigated the consequences of bribery and extortion on the design of incentives to supervisors. In a model of adverse selection, Celik (2009) finds a supervisor is useful only if the principal provides the agent with the possibility of blowing the whistle. Also in a model of adverse selection, Felli and Hortala-Vallve (2014) show the principal can design a whistleblowing program to deter bribery, which, unless it is carefully designed, may pave the way to extortion. In environments of moral hazard, Khalil et al. (2010) show that letting bribery occur in order to deter extortion is optimal, and Vafai (2012) shows that deterring both forms of corruption is possible in case the supervisor's information is verifiable.

Finally, our paper relates to the growing literature on bureaucracy intermediaries. Bertrand et al. (2007) empirically document their relevance in the context of driving examinations in India. Drugov et al. (2014) examine how intermediaries affect the moral costs of corruption. Theoretical studies include Hasker and Okten (2008), Bose and Gangopadhyay (2009), Fredriksson (2014) and Dusha (2015). Our work departs from such studies by considering citizen feedback.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 solves the game first assuming the government does not rely on entrepreneur feedback, and then allowing for it. Section 4 presents the extensions, including that on bureaucracy

⁸Mookherjee and Png (1992) consider complaints in a model without bribery. Prendergast (2003) looks at complaints as a means of bureaucratic oversight, but ignores corruption. Dufwenberg and Spagnolo (2015) examine the proposal by Basu (2011) to "legalize bribe giving," and find granting amnesty to citizens who self-report paying bribes is optimal.

intermediaries. Section 5 concludes. Proofs of all Propositions and Lemmas are relegated to the Appendix. Proofs of additional results and extensions can be found in the Supplementary Appendix.

2 The Setup

We consider a government and a continuum of pairs of entrepreneurs and government officials of size equal to one. Entrepreneurs wish to engage in an activity (e.g., production of a good) that generates a private benefit G . The activity is socially risky in that it imposes damages $D > G$ onto third-parties (e.g., pollution, health hazards) unless entrepreneurs comply with some regulation (e.g., environmental law). The government requests that all entrepreneurs comply with regulation, and hires officials to verify compliance. Upon verification, officials decide whether to grant permits necessary to undertake the activity.⁹

Actions and Information. Each entrepreneur decides whether to apply for the permit. We assume applying is costless, but require entrepreneurs to apply if and only if their expected payoff is strictly higher than zero. Entrepreneurs intent on applying for the permit unobservably choose whether to provide high ($e = h$) or low ($e = l$) effort, where exerting high (low) effort means complying (not complying) with regulation. We assume that entrepreneurs indifferent between complying or not choose to comply. An entrepreneur imposes an expected damage D on third parties if she has chosen not to comply with regulation (i.e., $e = l$) and yet is allowed to undertake the activity. In case damages occur, the government is unable to infer which entrepreneur is liable.¹⁰ Choosing $e = h$ implies a cost ψ to entrepreneurs, where ψ is i.i.d. across entrepreneurs according to the cumulative distribution function $H(\cdot)$ with full

⁹We refer to citizens as entrepreneurs for concreteness, but our analysis is more general. It applies, for instance, to the issuance of driver's licenses. Because driving is risky and requires training, governments typically require would-be drivers to undergo tests before being issued a license. There is abundant evidence suggesting corruption significantly weakens the effectiveness of such tests (e.g., Bertrand et al., 2007). We provide further examples in Section 5.

¹⁰For instance, establishing who is responsible for polluting a common resource (e.g., a river) is difficult when several firms exploit it.

support $[0, \bar{\psi}]$. Entrepreneurs are thus heterogeneous in the cost of complying with regulation. We assume ψ is private information to the entrepreneurs. We also assume $G \leq \bar{\psi} < D$: exerting high compliance effort is socially optimal, but not necessarily privately optimal.

Each entrepreneur (she) is randomly paired with an official (he). Within each pair, the official and the entrepreneur observe a signal σ correlated with the latter's effort level $e \in \{l, h\}$.¹¹ Specifically, σ can take two values: either $\sigma = c$ ("compliance") or $\sigma = n$ ("non-compliance"). We assume $\sigma = c$ with probability 1 if the entrepreneur chose $e = h$, and with probability $1 - \rho$ if instead $e = l$. Thus, $\sigma = n$ with probability $\rho \in (0, 1)$ when $e = l$. In words, government officials fail to detect all noncompliant entrepreneurs, but compliant entrepreneurs are never detected as noncompliant. This can capture a situation with limited resources in which (i) officials are unable to scrutinize all applicants and (ii) those who are not scrutinized are nevertheless eligible for the permit.¹² In this vein, ρ can be interpreted as the extent to which officials are time-constrained. We assume ρ is common knowledge and constant across officials.

We assume σ is observable only to the given official-entrepreneur pair, and that having it systematically verified by a third party (e.g., a court of law) is exceedingly costly. This is especially realistic in developing countries for which inefficiencies of judicial-like procedures are well-documented (see, e.g., Court et al. (2003)). The assumption that σ is observable to the entrepreneur best fits situations in which little margin exists for interpretation regarding compliance.¹³ This assumption also avoids unnecessary complications by ensuring bargaining between officials and entrepreneurs takes place under symmetric information.

¹¹To be precise, each pair's σ depends only on the associated entrepreneur's choice e . We do not introduce pair-specific indexes on signals and actions to save on notation.

¹²Ruling out the possibility that compliant entrepreneurs are detected as noncompliant allows us to focus squarely on the detrimental effects of corruption. However, our main results are robust to this modification, as long as the likelihood of this type of mistake is not too large.

¹³An example is the regulation of truck weight (see Olken and Barron (2009)). A simple threshold exists, known to both officials and drivers, above which a truck is considered overweight. If the driver is aware of the amount of cargo on the truck, he is also aware that the official observes non-compliance as soon as the truck is weighed. A further example is regulation requiring the installation of safety or anti-pollution equipment: it is relatively simple to verify that equipment is installed, and, upon receiving an inspection, it is reasonable to expect the entrepreneur knows whether non-compliance has been uncovered.

Within each pair, after having observed σ , the official rules whether to grant ($r = g$) or deny ($r = d$) the permit to the entrepreneur. The permit certifies that the entrepreneur is compliant. We assume entrepreneurs are able to undertake the activity only if they are in possession of the permit, and normalize the private gain of an entrepreneur without a permit to 0.¹⁴ Officials' decisions regarding whether to grant or deny a permit are observable to the government.

Absent corruption, it is socially optimal to request that permits be granted when $\sigma = c$ and denied when $\sigma = n$.¹⁵ However, officials are self-interested and can choose $r \in \{g, d\}$ independently of σ . In other words, they enjoy full *discretionary power*. Nevertheless, officials face an expected sanction s when deceiving the government, which we posit happens when either (i) $r = d$ even though $\sigma = c$ or (ii) $r = g$ even though $\sigma = n$. This (exogenous) sanction can have several interpretations: first, it may represent an expected penalty imposed by some monitor (e.g., who verifies a subset of applications). Second, it can represent a moral cost of dishonesty. Nonetheless, to capture the fact that officials operate in an environment of *low accountability*, we assume this sanction is small; specifically, $0 \leq s < \frac{G}{2}$. As we argue below, when $s \geq \frac{G}{2}$, the government can deter all forms of corruption even in the absence of feedback from entrepreneurs.

To increase the officials' accountability, the government may run an "entrepreneur feedback scheme" whereby entrepreneurs who were denied the permit indicate whether they agree ($f = 0$) or disagree ($f = 1$) with their officials' decision.¹⁶ For concreteness, we refer to $f = 1$ as "filing a complaint." Entrepreneurs are able to costlessly file complaints regardless

¹⁴For instance, entrepreneurs could be unable to legally register their business without the permit. In practice, though, entrepreneurs may be able to do business without permits (e.g., by operating in the informal sector). Our main results are robust to this modification, as long as the private gain obtained without a permit is (weakly) smaller than G , and as long as the expected harm imposed on society is not excessively larger than D .

¹⁵Systematically denying permits would lead to no entrepreneur applying, and thus no economic activity. Systematically granting the permit (i.e., not regulating the activity) would lead to no entrepreneur opting for compliance, which is undesirable because $D > G$. The same applies when $r = g$ (resp. $r = d$) when $\sigma = n$ ($\sigma = c$).

¹⁶Intuitively, disagreeing with the decision would never be optimal for an entrepreneur whose permit was issued. Note that we restrict communication between entrepreneurs and the government to be binary in order for the scheme to be as simple as possible.

of their actual level of effort e and signal σ , and regardless of whether corruption occurred (see below). For simplicity, we ignore private costs of filing complaints: t can be interpreted as the reward net of such costs, with no change in the analysis. We assume the government is unable (or does not attempt) to verify whether complaints are justified, and never overturns an official's decision following a complaint. Nevertheless, we show below that promising a small transfer t to any entrepreneur who files a complaint may be socially optimal.

Contracts. The government does not observe an official's signal σ , but observes his decision as well as whether the entrepreneur he was paired with filed a complaint. The government is thus able to tie each official's wage to the decision $r \in \{g, d\}$ he makes and to the feedback $f \in \{0, 1\}$ sent by the associated entrepreneur. Because all officials are identical and randomly matched with entrepreneurs, they all receive the same schedule of wages. We assume limited liability protects officials.^{17,18} Formally, officials are offered a schedule of non-negative wages denoted $\{w_g, w_{d,0}, w_{d,1}\}$, where an official receives $w_g \geq 0$ if he grants the permit (i.e., $r = g$), $w_{d,0} \geq 0$ in case he denies the permit (i.e., $r = d$) and the entrepreneur does not complain (i.e., $f = 0$), and $w_{d,1} \geq 0$ in case he denies the permit (i.e., $r = d$) and the entrepreneur files a complaint (i.e., $f = 1$).

Payoffs. Let $U(\psi, e, r, f, b)$ denote an entrepreneur's ex post payoff, that is, following the realization of σ (we do not make explicit the dependence on σ , because it affects the entrepreneur's payoff only indirectly). We assume $U(\psi, e, r, f, b)$ is additively separable in the gain G (if $r = g$), the cost of compliance ψ (if $e = h$), the bribe b paid to the official (if any), and the reward t (if $f = 1$). For instance, $U(\psi, h, g, 0, b) = G - b - \psi$ if an entrepreneur is issued a permit after having paid a bribe despite a high level of effort, and $U(\psi, h, d, 1, 0) = t - \psi$ if an entrepreneur complains about the permit being denied despite having exerted high effort,

¹⁷This captures the fact that the government cannot impose penalties without evidence of wrongdoing (i.e., based only on whether permits are granted/denied and whether complaints are filed). As will become clear, removing limited liability can only make feedback schemes more attractive.

¹⁸We ignore officials' participation constraints for simplicity.

and no bribe is paid.

Let $V(\sigma, r, f, b)$ denote an official's ex post payoff. We assume $V(\sigma, r, f, b)$ is additively separable in the wage w , the cost of lying s (if any), and the bribe b (if any). For instance, $V(n, g, 0, b) = w_g - s + b$ if an official collects a bribe b from the entrepreneur he is paired with and (unduly) grants her a permit after having observed $\sigma = n$. Similarly, $V(c, g, 0, b) = w_g + b$ if an official extorts a bribe in exchange for the permit, despite the entrepreneur being eligible.¹⁹

Finally, the government chooses $\{w_g, w_{d,0}, w_{d,1}, t\}$ to maximize the expected level of social welfare, which is equal to the sum of all entrepreneur and officials' expected payoffs, minus the expected level of damages imposed on third-parties and the expected wage bill. Entrepreneurs, officials, and third parties are given equal weight (set to 1). Moreover, we assume a cost $\lambda \geq 1$ to society of making transfers to officials (the "cost of public funds"). Finally, the government always has the option of banning the activity, in which case it systematically denies permits and welfare is equal to zero.

Throughout, we assume $G \leq \bar{\psi} < D$. In words, requesting that, upon undertaking the activity, entrepreneurs comply with regulation is socially optimal. However, undertaking the activity when requested to comply with regulation may not be socially (and privately) optimal.

Agreements Between Officials and Entrepreneurs. We assume officials have full bargaining power when making deals with entrepreneurs. Formally, after having observed σ , officials (possibly) make take-it-or-leave-it offers ("deals") to the entrepreneur with whom they are paired, where a deal specifies a bribe b and a pair of actions $\{r, f\}$ to play. This assumption is in line with our focus on circumstances in which ordinary citizens have little protection vis-à-vis corrupt officials. Nevertheless, our main results do not depend on this allocation of bargaining power. A more general treatment, in which we let the bargaining outcome within each official-entrepreneur pair be determined by the Nash Bargaining solution

¹⁹Observe that we assume officials face the expected sanction s when choosing r inconsistently with σ , and regardless of whether they take bribes. This captures a situation in which σ is more easily verifiable by third parties than the payment of bribes. Assuming officials also face s whenever they take bribes leaves our results qualitatively unchanged.

concept, is presented in Section 4.3 below (and solved in the Supplementary Appendix).

If a deal is agreed upon, entrepreneurs and officials play as promised (they play “cooperatively”). If the offer is rejected, no bribe is exchanged, and the game is played noncooperatively. An entrepreneur thus accepts a deal if and only if the payoff it guarantees her is higher than her payoff when playing non-cooperatively. We assume whether an entrepreneur-official pair engages in corruption is unobservable to the government.

Formally, after observing σ , an official solves

$$\begin{aligned} \max_{\{b,r,f\}} \quad & V(\sigma, r, w, b) \\ \text{s.t.} \quad & U(\psi, e, r, f, b) \geq U'_\sigma, \end{aligned} \tag{1}$$

where $U'_\sigma \equiv U(\psi, e, r'_\sigma, f'_\sigma, 0)$ and where $\{r'_\sigma, f'_\sigma\}$ denotes the pair of actions chosen by the entrepreneur and the official when playing noncooperatively (so that, by definition, no bribe is exchanged), for a given σ . Because bargaining occurs under symmetric information about σ , and payoffs are linear in the bribe b , it is always optimal for an official to design its offer such that the pair of actions $\{r, f\}$ maximizes the pair’s *collective payoff* $V(\sigma, r, f, b) + U(\psi, e, r, f, b)$.

In the following, we distinguish between two types of corrupt behaviors: *bribery* and *extortion*. *Bribery* occurs when an official obtains a payment from an entrepreneur found not compliant (i.e., when $\sigma = n$) in return for granting the permit. *Extortion* occurs when an official obtains a payment from an entrepreneur found compliant (i.e., when $\sigma = c$) in return for granting the permit. As we explain below, these two types of corrupt behavior have drastically different impacts on the entrepreneurs’ willingness to comply with regulation.

Observe that government officials can also abuse their discretionary power without engaging in corruption. Specifically, to pocket as high a wage as possible, officials may be tempted to make a decision r that contrasts with the signal realization they have observed. That is, officials can choose $r = d$ even though $\sigma = c$ (we refer to such behavior as *framing*)

or choose $r = g$ even though $\sigma = n$.

Note that we do not restrict bribes to be positive: a priori, payments may also flow from an official to an entrepreneur. Also, we do not impose any limit on the size of bribes, except, of course, for the entrepreneurs' willingness to pay for a permit. In Section 4.2, we present an extended version of the model that explicitly incorporates budgetary constraints for entrepreneurs.

Finally, we make the following additional assumptions to simplify the exposition. When an official is indifferent between several deals, he chooses the one the government prefers. Similarly, when playing noncooperatively, and if indifferent between $r = g$ and $r = d$, an official makes the decision the government prefers (for instance, $r = g$ if $\sigma = c$). These two assumptions are unimportant because, as long as $s > 0$, the government can always (and almost costlessly) break officials' indifference and ensure a unique equilibrium. Regarding entrepreneurs, we assume that, in case they are indifferent between accepting a deal or rejecting it, they accept it. This is because an official can always break an entrepreneur's indifference at an arbitrarily small cost.

Timing. We summarize the model by presenting the timing of moves:

1. The government decides whether to allow the activity. If the activity is allowed, the government chooses the officials' wage schedule $\{w_g, w_{d,0}, w_{d,1}\}$ and the transfer t paid to the entrepreneurs who file a complaint;
2. Entrepreneurs simultaneously decide whether to apply for the permit. If an entrepreneur applies, she decides her effort level $e \in \{l, h\}$ and is paired with an official.
3. For each entrepreneur-official pair, signal $\sigma \in \{c, n\}$ is realized;
4. Each entrepreneur-official pair possibly makes a deal. Each official decides whether to grant ($r = g$) or deny ($r = d$) the permit;

5. For all pairs such that $r = d$, the entrepreneur decides whether to file a complaint ($f \in \{0, 1\}$);
6. The officials' wages are paid, the entrepreneurs receive their private payoff, and damages occur (if any).

3 Solving the Model

We first consider the benchmark case in which officials are uncorruptible. Next, we introduce corruption, and characterize the officials' optimal wage schedule in both the absence and presence of an entrepreneur feedback scheme.

3.1 Uncorruptible Government Officials

Assume officials never make deals with entrepreneurs. To make sure officials choose (i) $r = g$ when $\sigma = c$ and (ii) $r = d$ when $\sigma = n$, the government can simply set all wages to zero, namely, $w_g = w_d = 0$. Intuitively, conditioning wages on entrepreneur feedback is not useful.²⁰ As a result, an entrepreneur intent on applying for the permit, and with cost of compliance ψ , chooses to comply with regulation if and only if

$$G - \psi \geq (1 - \rho)G, \tag{2}$$

which simplifies to $\psi \leq \rho G$. The gross benefit of complying is equal to ρG , that is, the net increase in the probability that the official observes $\sigma = c$ multiplied by the gain associated with obtaining the permit.

Because $\max[G - \psi, (1 - \rho)G] > 0$ for $\forall \psi$, all entrepreneurs apply for the permit.

However, only a fraction $H(\rho G)$ chooses to comply. Therefore, if the activity is allowed,

²⁰Suppose $\sigma = c$. An official's payoff is equal to w_g when choosing $r = g$, and equal to $w_d - s$ when $r = d$. Similarly, when $\sigma = n$, an official's payoff is equal to w_d when choosing $r = d$, and equal to $w_g - s$ when $r = g$. Thus, when $w_g = w_d = 0$, officials choose (i) $r = g$ when $\sigma = c$ and (ii) $r = d$ when $\sigma = n$.

the expected level of social welfare—hereafter the “no-corruption” level of welfare—is equal to

$$W^{NC} = \int_0^{\rho G} (G - \psi) dH(\psi) + (1 - \rho) \int_{\rho G}^{\bar{\psi}} (G - D) dH(\psi). \quad (3)$$

Observe that, because officials’ verification technology is imperfect, they fail to deny the permit to all noncompliant entrepreneurs. It follows that the expected level of damages is positive and equal to $(1 - \rho)(1 - H(\rho G))D$. As a consequence, social welfare is nonnegative if and only if

$$D \leq D_0^{NC} \equiv \frac{G(1 - \rho + \rho H(\rho G)) - \int_0^{\rho G} \psi dH(\psi)}{(1 - \rho)(1 - H(\rho G))}.$$

When $D > D_0^{NC}$, the government cannot do better than banning the activity.

3.2 Corruptible Government Officials

3.2.1 No Entrepreneur Feedback

Assume now officials are corruptible, but the government does not rely on entrepreneur feedback to discipline them. Officials who grant the permit receive w_g , and those who deny receive w_d . We show that deterring *both* bribery and extortion is impossible. As a result, either tolerating bribery so as to deter extortion, or forbidding the activity is optimal.

To understand the tension that arises when trying to deter bribery and extortion, we discuss both forms of corruption separately. Note that, because entrepreneur feedback is ruled out, an entrepreneur and an official need only agree on a decision r and a bribe b when engaging in corruption.

Bribery. Consider a given official whose signal indicates the entrepreneur he is paired with has not complied with regulation (i.e., $\sigma = n$). Ignoring possible bribes, if the official denies the permit (i.e., if $r = d$), his payoff is equal to w_d and the entrepreneur’s is equal to 0. By contrast, if the official unduly grants the permit (i.e., if $r = g$), his payoff is equal to

$w_g - s$ and the entrepreneur's is equal to G . As a result, the official and the entrepreneur are better off agreeing on $r = g$ —that is, the surplus to shared among them is highest by playing $r = g$ —whenever

$$w_g - s + G > w_d.$$

Suppose this inequality holds. If, moreover, $w_g - s > w_d$, the entrepreneur and the official agree on playing $r = g$ without exchanging money: the entrepreneur would reject any request for a bribe, anticipating that granting the permit is in the official's best interest. By contrast, if $w_g - s \leq w_d$, the wage w_d is high enough that, absent a bribe, denying the permit is in the official's interest. As a result, and because the official has full bargaining power, he is able to extract a bribe equal to G (i.e., the entrepreneur's willingness-to-pay for a permit).

Finally, if $w_d \geq w_g - s + G$, there does not exist a bribe that the entrepreneur is willing to pay and would lead to the official choosing $r = g$. Therefore, for the government to ensure that permits are denied when $\sigma = n$, it must necessarily set

$$w_d \geq w_g - s + G. \tag{4}$$

Because $G - s > 0$, for the government to deter bribery, it must necessarily reward officials who make decisions unfavorable to the entrepreneurs with whom they are paired. This finding is common in the literature on corruption within organizations (see, e.g., Tirole (1992)).

Extortion or Framing. Consider now an official whose signal indicates the entrepreneur should be granted the permit (i.e., $\sigma = c$). Ignoring possible bribes, if the official grants the permit, his payoff is equal to w_g and the entrepreneur's is equal to G . By contrast, if the official denies the permit, his payoff is equal to $w_d - s$ and the entrepreneur's is equal to 0. As a consequence, the official and the entrepreneur are better off choosing $r = g$ whenever $w_g + G \geq w_d - s$. Suppose this inequality holds. If, moreover, $w_g \geq w_d - s$, the official chooses $r = g$ without extracting a bribe. Indeed, the wage w_g is high enough that granting the permit

is in the official's interest: the entrepreneur would reject any request for a bribe. By contrast, if $w_d - s > w_g$, denying the permit is in the official's own interest. As a result, and because the official has full bargaining power, he is able to extort a bribe equal to G in return for the permit. Thus, when $w_g + G \geq w_d - s$, the official always chooses $r = g$ when observing $\sigma = c$, but does so without engaging in extortion only if $w_g \geq w_d - s$.

Finally, if $w_d - s > w_g + G$, a feasible bribe does not exist—that is, one the entrepreneur is willing to pay—that would lead to the official choosing $r = g$. The official then frames the entrepreneur by choosing $r = d$.

Summing up, for the government to ensure that officials grant permits without engaging in extortion, it must necessarily set

$$w_g \geq w_d - s. \tag{5}$$

Thus, to deter extortion, it is sufficient to set $w_g = w_d$; that is, it is sufficient to make the officials' wages unresponsive to their decisions. Indeed, when officials do not strictly gain from framing entrepreneurs (or even lose, because of s), it is in their best interest to grant permits.

Rearranging (4) and (5) leads to the following chain of inequalities: $s \geq w_d - w_g \geq G - s$, which cannot hold because $\frac{G}{2} > s$ by assumption.²¹ To prevent bribery, that is, to ensure $r = d$ when $\sigma = n$, the government has no choice but to reward officials who deny permits by setting w_d sufficiently high. However, doing so makes it in the officials' interest to systematically deny permits (that is, irrespective of σ), thereby paving the way to either extortion or framing. Furthermore, because of the officials' low accountability (i.e., the fact that expected sanctions for abusing their power are low), the government is unable to deter all forms of corruption, and has to choose between bribery and extortion.²²

To establish which corrupt behavior should be deterred, let us briefly comment on the

²¹In the Supplementary Appendix, we show that the exact same two conditions are relevant (and cannot jointly hold) when the outcome of the bargaining between entrepreneurs and officials is determined by the Nash Bargaining solution concept.

²²By contrast, in case $\frac{G}{2} \leq s$, the government can deter both bribery and extortion by setting wages appropriately.

distinct consequences of having either (4) or (5) hold on the entrepreneurs' incentives. Suppose (4) holds. Officials deny permits when $\sigma = n$, but either frame or extort entrepreneurs when $\sigma = c$. Because officials who engage in extortion are able to extract the entire value of a permit, the entrepreneurs' gross payoff is equal to zero both in case $\sigma = c$ and $\sigma = n$. Therefore, applying for the permit is of no value to the entrepreneurs, and welfare cannot be positive.²³

Suppose now (5) holds. Officials grant permits without extracting bribes when observing $\sigma = c$. Thus, the gross payoff to an entrepreneur whose official has observed $\sigma = c$ is equal to G . By contrast, because (4) does not hold, officials grant permits in exchange for bribes equal to G when $\sigma = n$. The gross payoff to an entrepreneur whose official has observed $\sigma = n$ is thus equal to zero. Anticipating officials' behavior, a given entrepreneur intent on applying complies with regulation if and only if

$$G - \psi \geq (1 - \rho)G, \tag{6}$$

which simplifies to $\psi \leq \rho G$. Because $\max[G - \psi, (1 - \rho)G] > 0$ for $\forall \psi$, all entrepreneurs apply for the permit, but only a fraction $H(\rho G)$ chooses to comply with regulation. Specifically, those who comply do so because their private cost of compliance ψ is smaller than the expected bribe ρG they would pay to obtain the permit if they chose $e = l$. For the remaining entrepreneurs, ψ is large enough that it is rational not to comply, and run the risk of having to pay the bribe if detected. Given that bribery is not deterred, all entrepreneurs who choose not to comply with regulation obtain the permit.

The next proposition states the government's optimal policy in the absence of an entrepreneur feedback scheme. In what follows, let $D_0^{NF} \equiv \frac{G - \int_0^{\rho G} \psi dH(\psi)}{1 - H(\rho G)} - \rho s$ denote a threshold on damages D .

²³In the Supplementary Appendix, we show that extortion continues to have a more detrimental consequence on welfare than bribery, unless entrepreneurs enjoy particularly high bargaining power. See Section 4.3 for a brief discussion.

Proposition 1. *Suppose the government does not exploit entrepreneur feedback to discipline officials. If $D \leq D_0^{NF}$, allowing the activity and tolerating bribery so as to prevent extortion is socially optimal. The optimal officials' wages are $w_g = 0$ and $w_d \in [0, s]$, and the associated level of social welfare is equal to*

$$W^{NF} = \int_0^{\rho G} (G - \psi) dH(\psi) + \int_{\rho G}^{\bar{\psi}} (G - D - \rho s) dH(\psi). \quad (7)$$

If $D > D_0^{NF}$, banning the activity is socially optimal.

If the government allows the activity, it must tolerate either bribery or extortion. However, it is clear from the above discussion that tolerating extortion can never be a viable option. If bribery is tolerated (so as to deter extortion), it is then sufficient to make the officials' wages unresponsive to their decisions (see (5)), and the government may as well set $w_d = w_g = 0$. It follows that tolerating bribery minimizes the wage bill. Moreover, bribery has a disciplining effect on entrepreneurs. Because those who are detected as noncompliant enjoy a lower payoff than those who are not—and it is more likely that $\sigma = c$ when $e = h$ —many entrepreneurs choose to comply with regulation, even if obtaining the permit with bribes is possible. The key social cost of allowing bribery is therefore that entrepreneurs who choose not to comply—and obtain the permit via bribery—impose damages D onto third-parties.

To further understand the consequences of corruption, comparing the achieved level of welfare in (7) to the “no-corruption” one in (3) is instructive. Although, in both cases, (i) the expected wage bill is zero and (ii) the number of compliant entrepreneurs is identical (see (6)), welfare when bribery is tolerated is lower than in the “no-corruption” benchmark, because, when bribery is tolerated, all noncompliant entrepreneurs obtain the permit. Without corruption, officials effectively screen out entrepreneurs caught in breach of regulation.²⁴ As a direct consequence, corruption reduces the threshold on the level of damages D above which the government prefers to ban the activity (i.e., $D_0^{NF} < D_0^{NC}$).

²⁴Recall that in the no-corruption benchmark, noncompliant entrepreneurs obtain the permit only if undetected (i.e., with probability $1 - \rho$).

In sum, we have found that in environments in which officials operate with high discretionary power and low accountability, a welfare-maximizing government may have no choice but to adopt low-powered incentives, thereby leaving the door open to bribery. This result is not novel (see, e.g., Hindriks et al. (1999), and Khalil et al. (2010)). In line with previous literature, it has been obtained assuming the government does not communicate with the entrepreneurs. We explore this possibility in the next section.

3.2.2 Introducing Entrepreneur Feedback

Suppose now the government offers entrepreneurs the ability to file a complaint if they are denied the permit. Specifically, although the government never overturns an official's decision, it commits to rewarding any entrepreneur who files a complaint with a transfer $t > 0$.²⁵ In addition, the government ties the officials' pay to these possible complaints by offering a schedule of wages $\{w_g, w_{d,0}, w_{d,1}\}$.

We assume t is paid without the need for entrepreneurs to provide any evidence of wrongdoing or of mistakes committed by the officials with whom they are paired, and officials are never investigated following a complaint. Nonetheless, as we now argue, this mechanism makes deterring both extortion and bribery possible.

To gain intuition, we revisit the incentives officials have to engage in corruption. Consider extortion first, and recall that to deter it, the government must set wages so that granting permits is in the officials' interest when $\sigma = c$ (otherwise, the threat of framing is credible). Because $t > 0$, in the absence of a deal with her official, an entrepreneur who is denied the permit systematically files a complaint (irrespective of σ). As a result, choosing $r = g$ is in an official's interest when $\sigma = c$ if and only if

$$w_g \geq w_{d,1} - s. \tag{8}$$

²⁵If we had made the assumption that an entrepreneur files a complaint when indifferent between filing or not, we could have set $t = 0$ and achieved the same outcome. However, to stress the fact that, in practice, it may be necessary to pay rewards to avoid multiple equilibria, we choose to set $t > 0$.

Now consider bribery. When $\sigma = n$, and entrepreneurs file complaints when denied the permit, officials choose $r = d$ if and only if

$$w_{d,1} \geq w_g - s + G. \quad (9)$$

As in the previous section, jointly satisfying (8) and (9) is impossible. However, it is not necessary to make a choice between deterring extortion and deterring bribery. The government can now exploit a third contingent wage (i.e., $w_{d,0}$) to its benefit. In particular, suppose the government sets t positive and arbitrarily close to zero, $w_{d,0} = G - s$, and $w_g = w_{d,1} = 0$. In words, the government rewards officials only when they deny permits without triggering complaints. First, extortion is deterred because, when $\sigma = c$, it is in an official's best interest to grant the permit rather than deny it and trigger a complaint. That is, the threat of framing is not credible: (8) is satisfied. Second, $w_{d,0}$ is set large enough that, when $\sigma = n$, an entrepreneur-official pair is collectively better off denying the permit *and not filing a complaint*. Indeed, the associated surplus to be shared (i.e., $w_{d,0}$) is weakly higher than (i) the surplus when the official unduly grants the permit (i.e., $G - s$) and (ii) the surplus when the official denies the permit and the entrepreneur files a complaint (i.e., t). Note that, for an agreement in which $r = d$ and $f = 0$ to be sustainable, an official needs to make a small transfer t to the entrepreneur to persuade her not to file a complaint (formally, $b = -t$).²⁶ Finally, observe that $w_{d,0}$ is not so large that an entrepreneur-official pair is better off denying the permit and not filing a complaint when $\sigma = c$ (i.e., $w_{d,0} - s < G + w_g$).

We summarize these findings in the following Lemma (the conditions under which this mechanism is socially optimal are stated in Proposition 2).²⁷

²⁶If the entrepreneur were to refuse, the official would subsequently deny the permit (because $w_{d,1} > w_g - s$), and, in turn, the entrepreneur would file a complaint. However, the associated payoff to the entrepreneur would be equal to t , which is weakly lower than the transfer promised by the official.

²⁷The fact that $w_{d,0}$ is equal to the value of the permit G , minus s , is a by-product of the assumption that entrepreneurs face no budget constraints. We relax this assumption in the Supplementary Appendix (and discuss it in Section 4.2). We show that, as the size of bribes is limited by budgetary constraints, so is the level that $w_{d,0}$ needs to attain in order to deter bribery. Our results are qualitatively unaffected.

Lemma 1. *The government can deter both bribery and extortion by implementing a feedback scheme such that (i) a transfer t (arbitrarily close to 0) is promised to the entrepreneurs who file a complaint and (ii) officials' wages are $w_g = w_{d,1} = 0 < w_{d,0} = G - s$.*

Before commenting on the properties of the feedback scheme, we briefly discuss some conditions necessary for its effective implementation. To avoid unnecessary modelling complications, we assumed officials are able to give a *small* compensation to entrepreneurs who renounce their right to complain. We also assumed entrepreneurs are able to credibly commit not to file a complaint. In the model, both features are exploited by the government to deter bribery. In practice, simple (and common) institutional measures can be adopted to ensure the same outcome, without officials actually having to make payments and without relying on entrepreneurs' promises. To give a concrete example, suppose the government includes a pre-filled complaint form together with each application file; to express dissatisfaction with the official, unsuccessful applicants must return the form to, say, an office of complaints. Applicants can credibly *wave their right to file a complaint* by returning the form to their official instead. In addition, to enable officials to persuade entrepreneurs not to complain, the government can grant them authority to make unsuccessful applicants eligible to, for instance, a refund of application fees.²⁸ We return in greater detail to the issue of implementation in Section 3.2.3.

In the mechanism we propose, the ability to file a complaint is no more than a token that allows entrepreneurs to obtain a limited compensation after being denied the permit. For the government, the value of a complaint does not lie in its informational content, but rather in how it affects the incentives of officials and entrepreneurs. Officials are aware that they will face a complaint (and thus obtain no reward) if they deny the permit arbitrarily. On the one hand, the ability to file a complaint puts compliant entrepreneurs in a position to rebuff

²⁸Schemes whereby individuals explicitly waive rights in order to qualify for compensations are common in reality. Consider, for instance, traffic law enforcement. In several countries (including France, Italy, and the UK) drivers who are issued fines are entitled to discounts in case they immediately renounce their right to appeal. The Supplementary Appendix contains two concrete and detailed examples of possible feedback schemes.

extortionary threats. On the other hand, it does not prevent officials from performing their duty when paired with noncompliant entrepreneurs, because the government is able to instigate a mutually beneficial outcome that involves the permit being denied. Thus, officials' decisions conform to what the government requires: in equilibrium, only entrepreneurs detected as noncompliant are denied the permit, and no complaints are filed. In sum, by linking officials' compensations to entrepreneur feedback, the government is able to introduce an effective high-powered incentive scheme, despite the lack of transparency that surrounds officials' decisions.

A virtue of this mechanism is its simplicity, primarily because it does not rely on the government being able to discern fair complaints from opportunistic ones. As a result, complaints can consist of very simple (and inexpensive) actions for ordinary individuals, such as sending text messages from mobile phones. Furthermore, the scheme imposes little additional informational burden on the administration. In addition, because the mechanism makes it rational for officials to be loyal because of the possibility of complaints, it minimizes the need to rely on internal or external monitors (who may also be prone to corruption) to discipline low-level public servants.

Welfare analysis. Having established that exploiting entrepreneur feedback makes deterring both bribery and extortion feasible, we now turn to the question of whether adopting such a scheme is socially optimal. The next proposition states the conditions under which implementing the entrepreneur feedback scheme is socially optimal. Let $D^F \equiv \lambda(G - s)$ and $D_0^F = \frac{D_0^{NF} - \lambda\rho(G-s)}{1-\rho}$ denote two thresholds on the damages D .

Proposition 2. *Suppose the cost of public funds is such that $1 \leq \lambda < \frac{D_0^{NF}}{G-s}$, then:*

1. *When $D \leq D^F$, not exploiting entrepreneur feedback, and tolerating bribery so as to prevent extortion by setting $w_g = w_d = 0$, is optimal .*
2. *When $D^F < D \leq D_0^F$, introducing an entrepreneur feedback scheme that (i) promises a transfer t (arbitrarily close to 0) to entrepreneurs who file a complaint and (ii) specifies wages $w_g = w_{d,1} = 0 < w_{d,0} = G - s$ is optimal.*

3. When $D > D_0^F$, banning the activity is optimal.

When $\lambda \geq \frac{D_0^{NF}}{G-s}$, not exploiting entrepreneur feedback, and tolerating bribery so as to prevent extortion by setting $w_g = w_d = 0$, is optimal if and only if $D < D_0^{NF}$. Otherwise, banning the activity is optimal.

To gain intuition, a review of the advantages and drawbacks of the entrepreneur feedback scheme is useful. To begin with, the scheme allows the government not only to deter extortion, but also to deter bribery. As a result, no entrepreneur found ineligible obtains the permit. Also, by setting t very small, the government makes incentives to comply with regulation virtually as strong as in the no-corruption benchmark, because an entrepreneur's payoff is equal to G when $\sigma = c$ and equal to t when $\sigma = n$.²⁹ Thus, the expected level of gains and damages the activity generates is identical to that when corruption is unfeasible. Finally, the only drawback is that the government must promise officials a positive wage $w_{d,0}$ for denying permits. Because it is paid in equilibrium, this bonus increases the government's wage bill.

When the entrepreneur feedback scheme is implemented, social welfare is equal to

$$W^F = \int_0^{\rho G} (G - \psi) dH(\psi) + (1 - \rho) \int_{\rho G}^{\bar{\psi}} (G - D) dH(\psi) - (1 - H(\rho G)) \rho (\lambda - 1) (G - s). \quad (10)$$

Because of the positive wage bill, the cost of public funds λ cannot be excessively high for the entrepreneur feedback scheme to be optimal. We find that, if $\lambda \leq \frac{D_0^{NF}}{G-s}$, the feedback scheme dominates the "low-powered" scheme that tolerates bribery stated in Proposition 1—the best alternative for the government, provided it wishes to allow the activity—as long as the damages D are large enough but not excessively so (i.e., $D^F < D \leq D_0^F$).³⁰ Intuitively, paying high wages in order to deter bribery is worthwhile for the government only if the

²⁹An entrepreneur with cost ψ intent on applying chooses $e = h$ if and only if $G - \psi \geq \rho t + (1 - \rho)G$. Because $\max[G - \psi, \rho t + (1 - \rho)G] > 0$, all entrepreneurs apply. Therefore, the share of compliant entrepreneurs is arbitrarily close to $H(\rho G)$; that is, arbitrarily close to that of the "no-corruption" benchmark.

³⁰To show that $\frac{D_0^{NF}}{G-s} > 1$, observe that the inequality $G - s < \frac{G - \int_0^{\rho G} \psi dH(\psi)}{1 - H(\rho G)} - \rho s$ simplifies to $(G - (1 - \rho)s)(1 - H(\rho G)) < G - \int_0^{\rho G} \psi dH(\psi)$. This last inequality holds because $\int_0^{\rho G} \psi dH(\psi) < GH(\rho G)$ implies $G - \int_0^{\rho G} \psi dH(\psi) > G(1 - H(\rho G))$.

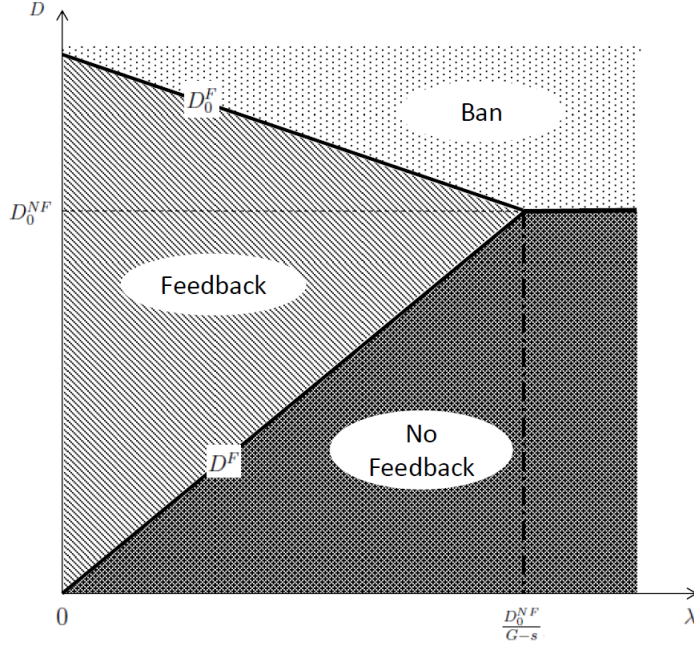


Figure 1: Illustration of the optimal policy as a function D and λ .

damages it avoids are large enough. Nevertheless, because the officials' verification technology is imperfect, denying permits to all noncompliant entrepreneurs is not possible even in the presence of the feedback scheme. As a result, the government cannot do better than to ban the activity when damages are very high (i.e., $D > D_0^F$). Finally, if λ is high (i.e., $\lambda > \frac{D_0^{NF}}{G-s}$), exploiting entrepreneur feedback is never optimal. The severity of the damages required for the feedback scheme to dominate the low-powered scheme is so high that social welfare would be negative if the activity was allowed. The government then adopts the same policy as in Proposition 1, that is, tolerate bribery so as to deter extortion when $D < D_0^{NF}$, and otherwise ban the activity. For illustrative purposes, we provide a graphical representation of the regions where each policy is optimal in Figure 1.

3.2.3 Implementing the Feedback Scheme

We now discuss the main conditions for the effective implementation of the feedback scheme outlined above. In line with the preceding analysis, the discussion assumes deterring corruption is the government's objective.

Our model assumes the government is able to gather feedback and distribute the rewards promised to individuals filing complaints. A separate agency, created for this purpose, may perform this function. A natural concern arises that the scheme's administrators might also be corrupt (see, e.g., Mishra (2006)). However, the properties of the system we propose suggest this issue should not be too strong. First, the administrators do not need to interact in person with citizens or other agencies' administrators (feedback can be gathered through, for instance, a hotline, an sms service, or an internet website), thereby reducing opportunities for collusion. In addition, our scheme is such that verifying the accuracy of complaints (e.g., through hearings, internal investigations, etc.) is unnecessary, so that the administrators are left with little discretion to exercise.

In our analysis, the government is also able to tie officials' pay to the decisions they make, and to possible complaints. As the Punjab Feedback Model suggests, governments can keep track of officials' decisions and feedback from citizens, conceivably with the aid of basic communication technologies (Callen and Hasanain (2011)). A common way of achieving this is to request (i) that all applicants be issued a unique identification number (e.g., via a government website) and (ii) that officials enter individuals' identification numbers in the system before reviewing their case.³¹

Our mechanism relies on the ability of officials who deny permits to convince ineligible applicants not to file complaints. Indeed, because the government promises rewards to all unsuccessful applicants filing a complaint, the latter have incentives to complain even when their official's decision was fair. In our formal model, officials convince entrepreneurs not to file a complaint by making a *small* monetary transfer. In practice, transparent institutional measures can be taken to empower officials with the ability to raise the payoff of unsuccessful candidates. Suppose, as is common, that applicants are required to pay an application fee to have their case reviewed.³² Suppose also that the government creates a procedure through

³¹As a side note, making the obtention of identification numbers slightly costly (or time consuming) can also prevent individuals from abusing the scheme and initiate bogus applications only to file complaints and pocket rewards.

³²Application fees can be incorporated in our model without affecting the main results. We consider them

which applicants can waive their right to file a complaint. Government officials can be granted discretion to make unsuccessful candidates eligible for a small refund in case they activate the waiver. Alternatively, unsuccessful applicants wishing to apply again could become eligible to have the process expedited, be exempt from future application fees, and so on.

Further, we solved our model assuming entrepreneurs and officials could reach binding agreements. We found it was in the government's interest to foster welfare-enhancing cooperation between ineligible entrepreneurs and officials. To ensure the same outcome when agreements must be self-sustainable (and at the same time deter extortion), the government should ensure an applicant's decision to waive her right to complain (i) permanently and automatically eliminates her ability to file a complaint,³³ (ii) be observable to the officials, and (iii) be made *before* the decision regarding the issuance of the permit. Applicants are then given a credible and observable commitment device not to file a complaint. Moreover, because, to be valid, the waiver must be activated before the officials' final decision, it is enough for *eligible* applicants to *not* exercise the waiver—a decision observed by officials—to make it subsequently rational for the officials (who found no evidence of non-compliance) to issue the permit; that is, extortion is deterred.³⁴

Finally, as for all policy innovations at the grassroots level, significant care should be devoted to informing citizens of the features of the scheme. For instance, a necessary condition for the scheme to be effective is that applicants are aware of officials' incentives in case they rebuff extortionary threats. Informing them of the consequences of filing a complaint is therefore important.

For the sake of concreteness, we present in the Supplementary Appendix two detailed in an extension (see Section 4.2).

³³Applicants could otherwise choose to benefit both from the compensation made when exercising the waiver and that when filing a complaint. Officials would anticipate this event, their incentives to deny permits would be weakened, and bribery would no longer be deterred.

³⁴Naturally, applicants alone should decide whether to activate the waiver. Officials would otherwise have incentives to systematically impose waivers, and extortion would no longer be deterred. The examples we provide in the Supplementary Appendix suggest this is easily avoidable. For instance, applicants may be assigned a code (unknown to the official) at the start of the application process. Entering the code would be necessary to file a complaint. To credibly waive the right to complain, the applicant can reveal the code to the official (who can then enter it in the system, thereby making any complaint void).

examples of possible feedback schemes that conform to the conditions discussed above.

4 Extensions

4.1 Bureaucracy Intermediaries

We have so far assumed the interaction between officials and entrepreneurs takes place directly. We now extend the model to consider indirect interaction through intermediaries (e.g., paralegals, brokers, facilitators, etc.). This extension is of natural interest because, as previous literature has emphasized, intermediaries are quite common in developing countries (see, for instance, Bertrand et al. (2007) and Fredriksson (2014)).

Anecdotal evidence suggests intermediaries perform several functions. On the one hand, they reduce the transaction costs of dealing with the administration. Intermediaries generally possess a superior technology for handling paperwork. On the other hand, intermediaries also facilitate corruption: by developing stable relationships with officials, they guarantee a preferential treatment for their customers. Fully capturing the role of intermediaries in a single model is difficult, and the objective of this section is therefore limited in scope. Because our primary interest is in the interplay between corruption and intermediaries, we ignore the cost-saving aspect of the services they provide.

We show that the pervasiveness of intermediaries is a by-product of providing low-powered incentives to officials. When entrepreneur feedback is ruled out, the optimal incentive scheme is such that officials collect bribes from noncompliant entrepreneurs by means of intermediaries. Therefore, much like direct bribery, intermediaries are a “necessary evil.” Next, we show that, if exploited appropriately, the entrepreneur feedback scheme can reduce the pervasiveness of intermediaries, thereby improving the effectiveness of the regulatory system.

Modified setup. The action space of entrepreneurs is expanded to allow them to acquire the permit via an intermediary, instead of interacting directly with an official. Specifically,

$e = \{h, l, i\}$, where i denotes “using an intermediary.” An intermediary guarantees a permit by means of his connection with the official. Hence, if $e = i$, the official always chooses $r = g$. It follows that obtaining the permit via the intermediary does not require any compliance effort on the entrepreneur’s part. However, a fee φ has to be paid for the intermediary’s service. In turn, the intermediary pays a price p to the official issuing the permit. In other words, the official simply sells the permit to the intermediary, who then re-sells it to the entrepreneur. When an entrepreneur is indifferent between $e = i$ and $e = l$, we suppose she chooses $e = i$. For simplicity, we also assume intermediaries sustain no costs (except for the money paid to the official) and make no profits (e.g., because of free entry); relaxing these assumptions would slightly complicate the analysis without altering the results.

One of the main reasons intermediaries enjoy preferential access to officials is that they develop long-term relationships. Such relationships require mutual trust and commitment to not renege on agreements. Accordingly, we assume each official can commit to the price p *before* entrepreneurs choose e . By contrast, officials cannot commit in advance to the bribes they would request when interacting with entrepreneurs directly—the relationship between officials and entrepreneurs being “one shot”. Hence, if $e = \{h, l\}$ are chosen, the continuation game is exactly as in our basic setup. We assume that if an entrepreneur has chosen to deal with the official directly, she cannot revise her decision (and switch to an intermediary) at a later stage.

As in the baseline model, we assume e is unobservable to the government. Specifically, whether a permit has been issued by means of an intermediary cannot be detected. Each official deals with an exogenous set of intermediaries. To facilitate comparison with previous results, we retain the assumption that entrepreneurs are matched exogenously with officials and, consequently, with (one of) the intermediaries with whom the official regularly deals. We therefore abstract from competition among officials.

Similarly to our baseline model, the feedback scheme we propose involves paying a bonus to officials who deny permits. As we show below, in the presence of intermediaries, officials may

be tempted to abuse the scheme in case these bonuses are very large: they can systematically deny permits to compliant entrepreneurs, and compensate them with bribes greater than the value of a permit. To capture the fact that, in practice, it may be difficult for officials to pay large “bribes” without being detected, we assume there is a transaction cost equal to $z - 1$, with $z \geq 1$, for every dollar that officials transfer to entrepreneurs.³⁵ Formally, we assume that when making a deal with entrepreneurs such that $b < 0$, the official sustains a total cost equal to zb . Of course, transaction costs could also affect the bribes that entrepreneurs pay to officials. However, introducing such costs can only strengthen our results (by making bribery less profitable, transaction costs would decrease the government’s wage bill when implementing the feedback scheme).

Finally, we make some assumptions to streamline exposition. We assume $\psi \sim U [0, \bar{\psi}]$. Hence, $H(\psi) = \frac{\psi}{\bar{\psi}}$. Also, we assume D is never so large that the government cannot do better than banning the productive activity.

Timing. The timing of the game is as follows:

1. The government chooses the officials’ wage schedule $\{w_g, w_{d,1}, w_{d,0}\}$ and, when applicable, the transfer t to the entrepreneurs who file complaints;
2. Each official sets p , and intermediaries set φ ;
3. Each entrepreneur is paired with an official and an intermediary, and chooses $e = \{h, l, i\}$;
4. All entrepreneurs who chose $e = i$ pay $\varphi = p$ to the intermediary. The latter transfers p to the official, who grants the permit regardless of σ . For all other entrepreneurs, the game proceeds as in the baseline model.

³⁵This formulation of transaction costs is widely used in the literature on corruption. See, e.g., Tirole (1992). Note also that the incentive scheme in Section 3.2.2 is never subject to this kind of abuses. Introducing this transaction cost would thus have vitually no implication on the analysis.

Entrepreneurs' incentives. Consider the problem faced by an entrepreneur with cost of compliance ψ . If she chooses $e = \{h, l\}$, she obtains the same payoffs as in Section 3. If instead $e = i$, her payoff is $G - p$. Let $\tilde{\psi}$ denote the cost of the entrepreneur indifferent between complying and not complying with regulation; that is, let $\tilde{\psi}$ be defined as

$$U(\tilde{\psi}, h) = \max[U(l), U(i)]. \quad (11)$$

To save on notation, we drop the arguments other than e in the function $U(\cdot)$. A quantity $H(\tilde{\psi})$ of entrepreneurs chooses $e = h$, and the remainder choose either $e = l$ or $e = i$. To simplify exposition, we assume all entrepreneurs apply for the permit.³⁶

Officials' incentives. For notational convenience, we write $V(\sigma)$ as shorthand for $V(\sigma, r, w, b)$. Assume an entrepreneur chooses to deal directly with the official with whom she is paired, i.e., $e = \{h, l\}$. The official's interim payoff (i.e., before the realization of σ) is then $V(c)$ if the entrepreneur chooses $e = h$, and $\rho V(n) + (1 - \rho)V(c)$ if the entrepreneur chooses $e = l$.

Assume now the entrepreneur chooses $e = i$. The official with whom she is paired pockets the bribe p from the intermediary, the salary w_g , and incurs the cost s with probability ρ (i.e., the probability that $\sigma = n$). Hence, the official's payoff is $w_g + p - \rho s$.

When choosing p , an official maximizes his ex ante expected payoff, that is, his expected payoff computed using $H(\tilde{\psi})$. Assume noncompliant entrepreneurs use intermediaries, i.e., $U(i) \geq U(l)$. Then, the official's ex ante payoff is

$$H(\tilde{\psi}) \cdot (V(c)) + (1 - H(\tilde{\psi})) \cdot (w_g + p - \rho s)$$

³⁶This is without loss of generality. As in the baseline model, it is never optimal to tolerate extortion. As a result, the expected payoff of an entrepreneur who does not comply with regulation but applies for the permit (without going through an intermediary) is strictly positive (because $\sigma = c$ with probability $1 - \rho$ when $e \neq h$).

$$= H(\tilde{\psi}) \cdot (w_{r_c} + b_c - l(c, r)s) + \left(1 - H(\tilde{\psi})\right) \cdot (w_g + p - \rho s).$$

In the expression, w_{r_c} and b_c denote, respectively, the wage and the (direct) bribe the official collects when $\sigma = c$. As before, $l(c, r)$ is an indicator function taking a value of 1 if $r = d$, and 0 otherwise. To interpret this expression, observe that $H(\tilde{\psi})$ is the ex ante probability of facing an entrepreneur that chose to comply with regulation. By contrast, with probability $1 - H(\tilde{\psi})$, the entrepreneur chooses $e = i$, which results in an expected payoff equal to $w_g + p - \rho s$. Note that, by assumption, p does not affect the size of the pool of potential applicants for an official, but only their compliance effort e .

Assume now $U(i) < U(l)$. The official's ex ante payoff is then equal to

$$H(\tilde{\psi}) \cdot (V(c)) + \left(1 - H(\tilde{\psi})\right) \cdot (\rho V(n) + (1 - \rho) V(c)) =$$

$$H(\tilde{\psi}) \cdot (w_{r_c} + b_c - l(c, r)s) + \left(1 - H(\tilde{\psi})\right) \cdot (\rho(w_{r_n} + b_n - l(n, r)s) + (1 - \rho)(w_{r_c} + b_c - l(c, r)s)).$$

In the expression, w_{r_n} and b_n denote, respectively, the wage and the bribe when $\sigma = n$, and $l(n, r)$ is an indicator function taking a value of 1 if $r = g$, and 0 otherwise. With probability $H(\tilde{\psi})$ (resp. $1 - H(\tilde{\psi})$), the official is paired with an entrepreneur who chooses $e = h$ ($e = l$).

No entrepreneur feedback. We begin from the benchmark case in which the government does not make use of entrepreneur feedback; that is, $w_{d,0} = w_{d,1} = w_d$ and $t = 0$. Consider the direct interaction between an official and an entrepreneur. The game played by the two parties is identical to that in the baseline model. Hence, (4) has to hold in order to deter bribery, whereas (5) has to hold to deter extortion (see Section 3.2). As previously shown, the two conditions cannot hold jointly, and the optimal incentive scheme has to be such that (5) holds.³⁷ Therefore, we have $b_c = 0$, $b_n = G$, and $r = g$ for $\forall \sigma$. In words, permits are always

³⁷We provide an informal argument. Suppose the government did not deter extortion. Any entrepreneur complying with regulation would, with probability 1, have to pay a bribe $b = G$ to obtain the permit. Hence, the payoff to an entrepreneur choosing $e = h$ would be nonpositive, implying that no entrepreneur would

granted, but a bribe equal to G is paid when non-compliance is detected.

The following Proposition (proved in the Appendix) describes the outcome in the absence of a feedback scheme:

Proposition 3. *Suppose the government does not rely on entrepreneur feedback to discipline officials.*

- *The optimal incentive scheme is such that $w_g = 0$ and $w_d \in [0, s]$. Officials set $p = \min \left[\frac{\bar{\psi} + \rho s}{2}, \rho G \right]$. A share of entrepreneurs equal to $\min \left[H(\rho G), H \left(\frac{\bar{\psi} + \rho s}{2} \right) \right]$ complies with regulation. The remainder obtain the permit via an intermediary.*
- *If $G > \frac{\bar{\psi} + \rho s}{2\rho}$, the share of noncompliant entrepreneurs is strictly larger than in the baseline model (where intermediaries are ruled out). Otherwise, it is identical.*

In the absence of a feedback scheme, providing officials with low-powered incentives—thereby leaving the door open to bribery—is optimal. Moreover, officials collect bribes from intermediaries rather than directly from noncompliant entrepreneurs. The intuition is as follows. Consider an entrepreneur who is unwilling to comply with regulation. The cost of acquiring the permit via an intermediary is p , and equal to the expected bribe ρG if dealing with the official directly (i.e., the probability ρ that non-compliance is uncovered times the bribe G). Suppose $p = \rho G$. Because the expected share of noncompliant entrepreneurs (i.e., those for which $\psi < p$) is $1 - H(\rho G)$, and because the official collects ρG from each, he obtains an expected payoff equal to that he would have enjoyed had he decided not to deal with intermediaries.³⁸ Nevertheless, when the expected bribe ρG is large enough, the official finds it profitable to reduce p . By so doing, he reduces the expected revenue collected from inframarginal noncompliant entrepreneurs (who would have chosen $e = i$ even at $p = \rho G$), but the higher probability of facing a noncompliant entrepreneur more than compensates the

choose to comply with regulation. Clearly, this outcome cannot be socially desirable.

³⁸If an official sets $p > \rho G$, all associated entrepreneurs who do not comply with regulation avoid intermediaries, i.e., they choose $e = l$. However, the official's expected payoff would be the same as when $p = \rho G$. Hence, this strategy is weakly dominated.

reduction. However, in a one-shot interaction with an entrepreneur, the official cannot commit to an expected bribe lower than ρG , even if reducing it to attract more “customers” (i.e., more entrepreneurs choosing not to comply with regulation) could be desirable. By contrast, the official can commit to p before entrepreneurs choose e . As a result, the expected cost of obtaining a permit without compliance can be credibly set below ρG .

An immediate consequence of Proposition 3 is that intermediaries make non-compliance more pervasive when $G > \frac{\bar{\psi} + \rho s}{2\rho}$ (and do not affect it otherwise). Under this condition, the role of intermediaries reduces social welfare.

Corollary. *Suppose the government does not rely on entrepreneur feedback to discipline officials. Banning intermediaries would be socially desirable if and only if $G > \frac{\bar{\psi} + \rho s}{2\rho}$.*

Of course, even a welfare-maximizing government could have difficulties cracking down on intermediaries, given that many operate in the informal sector. The government may therefore have to devise a strategy to provide officials with the right incentives to reject indirect bribes. However, just like in our baseline model, the threat of extortion makes it impossible, and there is no better option than designing low-powered incentives.

Entrepreneur Feedback. We now let the government exploit entrepreneur feedback. We restrict attention to the case in which $G > \frac{\bar{\psi} + \rho s}{2\rho}$, because we are interested in situations in which, in the absence of feedback, social welfare would improve if intermediaries were unavailable (see above). Furthermore, we do not characterize the optimal incentive scheme. Rather, we establish the existence of a scheme that (i) makes it possible to deter both extortion and bribery (direct as well indirect), and (ii) increases social welfare. This partial approach is sufficient to establish that exploiting entrepreneur feedback is useful also in presence of intermediaries. The mechanism we characterize is close in spirit to that of Proposition 2, and is such that officials are rewarded only when they deny permits without triggering complaints, i.e., $w_{d,0} \geq G - s > w_{d,1} = w_g = 0$.

In the following, let $\bar{G} \equiv \frac{\bar{\psi} - \frac{\rho s}{z} + \sqrt{(\bar{\psi} - \rho s/z)^2 - \frac{1}{z}((\bar{\psi} - \rho s)^2 - 4\rho s\bar{\psi})}}{2\rho}$ denote a threshold on G and let $\bar{w} \equiv \frac{(\bar{\psi} - \rho s)^2}{4\rho(\bar{\psi} - \rho G)}$ denote a threshold on $w_{d,0}$.

Proposition 4. *Assume deterring bribery is socially optimal, but not possible without exploiting entrepreneur feedback.*

Provided $G \leq \bar{G}$, by exploiting feedback and setting $w_{d,0} = \bar{w} > w_{d,1} = w_g = 0$, the government can deter all forms of corruption, including indirect bribery. Also, a threshold D^I exists such that, when $D > D^I$, social welfare is strictly higher when this scheme is implemented than when entrepreneur feedback is not exploited.

If $G > \bar{G}$, the feedback scheme fails to deter all forms of corruption.

The logic underpinning this scheme is identical to the baseline model. To fully deter bribery, however, the government also needs to make sure officials do not find it profitable to sell permits through intermediaries. This can be achieved by raising $w_{d,0}$ up to \bar{w} (observe that the optimal $w_{d,0}$ in absence of intermediaries, as stated in Proposition 2, is equal to $G - s$, which is smaller than \bar{w}). Intuitively, when the expected gain from catching noncompliant entrepreneurs is large enough, officials are better off not dealing with intermediaries (formally, they set p so high that using intermediaries is prohibitively expensive for entrepreneurs).

Proposition 4 states that entrepreneur feedback may help tackle intermediated corruption.³⁹ However, when it is feasible, the scheme is more expensive than if intermediaries were absent. This is not surprising: in our model, intermediaries allow officials to commit to bribes which would be unfeasible otherwise. Hence, they leave the government with no choice but to pay higher bonuses to deter bribery. In fact, the feedback scheme may require a bonus so large that, ultimately, it may not be implementable (without being abused). Specifically, \bar{w} cannot exceed $Gz + s$ —or, equivalently, $G \leq \bar{G}$, for otherwise an official receives so much when

³⁹Recall that, for the sake of brevity, we do not compute the thresholds on damages D that ensure that the achieved level of social welfare is nonnegative. However, by, for instance, setting $\lambda = 1$, one immediately derives that the region of parameter values such that exploiting feedback is optimal and social welfare positive is nonempty.

denying a permit that he finds it profitable to systematically choose $r = d$ and compensate compliant entrepreneurs for the value of the permit.⁴⁰ Intuitively, this condition is more easily satisfied when the cost of abusing the scheme for officials increases: \bar{G} is increasing in both z and s .

4.2 Limited ability to pay

In the Supplementary Appendix, we extend our model to incorporate the fact that entrepreneurs' ability to pay for permits might not match their willingness to pay. At the time when they interact with officials, financial resources available to entrepreneurs could be lower than the value of a permit, for example, due to imperfections on the credit market (e.g., Banerjee (1997)). As a consequence, the size of bribes that entrepreneurs can pay may be smaller than what we considered in Section 3 (i.e., G). We briefly discuss the consequences of taking in account entrepreneurs' budget constraints on our main results.

For reasons of space, we only discuss the main results here (we present and solve the extended model in the Supplementary Appendix). We find that limited ability to pay increases the desirability of adopting an entrepreneur feedback scheme. Specifically, let the entrepreneur's budget be denoted as y . If $y < G$, the set of parameter values for which exploiting feedback is optimal is strictly larger than in the baseline model. The intuition is as follows. As argued in Proposition 2, deterring both forms of corruption is optimal only if the harm produced by non-compliance is sufficiently large. Otherwise, the government should tolerate bribery. One reason bribery is less detrimental than extortion is that it hurts entrepreneurs found noncompliant with regulation—by paying a bribe, they forego some of the benefits associated with obtaining the permit without complying, thereby inducing some

⁴⁰To understand the inequality $G \leq \bar{G}$, observe that the probability of receiving $w_{d,0}$ is the joint probability of being paired with a noncompliant entrepreneur and observing $\sigma = n$. When corruption is deterred, this probability is $(1 - H(\rho G)) \rho = \frac{\bar{\psi} - \rho G}{\bar{\psi}} \rho$ (see the commentary to Proposition 2 for the intuition). Intuitively, the smaller the probability of receiving $w_{d,0}$, the larger $w_{d,0}$ must be to make the commitment not to deal with intermediaries rational. Thus, \bar{w} increases with G . Moreover, because we are restricting attention to $\frac{\bar{\psi} + \rho s}{2\rho} < G$, the upper bound $Gz + s$ increases with G with a smaller slope than \bar{w} (except if z is so large that \bar{G} exceeds $\bar{\psi}$).

to comply with regulation to avoid having to pay a bribe. However, when bribes are limited at $y < G$, this disciplining effect of bribes is weakened, and tolerating bribery becomes more costly.

4.3 Bargaining power of entrepreneurs

We have so far worked under the assumption that officials have full bargaining power when making deals with entrepreneurs. This assumption is justified by our focus on settings in which ordinary citizens and small businesses deal with public officials to obtain a government service. Nevertheless, in the Supplementary Appendix, we generalize our setting to allow for the bargaining outcome between officials and entrepreneurs to be determined by the Nash Bargaining solution concept. The main results of our analysis remain unchanged when entrepreneurs enjoy some bargaining power. In particular, the government is still unable—if it does not exploit feedback—to deter both extortion and bribery. To deter bribery, the government must still satisfy inequality (4); that is, the surplus to be shared between an official and an entrepreneur when $\sigma = n$ must be highest when $r = d$. Similarly, to deter extortion, the government must still ensure inequality (5) holds; that is, the threat of framing must not be credible. Both inequalities cannot jointly hold, and the government must again choose between tolerating either extortion or bribery. Tolerating bribery is still socially optimal, unless entrepreneurs enjoy high bargaining power. In the latter case, extortion’s detrimental consequences on the incentives to comply with regulation are low, and avoiding bribery (and the negative externalities that would ensue) is preferable.

By exploiting feedback, we show the government is able to deter both forms of corruption. As in the baseline model, implementing the feedback scheme is socially optimal as long as the damages D are sufficiently high to justify the increased payroll expenses.

5 Conclusion

One of the most detrimental consequences of petty corruption is that it undermines regulations aiming to protect society from risks and hazards. We have made the case for a simple mechanism that exploits entrepreneurs' complaints and enables the government to deter corruption. The mechanism does not rely on the government being able to distinguish accurate from opportunistic complaints, and neither does it require the involvement of costly (and possibly corrupt) internal or external monitors. We have also shown that, under reasonable conditions, the presence of intermediaries makes exploiting entrepreneur feedback even more desirable.

We believe the feedback scheme developed in this paper could be helpful in settings different from the one we have considered. A first example is tax collection. Tax inspectors—whose task is to uncover and punish fraud—may be tempted to both collect bribes from violators and to extort money from compliant tax payers. Such misbehavior clearly has the potential to distort individuals' and firms' incentives to pay taxes (see, e.g., Hindriks et al. (1999)), and, presumably, the feedback scheme could allow the government to deter corruption *and* tax evasion. A similar logic holds for customs duties, which represent an important source of revenue to governments in many countries, and for which widespread corruption is documented (Sequeira and Djankov (2013)). In both examples, governments could compensate taxpayers who cooperate by promising appropriate reductions in the fines.

The enforcement of traffic law provides yet another example. For instance, because overweight trucks increase the wear and tear of roads and the risk of accidents, trucking firms are generally required to respect ceilings on truck weight. Weigh stations are set up along the main commercial routes and, in case of non-compliance, governments mandate the unloading of excessive cargo and the imposition of fines. However, officials manning these stations are often corrupt (see, e.g., Olken and Barron (2009) for Indonesia and Foltz and Bromley (2014) for West Africa). Exactly as in the context of tax compliance, to deter corruption, governments

could introduce a feedback scheme and promise reduced sanctions to firms or drivers filing complaints.

Finally, we also believe the mechanism we propose can be applied to tackle collusion and abuses of authority within firms. Monitoring by supervisors is crucial to ensure employees have adequate incentives to follow directives. As previous literature has pointed out (see, e.g., Tirole (1992), Khalil et al. (2010)), collusion with (and harassment of) subordinates is common in organizations. Although the ultimate objective of the principal might be to maximize profit rather than social welfare, we believe the mechanism we propose can also help deter opportunism by supervisors.

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A Appendix: Proofs of Propositions and Lemmas

A.1 Preliminaries.

We introduce the following notation. Consider a given entrepreneur-official pair.

- We denote by r'_σ (resp. f'_σ) the official's equilibrium decision (resp. the entrepreneur's equilibrium feedback to the government) played in the subgame that follows the entrepreneur's rejection of the official's deal, for a given σ . We refer to this subgame as the "noncooperative game."
- We denote by r_σ^* (resp. f_σ^* and b_σ^*) the official's equilibrium decision (resp. the entrepreneur's equilibrium feedback and the equilibrium bribe) played in the subgame that follows the entrepreneur's acceptance of the official's deal, for a given σ . This is the solution to problem (1), and we refer to this subgame as the "cooperative game."
- Because payoff functions are additively separable in their arguments, we can write $U(\psi, e, r, f, b) \equiv u(r, f) - \psi I(e) - b$, where $I(h) = 1$ and $I(l) = 0$. We denote $u'_\sigma \equiv u(r'_\sigma, f'_\sigma)$ the payoff obtained by the entrepreneur in the noncooperative game,⁴¹ and $V'_\sigma \equiv V(\sigma, r'_\sigma, f'_\sigma)$ the corresponding payoff of the official.

The following lemma is useful in limiting the number of cases that need to be considered in the proofs to come.

Lemma A.1

Any schedule of wages that leads to $(r'_c, f'_c) = (r'_n, f'_n)$ results in a nonpositive level of social welfare if the activity is allowed.

Proof. Consider (1). Because payoff functions are additively separable in their arguments, we can write $U(\psi, e, r, f, b) \equiv u(r, f) - \psi I(e) - b$ and $V(\sigma, r, f, b) \equiv v(\sigma, r, f) + b$. (1) can be

⁴¹Recall that the compliance cost $I(e)\psi$ is sunk at this stage.

rewritten as

$$\begin{aligned} \max_{\{\sigma, r, f, b\}} \quad & v(\sigma, r, f) + b \quad \text{subject to} \\ & u(r, f) - \psi I(e) - b \geq u(r'_\sigma, f'_\sigma) - \psi I(e). \end{aligned}$$

Clearly, $b_\sigma^* = u(r_\sigma^*, f_\sigma^*) - u(r'_\sigma, f'_\sigma)$, and therefore, $U(\psi, e, r_\sigma^*, f_\sigma^*, b_\sigma^*) = u(r'_\sigma, f'_\sigma) - \psi I(e)$ for $\forall \sigma, e$.

An entrepreneur intent on applying, and with compliance cost ψ , chooses $e = h$ if and only if

$$U(\psi, h, r_c^*, f_c^*, b_c^*) \geq \rho U(\psi, l, r_n^*, f_n^*, b_n^*) + (1 - \rho) U(\psi, l, r_c^*, f_c^*, b_c^*).$$

Substituting in $U(\psi, e, r_\sigma^*, f_\sigma^*, b_\sigma^*) = u(r'_\sigma, f'_\sigma) - \psi I(e)$, the inequality becomes

$$u(r'_c, f'_c) - \psi \geq \rho u(r'_n, f'_n) + (1 - \rho) u(r'_c, f'_c).$$

In case $(r'_c, f'_c) = (r'_n, f'_n)$, the inequality is violated. As a result, no entrepreneur chooses $e = h$, and, because $D > G$ by assumption, social welfare is bounded from above by 0. □

A.2 Proof of Proposition 1

Noncooperative Game

We first compute r'_σ and u'_σ for $\forall \sigma$. If $w_d > w_g + s$, then $r'_\sigma = d$ for $\forall \sigma$ and, thus, $u'_\sigma = 0$ for $\forall \sigma$. If $w_g + s \geq w_d \geq w_g - s$, then $r'_c = g$ and $r'_n = d$. Thus $u'_c = G$ and $u'_n = 0$. Finally, if $w_g - s > w_d$, then $r'_\sigma = g$ for $\forall \sigma$, and thus $u'_\sigma = G$ for $\forall \sigma$.

Cooperative Game

We now compute r_σ^* for $\forall \sigma$. Given e and σ , any entrepreneur-official pair's collective payoff is given by

$$U(\psi, e, r, f, b) + V(\sigma, r, f, b) = \begin{cases} w_g + G - l(\sigma, g) s - \psi I(e) & \text{if } r = g, \\ w_d - l(\sigma, d) s - \psi I(e) & \text{if } r = d, \end{cases}$$

where $l(\sigma, g)$ (resp. $l(\sigma, d)$) is equal to 1 if $\sigma = n$ (resp. $\sigma = c$), and 0 otherwise. Therefore, if $w_d > w_g + s + G$, then $r_\sigma^* = d$ for $\forall \sigma$. If $w_g + s + G \geq w_d \geq w_g - s + G$, then $r_c^* = g$ and $r_n^* = d$. Finally, if $w_g - s + G > w_d$, then $r_\sigma^* = g$ for $\forall \sigma$.

Officials' Optimal Schedule of Wages

From Lemma A.1, we know no loss of generality occurs in restricting our attention to schedules of wages satisfying: $w_g + s \geq w_d \geq w_g - s$. Thus, $r'_c = g$ and $r'_n = d$, so that $u'_c = G$ and $u'_n = 0$. Moreover, because $w_g + s \geq w_d$ and $G > 2s$, it must be the case that $w_g - s + G > w_d$. Hence, $r^*_\sigma = g$ for $\forall \sigma$.

To determine b^*_c , the official maximizes $w_g + b_c$ subject to $G - b_c \geq u'_c = G$, which yields $b^*_c = 0$. To determine b^*_n , the official maximizes $w_g - s + b_n$ subject to $G - b_n \geq u'_n = 0$, which yields $b^*_n = G$.

Therefore, an entrepreneur intent on applying, and with compliance cost ψ , chooses $e = h$ if and only if $G - b^*_c - \psi \geq \rho(G - b^*_n) + (1 - \rho)(G - b^*_c)$, which simplifies to $\rho G \geq \psi$. Because $\rho(G - b^*_n) + (1 - \rho)(G - b^*_c) = (1 - \rho)G > 0$, all entrepreneurs apply for the permit. Also, a fraction $H(\rho G)$ of entrepreneurs chooses $e = h$, and the rest choose $e = l$.

The government chooses $\{w_g, w_d\}$ to maximize

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) + \int_{\rho G}^{\bar{\psi}} (G - D) dH(\psi) - (\lambda - 1)w_g \text{ subject to} \quad (12)$$

$$w_d \in [w_g - s, w_g + s].$$

Setting $w_g = 0$ and $w_d \in [0, s]$ is optimal. Moreover, expression (12), plugging in $w_g = 0$, is strictly positive if and only if $D < D_0^{NF} \equiv \frac{G - \int_0^{\rho G} \psi dH(\psi)}{1 - H(\rho G)}$. Therefore, when this inequality holds, setting $w_g^* = 0$ and $w_d^* \in [0, s]$ is socially optimal. Otherwise, the government cannot do better than to ban the activity.

A.3 Proof of Proposition 2

Noncooperative Game

We compute r'_σ , f'_σ , and u'_σ for $\forall \sigma$. Because $t > 0$, an entrepreneur chooses $f_\sigma = 1 \forall \sigma$ when $r = d$. This leads to three possible outcomes of the noncooperative game. If $w_g > w_{d,1} + s$, then $r'_\sigma = g$ and $u'_\sigma = G$ for $\forall \sigma$. If $w_{d,1} + s \geq w_g \geq w_{d,1} - s$, then $r'_c = g$, $u'_c = G$, $r'_n = d$, $f'_n = 1$, and $u'_n = t$. If $w_{d,1} - s > w_g$, then $r'_\sigma = d$, $f'_\sigma = 1$, and $u'_\sigma = t$, $\forall \sigma$.

Cooperative Game

We now compute r_σ^* and f_σ^* for $\forall\sigma$. Any entrepreneur-official pair's collective payoff is given by

$$U(\psi, e, r, f, b) + V(\sigma, r, f, b) = \begin{cases} w_g + G - l(\sigma, g) s - \psi I(e) & \text{if } r = g, \\ w_{d,0} - l(\sigma, d) s - \psi I(e) & \text{if } r = d \text{ and } f = 0, \\ w_{d,1} + t - l(\sigma, d) s - \psi I(e) & \text{if } r = d \text{ and } f = 1, \end{cases}$$

where $l(\sigma, g)$ (resp. $l(\sigma, d)$) is equal to 1 if $\sigma = n$ (resp. $\sigma = c$), and 0 otherwise. We disregard the schedules of wages $\{w_g, w_{d,0}, w_{d,1}\}$ that would lead to $r_\sigma^* = d$ for $\forall\sigma$. Indeed, the government can always do better than to systematically deny permits by banning the activity. This leaves us with three possible outcomes of the cooperative game to consider

- **Case i:** $w_g + G > \max[w_{d,0} + s, w_{d,1} + t + s]$, so that $r_\sigma^* = g$ for $\forall\sigma$.
- **Case ii:** $w_{d,0} - s \leq w_g + G \leq w_{d,0} + s$ and $w_{d,0} \geq w_{d,1} + t$, so that $r_c^* = c$, $r_n^* = d$, and $f_n^* = 0$.
- **Case iii:** $w_{d,1} - s + t \leq w_g + G \leq w_{d,1} + s + t$ and $w_{d,1} + t \geq w_{d,0}$, so that $r_c^* = g$, $r_n^* = d$, and $f_n^* = 1$.

Officials' Optimal Schedule of Wages

From Lemma A.1, we know no loss of generality occurs in restricting our attention to schedules of wages satisfying: $w_{d,1} + s \geq w_g \geq w_{d,1} - s$. Thus, $r'_c = g$, $r'_n = d$, and $f'_n = 1$. Also, $u'_c = G$ and $u'_n = t$.

For each case, if relevant, we characterize the associated expression for the social welfare function, and the (locally) optimal schedule of wages. We then compare welfare levels to determine the globally optimal schedule of wages $\{w_g, w_{d,0}, w_{d,1}\}$.

Case i

Here, $r_\sigma^* = g$ for $\forall\sigma$. To determine b_c^* , the official maximizes $w_g + b_c$ subject to $G - b_c \geq u'_c = G$, which yields $b_c^* = 0$ for $\forall\sigma$. To determine b_n^* , the official maximizes $w_g - s + b_n$ subject to $G - b_n \geq u'_n = t$, which yields $b_n^* = G - t$ for $\forall\sigma$. As a result, an entrepreneur intent on applying, with compliance cost ψ , chooses $e = h$ if and only if

$$G - b_c^* - \psi \geq \rho(G - b_n^*) + (1 - \rho)(G - b_c^*),$$

which simplifies to $\psi \leq \rho(G - t)$. Because $\rho t + (1 - \rho)G > 0$, all entrepreneurs apply for the permit. A fraction $H(\rho(G - t))$ of them chooses $e = h$, and the rest choose $e = l$.

The government chooses $\{w_g, w_{d,0}, w_{d,1}, t\}$ to maximize

$$W = \int_0^{\rho(G-t)} (G - \psi) dH(\psi) + (1 - H(\rho(G - t))) (G - D - \rho s) - (\lambda - 1) w_g \text{ s. t.} \quad (13)$$

$$w_g \in [w_{d,1} - s, w_{d,1} + s], \quad (14)$$

$$w_{d,1} + (t + s) < w_g + G, \quad (15)$$

$$w_{d,0} + s < w_g + G. \quad (16)$$

Setting $w_g = 0$, $w_{d,0} \in [0, G - s)$, and $w_{d,1} \in [0, s]$ is optimal because it achieves the highest possible value of (13) while satisfying all constraints. Observe also that (13) is decreasing in t , so that setting t arbitrarily close to 0 is optimal. Social welfare is then made arbitrarily close to

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) + \int_{\rho G}^{\bar{\psi}} (G - D - \rho s) dH(\psi). \quad (17)$$

Case ii

Here, $r_c^* = g$, $r_n^* = d$, and $f_n^* = 0$. To determine b_c^* , the official maximizes $w_g + b_c$ subject to $G - b_c \geq u'_c = G$, which yields $b_c^* = 0$. To determine b_n^* , the official maximizes $w_{d,0} + b_n$ subject to $0 - b_n \geq u'_n = t$, which yields $b_n^* = -t$.

An entrepreneur intent on applying, with compliance cost ψ , chooses $e = h$ if and only if

$$G - b_c^* - \psi \geq \rho(0 - b_n^*) + (1 - \rho)(G - b_c^*),$$

which simplifies to $\psi \leq \rho(G - t)$. Because $\rho t + (1 - \rho)G > 0$, all entrepreneurs apply for the permit. A fraction $H(\rho(G - t))$ of them chooses $e = h$, and the rest choose $e = l$.

The government chooses $\{w_g, w_{d,0}, w_{d,1}, t\}$ to maximize

$$W = \int_0^{\rho(G-t)} (G - \psi) dH(\psi) + (1 - \rho) \int_{\rho(G-t)}^{\bar{\psi}} (G - D) dH(\psi) \quad (18)$$

$$- [1 - \rho(1 - H(\rho(G - t)))] (\lambda - 1) w_g - (1 - H(\rho(G - t))) \rho (\lambda - 1) w_{d,0} \text{ s.t.}$$

$$w_g + G \in [w_{d,0} - s, w_{d,0} + s], \quad (19)$$

$$w_{d,0} \geq w_{d,1} + t, \quad (20)$$

$$w_g \in [w_{d,1} - s, w_{d,1} + s]. \quad (21)$$

Notice objective function (18) is decreasing in w_g and $w_{d,0}$. Also, from (19) and (20), $w_{d,0}$ is bounded from below by $w_{d,1} + t$ and $w_g + G - s$. Suppose only constraint $w_{d,0} \geq w_g + G - s$

binds. Substituting $w_{d,0} = w_g + G - s$ into (18), one immediately derives that setting $w_g = 0$ and t arbitrarily close to 0 is optimal. Moreover, setting $w_{d,1} \in [0, s]$ ensures that the other constraints are indeed satisfied. Social welfare is then equal to

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) + (1 - \rho) \int_{\rho G}^{\bar{\psi}} (G - D) dH(\psi) - (1 - H(\rho G)) \rho (\lambda - 1) (G - s). \quad (22)$$

Observe that (22) is positive if and only if

$$D \leq D_0^F \equiv \frac{1}{1 - \rho} \left(\bar{D} - \lambda \rho (G - s) \right).$$

Case iii

Here, $r_c^* = g$, $r_n^* = d$, and $f_n^* = 1$. To determine b_c^* , the official maximizes $w_g + b_c$ subject to $G - b_c \geq u'_c = G$, which yields $b_c^* = 0$. To determine b_n^* , the official maximizes $w_{d,1} + b_n$ subject to $t - b_n \geq u'_n = t$, which yields $b_n^* = 0$.

An entrepreneur intent on applying, and with compliance cost ψ , chooses $e = h$ if and only if

$$G - b_c^* - \psi \geq \rho (t - b_n^*) + (1 - \rho) (G - b_c^*),$$

which simplifies to $\psi \leq \rho (G - t)$. Because $\rho t + (1 - \rho) G > 0$, all entrepreneurs apply. A fraction $H(\rho (G - t))$ of them chooses $e = h$, and the rest choose $e = l$.

The government chooses $\{w_g, w_{d,0}, w_{d,1}, t\}$ to maximize

$$W = \int_0^{\rho(G-t)} (G - \psi - (\lambda - 1) w_g) dH(\psi) + (1 - H(\rho(G-t))) (1 - \rho) (G - D - (\lambda - 1) w_g) - (1 - H(\rho(G-t))) \rho (\lambda - 1) (w_{d,1} + t), \quad (23)$$

subject to the conditions on w_g , $w_{d,0}$, and $w_{d,1}$ that define Case iii.

Because the inequality $w_{d,1} + t \geq w_g + G - s$ must hold, for expression (23) to be equal to (22), it must necessarily be the case that $w_g = 0$, $w_{d,1} = G - s$, and t be set arbitrarily close to 0. Any other combination of w_g , $w_{d,1}$, and t satisfying the inequality $w_{d,1} + t \geq w_g + G - s$ leads to (23) being strictly lower than (22). Moreover, setting $w_g = 0$, $w_{d,1} = G - s$, and t arbitrarily close to 0 violates the condition whereby $w_g \geq w_{d,1} - s$. We can therefore infer that the highest possible level of welfare in Case iii is lower than that achieved in Case ii. We can safely disregard schedules of wages that satisfy the conditions of Case iii.

Socially optimal scheme

The last step involves comparing welfare levels. Only two wage schedules are relevant: those associated with Case i and Case ii. Welfare level (22) is strictly higher than (17) if and only if $D > D^F \equiv \lambda(G - s)$. It is thus necessary for this condition to hold for the feedback scheme to be optimal. Further, welfare level (22) is nonnegative if and only if $D \leq D_0^F$. Thus, it is also necessary that this condition holds for the implementation of the feedback scheme to be preferred over banning the activity. Finally, $D_0^F \geq D^F$ if and only if $\lambda \leq \frac{D_0^{NF}}{G-s}$. Thus, it is optimal to exploit feedback whenever $\lambda \leq \frac{D_0^{NF}}{G-s}$ and $D^F < D \leq D_0^F$. If $\lambda \leq \frac{D_0^{NF}}{G-s}$ and $D \leq D^F$, the wage schedule associated to Case i is optimal: the government does not exploit feedback but allows the activity.

Finally, if $\lambda > \frac{D_0^{NF}}{G-s}$ and $D \leq D_0^{NF}$, the optimal incentive scheme is again the wage schedule associated to Case i. If $\lambda > \frac{D_0^{NF}}{G-s}$ and $D > D_0^{NF}$, the government should ban the activity.

A.4 Proof of Proposition 3

In Section 4.1, we argued that tolerating bribery so as to deter extortion was optimal. Recall also that we anticipate, without loss of generality, that all entrepreneurs apply for the permit. Because $b_c = 0$, $b_n = G$, and $r = g$ for $\forall \sigma$, an entrepreneur chooses $e = h$ if and only if

$$G - \psi \geq \begin{cases} (1 - \rho)G & \text{if } p > \rho G, \\ G - p & \text{if } \rho G \geq p. \end{cases} \quad (24)$$

In (24), the right-hand side is the maximum between the expected payoff an entrepreneur enjoys when $e = l$ and that when $e = i$. Given that extortion is ruled out, an entrepreneur who complies with regulation obtains the permit with probability 1. Those who do not comply either directly bribe officials (when detected) or acquire the permit through an intermediary. In the former case, the cost of obtaining the permit is the expected bribe ρG . In the latter, it is p . Hence, when $p > \rho G$, all entrepreneurs who do not comply with regulation prefer to deal directly with officials. When $\rho G \geq p$, they all prefer to deal with intermediaries. Hence, $\tilde{\psi} = \min(\rho G, p)$. As one would expect, the fraction of entrepreneurs who comply with regulation is nondecreasing in p .

Consider now the ex ante payoff of a given official. This payoff can be written as

$$w_g + \begin{cases} (1 - H(\rho G)) \cdot \rho(G - s) & \text{if } p > \rho G, \\ (1 - H(p)) \cdot (p - \rho s) & \text{if } \rho G \geq p. \end{cases} \quad (25)$$

When $p > \rho G$, the entrepreneur with whom the official is paired does not use an intermediary. Therefore, the official anticipates that the probability of dealing with a noncompliant entrepreneur is $1 - H(\rho G)$, and that the expected bribe from such an entrepreneur (net of the lying cost s) is $\rho(G - s)$. When $\rho G \geq p$, the official knows the entrepreneur with whom he is paired uses an intermediary if noncompliant (i.e., all entrepreneurs for which $\psi \leq p$ choose $e = h$). Hence, the probability of dealing with an intermediary is $1 - H(p)$, and the payoff is equal to $p - \rho s$. Finally, because bribery is tolerated, the official always grants the permit and pockets w_g .

We maximize (25) with respect to p . The objective function is $\frac{\bar{\psi} - \rho G}{\bar{\psi}} \cdot \rho(G - s)$ for $\forall p > \rho G$. If $p \leq \rho G$, the objective function is $(1 - H(p)) \cdot (p - \rho s) = \left(1 - \frac{p}{\bar{\psi}}\right)(p - \rho s)$. Because $H(p) = \frac{p}{\bar{\psi}}$, the locally optimal p is equal to $\min\left[\rho G, \frac{\bar{\psi} + \rho s}{2}\right]$, which leads to an ex ante payoff equal to $\max\left[\frac{\bar{\psi} - \rho G}{\bar{\psi}} \cdot \rho(G - s), \frac{\bar{\psi}^2 - (\rho s)^2}{4\bar{\psi}}\right]$. The globally optimal p is equal to $\min\left[\rho G, \frac{\bar{\psi} + \rho s}{2}\right]$.⁴² Using (24), it follows that a fraction $\min\left[H\left(\frac{\bar{\psi} + \rho s}{2}\right), H(\rho G)\right]$ of entrepreneurs chooses $e = h$, whereas the remainder choose $e = i$.

A.5 Proof of the Corollary to Proposition 3

Following Proposition 3, when $G > \frac{\bar{\psi} + \rho s}{2\rho}$, welfare is equal to

$$W = \int_0^{\frac{\bar{\psi} + \rho s}{2}} (G - \psi) dH(\psi) - \int_{\frac{\bar{\psi} + \rho s}{2}}^{\bar{\psi}} (D - G + \rho s) dH(\psi) - (\lambda - 1) w_g.$$

Because (5) must hold, setting $w_g = 0$ and $w_d \in [0, s]$ is optimal. Hence,

$$W = \int_0^{\frac{\bar{\psi} + \rho s}{2}} (G - \psi) dH(\psi) - \int_{\frac{\bar{\psi} + \rho s}{2}}^{\bar{\psi}} (D - G + \rho s) dH(\psi). \quad (26)$$

Assume now $G \leq \frac{\bar{\psi} + \rho s}{2\rho}$. From Proposition 3, we have

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) - \int_{\rho G}^{\bar{\psi}} (D - G + \rho s) dH(\psi) - (\lambda - 1) w_g.$$

Again, setting $w_g = 0$ and $w_d \in [0, s]$ is optimal. Hence,

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) - \int_{\rho G}^{\bar{\psi}} (D - G + \rho s) dH(\psi). \quad (27)$$

⁴²The official's ex ante payoff is constant for any $p \geq \rho G$, we assume that, when indifferent between several values of p , the official chooses the smallest.

Finally, assume that the government bans intermediaries. The action space is restricted to $e = \{l, h\}$. Following the same steps as in the proof of Proposition 1, one obtains that

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) - \int_{\rho G}^{\bar{\psi}} (D - G + \rho s) dH(\psi). \quad (28)$$

We can now compare social welfare in the presence and in the absence of intermediaries. When $G > \frac{\bar{\psi} + \rho s}{2\rho}$, (26) is strictly smaller than (28). When $G \leq \frac{\bar{\psi} + \rho s}{2\rho}$, (28) and (27) are identical.

A.6 Proof of Proposition 4

We first characterize the outcome of the noncooperative and cooperative games played by a given entrepreneur-official pair. We then compute the optimal price an intermediary charges, and end with a welfare analysis. Recall also that we assume $w_{d,0} \geq G - s > w_{d,1} = w_g = 0$ and $t = \epsilon > 0$ and arbitrarily small.

Direct interaction between official and entrepreneur ($e = h, l$).

Consider the noncooperative game played by a given entrepreneur-official pair. Because $t > 0$, $f = 1$ when $r = d$. Thus, when $\sigma = c$, the official's payoff is equal to 0 if $r = g$ and equal to $-s$ otherwise. When $\sigma = n$, the official's payoff is equal to $-s$ when $r = g$, and equal to 0 otherwise. It follows that (i) $r'_c = g$ and $u'_c = G$ and (ii) $r'_n = d$ and $u'_n = t$.

Consider now the cooperative game. Because $u'_c = G$, the official proposes $b_c^* = 0$ and $r_c^* = g$ if $w_{d,0} \leq Gz + s$, and $b_c^* = -G$, $r_c^* = d$, and $f_c^* = 0$ otherwise. Hence, when $\sigma = c$, the entrepreneur (official) obtains G (0) if $w_{d,0} \leq Gz + s$, and $G(w_{d,0} - Gz - s)$ otherwise. Suppose now $\sigma = n$. The official chooses $b_n^* = -\epsilon$ and $r_n^* = d$, and $f_n^* = 0$. Hence, when $\sigma = n$, the entrepreneur (official) obtains $\epsilon(w_{d,0} - \epsilon)$. Recall that ϵ is arbitrarily small.

Given that setting $w_{d,0} > Gz + s$ entails $r_\sigma^* = d$ for $\forall \sigma$, we disregard incentive schemes such that this condition holds: permits would be systematically denied and social welfare would be bounded from above by 0.

Interaction with intermediary ($e = i$).

When interacting with an intermediary, an official grants the permit in exchange for p . The entrepreneur (official) obtains $G - p$ ($p - \rho s$).

Price setting by the official.

An entrepreneur with cost of compliance ψ chooses $e = h$ if and only if

$$G - b_c^* - \psi \geq \max[(1 - \rho)(G - b_c^*) + \rho b_n^*, G - p, 0],$$

which simplifies to $G - \psi \geq \max[(1 - \rho)G, G - p]$. Making use of this constraint, and recalling

that $w_g = 0$, an official's ex ante payoff is equal to

$$\begin{cases} (1 - H(p)) \cdot (p - \rho s) & \text{if } \rho G \geq p \\ (1 - H(\rho G)) \cdot \rho w_{d,0} & \text{if } p > \rho G. \end{cases}$$

Maximizing the above with respect to p yields the following. If $p \leq \rho G$, the official's payoff is $(1 - H(p)) \cdot (p - \rho s) = \left(1 - \frac{p}{\bar{\psi}}\right) (p - \rho s)$. Because $H(p) = \frac{p}{\bar{\psi}}$, the locally optimal p is $\min \left[\rho G, \frac{\bar{\psi} + \rho s}{2} \right]$, which entails an ex ante payoff of $\max \left[\frac{\bar{\psi} - \rho G}{\bar{\psi}} \cdot \rho (G - s), \frac{\bar{\psi}^2 - (\rho s)^2}{4\bar{\psi}} \right]$. The payoff is $\left(\frac{\bar{\psi} - \rho G}{\bar{\psi}} \right) \cdot \rho w_{d,0}$, for $\forall p > \rho G$. As mentioned in the statement of Proposition 4, we restrict attention to the case $G > \frac{\bar{\psi} + \rho s}{2\rho}$. Hence, the official sets $p = \frac{\bar{\psi} + \rho s}{2}$ if $w_{d,0} < \bar{w} \equiv \frac{\bar{\psi}^2 - (\rho s)^2}{4\rho(\bar{\psi} - \rho G)}$, and $\rho G < p$ otherwise.

Because $w_{d,0} \leq Gz + s$ must hold, for $w_{d,0} \geq \bar{w}$ to be feasible it must be that $\bar{w} \leq Gz + s$. Solving this last inequality with respect to G , we obtain that it holds if and only if $\underline{G} \leq G \leq \bar{G}$, where

$$\underline{G} \equiv \frac{(\bar{\psi} - \rho s/z) - \sqrt{(\bar{\psi} - \rho s/z)^2 - \frac{1}{z} \left((\bar{\psi} - \rho s)^2 - 4\rho s \bar{\psi} \right)}}{2\rho},$$

$$\bar{G} \equiv \frac{(\bar{\psi} - \rho s/z) + \sqrt{(\bar{\psi} - \rho s/z)^2 - \frac{1}{z} \left((\bar{\psi} - \rho s)^2 - 4\rho s \bar{\psi} \right)}}{2\rho}.$$

Recalling that $z \geq 1$, we can show that $\underline{G} < \frac{\bar{\psi} + \rho s}{2\rho} < \bar{G}$. To see this, consider that, when $z = 1$,

$$\bar{G} = \frac{(\bar{\psi} - \rho s) + 2\sqrt{\rho s \bar{\psi}}}{2\rho} > \frac{\bar{\psi} + \rho s}{2\rho},$$

which follows from the fact that $\bar{\psi} > \rho s$. Furthermore, it is easily seen that $\frac{\partial \bar{G}}{\partial z} > 0$. Finally, we have $\underline{G} < \frac{\bar{\psi} - \rho s/z}{2\rho} < \frac{\bar{\psi} + \rho s}{2\rho}$, for any z . Since $G > \frac{\bar{\psi} + \rho s}{2\rho}$ by assumption, we have established that $G \leq \bar{G}$ is necessary for $w_{d,0} \geq \bar{w}$ to be feasible.

Behavior of entrepreneurs and social welfare.

If $w_{d,0} < \bar{w}$, so that $p = \frac{\bar{\psi} + \rho s}{2}$, a fraction $H\left(\frac{\bar{\psi} + \rho s}{2}\right)$ of entrepreneurs choose $e = h$, whereas the remainder choose $e = i$. If $w_{d,0} \geq \bar{w}$, so that $\rho G < p$, a fraction $H(\rho G)$ of entrepreneurs choose $e = h$, whereas the remainder choose $e = l$ and obtain a permit only if $\sigma = c$; that is,

with probability $1 - \rho$. Thus, conditionally on $w_{d,0} < \bar{w}$, social welfare is equal to

$$W = \int_0^{\frac{\bar{\psi} + \rho s}{2}} (G - \psi) dH(\psi) - \int_{\frac{\bar{\psi} + \rho s}{2}}^{\bar{\psi}} (D - G + \rho s) dH(\psi). \quad (29)$$

Assume now $w_{d,0} \geq \bar{w}$. Social welfare is equal to

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) - (1 - \rho) \int_{\rho G}^{\bar{\psi}} (D - G) dH(\psi) - (\lambda - 1) \rho (1 - H(\rho G)) w_{d,0}.$$

it is clearly optimal to set $w_{d,0} = \bar{w}$. Hence,

$$W = \int_0^{\rho G} (G - \psi) dH(\psi) - (1 - \rho) \int_{\rho G}^{\bar{\psi}} (D - G) dH(\psi) - (\lambda - 1) \rho (1 - H(\rho G)) \bar{w}. \quad (30)$$

As shown above, $w_{d,0} = \bar{w}$ is feasible if and only if $G \leq \bar{G}$. Assume this condition holds. Comparing (29) and (30), we can conclude that there exists a threshold D^I such that (29) is smaller than (30) if and only if $D > D^I$.