

Modelling Domestic Corruption Deterrence Through Self-Reporting and Collaborations

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Abstract

Past studies have shown that giving sanction reductions to self-reporters who collaborate with investigations is an effective way to prevent and disrupt corruption schemes. However, poorly designed policies may induce criminal activities. In this sense, this work models the crime of corruption under complete and incomplete information. Additionally, agents are allowed to self-report their crimes in exchange for some judicial benefit before and/or after being detected by the authorities. It shows that leniencies to self-reporters have a bad dynamic which provides a credible threat to players that may enforce corrupt deals. However, it also shows that uncertainties from agents are strong constraints to engage in corruption. Consequently, the level of information about players is crucial to determine the deterrent effect from anti-corruption policies.

1 Introduction

Using one party against another to disrupt criminal agreements is an old prosecutorial practice. However, the design of the strategies varied throughout time. Notably, corruption or bribery requires at least one agent to pay a bribe and another receive it. Therefore, stimulating self-reporting can be particularly effective against this type of crime.

Since the seminal work of Becker (1968), economists formalized a way to analyse the decision to engage in crimes¹. Notably Kaplow and Shavell (1994) first described how giving fine reductions to self-reporters could deter crimes² for sufficiently risk-averse individuals. However, their analysis was only one-sided or static.

The dynamic features of interaction between agents was initially added in the work from Motta and Polo (2003)³, which was focused on anti-trust offences⁴, and later Spagnolo

¹More recently Polinsky and Shavell (2007) devised a general static model based on contributions of a vast literature. The model accommodates a series of effects such as different liability rules, different risk preferences, non-monetary sanctions, expected fines, judicial errors, deterrence effect, incapacitation effect, Principal-Agent relation, settlements, repeated offenders, corruption on judgements, social norms and self-reporting. Also Garoupa (1997) resumes the relevant literature.

²Specific literature in corruption starts earlier. Rose-Ackerman (1975) shows where incentives to corruption rise on different market structures. Later on, Polinsky and Shavell (2001) deal with the problem of corruption when framing individuals and extortions. These works are remarkable advances and many others were written on the same line, however here the focus is on the self-reporting dynamics and how it can deter corruption.

³One important difference between the static and dynamic approaches so far is that the first were set on individual level, or else, the decisions were taken by natural persons. The later dynamic models were set on the corporate level, with the exception of Spagnolo (2005) extends on criminal organizations.

⁴Notable theoretical contributions in the leniency literature are Harrington (2008), Motchenkova (2004),

(2005) acknowledged that the methodology could be extended to other types of criminal organizations. Later on, Buccirosi and Spagnolo (2006) framed a similar methodology as a corruption game⁵. All of them found situations in which leniency for self-reporters may deter or increase criminal activities, depending on the policy design.

Even though the model of Motta and Polo (2003) allow the agents to report both before and after an eventual detection by the authorities, the literature that followed their strand mostly do not allow for it. In parallel, the literature on plea bargaining, starting with Landes (1971), analyses specifically the case in which defendants would collaborate with justice and report their criminal actions after an accusation. Later, Grossman and Katz (1983) devised a dynamic model of plea bargaining pointing out to screening effects that would help prosecutors in their choices. Kobayashi (1992) developed a model accounting for multi-defendant plea bargain which is closer to this study's case of corruption analysis⁶.

In this work, the model devised allow agents to report their crimes both before and after being detected. At this point the reader may wonder why is it relevant to analyse both policies together. First, it is more realistic, being better suited to most jurisdictions, as agents face both choices to report their actions and different benefits in each case⁷. Additionally, if we consider that corruption schemes are strategic interactions, the intelligent use of both policies together can increase jointly the deterrence or disruption of the criminal schemes⁸.

Note that there are two channels in which well-designed anti-corruption policies can be effective. It can work ex-ante, deterring the crime or impeding agents from performing it. Or it can be effective after the crime is committed, as a good framework to prosecute or to disrupt an eventual ongoing crime. This paper focuses on the deterrent aspect of the policies, the disrupting effect is explored in further opportunity⁹.

In this sense, this paper tries to answer how deterrent can leniency policies against corruption be. What are the characteristics of an effective leniency policy for corruption? Does the possibility of self-reporting before and after have a joint effect in deterring corruption? How does the fear of being reported affects the decision to engage in corruption?

At the end, beyond confirming some past findings of the specific literature, it is clear that the level of information that agents have plays an important role on the effectiveness anti-corruption policies. If agents do not have complete information about other players (do not know what type of players they are playing against), the constraint of the leniency policies is bigger. Moreover, self-reporting before and after detection may independently deter corruption¹⁰.

Aubert et al. (2006), Motchenkova and van der Laan (2011), Buccirosi and Spagnolo (2000) and Chang and Harrington (2015). Interesting experimental findings are Bigoni et al. (2012) and Bigoni et al. (2015). Also, empirical approaches are explored by Brenner (2009) and Miller (2009).

⁵Other remarkable literature on theoretical games of corruption are Dufwenberg and Spagnolo (2014) and Basu and Cordella (2016), and experimentally Engel et al. (2016).

⁶Previous literature goes further on the analysis of optimum decision both for defendants and justice taking into account the trade-off between certain of conviction and wrongful pleas from risk-averse defendants (Grossman and Katz, 1983; Kobayashi, 1992; Givati, 2014; Mungan and Klick, 2016; Berg and Kim, 2018). However, since the objective here is to analyse the defendant's decision making, the prosecutor's choice is assumed as exogenous.

⁷It is indeed similar to Brazilian recent judicial reform that is going to be used as an empirical example in further developments of this work.

⁸I speculate that it should work better for disrupting corruption than it is for deterring it.

⁹The deterrent effect of self-reporting is somehow simpler to show, since agents make their forecasts of the future and then make a decision. The parameters in which the decision was made are fixed, so there is a lot less degrees of freedom in the model.

¹⁰If the value of corruption is decided by the parties, self-reporting policies can increase the values of

In the next section the basic model is devised and following subsections show the results under different designs and assumptions. At the end of the paper some conclusions are drawn from the model and further studies and extensions of the model are proposed.

2 Domestic Corruption Model

This section contains a theoretical analysis of domestic corruption. Furthermore, it focuses on the deterrent effects from the leniency policies. Notably a lot has been written on leniency for cartels (Marvão and Spagnolo, 2014) and a lot less for corruption criminals. In this case it is necessary to frame the model as a corruption game in order to verify if conclusions from past works on leniency for cartels apply to the case of corruption. Importantly, this study considers only one dimension of the corruption activities, the bribery related crimes.

The model begins with the agent's choice. In this sense, considering that the relevant objective of the policy (policymaker) is to maximize society's welfare. Also, supposing that the enforcement expenditures are exogenous¹¹. Thus, the welfare maximization is given by restricting the set of possible enforcement combinations in which corruption would occur. Note that it is implicitly assumed that there is no 'grease money hypothesis' (Kaufmann and Wei, 1999), i.e. there are no gains for society from corruption. Therefore, society's welfare is monotonically decreasing in the number of corruption crimes¹².

The study's overall methodological approach to achieve this goal is to devise an economic model of public enforcement against corruption that accounts for the possibility of defendants or potential criminals to report their acts to the authorities in exchange of some judicial benefit. If the model is consistent with reality, the theoretical predictions extracted here should be confirmed by an eventual empirical test.

The model consists of risk-neutral agents which can either be a firm¹³ or an individual. Here, corruption is defined as bribes paid in a *quid pro quo* exchange for some advantage. This deal is illegal and if detected an investigation/accusation is brought against involved parties. If the parties are convicted they pay a monetary sanction¹⁴. The bribery can be performed in one-shot (one time only) or in repeated interactions.

The game arises when two agents¹⁵, the government bureaucrat and private entrepreneur¹⁶,

bribes and advantages from corruption. However, it is doubtful that players would choose values of bribe and advantages less than maximum. If values are tied to the probability of detection and conviction, this result may not appear at all.

¹¹This model has an endogenous revenue from fines. To consider it as welfare neutral it is needed to assume that fines are mere transfers from corrupt agents back to society. In other words, the welfare lost from paying a fine from one agent is diluted in a gain for the society, i.e. no dead-weight loss.

¹²Polinsky and Shavell (2001) found this result applying traditional methodology from Becker (1968). More specifically, by weighting the costs and benefits from crimes to the welfare from society. For simplicity this is not done here.

¹³Note that, for corporate crime deterrence model, there is an intrinsic assumption that there is no principal-agent conflict which sometimes is not always explicit in models (Søreide and Rose-Ackerman, 2018), e.g. no conflict between the bureaucrats performing the corruption activity and the politicians or political parties that back them up. Also, there is no conflict between the firm's shareholders or owners and their employees that pay the bribe. Aubert et al. (2006) discuss the principal-agent and the extents of individual and corporate decisions when addressing the whistle-blowing issues. Also Garoupa (2007) deals with agency problems when agents can rely on plea bargains. In his model, it is a superior equilibrium to pay low wages for agents and give little information that can lead to the principal arrest.

¹⁴Non-monetary sanctions are discussed in the extension of the model.

¹⁵Since corruption requires at least two players, a payer and a receiver, this assumption will always hold true. Notably there can be more players, the extensions to account more players is discussed further.

¹⁶The model can account for more agents, such as politicians, government agents and private companies. Also, bribes could happen between private parties, although the case of bribery between public and

decide whether to play or not a strategy of corruption (cooperation), constrained by probabilities of being detected and later convicted.

Given the above conditions, let:

B = Bureaucrat;
 E = Entrepreneur;
 π = Advantage from corruption;
 b = Bribe; and
 c = Cost of the bureaucrat for generating π ,

where $\pi > 0$ is the gain from the entrepreneur from corruption and b is the gain from the bureaucrat, such that $0 < b < \pi$. Note that, the existence of $\pi > 0$ rules out crimes of extortion from the bureaucrat, since in that case the entrepreneur would not face any positive benefit from corruption¹⁷.

Additionally, agents are assumed to be under a fault-based liability regime¹⁸. Furthermore, judiciary and prosecution have jurisdiction over all agents (domestic bribery).

Let the enforcement variables be:

α = probability of detection¹⁹; and
 β = probability of conviction.

In the traditional Beckerian approaches of crime deterrence, the probability of detection and conviction are merged. Here, in line with the study of Motta and Polo (2003) the probabilities are split. This feature allows for the specific propose of analysing self-reporting after detection.

Finally, for $i = B, E$, let:

S_i = Sanction; and
 F = Fine.

For the moment, it is considered that S_i is given by the gains of each player with addition of F which is the same for the payer and the receiver. Consequently, $S_E = \pi + F$ and $S_B = b + F$ ²⁰. It is assumed that there are only monetary sanctions, or they can be represented in a monetary fashion at least²¹. Lastly, it is assumed that fines are costless to implement.

In order to derive the agent's decision rule, and for the sake of simplicity let,

private parties is more emblematic and easier to picture.

¹⁷In this sense, the best way to tackle extortions would be by following the hypothesis of Basu (2011) better explored in Dufwenberg and Spagnolo (2014) and Basu and Cordella (2016).

¹⁸Since the agents can be either firms or individuals, there can be differences between each type of agent in different countries or for each distinct purpose. Previous literature discussed the optimal liability regimes. For instance, for individuals, Polinsky and Shavell (2007) conclude that, for risk-averse defendants, fault-based liability is preferable than strict-liability, however strict-liability is easier to implement. Arlen and Kraakman (1997) discuss corporate liability. The authors identify that, based on optimum activities of monitoring and compliance from firms along with preventive measures to avoid criminal activity, duty-based liability together with residual strict liability can be optimum. In fact, distinct liability can induce different incentives on self-enforcements, in this case, there can be a compound corporate liability that maximizes social welfare, as Oded (2012) would suggest.

¹⁹Innocent agents will never be subjected to detection so they can never be wrongfully convicted, i.e. there is no Type I judicial errors.

²⁰Agents are not liable for damages by third parties or for crimes in other jurisdictions regarding the reported offence.

²¹This simplification may be more real for corporate agents than it is for natural persons. More specifically, imprisonment would be expected for individuals but not for firms. Nonetheless, there are also other types of non-monetary sanctions that can be applied to firms. In expanded model, this specific issue is revisited.

p_k = probability that k happens for $k = \pi, F, b$,
 $p_F \equiv \alpha\beta$ and,
 $p_b = p_\pi \equiv (1 - \alpha\beta)$.

Under risk neutrality, the agents' utilities U_i are given by the differences between the costs and the expected benefits for each agent:

$$U_E \equiv -b + (1 - \alpha\beta)\pi - \alpha\beta F = -b + p_\pi - \pi p_F F,$$

and

$$U_B \equiv -c + (1 - \alpha\beta)b - \alpha\beta F = -c + p_b b - p_F F.$$

Let us define some profitable bribery as being the fixed cost paid by agents which make their utilities at least greater than zero:

$$b > p_\pi \pi - p_F F, \quad (1)$$

and

$$c > p_b b - p_F F, \quad (2)$$

Consequently, the enforcement level $\alpha\beta$ needs to be lower than the relation between premium from corruption and the sanctions,

$$p_{FE} = \alpha\beta < \frac{-b + \pi}{F + \pi}, \quad (3)$$

and,

$$p_{FB} = \alpha\beta < \frac{-c + b}{F + b}. \quad (4)$$

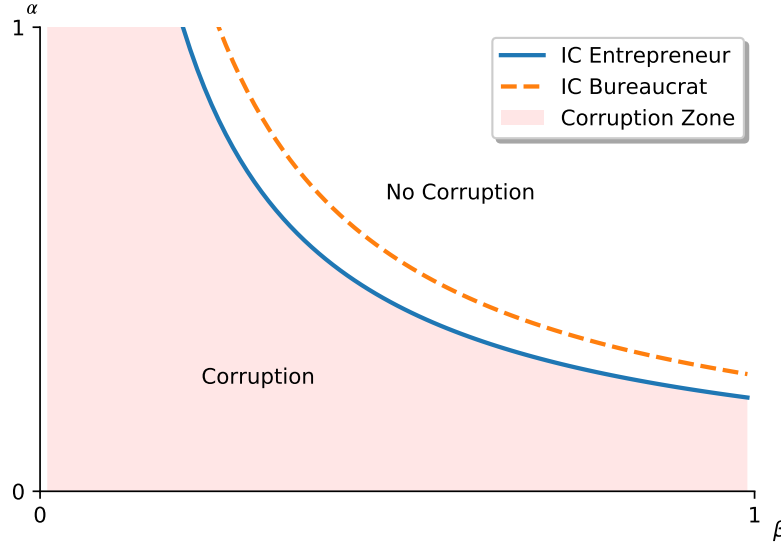
Importantly, given fixed levels of $\alpha\beta$, higher fines will always lead to higher constraints for bribe acceptance in both cases. Thus, if F is costless to implement, policymakers should set it as high as feasible (generally up to the agents' total wealth) lowering the enforcement levels $\alpha\beta$, which are usually costly. This conclusion is in line with traditional Beckerian approaches ²².

Analogously, for fixed feasible conditions of c, b, π and F ²³ there will be some combination of α and β which makes bribes profitable for bureaucrats and entrepreneurs. The Figure 1 shows the Indifference Curves between prosecutorial or judicial efficiency against the agents

²²Assuming that enforcement variables α and β are functions of some exogenous government expenditure $f(e)$, such that, for both cases, $f'(e) > 0$ and $f''(e) < 0$. It is possible to note from (3) and (4) that it is always possible to exchange (F) for lower levels of $\alpha\beta$ and maintain the decision rule unchanged (deterrence level). This conclusion is in line with what Becker (1968) suggests.

²³Since the minimum bribe is given by the bureaucrat and the maximum is given by the entrepreneur, it is straightforward to see that feasible bribes would lie in $b \in (\frac{c + \alpha\beta F}{1 - \alpha\beta}, (1 + \alpha\beta)\pi - \alpha\beta F)$. Additionally, the minimum advantage from corruption necessary for the bribery is $\pi = c + (2 - \alpha\beta)\alpha\beta F$.

Figure 1: Indifference Curves for Profitable Bribes



Given the above conditions, bribes are profitable if $\alpha < \frac{\pi-b}{\beta(\pi+F)}$ or $\beta < \frac{\pi-b}{\alpha(\pi+F)}$ for the entrepreneur and $\alpha < \frac{b}{\beta(b+F)}$ and $\beta < \frac{b}{\alpha(b+F)}$ for the bureaucrat. Therefore, an increase in F moves both curves to the left, increasing the deterrent effect. Meanwhile, a decrease in $(b - c)$ moves the bureaucrat indifference curve towards a more deterrent set, whereas for the entrepreneur's indifference curve, it moves left if $(\pi - b)$ decreases.

If agents can mutually enforce some the bribery agreement, then conditions (1) and (2) suffice for agents to collude. However, since the deal is illegal, agents cannot rely on traditional contracts to enforce their commitments. Therefore, they would need to rely on other means for it, such as threats of violence, trust and other strategies. In this sense, information about parties and timing protocols are important to determine the conditions for agreements to hold in an environment without legally enforceable contracts.

Lastly, note that p_k depends on the level of uncertainty (private information) that agents have over the k variables. Therefore conditions (3) and (4) may change under uncertainty. Additionally, since players interact sequentially with each other, the conditions will also depend on the dynamics of the game (timing). These relations become more explicit if one allows agents to self-report. Therefore, profitable bribes ((1) and (2)) are necessary but not sufficient for agents to start colluding. The different cases regarding the level of information of agents and different timings are discussed below.

Timing and Information

In the next section different stylized cases of the model are set. The main difference between them is the level of information of the agents and the timing protocol. This is precisely the intended contribution from this paper, to isolate and highlight effect of different timing rules under distinct levels of information about players.

Regarding the timing protocol, the judicial frameworks that allow criminals to self-report in exchange for fine reductions are numerous, such as leniency agreements, whistle-blowing and plea bargaining. They differ between each other in their procedures, intentions and, consequently, in their outcomes. For simplicity, in this model there are only two types of self-reporting: before and after detection.

There are four different self-reporting regimes. In other words, there are four distinct timings for agents to self-report in exchange for some benefit or leniency in their sanctions: 1- No fine reductions for self-reporters (benchmark); 2- Fine reductions for agents who self-report only before detections from the authorities; 3- Fine reductions for agents who self-report after detected; and 4- Distinct rules for agents who self-report before or after detected.

For convenience, the representative game in which the entrepreneur plays first is the standard approach. However, the same results can be mirrored if the bureaucrat plays first. The timing for the benchmark, without fine reductions for self-reporters, is the following:

- t_0 = Policymakers set the rules for fines F ;
- t_1 = Nature sets the distribution of the advantages π that the entrepreneur can explore from a bureaucrat. Then, the entrepreneur decides whether to offer a bribe b ;
- t_2 = The bureaucrat decides to accept or not. If the bribe is accepted, the bureaucrat decides to perform or not the corruption act;
- t_3 = Prosecution authority investigates (detects) with probability α ; and
- t_4 = If detected by the prosecution, judicial authority convicts with probability β .

Agents can decide to keep ‘hard evidence’ from corruption (cooperation). This evidence can never be manipulated and if it is shown to the authorities, it would convict the other party with certainty^{24,25}.

If the policymakers decide to include fine reductions policies in t_0 to self-reporters. Then, there are three more timing possibilities: agents can only self-report if not detected (before t_3); agents can only self-report after detected (before t_4); and agents can either self-report before (before t_3) or after detection (before t_4) and there are specific rules for fine reductions²⁶.

Since this model explores the deterrent effect from the anti-corruption policy. All the variables are chosen or set before the decision whether or not to bribe (accept a bribe) ($t = 1$ and $t = 2$), and remain constant after. This happens because the agents must decide their actions ex-ante and have no reason to believe that variables would change over time²⁷.

Past literature points out to counter-productive dynamics from giving fine reduction to self-reporters (breaking a sequential prisoner’s dilemma) (Buccirosi and Spagnolo, 2000;

²⁴This assumption somewhat similar to the ones in Aubert et al. (2006) and Buccirosi and Spagnolo (2006). However, in the last, agents always create the evidence and if detected they are convicted for sure because for that. Note that this is not the case here, since agents will still have the opportunity to go to trial, they can still try to hide the evidence. Therefore, since agents will only use the evidence if they want to self-report, the assumption here is less strong than it is in Buccirosi and Spagnolo (2006).

²⁵ The role of information on self-reporting is more elaborated in Garoupa (2007). However, his concept of criminal organization may not apply to this situation of corruption between public and private sectors. His modelling cares more about agency problems inside a hierarchical criminal organization.

²⁶Note that, in practice, agents who can self-report only after detection, can do so before $t = 3$ as well, since they can turn their selves in to the authorities. The difference between only self-reporting after, and self-reporting both before and after is that in the last case, it is allowed for different leniency rules for agents who self-report before or after detection.

²⁷This is consistent with rationality. Also, this feature makes the deterrent effect somewhat easier to model than the disruptive effects of self-reporting. In order to model a run for court effect or a desistance effect, one would need to set the variables free to changes over time. This was done by Motchenkova (2004) and Harrington (2008) and is a natural improvement of this analysis, or else, an intended further analysis.

Spagnolo, 2005; Buccirossi and Spagnolo, 2006; Dufwenberg and Spagnolo, 2014). However, there are positive deterrent effects from the fear of being reported (Spagnolo, 2005; Harrington, 2008; Chang and Harrington, 2015). Moreover, these findings are confirmed by experimental evidence (Engel et al., 2016; Bigoni et al., 2012, 2015). Therefore, in order to isolate these two effects, different assumptions about completeness of information are set. In particular, the complete information model extracts the dynamics of the game. Meanwhile, the incomplete information settings analyse the difference in expected outcomes resulting from the addition of uncertainty to the system.

In the following subsections all different specifications of the games are discussed.

3 Complete Information

In this section, agents have complete information, meaning that, they know their and other's benefits from corruption ($\pi - b$ for the entrepreneur and $b - c$ for the bureaucrat). Moreover, agents know their fines F and probability of being caught α and if so convicted β . Since agents are risk neutral and act rationally, the agents' utilities U_i are given explicitly by the game pay-offs which they are trying to maximize.

3.1 One-Shot Complete Information

In this setting, agents play a sequential game in which the first mover offers a bribe then the second mover delivers the favour. Importantly, the deal is never repeated between the players, neither there are any reputational gains or any other ways for parties to enforce their claim. This particular framing resembles typical routine interactions between entrepreneurs wishing to explore some procurement contract and bureaucrats or civil servants entitled to execute them. In this case, entrepreneurs pay a bribe then bureaucrats place some adverse condition (overpricing, defrauded quantities) in the contract that generates an uncompetitive value. Other examples are queuing hold ups, in which someone can pay a bureaucrat to put a process further in a waiting list.

Note that there must be some sequential order of paying and there must be some value generated to the bribe payer and some non-negative cost to a bureaucrat. This leaves out some specific type of corruption, such as extortion and avoiding framing individuals. Since in extortions there is no value added, bribe payer is just avoiding a cost. Such as paying a civil servant emit a licence that one would be entitled to. In the case of framing, if the bribe payer refuses to pay, they are going to be immediately detected by authority. For an example, if people try to bribe a police officer to avoid a speed limit ticket or bribe a judge to acquit a guilty defendant.

Needless to say, in this case, agents are very sophisticated and they know all the variables involved for them and for the other parties. The dynamics of different cases are discussed below.

3.1.1 Benchmark Without Fine Reductions for Self-Reporters

In this first case, the one-shot (one-time) game implies that agents have perfect information, meaning that they know where they are in the sequential game. In other words, players can observe what the others have done. This is a natural real assumption of paying a bribe, agents know whether they paid or received a bribe.

The game consists of an entrepreneur making a 'take it or leave it' offer of a bribe to a bureaucrat who decides whether to reject, accept and perform or accept and not perform

the corruption act. Figure 2 shows the extensive form of the game, in which the nodes E and B are the entrepreneur and the bureaucrat. The strategies nb , b , r , p and np represent respectively, ‘no bribe’, ‘bribe’, ‘reject the bribe’, ‘perform the act’ and ‘not perform the act’. Finally, the upper pay-offs are from the entrepreneur and the lower from the bureaucrat.

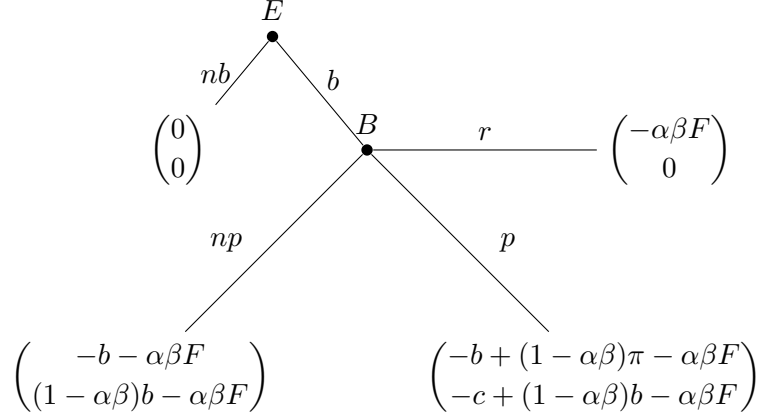


Figure 2: One-Shot Sequential Game Tree

Following the timing structure, after the bureaucrat chooses either to perform or not the act, the prosecutors play and after them the judges play. Note that these moves are exogenous to this model. Thereafter, the expected values from each node are condensed in the pay-off following B 's decision. Thus, in this reduced form only the nodes in which the relevant players E and B play are displayed.

It is also important to point out that the expected fine $\alpha\beta F$ is the same in cases of the bureaucrat performing or not the corruption, both for the public official and for the entrepreneur. This assumption is in line with many national laws²⁸, since the mere attempt or promise to corrupt is considered a crime. For simplicity, it is considered that rejection does not constitute a crime for the bureaucrat but the attempt to pay is for the entrepreneur.

Solving the game backwards. For any non-negative cost of corruption ($c \geq 0$)²⁹, if expected return from bribes is not positive $(1 - \alpha\beta)b - \alpha\beta F \leq 0$, or else the bribe is too low $b \leq \frac{\alpha\beta F}{(1 - \alpha\beta)}$, then the bureaucrat chooses rejection. Whereas, if the expected pay-off from the bribe is positive, the bureaucrat would chose to ‘not perform’ the corruption since $(1 - \alpha\beta)b - \alpha\beta F \geq -c + (1 - \alpha\beta)b - \alpha\beta F$. Therefore, no benefit π for the entrepreneur would be generated. Consequently, the entrepreneur is not going to offer the bribe. Hence, no corruption (not colluding) is a unique Subgame Perfect Nash Equilibrium (SPNE)³⁰. Furthermore, by symmetry, since the bribe will always be costly to the entrepreneur, there is no corruption if the bureaucrat plays first. Once again, in both cases, second mover would prefer to take the benefit and not perform the activity, then the first mover is not offering the bribe.

One can argue that this design is too restrict, and there can be a way in which agents can intelligently and tacitly collude³¹. However, this is a particular case of a ‘trust game’.

²⁸For example, Brazilian Law No. 2.848/40 Art. 317 and 333.

²⁹Dufwenberg and Spagnolo (2014) allow for a $c < 0$. This is possible in their framing since they deal with extortive or harassment bribes. In this case, if the bureaucrat denies a licence or other service, she can be caught-in-act and fired. Of course, this condition does not apply for this current model.

³⁰Considering that in the special case in which $c = 0$, then it is assumed that agents weakly prefer not to act, since acting would represent at least a change in current status quo.

³¹The non-cooperation equilibrium persists under different payment strategies, such as paying a part

Consequently, if players approach it rationally, then it will always lead to non-cooperation. This may appear unrealistic, since occasional corruption is often observed in the society. Perhaps, the occurrence of such behaviour may be due to the use of other enforceable agreements (threats of violence, shadow contracts, trust, cheap talk, etc.). Or even due to the presence of bounded rationality, and effects such as reciprocity (positive and negative) or inequity aversion³².

The important message is that the dynamics of corruption does not favour collusion. This is true to any other illegal sequential transactions that cannot be enforced through contracts or legal systems. They resemble trust games and rational players would not collude if they do not have any enforceable mechanism to assure their agreements.

Proposition 1. *There is a crime deterrent effect from the dynamics of corruption if bribes are paid in a sequential one-shot game without enforceable agreements.*

This outcome is in line with previous literature. Buccirosi and Spagnolo (2006), in their work with a similar game structure found that corruption would not be implemented because parties' dominant strategy would lead to mutual defection. Nonetheless, Lambsdorff and Nell (2007) found that, if punishments are asymmetric (either by being different between agents or between the action of reciprocating), there can be a punishment structure that allow players to collude. However, asymmetric punishments are more similar to the cases ahead (fine reductions to self-reporters) than they are to the benchmark.

3.1.2 Self-Reporting Before Detection

In this setting, the agents receive fine reductions if they self-report only before an eventual detection from the prosecutorial authority. This kind of setting approaches the ones used on 'leniency policy' studies, most of them aiming to analyse anti-trust policies (Marvão and Spagnolo, 2014). However, extensions from these approaches acknowledge the possibility of analysing other crimes such as corruption (Buccirosi and Spagnolo, 2006; Dufwenberg and Spagnolo, 2014) and other criminal organizations (Spagnolo, 2005).

This feature implies that the information in the game is imperfect from now on. In other words, the agents cannot know what the other players have done, or else, they do not know with certainty in which node they are in the game. For an example, if the entrepreneur decides to self-report, she can only know if the bureaucrat did the same after taking the decision to the authority. On the other hand, if an agent does not self-report, she can only know if she was reported when the authority pronounces about it, or when the game ends (or round, if repeated)³³.

In this section, the model allows agents to self-report after committing a corruption crime but before any detection from competent authority. The self-reporter pays a reduced fine of RF , with $R \in (-\infty, 1]$. Lastly, if both players self-report at the same time they pay a reduced fine rF . Note that, under the usual rule that leniencies are only given to the first to self-report, then $E[r] = (1 - R/n)$, i.e. the real fine is still $r = R$ for the first to come up and $r = 1$ for all the others.

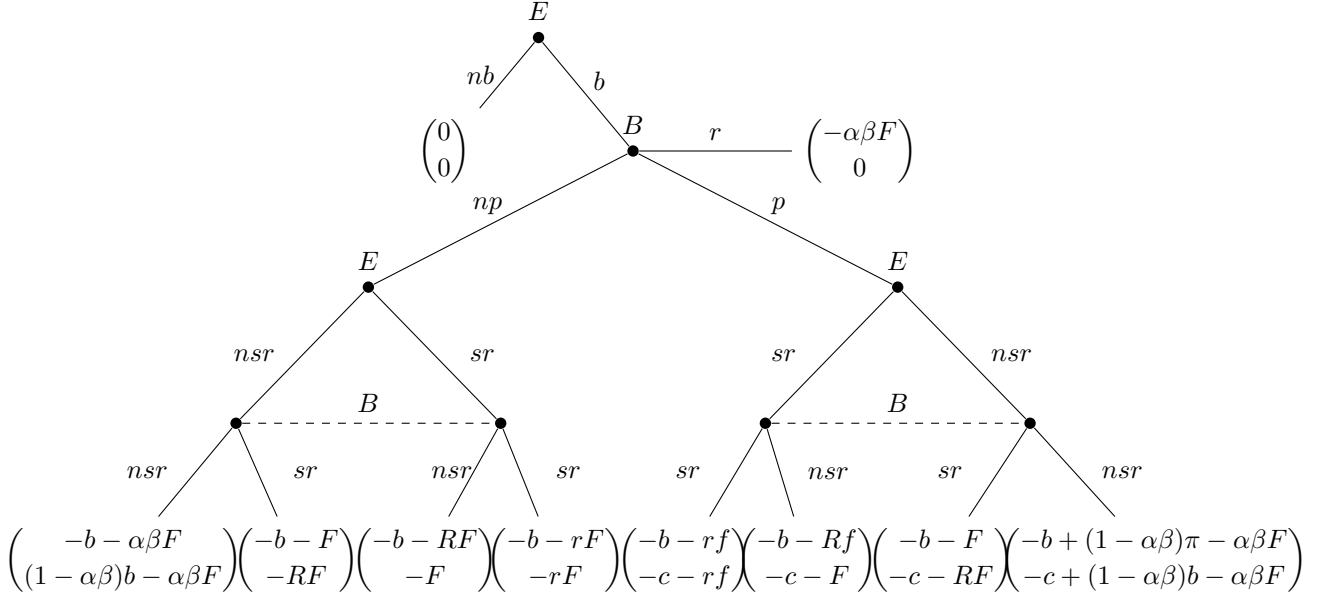
of the bribe before the act and other after (Buccirosi and Spagnolo, 2006). Nonetheless, fractioning the payment would approach the design to a repeated game, which is going to be explored ahead.

³²Engel et al. (2016) explore the effect of asymmetric punishments on collusive bribery. Their benchmark is very similar to this one, and they observed that corruption (offers and acceptance) occurs frequently. The authors discuss several behavioural explanations for their results. However, they also show that their benchmark is more deterrent than their control with asymmetric punishments.

³³Although the absence of a clear game ending may be confusing. It is possible to assume that, for a one-shot corruption, the game finishes at the prescription date.

The Figure 3 shows the extensive form of the game for the players, where ‘*nsr*’ and ‘*sr*’ stand for not ‘self-report’ and ‘self-report’ respectively:

Figure 3: Corruption Game With Self-Reporting Before Detection



Note that the crime can only be performed if bribery is profitable, i.e. if conditions in (1) and (2) are met. First, it is interesting to check in which ex-ante conditions would agents commit the crime and self-report. They would only do so if the premium for self-reporting is greater than the expected pay-off of corruption, or else $-RF > -b + (1 - \alpha\beta)\pi - \alpha\beta F$ for the entrepreneur and $-RF > -c + (1 - \alpha\beta)b - \alpha\beta F$ for the bureaucrat. This condition is only true if $-RF > 0$, this implies that $R < 0$, which means that agents would need to earn some bonus from self-reporting, otherwise they would certainly prefer to stick with the expected returns from corruption. More specifically, if bonuses are sufficiently big ($R < -\frac{-b + (1 - \alpha\beta)\pi - \alpha\beta F}{F}$ for the entrepreneur or $R < -\frac{-c + (1 - \alpha\beta)b - \alpha\beta F}{F}$ for the bureaucrat), agents would enter the game only to exploit it³⁴. One player would pay the fine the other would earn the bonus. Consequentially, the other party is never going to accept any bribe offer. Thereby, deterring eventual corruption³⁵. However, if $-(1 - R/n)F = -rF > (-b + (1 - \alpha\beta)\pi - \alpha\beta F)$ for the entrepreneur and $-(1 - R/n)F = -rF > (-c + (1 - \alpha\beta)b - \alpha\beta F)$ for the bureaucrat, then both players would enter in corruption and both would self-report. Such high enough bonus, as any other bonus are not reasonable to assume. From now on, this situation where agents accept a bribe only to self-report are referred as exploitable fine reductions.

Solving the game backwards³⁶, it is possible to see that if the bureaucrat does not perform

³⁴In summary, it is possible to conclude that self-reporting is non-exploitable if:

$$R < \max \left[-\frac{-b + (1 - \alpha\beta)\pi - \alpha\beta F}{F}; -\frac{-c + (1 - \alpha\beta)b - \alpha\beta F}{F} \right].$$

³⁵Spagnolo (2005) using endogenous enforcement expenditures, finds that giving all the profits from corruption to the other party as bonus constitutes a first best solution to the problem. Because they would achieve full deterrence with costless enforcements.

³⁶Note that the entrepreneur could self-report if rejected. However, since the node is never going to be

the corruption, then the entrepreneur would self-report if $-\alpha\beta F < \max[-RF, -rF]$, or else if $\min[r, R] > \alpha\beta$. Furthermore, under the rule that leniency is divided between self-reporters or only given to the first to self-report, then $r > R$. Consequently, if RF is smaller than the expected fine $\alpha\beta F$, self-reporting here acts like a credible threat to the bureaucrat inducing her to perform the illegal act. From now on, this condition that generates credible threats is going to be referred as feasible fine reductions.

Given the above conditions, if leniency is either moderated³⁷ up to full amnesty ($R \in [0, \alpha\beta]$) like in most jurisdictions, self-reporting can only happen in pure strategies if α or β vary. Since, in the deterrence analysis agents assess the probabilities before playing the game, then they have no incentive to change their strategy, leading to corruption being performed.

In summary, allowing agents to self-report before being detected by authority's in exchange for benefits can induce corruption. This output is in line with Buccrossi and Spagnolo (2006), in which the addition of a self-reporting mechanism provides a credible threat that can make collusion possible. On the other hand, if prosecutors allow bounties for collaborators $R < 0$ then, there can be situations in which collusion would be profitable, but enforcements deter the criminal act. Because agents would want to accept (offer) a bribe just to self-report. Therefore, in this case no one would offer (propose) a bribe. This result is in line with Spagnolo (2005) and Aubert et al. (2006).

3.1.3 Self-Reporting After Detection

In this setting, agents can earn judicial benefits if they self-report after being detected by the authorities. This type of self-reporting has been investigated by a particular strand of literature that mostly deals with plea bargaining such as the works of Grossman and Katz (1983), Kobayashi (1992), Franzoni (1999) and Mungan and Klick (2016). Literature about the subject traditionally focuses on the screening effects of plea bargaining. Prosecutors use them to decrease type I judicial errors, i.e. to prevent the conviction of innocent defendants. However, here the prosecutor choice is exogenous and agents cannot be detected if they are innocent. In this sense, the objective here is to assess the conditions in which self-reporting would be preferable and how they can contribute with the ex-ante deterrence of crimes.

Like in the past example, the game has incomplete information. However, now uncertainty lies on the node after the detection of the authorities. Due to the fact that players cannot know the other's action until the end of the round.

Once again, corruption happens if the bureaucrat has any incentive to perform the bribery act. As seen before, this happens when returns from bribery are positive and the entrepreneur can credibly threat the bureaucrat with some punishment. In this case the threat of self-reporting.

Note that the agents control the probability of being detected α , because they can, at any time, turn themselves in to the authorities. In practice, being able to self-report after being detected necessarily allows agents to do so before as well. In this case, the analysis focuses in the fine reduction rule as fixed for self-reporting after detection. In the next case, the analysis allows for different fine reduction rules.

Given a fine reduction rule where PF is the reduced fine, for $P \in (-\infty, 1]$ in case of an unilateral self-reporting, and pF if both parties self-report simultaneously, where $PF < pF$

played in any non-exploitable design, the extension from this node is severed.

³⁷Note that ex-ante, if policymakers set the reduced fine RF bigger than the expected value of being caught and convicted $\alpha\beta F$, they would not expect self-reporting from wrongdoers, only from enough risk-averse agents (Kaplrow and Shavell, 1994).

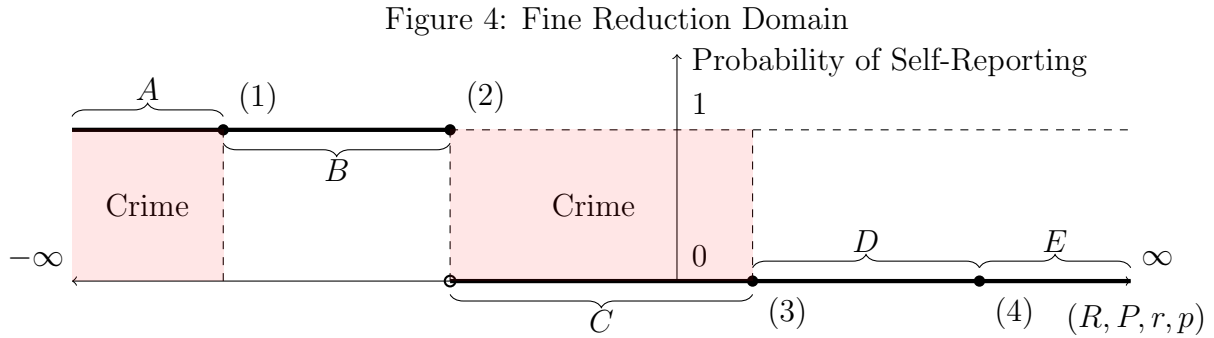
or $p > P$. In this case, if the entrepreneur wants to threaten the bureaucrat with self-reporting, the reduction P must meet the same conditions as in the past example, i.e. $P < \alpha\beta$. Note that if $\beta > P > \alpha\beta$, the bureaucrat would expect that the entrepreneur would only self-report if detected. Thus, the threat is only credible in the case of certain detection ($\beta = \alpha\beta$). Therefore, if $P > \alpha\beta$ then self-reporting is not a credible threat.

It is important to observe that conditions for exploiting the game are the same, i.e. agents would enter in a collusion just to self-report if $P < \max \left[-\frac{-b+(1-\alpha\beta)\pi-\alpha\beta F}{F}; -\frac{-c+(1-\alpha\beta)b-\alpha\beta F}{F} \right]$. Then there is no collusion. Similarly, given the rule that agents divide the reduced fine PF if they self-report at the same time, then both players would enter in corruption and both would self-report if $-(1 - P/n)F = -pF > (-b + (1 - \alpha\beta)\pi - \alpha\beta F)$ for the entrepreneur and $-(1 - P/n)F = -pF > (-c + (1 - \alpha\beta)b - \alpha\beta F)$ for the bureaucrat.

3.1.4 Self-Reporting Before and After Detection

In the last case, agents would receive the same fine reduction P if self-report both before or after detected. Here, agents face different fine reduction rules if they self-report before authority's detection RF or after PF ³⁸. As previous examples show, the existence of profitable corruption schemes (1) and (2) together with feasible self-reporting programs (R or $P < \alpha\beta$) are together sufficient conditions for inducing corruption. Once again, it happens because bribe givers gain a credible threat under these conditions.

In the case of different rules for fine reductions, the only remarkable issue lies in the special case in which the reduced fine for early self-reporters RF is non-exploitable and lower than the expected fine $\alpha\beta F$. Simultaneously, the reduced fine for post-detected self-reporters is $\alpha\beta F < PF < \beta F$. Consequently, in this particular case, there would be corruption led by the credible threat from RF . However, if the crime is detected, one would expect agents to self-report. The Figure 4 resumes the expected output from agents given the domains of R , r , P and p .



Notes: (1) r or $p < \min \left[-\frac{-b+(1-\alpha\beta)\pi-\alpha\beta F}{F}; -\frac{-c+(1-\alpha\beta)b-\alpha\beta F}{F} \right]$; (2) R or $P < \max \left[-\frac{-b+(1-\alpha\beta)\pi-\alpha\beta F}{F}; -\frac{-c+(1-\alpha\beta)b-\alpha\beta F}{F} \right]$; (3) $\alpha\beta$; and (4) β . (A) Agents Collude and Self-Report; (B) Agents do not collude fearing other party's self-reporting; (C) Agents collude because first mover uses self-reporting as a credible threat; (D) No collusion or Collusion and Self-Report if detected only if $2 < R < 3$ and $3 < P < 4$; and (E) No Collusion and no Self-Reporting (Trust Game).

³⁸The leniencies are mutually exclusive, i.e. agents can only choose one regime of fine reduction. In other words, agents cannot self-report before detections and then plea bargain. No jurisdiction which I am aware would allow for it, nor would judges or prosecutors want, since one self-report is enough to convict the other involved party.

In summary, under complete information the fine reduction dynamics may induce corruption. It doesn't matter when the agents are allowed to self-report, only the size of the reduction³⁹. The only crime deterrent case for leniencies is when a self-reporter receives a bonus greater than expected return from the corruption act, but not big enough that both agents could explore. In this case, the fear that the other party will exploit the game deters bribery.

Proposition 2. *There is a crime inducing effect from non-exploitable and high enough fine reductions for agents, independently if they can self-report before or after detection.*

3.2 Repeated and Complete Information

The one-shot bribe game can be seen as a small bribery act. This is the type of interaction that occurs occasionally, such as paying a civil servant to have priority in some process in a queue. However, if the game is repeated, this can represent a more serious offence. Generally, it is the indication of other associated crimes and is a common characteristic of big corruption cases. Of course, it does not mean strictly that one-time corruption is a small bribe and repeated ones are big. Therefore, no judgement about the size (value involved) of the corruption scheme is done based on the periodicity.

In fact, the examples suggested in Section 3.1 are the same as here. However, agents can expect to repeat the bribery indefinitely.

3.2.1 Benchmark Without Fine Reductions for Self-Reporters

An indefinitely repeated game can be represented in a matrix form. The benefits of iterated collusion are represented as the present value from infinite collusions given a certain time discount δ_i for $i = [E, B]$ and $\delta_i \in [0, 1]$. Lastly, defection is a one-time gain⁴⁰. Given these characteristics, the matrix form of repeated collusion can be given as:

E/B	Perform	Not Perform	Reject
Bribe	$\frac{-b+(1-\alpha\beta)\pi-\alpha\beta F}{1-\delta_E}$ $\frac{-c+(1-\alpha\beta)b-\alpha\beta F}{1-\delta_B}$	$-b - \alpha\beta F$ $(1 - \alpha\beta)b - \alpha\beta F$	$-\alpha\beta F$ 0

The possibility of repetition induces corruption when the entrepreneur plays first if:

$$\frac{-c + (1 - \alpha\beta)b - \alpha\beta F}{1 - \delta_B} > (1 - \alpha\beta)b - \alpha\beta F,$$

or,

$$c < \delta_B[(1 - \alpha\beta)b - \alpha\beta F],$$

or even,

$$\delta_B > \frac{c}{(1 - \alpha\beta)b - \alpha\beta F} = \frac{c}{p_b b - p_F F}. \quad (5)$$

This result shows that the entrepreneur is going to propose the bribe if bureaucrat's time discount is sufficiently bigger than the bureaucrat's cost benefit from corruption (right side

³⁹In Figure 4, (1) is a minimum because both players need to show the condition for the equilibrium to change. Whereas, (2) if only one agent satisfy the condition then there is no collusion.

⁴⁰The underlining assumption is that, if agents see a defection, they punish the other player by never colluding again (grim trigger).

of (5)). Symmetrically, it is straightforward to see that, corruption is going to happen when the bureaucrat plays first, if:

$$\delta_E > \frac{b}{(1 - \alpha\beta)\pi - \alpha\beta F} = \frac{b}{p_\pi\pi - p_FF}. \quad (6)$$

Note that, for a given set of pay-offs, corruption always happens if the time discount is big enough (Folk Theorem). In other words the time discount from agents needs to be bigger than the cost benefit from bribery in order to overcome the one-time defection constraint. Furthermore, if bribes are profitable, i.e. if conditions (1) and (2) are true than $\delta_i \in (0, 1]$.

Proposition 3. *Without fine reduction for self-reporters, if returns from bribes are positive and agents have high enough time discounts, there is a crime inducing effect from repetitions.*

3.2.2 All cases

After analysing individually the one-shot corruption game with complete information in each distinct self-reporting regimes, it becomes easier to proclaim the results for the repeated game. This happens because, if the game is not exploitable and fine reductions are lenient enough (RP or $RF < \alpha\beta F$), then one would simply expect that corruption would be induced like a sequence of one-shot games. Therefore, choosing collusion is a Sub-game Perfect Nash Equilibrium (SPNE) every round. Since, in this deterrence analysis, the parameters do not change over time, there is no need to expect a change in strategies.

Note that for less lenient fine reductions $R \in (\alpha\beta, 1]$, the game is similar to the benchmark in which there must be a sufficiently high time discount δ_i that make the collusion profitable. In other words, more lenient fine reductions drop the necessity for the time discount conditions (5) and (6). This result is similar to the one in Buccirosi and Spagnolo (2006).

Proposition 4. *In a repeated non-exploitable corruption game with risk-neutral agents, repetitions only induce bribes if fine reductions are less lenient ($R \in (\alpha\beta, 1]$), and agents cannot use them as credible threats.*

4 Incomplete Information

With incomplete information agents cannot know for sure what type of player one is playing against. However, they know what are the pay-offs for each type of player. In this sense, agents estimate the probability of each type and solve their decision problem accordingly.

Note that there are two distinct sources of uncertainties. Either the first mover does not know if the second mover will reject, accept and perform or accept and not perform the act. In other words, agents have incomplete information about the execution of the corruption act. On the other hand, agents may not know if other players will be self-reporters or not, i.e there is incomplete information about self-reporting. Both cases are treated separately below.

4.1 One-Shot with Uncertainty About Favour Execution

In this case, one can use the same examples as in Section 3.1. However, entrepreneurs now have some idea about the environment they are in. In other words, they estimate some probability of bureaucrats being of a certain type. In this specific example, entrepreneurs

know that there are bureaucrats who are never going to accept the bribe, conversely there are some that will, and between them, some that one can trust to perform the favour and others that are going to defect. The bribe payer estimates the probability of each type and makes her decision accordingly.

Note that, there are no cases in which agents would rely on credible threats. This due to the fact that the execution of the favour is now taken for granted. In other words, the execution of the corruption act does not depend on the possibility of the other party self-reporting or not. The formalization and conclusions from this setting are discussed below.

4.1.1 Benchmark Without Self-Reporting

In this setting, suppose that there are three type of bureaucrats: honest who never accepts the bribes; dishonest and trustworthy who accepts the bribe and perform the act; dishonest and not trustworthy who accepts the bribe and do not perform the act⁴¹. Assuming that the probability of being of each type is λ_h , λ_t and λ_{nt} respectively, such that $\lambda_h + \lambda_{nt} + \lambda_t = 1$.

If the game is played under the conditions from Figure 2, the pay-off matrix with the type specific probability is the following:

E/B	Perform (λ_t)	Not Perform (λ_{nt})	Reject (λ_h)
Bribe	$-b + (1 - \alpha\beta)\pi - \alpha\beta F$ $-c + (1 - \alpha\beta)b - \alpha\beta F$	$-b - \alpha\beta F$ $(1 - \alpha\beta)b - \alpha\beta F$	$-\alpha\beta F$ 0
NB	0 0	0 0	0 0

The entrepreneur decides what to do based on the bureaucrats best option. In this game, for positive expected pay-offs from corruption, collusion will be a dominant strategy for the entrepreneur if:

$$\lambda_t(-c + (1 - \alpha\rho)b - \alpha\rho F) > \lambda_{nt}((1 - \alpha\rho)b - \alpha\rho F),$$

rearranging,

$$\frac{\lambda_t - \lambda_{nt}}{\lambda_t} > \frac{c}{(1 - \alpha\rho)b - \alpha\rho F}. \quad (7)$$

In conclusion, following the inequality (7), corruption occurs if the share of not trustworthy bureaucrats (left side) is bigger than the cost-benefit of corruption (right side) for bureaucrats. Likewise, the same results can be mirrored if the bureaucrat plays first and expect different types of entrepreneurs in the market, or else⁴²:

$$\frac{\lambda_t - \lambda_{nt}}{\lambda_t} > \frac{b}{(1 - \alpha\rho)\pi - \alpha\rho F}. \quad (8)$$

In this way, if the first mover believes (trust) that there are enough trustworthy people in the bribery market ((7) and (8)). Consequently, this disrupts the trust game structure of the case with complete information. Therefore, leading to bribes being offered.

⁴¹One can argue that these types of bureaucrat are not rational. However, this could be fixed by imposing a moral cost for each type of bureaucrat, such that pay-offs would be negative to honest bureaucrats that receive bribes, or trustworthy bureaucrats that do not perform the act.

⁴²One can suggest that the proportion of honest and dishonest is some function of the public enforcement variables α , β and F . However, for now, the proportions are considered constant. This result may support the hypothesis that there are some environments more prone to corruption than others.

Proposition 5. *With incomplete information over the performance of corruption and without enforceable agreements, a one-shot corruption is induced if there are enough trustworthy agents in the bribery market.*

4.1.2 All cases

As seen above. The uncertainty about the type of agent can induce some agents to propose bribes. If bureaucrats are still playing rationally⁴³, it is expected that the number of bribes paid is not going to change with the addition of fine reductions. Hence, there are corruption acts that are going to be performed if R or $P < \alpha\beta$. Because bureaucrats would fear retaliation. However, there are bribes that are not going to be performed if R or $P > \alpha\beta$. Consequently, the not performed corruption is not going to be self-reported before any detection, with the exception of the case where $\beta > P > \alpha\beta$, in which agents would report if detected.

Importantly, it is expected that, if R or P are non-exploitable and lower than $\alpha\beta$, then there would be fewer corruption cases under incomplete information than it would under complete information. This happens because the crime inducing effects from trust ((7) and (8)) that disrupts the trust game, act like a constraint in the case where conditions would favour corruption. In other words, for these levels of fine reduction, profitable bribes (1) and (2) are enough to induce corruption under complete information. Whereas under incomplete information agents would need to fulfil conditions (1), (2), (7) and (8).

Proposition 6. *With incomplete information over the performance of corruption, fine reductions for self-reporters do not deter bribe offering. They only determine if corruption is going to be performed or not.*

4.2 Repeated with Uncertainty About Favour Execution

If agents expect to have repeated interactions, then through Folk Theorem there is a time discount δ_i that makes it profitable to enter collusion. The question here is to compare the time discount between the case with complete and incomplete information.

In this way, constraints from incomplete information over bribery performance (7) and (8) must be lower than the incentives given by repetitions (5) and (6). More specifically, agents would offer bribes if outcomes from repeated interactions are greater than the probability of the one-time defection. Combining both restrictions then:

$$\delta_i > \frac{\lambda_t - \lambda_{nt}}{\lambda_t}$$

In other words, if the time discount for both players is bigger than the expected proportions of trustworthy bribe receivers in the system, then corruption is going to be performed in repeated games and not offered in one-time games.

Proposition 7. *With incomplete information, repetition induces crime if time discounts are bigger than the share of trustworthy bribe receivers.*

⁴³If, somehow, agents play according to the expectations. Then, due to miscalculated trust, some bribes are going to be paid to untrustworthy agents. In this case, if the bureaucrat is not performing the act and if fine reductions R or P are lower than $\alpha\beta$ then first the entrepreneur is going to self-report as retaliation. It would be the only case in which one would observe self-reporting as retaliation for non-executed corruption.

4.3 One-Shot with Uncertainty About Self-Reporting

In this case agents do not have complete information about their or the other parties' decision to self-report, i.e. agents do not know which type of agent they are facing (self-reporter or not). This is the same as if agents consider an autonomous exogenous probability of self-reporting sometime after starting a corruption scheme⁴⁴. Note that it does not mean that game has lost its dynamic. It means that agents consider some ex-ante probability of self-reporting due to uncertainty, but they can still rationally use self-reporting in their advantage whenever pay-offs are favourable. Be it by using self-reporting as a credible threat or to exploiting the game.

Note that, differently from the past cases, there is no benchmark without fine reductions to compare to. Obviously, there are only cases in which agents can self-report. Therefore, the impact of uncertainty about parties' decision to self-report is discussed below.

4.3.1 Self-Reporting Before Detection

With complete information, the decision to self-report was completely deterministic. In this case agents consider that there is some source of uncertainty, in other words, there is a probability of self-reporting after committing a crime and given by γ_i for $i = [E, B]$ ⁴⁵. For simplicity, let γ_i be exogenous⁴⁶ and constant in all the feasible domain of R .

Given the above conditions, profitable bribes (1) and (2) are now a function of $(\alpha, \beta, \gamma_B, \gamma_E, R$ and $R)$ ⁴⁷. In this case,

$$p_{F_E} \equiv \underbrace{\alpha\beta(1-\gamma_E)(1-\gamma_B)}_{\text{Prob. being convicted}} + \underbrace{(1-\gamma_B)\gamma_E}_{\text{Prob. reporting}} R + \underbrace{(1-\gamma_E)\gamma_B}_{\text{Prob. being reported}} + \underbrace{\gamma_E\gamma_B}_{\text{Prob. reporting together}} r,$$

$$p_\pi \equiv \underbrace{(1-\alpha\beta)(1-\gamma_E)(1-\gamma_B)}_{\text{Prob. of success}},$$

aggregating for $(1-\gamma_E)(1-\gamma_B) = \Gamma$, then,

$$p_{F_E} \equiv \alpha\beta\Gamma + (1-\gamma_B)\gamma_E R + (1-\gamma_E)\gamma_B + \gamma_E\gamma_B r, \text{ and}$$

$$p_\pi \equiv (1-\alpha\beta)\Gamma.$$

Probabilities of being fined now depend on other player's decision. Therefore, condition 1,

$$-b + p_\pi\pi - p_F F > 0,$$

can be rewritten as,

$$-b + \pi\Gamma(1-\alpha\beta) - F(\alpha\beta\Gamma + (1-\gamma_B)\gamma_E R + (1-\gamma_E)\gamma_B + \gamma_E\gamma_B r) > 0.$$

By the same way, for the bureaucrat, if:

$$p_{F_B} \equiv \alpha\beta(1-\gamma_E)(1-\gamma_B) + (1-\gamma_B)\gamma_E + (1-\gamma_E)\gamma_B R + \gamma_E\gamma_B r,$$

⁴⁴Be it because they do not know the future or they do not know perfectly what are the variables or any other characteristic that could make the other party self-report.

⁴⁵Note that it is algebraically equal to use an exogenous probability of γ_i to the situations in which self-report is happening than it is to use a probability of γ_i for an agent being a 'self-reporter' and a $(1-\gamma_i)$ for a 'not self-reporter'.

⁴⁶Of course, one might think it is a function of α, β, R or γ_j . This would add a lot of complexity to the model, and conditions for an internal solution to the agent's maximization problem would turn dynamic. Nonetheless, this is an excellent topic for further studies.

⁴⁷Technically p_{F_i} is not strictly the probability of F_i being paid, but the expected value of F_i . And it is given by the probabilities of F_i, RF_i or rF_i happening. The same interpretation can be used in the following example with self-reporting after detections.

$$p_b = p_\pi \equiv (1 - \alpha\beta)(1 - \gamma_E)(1 - \gamma_B),$$

or,

$$p_{FB} \equiv \alpha\beta\Gamma + (1 - \gamma_B)\gamma_E + (1 - \gamma_E)\gamma_B R + \gamma_E\gamma_B r,$$

$p_b \equiv (1 - \alpha\beta)\Gamma$ than condition (2),

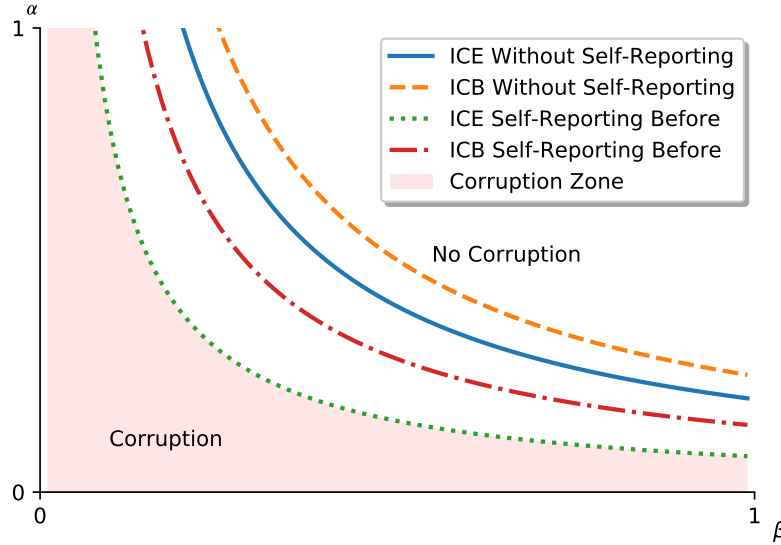
$$-c + p_b b - p_F F > 0,$$

is now written as,

$$-c + b(1 - \alpha\beta) - F(\alpha\beta\Gamma + (1 - \gamma_B)\gamma_E + (1 - \gamma_E)\gamma_B R + \gamma_E\gamma_B r)\Gamma > 0.$$

Given the above conditions, p_{F_i} is different for each player. And both expected values of being fined or earn the corruption premium are now dependent on the other player's action. More specifically, for any positive probabilities of self-reporting $\gamma_i > 0$ the expected fine $p_F F$ is bigger and expected advantages from corruption ($p_b b$ and $p_\pi \pi$) are smaller in relation to the case without self-reporting. Therefore, the self-reporting uncertainty decreases the combination set in which corruption would be feasible for the same level of enforcements α and β . Hence, the deterrence effect can be seen by the retraction of the indifference curves in relation to the ones with no self-reporting. Figure 5 shows the indifference curves for the same level of π , b and F from Figure 1 along with $\gamma_i > 0$ and $R > 0$.

Figure 5: Indifference Curves With Self-Reporting Before Authorities' Detection



In summary, the deterrent effect from $\gamma_i > 0$ requires a softer combination of α and β to start colluding ⁴⁸.

Note that, γ_i is a probability of self-reporting after the crime is committed, agents still need to figure out if crime is going to be performed. Like in the past examples, if entrepreneur plays first, than the bureaucrat performs the crime if agents can credibly threat the other party⁴⁹. Since, the condition in R for credible threats (feasible fine reductions) is $RF < p_{F_i} R$,

⁴⁸Notice that, b and π are fixed in this example. If one allows them to vary, it could be the case that, in order for corruption to be profitable under self-reporting constraints, the price of bribe and the size of the corruption may go up as Bigoni et al. (2012) found in their experiment with higher cartel prices.

⁴⁹Assuming incomplete information from the second mover also would result in always performing the act and the analysis loses its dynamic characteristic.

i.e. reduced fine is smaller than the expected fine. The constraint moved up from $\alpha\beta$ to p_{F_i} ⁵⁰. Fine reductions need to be less lenient for second movers to perform their act. By the same way, conditions for exploitable fines are now $R < \max \left[\frac{p_\pi \pi - p_{F_E} F}{F}, \frac{p_b b - p_{F_B} F}{F} \right]$, which are less lenient than $R < \max \left[-\frac{-b + (1 - \alpha\beta)\pi - \alpha\beta F}{F}; -\frac{-c + (1 - \alpha\beta)b - \alpha\beta F}{F} \right]$ ⁵¹.

The conditions above imply that, circumstances in which agents would use fine reductions as credible threats have increased. However, conditions in which agents would exploit the game are less lenient, thereby less costly to implement.

Lastly, one can note that p_{F_i} is monotonically increasing in R , $\left(\frac{\partial p_{F_i}}{\partial R} > 0 \right)$. In this case, optimum leniency R should be the maximum feasible p_{F_i} . However, if γ_i is some function of R it is likely that optimal fine reduction is an interior solution within the non-exploitable and feasible domain of R . To solve this problem, one must have a good theory on how agents imperfectly calculate their probability of self-reporting γ_i . This issue is revisited in the next section with endogenous probability of self-reporting.

4.3.2 Self-Report After Detection

Like in the past examples with complete information. The bribe is going to be performed if fine reductions for self-reporters after detection are feasible and non-exploitable.

In this case, let ω_i be the probability of an agent to self-report for $i = [E, B]$ and $\Omega = (1 - \omega_E)(1 - \omega_B)$ be the probability of not self-reporting, then p_{F_i} and $p_\pi = p_b$ are $f(\alpha, \beta, \omega_B, \omega_E, P, p)$ which is different for each i , such as,

$$p_{F_E} \equiv \alpha[\beta\Omega + (1 - \omega_B)\omega_E P + (1 - \omega_E)\omega_B + \omega_B\omega_E p] \text{ and } \\ p_\pi = p_b \equiv (1 - \alpha) + \alpha\Omega(1 - \beta).$$

By symmetry, for the bureaucrat, if

$$p_{F_B} \equiv \alpha[\beta\Omega + (1 - \omega_B)\omega_E + (1 - \omega_E)\omega_B P + \omega_B\omega_E p],$$

So, the profitability condition for the entrepreneur (1), can be written as,

$$-b + p_\pi \pi - p_F F > 0,$$

or else,

$$-b + \pi((1 - \alpha) + \alpha\Omega(1 - \beta)) - F\alpha[\beta\Omega + (1 - \omega_B)\omega_E P + (1 - \omega_E)\omega_B + \omega_B\omega_E p] > 0.$$

Likewise, for the bureaucrat the decision rules is also,

$$-c + p_b b - p_F F > 0,$$

or else, when substituting the terms ,

$$-c + b((1 - \alpha) + \alpha\Omega(1 - \beta)) - F\alpha[\beta\Omega + (1 - \omega_B)\omega_E + (1 - \omega_E)\omega_B P + \omega_B\omega_E p] > 0.$$

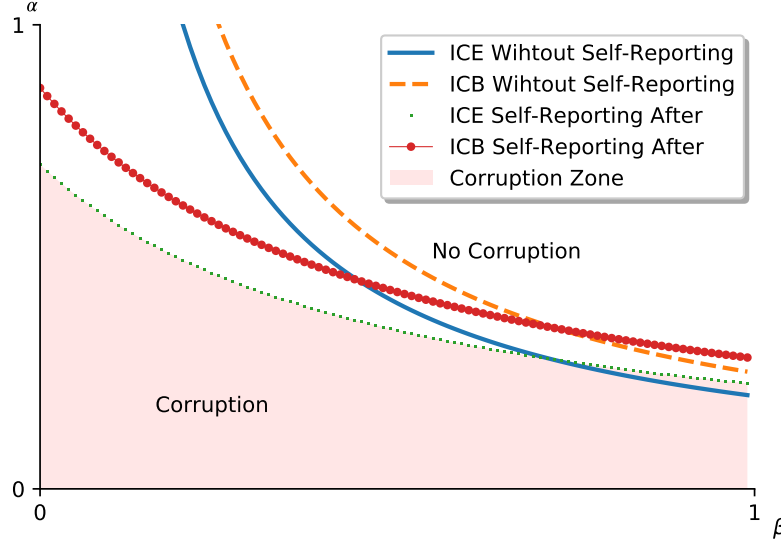
The most notable difference between self-reporting before or after detection is given by the impact of α in the decision choice. In the current case, by definition, agents would fear

⁵⁰There is a $\hat{R} \in (0, 1]$ such that $p_{F_i}(R) = \hat{R}$ and $p_{F_i} > \alpha\rho$. The quick interpretation is that, if $p_b = p_\pi = f(1 - p_{F_i})$, if γ_i and γ_j are positive, then the decrease in p_π or p_b follows an increase in $p_{F_i}(R)$. Proof is in Appendix X.

⁵¹Once again, this result only holds in a setting where γ_i is not a function of R .

self-reporting only if detected. Or else, they are more afraid of prosecutors than they are afraid of the judges. This peculiar effect can be shown in the Figure 6, in which indifference curves are more restrictive to increases in the probability of detection α than they are with probabilities of conviction β .

Figure 6: Indifference Curves for Self-Reporting After Detection



Note that, for a given fine reduction P , crimes with a high enough probability of conviction $\hat{\beta}$ (crimes that produces undeniable evidence), self-reporting after detection may be crime inducing. This is due to the fact that, if agents know they can self-report after being detected, they will do it, because there is almost certainty of conviction in any case.

4.3.3 Self-Reporting Before and After Detection

If fine reductions are feasible and not exploitable, then corruption is performed if profitability conditions are met. In order to calculate them in a staged game with incomplete information ($\gamma_i > 0$ and $\omega_i > 0$) and distinct rules for fine reductions R and P , let:

$$\begin{aligned} p_{F_i} &= f(\alpha, \beta, \gamma_E, \gamma_B, \omega_B, \omega_E, P, R, p, r), \\ p_{F_E} &\equiv \alpha\Gamma(\Omega\beta + (1 - \omega_B)\omega_E P + (1 - \omega_E)\omega_B + \omega_E\omega_B p) + (1 - \gamma_B)\gamma_E R + (1 - \gamma_E)\gamma_B + \gamma_E\gamma_B r, \\ p_{F_B} &\equiv \alpha\Gamma(\Omega\beta + (1 - \omega_B)\omega_E + (1 - \omega_E)\omega_B P + \omega_E\omega_B p) + (1 - \gamma_B)\gamma_E + (1 - \gamma_E)\gamma_B R + \gamma_E\gamma_B r, \\ &\text{in the same way,} \\ p_\pi = p_b &\equiv \Gamma[(1 - \alpha) + \alpha\Omega(1 - \beta)]. \end{aligned}$$

Given that agents still face the same problem of having a positive expected pay-off from collusion (1 and 2). Then, the constraints given by the positive probability of being reported may decrease expected pay-offs from corruption through bigger expected fines $p_{F_i} F$ and lower probability of going unpunished and receiving the advantage of corruption p_b and p_π . Therefore, the decision rule for the entrepreneur can be expressed as:

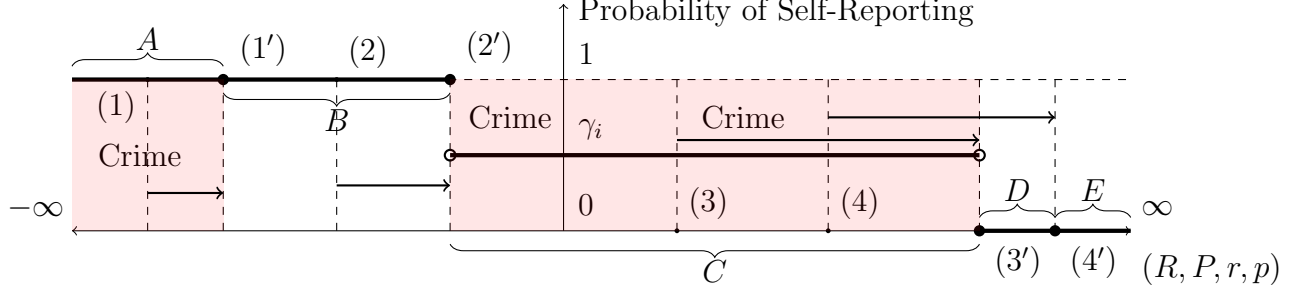
$$-b + \pi\Gamma[(1 - \alpha) + \alpha\Omega(1 - \beta)] - F(\alpha\Gamma(\Omega\beta + (1 - \omega_B)\omega_E P + (1 - \omega_E)\omega_B + \omega_E\omega_B p) + (1 - \gamma_B)\gamma_E R + (1 - \gamma_E)\gamma_B + \gamma_E\gamma_B r) > 0,$$

and for the bureaucrat,

$$-c + b\Gamma[(1 - \alpha) + \alpha\Omega(1 - \beta) - F(\alpha\Gamma(\Omega\beta + (1 - \omega_B)\omega_E + (1 - \omega_E)\omega_BP + \omega_E\omega_BP) + (1 - \gamma_B)\gamma_E + (1 - \gamma_E)\gamma_BR + \gamma_E\gamma_BR)] > 0.$$

Regarding the dynamic constraint from using self-reporting as a credible threat to induce collusion, Figure 7 resumes how the domain in R and P changed with the addition of self-reporting uncertainty γ_i and ω_i .

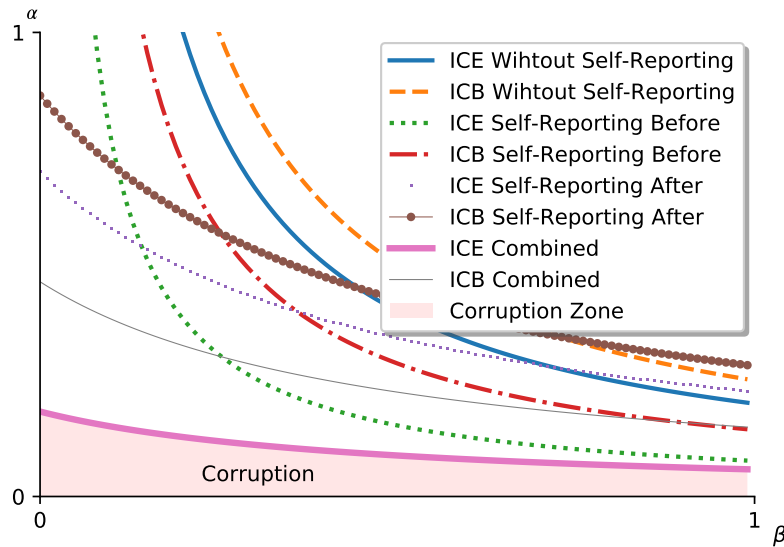
Figure 7: Fine Reduction Domain



Notes: Arrows from i to i' , show the direction of the effect when the probability of self-reporting γ_i and ω_i grow. (1) r or $p < \min \left[\frac{-b+p\pi\pi-p_{FE}F}{F}; -\frac{-c+p_b b-p_{FB}F}{F} \right]$; (2) R or $P < \max \left[-\frac{-b+p\pi\pi-p_{FE}F}{F}; -\frac{-c+p_b b-p_{FB}F}{F} \right]$; (3) p_{Fi} ; and (4) $p_{Fi}\alpha = 1$. (A) Agents collude and self-report; (B) Agents do not collude fearing other party's self-reporting; (C) Agents collude because first mover uses self-reporting as a credible threat; (D) No collusion or Collusion and Self-Report if detected only if $2' < R < 3'$ and $3' < P < 4'$; and (E) No Collusion and no Self-Reporting (Trust Game).

Computing the indifference curves from the above conditions and comparing with the previous calculated ones, from Figure 8 it is clear to see the deterrent effect of the combined policies when $\gamma_i > 0$ and $\omega_i > 0$. The deterrence effect is given by the reduced set of combinations of the public enforcements in which corruption would be feasible.

Figure 8: Indifference Curves With Combined Policies



Proposition 8. *With incomplete information over self-reporting, the possibility of reporting ($\gamma_i \geq \gamma_j > 0$) and/or being reported ($\omega_i \geq \omega_j > 0$) cumulatively deter corruption by*

decreasing expected pay-offs from corruption. Whereas the size of the reductions P and R induces the crime through decreasing expected fines.

The effect above is similar to the ‘pre-emption effect’ pointed by Harrington (2013), although he assesses the effect from private signals in an environment after the crime is committed. Nonetheless, results point to the same mechanism, the fear of being reported feeds fear on the other party, mutually affecting the expected value from self-reporting. Spagnolo (2005) also considers the role of uncertainties by another methodology, using riskiness analysis, he finds that the risk from being reported affects the decision to collude more than the current level of detection.

In summary, if agents are uncertain about the other party decision to self-report, then the expected fine is lower, given fixed values of the other enforcement variables. Through this, agents can use less deterrent fine reductions as credible threats. However, they have lower expected returns from bribe, so they would need lower bonuses to exploit the game or bigger expected proportion of trustworthy crime partners to enter in bribery.

4.3.4 Endogenous Probability of Self-Reporting

From past examples it is possible to observe that uncertainty about self-reporting represents a major constraint to corruption. However, uncertainties were not related to the fine reductions R and P . By this way, it was possible to isolate the deterrent effect from introducing leniency to self-reporters in a game without complete information from agents.

Note that the only effect of fine reductions changes R and P in corruption for given probabilities of self-reporting γ_i or ω_i , is that less lenient fine reductions deter corruption through higher expected fines $P_{F_i}F$. However, it is likely that the probability of self-reporting γ_i or ω_i is some negative function of R and P . Although, there is no good theory about the functional form of this relation⁵², the linear case is the one addressed here.

In order to address the effect of leniencies over corruption deterrence, let θ_k be the linear coefficient that relates the k rules of fine reduction R and P to the probability of self-reporting γ_i and ω_i , in which $f'(\theta_k) < 0$, and $f''(\theta_k) = 0$ such that,

$$\gamma_i = \gamma_{i0} - \theta_R R,$$

and,

$$\omega_i = \omega_{i0} - \theta_P P.$$

If the functions above are bounded between 0 and 1⁵³, then, there must be a sufficiently high θ_k^* that makes the deterrent effect from a more lenient R bigger than the crime inducing effect. In other words, there is a point where the fear of other parties self-reporting (pre-emption effect(Harrington, 2013)) is higher than the crime inducing effects of the reduced expected fines from leniency. The proof of this statement is on Appendix X.

Lastly, the reader is invited to try different combinations of parameters in an interactive graph and check how indifference curves behave. An interactive application from this model is available at <https://colab.research.google.com/drive/1-kZ28JCB3uP5WvBwgOxxYCuDvyUMrwMA#scrollTo=NZUyifuQJKx9>⁵⁴.

⁵²Perhaps, hints about how fine reductions affect the probabilities of self-reporting could be better explored studying the disruption effect from self-reporting, i.e. ex-post behaviour of agents in a stochastic system.

⁵³One functional form that would be naturally fitted to this case would be a logistic curve, such that $\gamma_i = f(R) = \frac{1}{1+e^{\theta_R(R-\gamma_{i0})}}$, then $f'(R) < 0$ and $f(0) = \gamma_0$. However fitted it may be, the theory behind lacks some common features of logistic functions such as population growth. Moreover, it is a little less intuitive and proof is not so straightforward.

⁵⁴This is a preliminary code, the user may need to rerun the code by clicking on the play button on the top left corner of the coding shell. An HTML version is being prepared

4.4 Repeated With Uncertainty About Self-Reporting

As in the previous example of repetitions with complete information. If fine reductions R or P are greater than p_{Fi} , in other words, within the interval of D and E from Figure 7, than repetition can induce corruption. Since they give the necessary incentive to overcome one-time defection constraint (Folk Theorem). In this case, agents need to have high enough time discount δ_i that disrupts the prisoners dilemma and make them collude (5) and (6). If such condition is met, agents only need expected returns of corruption to be positive (1) and (2).

4.4.1 All cases

From previous examples, $p_{Fi} = f(R, P)$, thereby $\delta_i = f(R, P)$, and it must be different in every different type of leniency policy.

Note that, if $\gamma_i > 0$ and $\omega_i > 0$, then expected fines $p_{Fi}F$ is now bigger and probabilities of receiving the advantages of corruption p_b and p_π are smaller. Consequently, through (5) and (6), $\delta_i^{nsr} \leq \min[\delta_i^{srb}, \delta_i^{sra}] \leq \max[\delta_i^{srb}, \delta_i^{sra}] \leq \delta_i^{srba}$ for ‘ nsr ’ ‘ srb ’, ‘ sra ’ and ‘ $srba$ ’ being respectively no probability of self-report ($\gamma_i = 0, \omega_i = 0$), positive probability of self-reporting only before detection ($\gamma_i > 0, \omega_i = 0$), positive probability self-reporting after detection ($\gamma_i = 0, \omega_i > 0$) and positive probability of self-reporting at any time ($\gamma_i > 0, \omega_i > 0$). In other words, as probabilities of agents to self-report at any time grow, time discount must be higher to engage corruption than they would need to be in previous cases.

5 Conclusion

This paper explores the ex-ante deterrent effect from leniency programs in corruption crimes. Literature suggests that leniencies to self-reporters can be counterproductive against corruption. Sophisticated players could use the law in their favour, thereby incentivizing criminal behaviour (Buccirossi and Spagnolo, 2000, 2001, 2006). Nonetheless, recent studies in leniency policies (for cartels) point to the role of the risk, uncertainty (Spagnolo, 2005; Harrington, 2008, 2013) and other positive effects that the policy addresses to the problem (Marvão and Spagnolo, 2014). In this sense, most of the conclusions about fine reduction to self-reporters comes from anti-trust, a lot less is confirmed from the specific framing of corruption. This paper goes deeper in to this reasoning and shows that, most of the potential deterrent effect from the policies come from generating uncertainties to the wrongdoers. Moreover, it shows the potential differences between types of wrongdoers and how they devise their perceptions about other players are crucial for the success of the policies.

First, the study shows that, in order to perform corruption, bribes need to be profitable (conditions (1) and (2)). Then, it is crucial to define the level of information from the players. If agents are very sophisticated and they know well the players they are playing against, the information is assumed to be complete. In this setting, the absence of leniency to self-reporters deters one-shot non-enforceable agreements through the sequential game dynamic. Which approaches the structure of a trust game, in which rational players would always defect. If leniencies are given to self-reporters, if reductions are non exploitable and feasible (Figure 4) self-reporting is used as a credible threat inducing corruption. Importantly, it does not matter if agents can self-report before or after the detection from an authority. Furthermore, repetition can induce corruption if fine reductions are less lenient.

If information is incomplete, if there is some autonomous exogenous probability of agents self-reporting, then outcomes change. Uncertainty reduces the expected benefits from cor-

ruption and increase expected fines. Therefore, it constrains the profitability from bribes and eventual time discounts in repeated interactions. It also changes the domain in which fine reductions are feasible and non exploitable. Notably, lower bonuses for exploitability conditions and less lenient reductions for using self-reporting as a credible threat. Lastly, allowing agent to self-report before or after being detected by the authorities have a cumulative effect over corruption deterrence.

The study speculates on the role of fine reductions in the agents probability of self-reporting. If this relation is negative, there must be a point in which the crime inducing effect from lower expected fines is smaller than the crime deterrent effect from fear of being reported. This relation must be better explored by a more robust theory. Perhaps the ex-post analysis of leniency policies can help in this task. Certainly a more challenge set would involve the decision of agents after they committed a crime. Or else, the disruptive effects of self-reporting. This approach would require to let variables change over time. Perhaps, a state space model with dependent laws of motion may be a good way to start.

Other possible extensions to this simple model may account for: the welfare maximization problem; corporate Vs individual self-reporting; non monetary sanctions; different liability regimes (agency costs); asymmetric punishments; recidivism; endogenizing variables or letting them change over time; allowing Type I errors; risk-preferences; and social norms or other behavioural biases.

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