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Abstract

We construct a one-shot corruption game with three players, a briber who can decide to bribe or not, an official who can reciprocate or not and an inspector who can decide to inspect or not. We employ four penalties that can be distributed asymmetrically, making it possible to punish bribing and bribe-taking as well as reciprocating and accepting considerations to different degrees. Penalties apply if corruption is detected. The probability of detection is endogenised, as it depends on inspection. The model differs from other inspection games in that the offence (corruption) can only be completed in a joint effort between two of the players. This leads to surprising results, especially in conjunction with asymmetric penalties. First, in contrast to Tsebelis' counterintuitive results, we find confirmed that with endogenous detection, higher penalties do reduce the overall rate of offence. Second, this result holds only if the penalty for reciprocating on the official is raised. Surprisingly, and unlike other asymmetric penalty prescriptions in the corruption literature, higher penalties on on the briber have the opposite effect. They may reduce the probability of bribery, but they also increase the probability of reciprocation to the extent that the overall probability of reciprocated bribery is increased.

Keywords: Inspection game · Corruption · Asymmetric penalties · Endogenising detection

JEL Classification: K42 · H00 · C72 · O17

Introduction

By application of basic demand theory, Becker (1968) famously showed that when looking at the determinants of criminal behaviour, crime levels depend on the probability of detection and the size of penalty. More specifically he demonstrated that the combination of a maximum penalty combined with minimum detection efforts results

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in optimal deterrence. In contrast to these results, Tsebelis (1989; 1990; 1990; 1995)[1] showed that this only holds true in a decision theoretic context, where detection occurs with an exogenous probability. Converting the model into a game-theoretic one, where detection depends on the relative payoffs of an inspector, showed that raising the penalty, as Becker suggested, does not lead to a reduction in crime. Instead Tsebelis found the following; In a two-player crime game where the rate of inspection depends on the rate of offence and vice versa, an increase in the penalty for offending results in a reduction of the rate of inspection in equilibrium[2], while the rate of offence remains unchanged.

A literature has emerged in response to Tsebelis' strong and counter-intuitive results. Several scholars have pointed out that these results only hold under certain conditions[3]. We do the same. However, the innovation of our game lies in its specific setup. Where all other models of said literature assume either single offenders or populations of offenders, our model differs. Due to the nature of corruption two types of offenders are required, for example a briber and an official, who can bribe and reciprocate respectively. The hard crime of corruption as reciprocated bribery can thus only happen in a joint effort between the two players. To capture this, we create a basic corruption scenario with a briber who can decide to bribe an official in order to procure some sort of quid pro quo (e.g. a government contract); and an official who can decide to reciprocate or not to reciprocate. The game involves four penalties, one for bribing and one for reciprocating, as well as one for accepting a bribe and one for accepting a quid pro quo. This allows us to use asymmetric penalty distributions, and thus to offer more insightful policy recommendations. To transform this into an inspection game, we endogenise the probability of detection by incorporating a third player - an inspector -, whose payoffs depend on the actions of the other players.

The results are as follows. First, we are able to reproduce Tsebelis' result in our model. We achieve this by setting the parameters such that the official always reciprocates, for instance because penalties for reciprocating are very low. Second, we find a new full mixed-strategy equilibrium between all three players. In its case, asymmetric penalties have very significant effects. Raising the penalty for reciprocation asymmetrically may cause the rate of bribery at equilibrium to rise, cause the rate of reciprocation at equilibrium to fall, cause the rate of detection at equilibrium to fall as well, and cause the overall rate of reciprocated bribery to decrease. Contrarily, raising the penalties for the briber, that is for bribing and accepting quid pro quos after bribery, may reduce bribery itself, but it also leads to an overall increase of reciprocated bribery. We find confirmed that, in order to achieve optimal deterrence the penalty for reciprocation ought to be maximised, while the penalties for bribing and for accepting quid pro quos ought to be minimised.

The rest of the paper is organised as follows. Section 2 explains the relation to the corruption literature and the inspection game literature. Section 3 explains the model and its assumptions. In section 4 we provide an intuitive explanation of what happens in

[1]Graetz et al. (1986) developed a similar model already before Tsebelis. This will be discussed later.

[2]The game has a unique mixed-strategy Nash equilibrium.

[3]Bianco et al. (1990) argued that if the game was iterated or had more players, it might lead to different results. Graetz et al. (1986), Cox (1994), Friehe (2008), and Pradiptyo (2008) all offered different results in slight variations of Tsebelis' model.

our model. Section 5 discusses strategies and equilibria and section 6 elaborates on the full mixed-strategy equilibrium, providing insights into optimal corruption deterrence. Section 7 concludes.

2 Related research

This paper seeks to contribute to two literatures. First, in its treatment of the asymmetric penalties proposition, it ties in with research in the political economy and economic theory of corruption. Jain (2001) offers a general overview of corruption within said disciplines[4]. Aidt (2003) offers a review of microeconomic theory of corruption. A range of analyses in the corruption and optimal deterrence literature follow the orthodox approach of Gary Becker, in assuming that detection be an exogenous variable. This literature plays a significant role, because global anti corruption efforts rely predominantly on it.

The idea of asymmetric penalties was first developed by Rose-Ackerman (1999). She noted that, since it takes two people to commit the specific crime of corruption, it might in fact suffice to deter one of the two parties. To enforce this, she suggested asymmetric penalties to undermine the bond between corruptor and corruptee. This idea has been refined by Lambsdorff & Nell (2007), who developed the corresponding formal model and policy implications for the anti-corruption legislation in Germany and Turkey. Like Rose-Ackerman, the authors assume Becker's optimal deterrence formula and suggest asymmetric penalties to destroy the force of social norms/reciprocity in order to undermine corrupt behaviour[5]. They find that under exogenous detection, giving severe punishment for bribing and for reciprocating (but low punishment for accepting bribery and for accepting quid pro quos) is the most efficient penalty distribution. As mentioned earlier, the results of our game suggests, however, that only high punishment for reciprocation works as a deterrent, while penalties to the briber are counterproductive; they lead to more reciprocated bribery. A recent paper by Engel et al. (2012) compares symmetric and asymmetric punishment in an experiment, where it is confirmed that asymmetric penalties are the more effective deterrence mechanism.

It is worth noting that legislation differs widely between countries with respect to penalty symmetry, which stresses the importance of this research. Under German law, for instance, a briber is considered as guilty as a bribe-taker, which allegedly gives moral justification to equal punishment[6]. Our results show, however, that punishing officials more gravely is the more effective deterrent, suggesting that an asymmetric penalty distribution leads to the greater social good despite the putatively unjust nature of the punishment for the individuals involved in the crime.

[4] See also Rose-Ackerman (2006) for a more extensive handbook on the economics of corruption.

[5] Lambsdorff (2007) elaborated on this idea and developed what he refers to as the invisible foot principle. Basu et al. (1992) also use asymmetric penalties. However, they do so only for bribing and accepting bribery, but not for reciprocating.

[6] The upper bound of prison sentences and fines is equal for bribing and accepting bribes under §§331-335 of the German criminal code (Strafgesetzbuch). This is argued to be justified, since the misappropriation of public funds or goods happens in a mutual act. Thus, as people are deemed equal before the law as per the constitution, they deserve equal punishment.

More importantly, however, this paper offers an interesting addition to the literature around Tsebelis' inspection game. Like other contributions within this literature, our results depend on mixed-strategy Nash equilibria. A number of studies such as Graetz et al. (1986) and Dionne et al. (2009) show that mixed-strategies as expressions of population proportions or frequencies of activities are not at all meaningless. This is corroborated by empirical evidence (Levitt & Miles (2007). In fact, what this shows is that the basic idea of the inspection game had been developed in the tax evasion literature even before Tsebelis made the general case. A similar model appears in yet another stream of literature, looking at auditing around insurance fraud (Dionne et al. (2009)). Recent contributions to the inspection game literature are Andreozzi (2004), Friehe (2008) and Pradiptyo (2008). Basu et al. (1992), Besley & Mclaren (1993), Mookherjee & Png (1995) and Marjit & Shi (1998) develop corruption models, in which detection is endogenised, although not in the same way as in the inspection game. Common to all four is the basic model structure. It is assumed that a briber has to enter a Nash bargaining game with an official, whose trade-off lies between accepting/demanding a bribe or reporting the bribe/receiving a reward for doing so/etc. Even if bribery can ascend in an hierarchy, as is the case in Basu et al. (1992) and Besley & Mclaren (1993), there is always a connection between the briber and the official (inspector) in the higher tier, in so far as the former may choose to bribe the latter. In contrast to this family of models, we assume in our model that the corrupt collaborators and the inspector cannot strike any deals between each other[7]. Given rational agents, we assume that briber and official vis-à-vis the inspector can only anticipate each others' strategy choices, but they cannot collude.

3 Setup and assumptions

We begin with the original two-player one-shot game by Lambsdorff & Nell (2007), in which a briber (B) can decide to bribe or not to bribe and an official (O) can then decide to reciprocate or not to reciprocate. Penalties are given for bribing/accepting the bribe[8] (p_B^1 and p_O^1) on the one hand, and for reciprocating and accepting quid pro quos (p_O^2 and p_B^2) on the other. Penalties apply with probability α, an exogenous parameter. If there is bribery and the official decides to reciprocate, she will gain the bribe (b) and a reciprocity bonus (r), but she also faces penalties for accepting the bribe (p_O^1) and for reciprocation (p_O^2), if detected with α. In this case, the briber gains the benefits of the quid pro quo (v), but loses the bribe and faces the penalties for bribery (p_B^1) and for accepting the quid pro quo (p_B^2) if detected. If the official decides not to reciprocate after bribery, she gains the bribe, but she has to pay penalty p_O^1 if detected, and does not gain the social benefit r. The briber loses the bribe in this case and has to pay penalty

[7] If we were to convert our game into a cooperative one, this would require a bargaining game between all three parties, where briber, official and inspector have to negotiate on the payoff to the inspector. This might however lead to issues of crime control as shown in Marjit & Shi (1998).

[8] Note that in this game the official automatically accepts, if she is offered a bribe. She cannot reject. This is plausible if the size of the bribe is always high enough to achieve acceptance, but not necessarily reciprocation. Alternatively, one might think that an official would first decide whether to accept a bribe or not, and then reciprocate in case of acceptance. However, since we are focussed on detection there is no need to make alterations of this kind.

p_B^1 if detected. If there is no bribery, the payoff for both the briber and the official is zero. We adopt this structure in our model[9].

The reciprocity bonus (r) requires explanation. Lambsdorff and Nell assume that there is a social norm of reciprocation, which makes bribery possible in the first place. Corruption requires reciprocal trust, because it is amoral and illegal[10]. In real life it would always be better for a corrupt official to just accept bribes, but then not to reciprocate, if it was not for either the fear of losing reputation, or the threat of punishment or some other form of social pressure. This is reflected in the game. Backward induction shows that, if r is not sufficiently large, the official will never reciprocate and thus the briber will never bribe[11].

In our model we want to endogenise the detection parameter. First of all, in order to allow for mixed-strategy equilibria, we need to replace the actions of the briber and official with probability distributions. Let thus the probability of bribery be β_1 and the probability of not bribing $1-\beta_1$. Likewise, let β_2 be the probability for reciprocating and $1-\beta_2$ the probability for not reciprocating. Further, we introduce an inspector (I). The probability of detection α is replaced by the inspector, who can decide to inspect with probability α or not to inspect with probability $1-\alpha$. We construct her payoffs in Tsebelis' format, as is shown in Table 1. Similar to Tsebelis' inspection game, we assume that inspecting is better in case of (reciprocated) bribery, than it is in case of no bribery and vice versa: $a_I > b_I$; $c_I > d_I$; $e_I < f_I$. To fit the requirements of this three-player model, we also make a 'bigger catch' assumption ($a_I > c_I$ and $b_I > d_I$, or $a_I - b_I > c_I - d_I$), suggesting that finding a case of reciprocated bribery is more rewarding than mere bribery. To remain in line with Tsebelis' inspection game, we assume that every inspection is successful.

Table 1: Tsebelis-type inspector payoffs

Decision	Inspect α	Not inspect $1-\alpha$
Bribe, accepted and reciprocated: $\beta_1\beta_2$	a_I	b_I
Bribe, accepted but not reciprocated: $\beta_1(1-\beta_2)$	c_I	d_I
Not bribe: $1-\beta_1$	e_I	f_I

For reasonable and intelligible outcomes we make several assumptions about the variables in the game. For the standard game, we assume that $b > 0$, i.e. that a bribe cannot be zero or negative[12]. Further, we assume that $v > 0$, i.e. the briber's benefit from receiving the quid pro quo must be positive (otherwise the briber would not be interested in the quid pro quo, even if she could get it without bribery). The default

[9] Lambsdorff and Nell's original model also included additional nodes, where players could defect and report on each other. We exclude these for simplicity.

[10] The bonus (r) can then either be seen as an investment in the future (for instance as a positive discount factor) or one could replace it with a threat in form of a cost of punishment for not reciprocating

[11] As shown later, r needs to outbalance αp_O^2. The official gains r by reciprocating, but she also risks an additional penalty (p_O^2) with probability α.

[12] A negative bribe could be seen as a bribe from official to briber, but this case shall not concern us here.

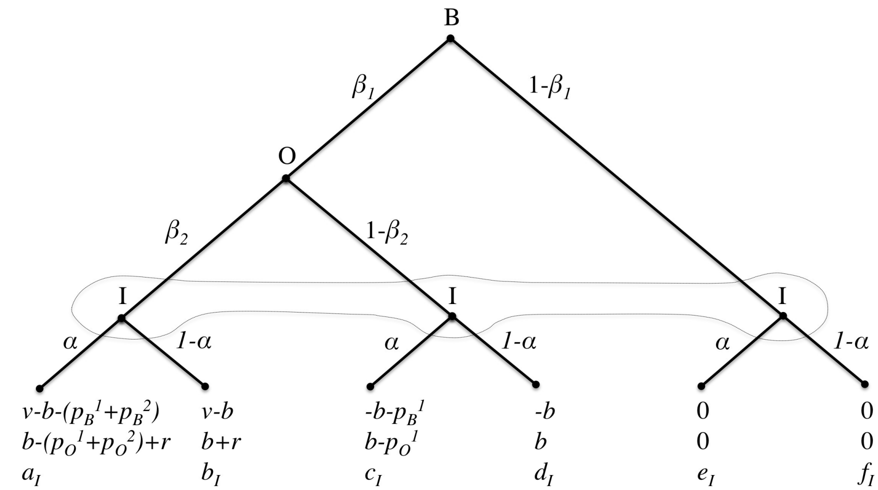

Figure 1: Extensive form game

assumption about the penalties is $p > 0$[13]. We further assume that $r \geq 0$. The necessary condition for reciprocation is then $r \geq \alpha p_O^2$.

4 An intuitive explanation

Since it is our aim to endogenise detection, we are interested in equilibria where the inspector plays a mixed-strategy such that $1 \geq \alpha \geq 0$. If this is is the case, we can use equation (1) to gain an intuitive understanding of the model. We are now interested in what happens if we raise any of the four penalties, that is if we move from one equilibrium to another. Looking at the payoffs of the inspector, we know from Figure 1 that for her to be indifferent between inspecting and not inspecting the following must be true:

$$\beta_1\beta_2(a_I - b_I) + \beta_1(1-\beta_2)(c_I - d_I) + (1-\beta_1)(e_I - f_I) = 0 \qquad (1)$$

Further, we know from our assumptions about the payoffs of the inspector that $(a_I - b_I) > (c_I - d_I) \geq 0 \geq (e_I - f_I)$. Thus, keeping the latter in mind, we can infer from (1) that if some penalty causes β_2 to increase, then, in equilibrium, this can only happen if β_1 decreases. For if β_2 increases, $(a_I - b_I)$ increases. So, to keep the whole equation

[13]This assumption can be changed to $p \geq 0$, depending on what we believe to be more realistic or more suitable with a view to determining the most effective way of deterring corruption. We might for example believe that not all four penalties are distinguished by some legislations. Moreover, in Lambsdorff and Nell's original game players could not only report on each other, but reporting was rewarded. They called this leniency. An investigation of this case might be worthwhile in a variation of our game. In yet another variation it might also be useful to think of the penalty for bribing as a positive incentive that cancels out the cost of the bribe. This makes sense, if bribing occurred in order to gain access to a public good, to which one was entitled to anyway (cf. Basu (2011)).

equal to zero, $(e_I - f_I)$ must change accordingly to balance out the effect of the change in β_2 (i.e., because $(e_I - f_I) \leq 0$, to balance out, $(1-\beta_1)$ must increase, and thus β_1 decrease). In fact, we can infer even more. If, as in this example, β_1 goes down, then β_2 must not only increase, but it must do so sufficiently as to keep the equation equal to zero. In other words, we know that a decrease in the probability of bribery (β_1) always involves an increase in the probability of reciprocation (β_2) *and* an increase in the overall probability of reciprocated bribery ($\beta_1\beta_2$).

Given this intuitive account, we can infer what should happen if we raise the penalties separately. Let's assume that the penalty for bribing (p_B^1) is raised, ceteris paribus. In the first instance, this would reduce the payoff of the briber for bribing and destroy the equilibrium. However, to remain in equilibrium, she ought to remain indifferent. We might think that this could be achieved if α went down. We know however that, in order to keep the official indifferent, α must not change (for if alpha went down, the official would reciprocate for sure and the equilibrium would once again be destabilised). Therefore, to keep the briber indifferent, β_2 must increase. However, if β_2 went up, the inspector would no longer be indifferent. Thus β_1, finally, needs to decrease. Now, if we look at (1), we find this confirmed. So, β_2, the probability of reciprocation, must increase exactly so much as to keep the briber indifferent, and moreover that it exceeds the decrease of β_1 in (1) as to keep the inspector indifferent.

We can repeat the same process with the other penalties. Assuming that the penalty for accepting a quid pro quo to the briber (p_B^2) went up, it is easy to see that this will have the same effect as raising (p_B^1) in the first example. Again, the penalty will deter bribery in the first instance, however to keep everyone indifferent, α must remain unchanged and β_2 and $\beta_1\beta_2$ must increase while β_1 decreases. Now, assuming that p_O^2 is raised, the situation is the opposite. In the first instance the equilibrium is destroyed, because the official is deterred from reciprocating. In the new equilibrium α must therefore decrease accordingly, so as to make the official indifferent again. As this would deter the briber from bribing, the rate of reciprocation has to decrease. Finally, as this in turn would deter the inspector from inspecting, the rate of bribery has to increase in order to form the new equilibrium. Again this is confirmed by (1). If β_2 went down, $(a_I - b_I)$ would also decrease. Thus, to keep the balance β_1 must increase accordingly, i.e. proportionally less compared to the decrease of β_2, and therefore ensuring that $\beta_1\beta_2$ also decreases. Finally, raising p_O^1 will not have any effect, because, as we can see in Figure 1, it is an element of the official's payoff whatever she chooses to do, which is the result of our assumption that bribes are never rejected.

We can thus already infer policy implications, because we know what will happen to the overall probability of reciprocated bribery - the joint effort that is the crime of corruption. There is more corruption, if we penalise bribers harder (whether it is for their bribing or their accepting of bribe-induced quid pro quos), and there is less corruption if officials get tougher penalties for reciprocating as a response to bribery.

5 Strategies and equilibria

This section has two aims: We provide an algebraic proof of the above intuitive account, which was based on the full mixed-strategy equilibrium; and we explore other equilibria. Given α, β_1 and β_2, there are 27 theoretical permutations of equilibria in mixed and pure strategies. One way of arriving at a meaningful interpretation of these equilibria is to look at the value of α as the optimal detection strategy. In doing so, we consider the strategies of briber and official as functions of α. The necessary value of α is then determined by whichever is lowest among: the value of α at which the briber *might* bribe; the value of α at which the official *might* reciprocate; and $\alpha = 1$[14]. The briber might bribe so long as $\alpha \leq \frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}$[15]. The official might reciprocate so long as $\alpha \leq \frac{r}{p_O^2}$[16]. Finally, the value of α cannot intelligibly exceed one, since 1 denotes definite inspection ($0 \leq \alpha \leq 1$). In short, we are interested in what happens if $\alpha = min\{1, \frac{r}{p_O^2}, \frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}\}$. The set of possible equilibria is therefore divisible into three types of equilibria, as shown in Figure 2.

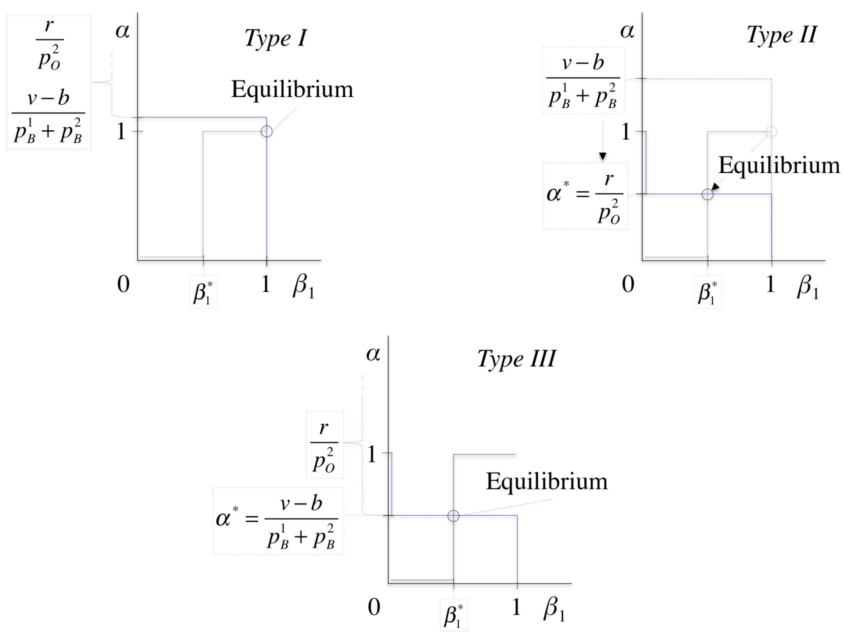

Figure 2: Equilibrium types

In *Type I* we assume that either the penalties are very low or the payoffs (in this

[14]For if α exceeded the minimum, we would have a contradiction. For instance, if $\alpha > \frac{r}{p_O^2}$ the official would not reciprocate ($\beta_2 = 0$), and therefore the briber would not bribe ($\beta_1 = 0$). However, the payoff structure of the inspector tells us that if there is no offence, he ought not to inspect. We know that $\frac{r}{p_O^2} > 0$, so if $\alpha > \frac{r}{p_O^2}$,then $\alpha > 0$ and $\alpha = 0$ is a contradiction.

[15]This equation is the result of solving $\beta_2(v - b - \alpha(p_B^1 + p_B^2)) + (1 - \beta_2)(-b - \alpha p_B^1) \geq 0$ for α, i.e. the condition under which bribing becomes more lucrative than not bribing.

[16]See also equation (2) below.

case r and $v-b$ respectively) are high enough so that $1 < \frac{r}{p_O^2}, \frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}$. In other words, reciprocated bribery happens regardless of definite detection and penalty. In this case the equilibrium is at $\alpha = 1$, $\beta_1 = 1$, $\beta_2 = 1$. If we were to increase either of the penalties p_O^2, p_B^2 or p_B^1, this would ultimately result in a scenario of either type II or III.

In *Type II* we assume that out of $\alpha = min\{1, \frac{r}{p_O^2}, \frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}\}$ the lowest value is $\frac{r}{p_O^2}$. In this case, the critical α (in the payoff structure of the official) is such that the official is indifferent between reciprocating and not reciprocating (β_2^*). As a result of the change in the value of β_2, the briber is now indifferent between bribing and not bribing at $\alpha^* = \frac{\beta_2 v - b}{p_B^2 + p_B^1}$. The emerging equilibrium is at α^*, β_1^*, β_2^*. What happens if we were to modify any of the penalties in this scenario, was shown in the intuitive account earlier and will be discussed again below.

In *Type III* we assume that the lowest value out of $\alpha = min\{1, \frac{r}{p_O^2}, \frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}\}$ is $\frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}$, in which case $\frac{r}{p_O^2} > \frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1}$. Thus, at α^*, at which the briber is indifferent between bribing and not bribing (and the inspector between inspecting and not inspecting because of β_1^*), the official will reciprocate for sure ($\beta_2 = 1$). So long as we assume that $v > b$, the equilibrium is unique at α^*, β_1^*, and $\beta_2 = 1$. In other words, the game reduces to Tsebelis' inspection game. As the graph shows, if we increase either of the penalties p_B^2 or p_B^1, it will result in a reduction of the level of detection (α^*), but the level of bribery (β_1^*) remains ultimately unaffected.

For the sake of completeness it should be noted that other similar equilibria are possible. For instance, in a case similar to the *Type II* equilibrium, α^* may happen to be one, in which case we would have one possible equilibrium where $\alpha = 1$, β_1^*, β_2^*, if $\frac{r}{p_O^2} = 1$ and subsequently $\frac{\beta_2 v - b}{\beta_2 p_B^2 + p_B^1} = 1$. All other possible equilibria are discussed briefly in the appendix.

6 The full mixed strategy equilibrium

In the interesting case of the *Type II* equilibrium, we find that asymmetric upwards modifications of the penalties for bribery and reciprocation lead to significantly different results than the strong results of Tsebelis' inspection game (*Type III*). Given the payoffs in Figure 1, we are looking for the equilibrium in mixed-strategies at which briber, official and inspector are each indifferent between their respective choices. The calculation of α^*, β_1^* and β_2^* gives:

$$\alpha^* = \frac{r}{p_O^2} \tag{2}$$

$$\beta_1^* = \frac{-e_I + f_I}{c_I - d_I - e_I + f_I + \beta_2(a_I - c_I + d_I - b_I)} \tag{3}$$

$$\beta_2^* = \frac{b + \alpha p_B^1}{v - \alpha p_B^2} \tag{4}$$

6.1 Asymmetric increase of the penalty for reciprocation

We know from the intuitive account that raising p_O^2 should be most desirable from the perspective of a social planner. We thus consider this case exemplarily. As (2) shows, raising p_O^2 decreases α^*. Following (2), (4) shows that raising p_O^2 decreases β_2^*. Knowing from our 'bigger catch' assumption that $a_I - c_I + d_I - b_I > 0$, we can infer from (4) that raising p_O^2 leads to an increase of β_1^* for sure. In equilibrium we find the following results. A higher penalty p_O^2 reduces the rate of α^* at which the official is indifferent between reciprocating and not reciprocating. This is in line with what we found with the intuitive account earlier; α needs to decrease in order to keep the official indifferent after her penalty went up. This, in turn, reduces the rate of β_2^* at which the briber is indifferent between bribing and not bribing (4), because the decrease in α would otherwise deter bribery for sure. Finally, (given our assumption that inspecting a case of reciprocated bribery is the [loss of the] 'bigger catch' vis-à-vis unreciprocated bribery), β_1^* must increase to balance out the decrease of β_2 so as to keep the inspector indifferent. We find confirmed as before that raising p_O^2 definitely results in a reduction of reciprocation, but also results in an increase of the rate of offence through bribery. It remains a question of what happens to the overall probability of a reciprocated bribe in equilibrium, if the rate of reciprocation changes. The calculation gives:

$$\frac{d\beta_1^*\beta_2^*}{-d\beta_2} = \frac{f_I - e_I}{c_I - d_I + f_I - e_I + [\beta_2(a_I - c_I + d_I - b_I)]} \tag{5}$$

Raising the penalty for reciprocation asymmetrically leads thus not only to an increase of β_1^* and a decrease of β_2^* and α^*, but it leads to a reduction of the overall probability of reciprocated bribery at equilibrium ($\beta_1\beta_2$).

6.2 Optimal deterrence

In search of the penalty structure for optimal deterrence, we find the following. As noted earlier, the penalty for accepting bribery (p_O^1) features in both reciprocated and unreciprocated bribery. Changing it has therefore no influence on the probability distributions over α, β_1 and β_2. As shown above, increasing p_O^2 reduces α and β_2, as well as $\beta_1\beta_2$, but it increases β_1. Further, we showed that increasing p_B^1 has the same effect as increasing p_B^2 does. It leads to an increase in β_2 and to an increase in the overall probability of reciprocated bribery at equilibrium (but a reduction of β_1). Table 2 illustrates those findings.

There are various combinations of penalty raises, all of which reduce to the same effects as the singular penalty raises. Obviously, increasing a penalty has the opposite effect of decreasing a penalty. The optimal deterrence mechanism is thus an asymmetric distribution of penalties, where p_B^1 and p_B^2 are minimised and p_O^2 is maximised. This will have the optimal effect of reducing both reciprocation and the overall probability of reciprocated bribery. With regards to the asymmetric penalties debate within the corruption literature, we are able to confirm Lambsdorff and Nell's finding that reciprocation should be punished severely. Their suggestion to also punish bribing severely is according to our results, however, not at all advisable. Regarding the inspection game literature, we offer yet another model in which Tsebelis' results do not hold. We

Table 2: Change over α, β_1 and β_2 when increasing penalties asymmetrically. *Note that decreasing the exogenous parameters gives the exact opposite results.*

	Exogenous parameter to be increased		
Endogenous variable	Penalty for bribing (p_B^1)	Penalty for reciprocating (p_O^2)	Penalty for accepting quid pro quos (p_B^2)
Probability of bribery (β_1)	$-$	$+$	$+$
Probability of reciprocation (β_2)	$+$	$-$	$-$
Probability of reciprocated bribery ($\beta_1\beta_2$)	$+$	$-$	$-$
Probability of detection (α)	No effect	$-$	No effect

can conclude that given two offenders and an asymmetric penalty distribution, an increase in the penalty for reciprocation does reduce the rate of offence in the case of corruption.

7 Conclusion

We have constructed a corruption game with two specialities, each catering to a specific literature. On the one hand, we built in asymmetric penalties as we found them in the political economy of corruption literature. This makes it possible to punish bribing and bribe-taking as well as reciprocating and accepting considerations to different degrees and allows us to make policy suggestions. On the other hand, we endogenise the probability of detection as is done in Tsebelis' inspection game. In contrast to other versions of the inspection game, our model incorporates three agents, a briber, an official and an inspector. The fact that the offence (corruption) can only be completed in a joint effort between two of the players leads to surprising results, especially in conjunction with asymmetric penalties. Lambsdorff and Nell showed that, under exogenous detection, optimal deterrence could be achieved if bribing and reciprocating are punished severely, while bribe-taking and accepting quid pro quos are punished only mildly. With detection as an endogenous variable, we find confirmed that higher penalties do reduce the overall rate of offence, if the offence is reciprocated bribery as a joint effort between briber and official. This stands in contrast to Tsebelis' strong and counterintuitive results. However, this result holds only if the penalty for reciprocating on the official is raised (maximised). For it increases the probability of bribery, but reduces the probability of both reciprocation and overall reciprocated bribery. Surprisingly, and unlike Lambsdorff and Nell's asymmetric penalty prescription, higher penalties on on the briber have the opposite effect. They may reduce the probability of bribery, but they also increase the probability of reciprocation to the extent that the overall probability of reciprocated bribery increases. Several interesting extensions of our model are possible and should be addressed in future research.

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Appendix

Out of the 27 permutations of equilibria in mixed and pure strategies, there are a number of possible equilibria. There is a possible equilibrium at $\alpha = 0$, β_1^*, $\beta_2 = 1$, if the briber is indifferent at $v - b = 0$, if for the official $b + r > b$ ($r > 0$), and if for the inspector $\beta_1^* < \frac{-e_I + f_I}{a_I - b_I - e_I + f_I}$. There is a possible equilibrium at $\alpha = 1$, $\beta_1 = 1$, and $\beta_2 = 1$, if $v - b - p_B^1 - p_B^2 > 0$ and if $r > p_O^1$ and if $a > b$, which are all possible according to the initial assumptions about the parameter values. There is a possible equilibrium at $\alpha = 1$, β_1^*, and $\beta_2 = 1$, if the briber is indifferent at $v - b - p_B^1 - p_B^2 = 0$, if for the official $b - p_O^1 - p_O^2 + r > b - p_O^1$, and if for the inspector $\beta_1^* > \frac{-e_I + f_I}{a - b - e_I + f_I}$. If α^*, β_1^*, and $\beta_2 = 1$, the game reduces to the original Tsebelis-type game. The briber is indifferent at $\alpha = \frac{v-b}{p_O^1 + p_O^2}$, while the inspector is indifferent at $\beta_1 = frac{-}e_I + f_I a - b + f - e$. The is a possible equilibrium at $\alpha = 0$, β_1^*, β_2^*, if the official is indifferent at $r = 0$, if the briber is indifferent at $\beta_2^* = b/v$, and if for the inspector $\beta_1^* < (-e_I + f_I)/[c - d - e_I + f_I + \beta_2(a_I - c_I + d_I - b_I)]$ and $\beta_2^* < [-e_I + f_I + \beta_1(d - c + e - f)]/(a - b + d - c)$. There is a possible equilibrium at $\alpha = 1$, $\beta_1 = 1$, β_2^*, depending on the values of the parameters of the briber's payoff. If $\beta_1 = 1$, if follows that $\alpha = 1$, because $a > b$ and $c > d$. Thus, $\alpha = 1$ is possible, if $\beta_2^* = (d - c)/(a_I - c_I + d_I - b_I)$. However,

$\beta_1 = 1$ is only possible, if $0 \geq \beta_2^* > (b + p_B^1)/(v - p_B^2) \leq 1$. There is a possible equilibrium at $\alpha = 1$, β_1^*, β_2^*, if the official is indifferent at $r = p_O^2$, if the briber is indifferent at and if it is given that $0 \geq \beta_2^* = (b + p_B^1)/(v - p_B^2) \leq 1$, and if for the inspector $\beta_1^* > \frac{-e_I + f_I}{c - d - e_I + f_I + \beta_2(a_I - c_I + d_I - b_I)}$ and $\beta_2^* > [-e_I + f_I + \beta_2(a_I - c_I + d_I - b_I)]$. If α^*, β_1^*, β_2^*, there is an equilibrium. The mixed strategies are: $\alpha^* = r/(p_O^2)$ and $\beta_1^* = \frac{-e_I + f_I}{c_I - d_I - e_I + f_I + \beta_2(a_I - c_I + d_I - b_I)}$ and $\beta_2^* = \frac{b + \alpha p_B^1}{v - \alpha p_B^2}$. There is a possible equilibrium at α^*, $\beta_1 = 1$, β_2^*, if for the briber $0 \geq \beta_2^* > \frac{b + \alpha p_B^1}{v - \alpha p_B^2} \leq 1$ and if $0 \geq \alpha^* < \frac{\beta_2 v - b}{p_B^1 + \beta_2 p_B^2} \leq 1$, if the official is indifferent at $\alpha^* = \frac{r}{p_O^2}$ and if the inspector is indifferent at $0 \geq \beta_2^* = \frac{b + p_B^1}{v - p_B^2} \leq 1$. However, since by definition $r \geq p_O^2$, the official can only be indifferent if $\alpha^* = \frac{r}{p_O^2} = 1$, i.e. $\alpha^* = 1$.

There are four cases, which are impossible according to the assumptions we made about the inspector's payoffs. However, they resemble the Becker type model, in which detection is exogenous. An equilibrium at $\alpha = 1$, $\beta_1 = 0$, and $\beta_2 = 0$ is only possible if $a_I + c_I \leq b_I + d_I$. Unless inspection is free, there is no equilibrium. This case is similar to the original Becker-type model, where detection is exogenous. An equilibrium at $\alpha = 1$, $\beta_1 = 0$, and $\beta_2 = 0$ is only possible if $a_I + c_I = b_I + d_I$. Unless inspection is free, there is no equilibrium. This case is similar to the original Becker-type model, where detection is exogenous. Similarly, depending on the assumption of endogeneity, an equilibrium at $\alpha = 1$, $\beta_1 = 0$, β_2^* or at α^*, $\beta_1 = 0$, β_2^*, is only possilbe if $e_I = f_I$. This would re-exogenise detection. However, assuming that $f_I > e_I$, there is no possible equilibrium in these strategies.

Furthermore, there are two more possible and several impossible equilibria. Technically there are infinite Nash equilibria, because the official must be indifferent between any value of $beta_2$ between zero and one, so long as $\beta_1 = 0$ and $\alpha_1 = 0$. If $\beta_1(v - b) + (1 - \beta_1)(-b) < 0$, then there is no bribery and if $\alpha = 0$ there are no penalties. It thus depends on our assumptions about the values of b and r what happens to β_2). If $b > 0$ and $r < 0$, then technically the subgame perfect Nash equilibrium (SPNE) would be at $\alpha = 0$, $\beta_1 = 0$, and $\beta_2 = 0$. However, intelligibility tells us that r cannot be negative and therefore there is no such equilibrium. If $b > 0$ and $r = 0$, then technically the SPNE would be at $\alpha = 0$, $\beta_1 = 0$, and β_2^*. If $b > 0$ and $r > 0$, then technically the SPNE would be at $\alpha = 0$, $\beta_1 = 0$, and $\beta_2 = 1$. There is no intelligible equilibrium at $\alpha = 0$, $\beta_1 = 1$, $\beta_2 = 0$ or at $\alpha = 0$, $\beta_1 = 1$, β_2^* without dropping the standard assumptions about the inspector's payoffs. If $\beta_1 = 1$, then the inspector must inspect, i.e. alpha cannot be zero, as per the assumption that $a > b$ and $c > d$. There is no possible equilibrium at $\alpha = 0$, β_1^*, and $\beta_2 = 0$, or at $\alpha = 1$, β_1^*, and $\beta_2 = 0$, or at $\alpha = 1$, β_1^*, $\beta_2 = 0$. These strategy combinations would require that $-b = 0$. However, we assume that $b > 0$. Knowing that the official will not reciprocate, there is thus no reason for the briber to be inclined to bribe or even to be indifferent. Expected unreciprocated bribery is not intelligible and subsequently this is not a possible equilibrium. There is no possible equilibrium at $\alpha = 1$, $\beta_1 = 1$, $\beta_2 = 0$, or at $\alpha = 1$, $\beta_1 = 1$, $\beta_2 = 0$. These strategy combinations would require that $-b - p_B^1 > 0$. However, we assume that $b > 0$ and that $p \geq 0$. Knowing that the official will not reciprocate, there is thus no reason for the briber to be inclined to bribe or even to be indifferent. Expected unreciprocated bribery is not intelligible and subsequently this is not a possible equilibrium. No equilibrium is possible at $\alpha = 0$, $\beta_1 = 1$, and $\beta_2 = 1$ or at α^*, $\beta_1 = 1$, and $\beta_2 = 1$. The calculations require $a < b$ and $a = b$ respectively in equilibrium, but our assumption is that $a > b$. According to the assumptions about the payoffs of the inspector, $e_I < f_I$, there cannot be an equilibrium at either $\alpha = 1$, $\beta_1 = 0$, $\beta_2 = 1$, or α^*, $\beta_1 = 0$, $\beta_2 = 1$, since they would require that $e_I > f_I$ and $e_I = f_I$ respectively.