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FIRM CORRUPTION IN THE PRESENCE OF AN AUDITOR

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Firm corruption in the presence of an auditor*

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Abstract

We develop a game theoretic framework exploring firm corruption accounting for interactions with an auditor who provides auditing and other services. A multiplicity of equilibria can exist including stable corruption and auditor controlled corruption. Whilst fining the auditor cannot eliminate all corruption, fining the firm can, but increasing this fine can also have perverse effects. Investing in corruption detection may be effective in deterring auditor corruption but ineffective in deterring firm corruption. Ultimately, policy effectiveness is highly dependent upon several factors which may be hard to observe in practice making general rules about policy interventions to address corruption very difficult.

Keywords: firm corruption; auditor corruption; perfect equilibrium
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1 Introduction

There is a complex interplay between institutions, government, firms and market structures in determining opportunities for engaging in rent-seeking behaviour and corrupt activity. However, the role of firms and the incentives they face in this context is a relatively neglected area of analysis. Previous research has largely focused on corruption where government or other state actors play the central role and where if firms are involved their role is typically reactive (see, for example Rose-Ackerman, 1999, 2007; Lessmann and Markwardt, 2010). Nonetheless, firm level corruption has been a significant problem. Between 1997 and 2002, nearly 10 per cent of US listed companies restated their earnings at least once due to accounting irregularities (cited in Aglietta and Reberioux, 2005). In addition, earnings restatements were effected in 414 cases involving US based firms in 2004 because of financial irregularities (cited in Coffee, 2005). These irregularities provide a background for the opinion expressed by Jensen (2006, p. 14), while discussing the overvaluation of equity in the late 1990s and early 2000s: "... this catastrophic overvaluation [of equity] was also the result of misleading data from managers, large numbers of naive investors, and breakdowns in the agency relationship within companies, in investment banks, and in Audit and law firms many of whom knowingly contributed to the misinformation that fed the overvaluation."

A similar view is presented by Stiglitz (2003, p.244), who, whilst discussing Enron suggests that: "It appears that its [Enron's] chief financial officer made the same discovery that so many other corporate executives made during the nineties: the same accounting tricks that could be used to distort information to boost stock market prices could be used to enrich themselves at the expense of other shareholders." Key issues emerge from the Jensen-Stiglitz opinions cited here. Firm corruption involves (a) a breakdown in agency relationships; (b) misleading activity not only by managers but also by audit firms (for example); and (c) 'accounting tricks' that were increasingly becoming standard. Given (a), (b) and (c), it is apparent that only some firms were corrupt, even though (following Stiglitz) the 'tricks' were becoming standard. The 414 (10 per cent of the total) cases of earnings restatements is a significant number but a small proportion of the total number of US firms. Hence many firms decided not to do what was apparently 'standard' practice. A preliminary conclusion might therefore suggest itself: a breakdown in agency relationships is a necessary but not sufficient condition for firm corruption. Sufficiency would appear to require (a) an agency breakdown in the relationship between firms and their owners; (b) a willingness on the part of firms to exploit this and engage in 'tricks'; and possibly also (c) collusion by supporting actors (e.g. auditing firms) in the 'tricks'.

While the basic idea in our framework is that firm corruption involves collusion between firms and auditors, a central problem exists in this relationship where auditors provide auditing and other consultancy services. The extent of these 'other' services depends on firm profitability i.e. the ability to buy them. In turn, firm and auditor profitability increases with corruption. This can provide an incentive for, not only firm corruption, but also auditor collusion in this corruption. The core problem analysed in this paper has, of course, been recognised by other authors. For example Posner (2006, p. 11) gives a characteristically pithy summary of the core idea for the current discussion: "Corporate executives, moreover, hire and pay the auditors who certify the correctness of the corporation's financial statements, dangle consulting contracts in front of auditors who also offer consulting services." Our work is also related in parts to Pagano and Immordino (2007) who consider a similar question. However, whilst Pagano and Immordino (2007) are concerned with the optimal regulation of an auditor, our paper focuses on the circumstances under which corruption can be an equilibrium outcome.

In this paper a framework is developed that assumes agency breakdown has occurred and explores the possibility of firms exploiting this and possible collusion by auditing firms. To illustrate the limits to the current discussion reference can be made to the recent case of Olympus. It is widely reported in the press that senior management in this company attempted to use corrupt accounting practices to cover investment losses. But two characteristics of this case suggest that it cannot be analysed using the framework developed here. First, the senior managers involved apparently did not make any personal financial gain from the corrupt practices. Secondly, while auditor collusion existed the suggestion is that the practices involved were incompetent rather than for any profit gain. The framework developed here cannot cover corruption of this type. Instead it can be used to analyse corruption aimed at financial gain by both firm and auditor and when this leads to a stable (equilibrium) outcome.[1]

Ideas akin to the firm/agent collusion in the corruption process have been addressed elsewhere in the literature. Lambert-Mogiliansky and Sonin (2006) analyse corruption and collusion in procurement. They argue that a corrupt agent would be willing to 'sell' his decision in return for a bribe. They also argue that the risks of collusion and of corruption need to be addressed simultaneously and indicate the potential for an external agent (an auctioneer) in having a role in providing the conditions which allow the stability of corruption and extracting of rents. The idea that an external agent may facilitate corruption as a stable equilibrium is used in this paper, but the emphasis is shifted from the external agent being an auctioneer to being an auditor. Carrillo (2000) constructs a dynamic model of corruption within which agents are aware of their 'propensity for corruption' and their clients choose an optimal level of bribe to be offered. Such a framework provides an explanation for different implicit prices for illegal services (bribes or kick-backs) for similar countries (or organisations within similar countries), based on an analysis of reaction of clients. Two of these ideas are carried forward into the current discussion: that there is a propensity for corruption and that the reactions of other agents (here auditors) are important for the equilibria that can be generated. In a context similar to this paper, Samuel (2009) employs a principal (or regulator), a supervisor (similar to our auditor) and firms, and considers a situation where the supervisor expends considerable effort to obtain information which, if revealed, would lead to the agent being fined with a given probability. However, the supervisor may collude with the agent and hide this adverse information in exchange for a bribe. It is shown that raising the supervisor's reward discourages such ex-post corruption, but it can lead to increased pre-emptive collusion and corrupt behaviour. However, the study focuses on the choice between good and bad technology where a bad technology may lead to emissions or negative externalities. If unregulated, adoption of the bad technology leads to a private benefit for the firm adopting the bad technology. The other main point of difference with our study is the emphasis on pre-emptive and other bribes. Laffont and N'Guessan (1999) consider competition and corruption in an

[1]The Olympus case has been widely reported in the press. See for example the following web-based discussions: http://www.nytimes.com/2011/10/27/business/global/olympus-chairman-resigns-amid-widening-scandal.html?_r=1 and http://www.bbc.co.uk/news/business-16044943.

agency relationship, where corruption arises from informational foundations. However, whilst they do look at market competition, they are primarily considering competition policy as formulated/ influenced by government and the role of bureaucracy.

Whilst corruption can take various forms, the approach adopted here concentrates on corrupt practices within a private firm sector in the form of misuse of corporate assets, as discussed, for example, in Svensson (2005). In particular a game theoretic framework is developed that examines incentives for firms to be corrupt given market-based monitoring by auditors and to examine whether, and in what circumstances, stable, equilibrium corruption is possible. Mishra (2006) demonstrates that a high level of corruption or a low level of compliance can become an equilibrium outcome, in spite of anti-corruption efforts. However, unlike our study, Mishra's analysis is based on evolutionary dynamics and involves social norms in addition to individual behaviour. It is chiefly directed at hierarchical and government type bureaucracies, rather than market based firms. The possibility of multiple equilibria involving corruption arising in the firm/agent context is demonstrated by Çule and Fulton (2009), although here the 'agent' interacting with the firm is a tax inspector and collusion involves bribes aimed at reducing tax liability.

The structure of the paper is as follows. The next section develops key assumptions involved with a corruption game. Section three specifies explicit payoffs. Section four explores the equilibria in the corruption game. Section five explores possible policy options for the players and regulatory body and identifies the extent to which players and the regulator can influence the equilibria of the game. The final section of the paper highlights a number of key policy conclusions that follow from the framework developed here.

2 The corruption game

In this paper we consider the scenario of a firm that has the option of pursuing a profit-making corrupt prospect in the knowledge that such corrupt activity would be detected by its auditor. However, the firm also purchases consultancy services from the auditor. We consider whether there are conditions under which corruption may be an equilibrium and examine the effectiveness of various regulatory policy interventions in dealing with corruption.
We now set out the key assumptions which underlie the framework of the corruption game.

A 1. *The game has two players: a Monopolist (M) and an Auditor (A).*

A 2. *Each player's action set has two elements: Corrupt (C) or Honest (H).*

Remark 1. Given the action set $\{C, H\}$ we rule out the possibility that the Auditor could mislead the regulatory authorities by indicating that the Monopolist has been corrupt when it has not been corrupt.

A 3. *The players choose their actions sequentially over two periods: the Monopolist is assumed to be the leader and the Auditor the follower. Hence, with subscripts denoting the period $\{1, 2\}$, we have: Period 1: M chooses $\{C_1, H_1\}$; Period 2: A chooses $[\ldots, \{C_2, H_2\}]$.*

Remark 2. It follows from Assumptions 1 and 2 that retaliation by the Monopolist to $\{C_1, H_2\}$ is ruled out in this game.

This restriction of the model seems reasonable because if the Monopolist sacks the Auditor for failing to support a corrupt strategy this would involve public disclosure of the corruption. The implication of this assumption is that we can restrict analysis to a two-stage, rather than three-stage, game.

A 4. *The game is one of complete and symmetric information.*

When the Auditor selects its action, $\{C_1, H_1\}$ is known. In addition, this assumption allows the use of backward induction to solve the game.

A 5. *There is an exogenous non-corrupt gross profit for the Monopolist:* $\Pi_M^H > 0$.

Thus corruption does not affect the profit attributable to the firm's underlying activity.

A 6. *The players are risk neutral and expected profit maximisers.*

A 7. *(i) The firm buys (compulsory) auditing services and additional consultancy services from the Auditor. (ii) Ex-ante the returns to the consultancy services are uncertain. As both agents are risk neutral they share this risk with a contract that has payment based upon expected returns. (iii) A constant proportion* $\alpha \in [0, 1)$ *of the Monopolist's profit is allocated to purchase Auditor consultancy services. (iv) The Monopolist's gross non-corrupt profit reflects productive and market characteristics and benefits from these Auditor services. The Monopolist's net (after taking into account the costs of the Auditor's consulting services) non-corrupt profit is therefore:* $\Pi_M\{H_1, \ldots\} \equiv \Pi_M^H(1 - \alpha)$.

A 8. *(i) The Monopolist has an opportunity to undertake a corrupt activity yielding income* $\gamma(g)\Pi_M^H$*. The parameter* g *measures the extent of the corrupt activity whilst* $\gamma(g)$ *is a (production) function which determines the value of corruption income relative to the exogenous non-corrupt gross Monopoly profit. (ii) The (production) function* $\gamma(g)$ *is continuous and concave on* g*, reflecting diminishing returns:* $\gamma(g) > 0$, $\gamma''(g) \leq 0$, $\forall g \in (0, \infty)$*. (iii) Corruption produces an additional gross (before taking into account consultancy fees and any penalties for detected corruption) profit gain to the Monopolist over the non-corrupt gross Monopoly profit:* $\Pi_M^C \equiv (1 + \gamma(g))\Pi_M^H$.

It is important to note that in this paper the level of corruption g in Assumption 8 is not a (continuous) choice variable of the Monopolist, rather, the Monopolist faces a discrete choice between not being corrupt $\{H_1, \ldots\}$ and pursuing a corrupt prospect, under $\{C_1, \ldots\}$, of value $\sigma(g)\Pi_M^H$. This reflects the fact that in many cases a firm may have a limited set of opportunities for corrupt activities making g discrete rather than continuous. The assumption also enables a simplified analysis.

A 9. *(i) In the case in which both players choose to be corrupt, the payoff to each agent is uncertain as Nature assigns a probability* $\sigma(g)$ *to the corrupt activity being detected and a strictly positive penalty being imposed on both Monopolist* ($F_M > 0$) *and Auditor* ($F_A > 0$)*. (ii) Under* $\{C_1, H_2\}$*, the monopolist incurs the penalty* F_M *with certainty.*

Remark 3. Assumption 9(ii) follows logically given Remark 1 and Assumption 4.

Remark 4. It follows from Assumptions 6 and 9 that the players' payoffs following Nature's actions under $\{C_1, C_2\}$ can be represented by an 'expected' payoff with probability weights $\sigma(g)$ and $1 - \sigma(g)$.

We now introduce the first of a number of critical values of g that will be helpful in developing the results of the game.

Definition 1. $\hat{g} \equiv \inf\{g : \sigma(g) = 1\}$.

A 10. *The probability of corruption being detected under* $\{C_1, C_2\}$ *depends upon the level of Monopolist corruption,* g*, with* $\sigma(0) = 0$ *and according to the* ***corruption detection profile*** $\sigma_i(g)$ $(i = 1, 2)$ *where either (i)* $\sigma_1(g) \in [0, 1]$*, where* $\sigma_1'(g) > 0$ *and* $\sigma_1''(g) > 0$ *for* $\forall g \in [0, \hat{g})$ *and* $\sigma_1'(g) = 0$ *for* $\forall g \in [\hat{g}, \infty)$ *and* $\hat{g} > 0$ *or (ii)* $\sigma_2(g) \in [0, 1)$ *where* $\sigma_2'(g) > 0$*,* $\sigma_2''(g) < 0$ *and* $\lim_{g \to \infty} \sigma_2(g) = T$ *where* $T \in (0, 1)$*.*

Thus, in either case, $\sigma(g)$ is positive monotonic for $\sigma(g) < 1$, which would appear to be reasonable as higher levels of g are likely to be more conspicuous and hence more likely to be detected. In the case of $\sigma_1(g)$, sufficiently high levels of corrupt activity will eventually result in the corruption being detected with certainty. Whilst under $\sigma_2(g)$ higher levels of corrupt activity will raise the probability of detection but never to the extent that corruption will be detected with certainty. The conditions regarding the second derivatives in these definitions are necessary to ensure that the functions $\sigma(g)$ and $\omega(g)$ (defined later) cross only once on their upward sloping segments. This 'well behaved' property helps to facilitate transparency in the model and keep the analysis manageable.[2]

Remark 5. $\hat{g}$ is not defined under corruption detection profile $\sigma_2(g)$.

The following assumption is a logical extension of the Monopolist 'non-retaliation' and Auditor 'non-misleading' properties of the model (see Remarks 2 and 1 respectively).

A 11. *The payoffs to each player under* $\{H_1, C_2\}$ *are the same as under* $\{H_1, H_2\}$*:* $\Pi_i\{H_1, C_2\} \equiv \Pi_i\{H_1, H_2\}$*,* $i = \{M, A\}$*.*

Costs are mostly not specified explicitly within the model (they play an unspecified role in Π_M^H and $\omega(g)$, defined later), however, the following assumption introduces a cost differential for the Auditor under corruption relative to honest behaviour.

A 12. *The Auditor incurs a cost* c_A *of supplying services to the Monopolist. These costs are higher under* $\{C_1, C_2\}$ *than under* $\{\ldots, H_2\}$*, respectively* c_A^C *and* c_A^H*. The cost differential is defined* $\triangle c \equiv c_A^C - c_A^H$ *and is assumed (i) to be positive and constant (not a function of the level of corruption) and, (ii)* $\triangle c < \alpha F_M$*.*

We argue that the positive differential is a sensible assumption given the higher transaction costs involved with hiding corrupt practices. The constancy of this differential is not as problematic as it may appear, the reason being that we are only interested in comparisons over no corruption and a given level of corruption - the level of corruption is not a continuous choice variable. As we see later, A 12(ii) ensures that the set of values of g for which the Auditor would support corruption is non-empty.

The game is illustrated in extensive form in Figure 1. Nodes M and N relate to the Monopolist and Nature, respectively, and nodes A_1 and A_2 relate to the Auditor. Payoffs are reported in parentheses - the single payoff following N is explained in Remark 4.

Insert Figure 1 here.

[2]If, with relatively simple functional forms and simple interactions between these functions, unusual results arise then this will be of greater interest than if the model were so complex that it could support any outcome however unusual.

Some further useful characteristics of the game are outlined below, their purpose will become apparent later.

Definition 2. Let $\varphi(\sigma) \equiv \frac{\sigma}{1-\sigma}F_A + \frac{\triangle c}{1-\sigma}$.

Lemma 1. $\varphi(\sigma)$ *is: (i) positive monotonic, (ii) convex in* σ*, and (iii)* $\lim_{\sigma \to 1^-} \varphi(\sigma) = \infty$.

Proof. It follows from As 9 and 12(i) that F_A and Δc are strictly positive, hence (i) $\varphi'(\sigma) = \frac{F_A}{1-\sigma} + \frac{\sigma F_A + \triangle c}{(1-\sigma)^2} > 0$ and (ii) $\varphi''(\sigma) = 2\frac{F_A}{(1-\sigma)^2} + 2\frac{\sigma F_A + \triangle c}{(1-\sigma)^3} > 0$. (iii) Since F_A and $\triangle c$ are exogenous and finite, $\lim_{\sigma \to 1^-} \frac{1}{1-\sigma} = 0$, and so $\lim_{\sigma \to 1^-} \varphi(\sigma) = \infty$. □

The L.H.S. of Figure 2, which we will see later captures the relevant information relating to the Auditor's decision, illustrates $\varphi(\sigma)$. The R.H.S. of Figure 2 is concerned with parameters affecting the Monopolist's decision of which Definition 3 introduces a key aspect.

Insert Figure 2 here.

Definition 3. Let $\omega(g) \equiv \frac{\Pi_M^H}{F_M}\gamma(g)$. We refer to $\omega(g)$ as the Monopolist's **corruption technology profile**.

Lemma 2. $\omega(g)$ *is (i) continuous, and (ii) concave.*

Proof. Given Π_M^H and F_M are strictly positive and exogenous, the proof follows from the properties of $\gamma(g)$ in A 8(ii). □

We now define further key values of g, examples of which are illustrated in Figure 2.

Definition 4. Let (i) g^* be the discrete level of corruption available to the Monopolist under $\{C_1, \ldots\}$, (ii) $g^{**} \equiv \{g : \varphi(\sigma(g)) = \alpha F_M\}$.

We will see in the next Section that g^{**} defines the level of corruption which produces a detection probability under which the Auditor is indifferent between $\{C_1, H_2\}$ and $\{C_1, C_2\}$ and that for $g^* <$ [$>$]g^{**} the Auditor would support [not support] a corrupt Monopolist.

Remark 6. There exist feasible profiles $\sigma(g)$ for which g^{**} is not defined. However, it follows from A 12(ii) that if g^{**} is defined it always yields $\sigma(g^{**}) \in (0, 1)$.

Definition 5. Let (i) $\tilde{g} \equiv \inf\{g : \omega(g) = 1\}$; (ii) $\tilde{\tilde{g}} \equiv \sup\{g : \omega(g) = 1\}$; (iii) $\bar{g} \equiv \inf\{g : \omega(g) = \sigma(g), g \in \mathbb{R}_{++}\}$; (iv) $\bar{\bar{g}} \equiv \sup\{g : \omega(g) = \sigma(g), g \in \mathbb{R}_{++}\}$; (v) $g^{max} \equiv \{g : \arg\max \omega(g)\}$.

Having introduced various critical values of g in the model, we can now outline the relationships between the level of Monopolist corruption and the return to corruption.

Definition 6. We define three categories of the Monopolist's corruption technology profile, $\omega_i(g)$ $(i = a, b, c)$. In addition to the conditions placed upon $\omega(g)$ from A 8(ii), we have that: (i) $\omega_a(g) \equiv \{\omega : \omega'(g) > 0, \forall g \in [0, \infty); \lim_{g \to \infty} \omega(g) > 1\}$; (ii) $\omega_b(g) \equiv \{\omega : \omega'(g) > 0, \forall g \in [0, g^{max}); \omega'(g) < 0, \forall g \in (g^{max}, \infty); \omega(g^{max}) \geq 1\}$; (iii) $\omega_c(g) \equiv \{\omega : \omega'(g) > 0, \forall g \in [0, \infty); \lim_{g \to \infty} \omega(g) = S, S \in (0, 1)\}$.

Insert Figure 3 here.

Given the characterisations of $\omega(g)$ in Definition 6 and $\sigma(g)$ in A 10, we now set out five cases describing different possible relationships between $\omega(g)$ and $\sigma(g)$ in the following Definition.

Definition 7. (i) **Case 1**: $\sigma_1'(0) > \omega'(0)$; (ii) **Case 2**: $\sigma_1'(0) < \omega'(0)$ and $\exists \hat{g}$ and $\bar{g}$ s.t. $\hat{g} > \bar{g}$; (iii) **Case 3**: $\sigma_1'(0) < \omega'(0)$ and $\exists \tilde{g}, \hat{g}$ s.t. $\tilde{g} \leq \hat{g}$; (iv) **Case 4**: $\sigma_2'(0) < \omega'(0)$ and $\bar{g}$ may exist but not $\bar{\bar{g}} \neq \bar{g}$; (v) **Case 5**: $\sigma_2'(0) > \omega'(0)$ and $\bar{g}$ may exist but not $\bar{\bar{g}} \neq \bar{g}$.

[3] Examples of the Cases 1-3 are illustrated in Figure 4.

Lemma 3. *Under corruption technology $\omega_c(g)$ **Case 3** is not defined.*

Proof. The proof follows directly from the the requirement in Case 3 of the existence of $\hat{g}$ in Definition 7(iii), which is ruled out under corruption technology $\omega_c(g)$ since, by Lemma 2(ii) $\omega_c(g)$ is concave and by Definition 6(iii) $\lim_{g\to\infty} < 1$. $\square$

Insert Figure 4 here.

Definition 7 (iv) and (v) ensure that there is a limit to the number of times the $\omega_i(g)$ and $\sigma_2(g)$ functions can cross. The following Remark makes it clear that the assumptions of the model also ensure similar crossing properties between the $\omega_i(g)$ and $\sigma_1(g)$ functions.

Remark 7. Given $\omega(g)$ is strictly concave and $\sigma_1(g)$ is strictly convex for $g \in (0, \tilde{g})$, then: (i) $\sigma_1'(0) > \omega'(0)$ in **Case 1** implies $\sigma_1'(0) > \omega'(0)$ $\forall g \in (0, \tilde{g})$; (ii) $\omega(g)$ and $\sigma_1(g)$ in **Case 2** cross exactly once for $g \in (0, \tilde{g})$.

For the analysis in Section 4 it is useful to make a distinction between *Perfect Nash Equilibria* (*PNE*) corruption profiles that are effectively unconstrained and those that are constrained. The following Definition makes explicit what is meant in each case, where k is an index.

Definition 8. (i) $PNEk$ is said to be **unconstrained** if g^* is $PNEk$ for $\forall g \in [a, \infty)$ where $a \in \mathbb{R}_{++}$; (ii) $PNEk$ is said to be **constrained** if g^* is $PNEk$ for $\forall g \in [a, b]$ where a and b are finite, $a, b \in \mathbb{R}_{++}$ and $a \leq b$.

Finally, it is also useful to classify cases where corruption is guaranteed to be an equilibrium for sufficiently small levels of g^*.

Definition 9. $PNEk$ is said to be **small-scale** if g^* is $PNEk$ for $\forall g^* \in (0, a)$, where a is finite and $a \in \mathbb{R}_{++}$.

3 Payoff Specification and equilibria

In this section we specify an explicit payoff structure for the corruption game set out above. First, from As 5, 7 and 11, the payoffs corresponding to z in Figure 1 are:

$$z_M \equiv \Pi_M\{H_1, H_2\} \equiv \Pi_M\{H_1, C_2\} \equiv (1-\alpha)\Pi_M^H, \tag{1a}$$

$$z_A \equiv \Pi_A\{H_1, H_2\} \equiv \Pi_A\{H_1, C_2\} \equiv \alpha\Pi_M^H - c_A^H. \tag{1b}$$

[3]The list of Cases outlined in Definition 7 is not intended to be exhaustive. There are many obvious, though uninteresting, ways of extending the Cases but we have tried to keep them to a minimum in order to allow us to explore the equilibria arising from the model with reasonably well-behaved functions. In particular, we have explicitly limited the number of times $\omega(g)$ and $\sigma(g)$ can cross. The more complicated the scenarios the more arbitrary the predictions.

Given A 9, if the Auditor does not collude in the corruption the Monopolist will face a punishment cost of F_M with certainty. Given As 7 and 8 the payoffs corresponding to y in Figure 1 are:

$$y_M \equiv \Pi_M\{C_1, H_2\} \equiv (1-\alpha)[(1+\gamma(g))\Pi_M^H - F_M], \tag{2a}$$
$$y_A \equiv \Pi_A\{C_1, H_2\} \equiv \alpha[(1+\gamma(g))\Pi_M^H - F_M] - c_A^H. \tag{2b}$$

If the Auditor colludes in the corruption the probability of corruption being detected is $\sigma(g)$, by A 10. By A 9, if the Auditor is found to be corrupt there is a punishment cost of F_A. Hence, given As 6 12, the payoffs corresponding to x in Figure 1 are:

$$x_M \equiv E(\Pi_M\{C_1, C_2\}) \equiv (1-\alpha)[(1+\gamma(g))\Pi_M^H - \sigma(g)F_M], \tag{3a}$$
$$x_A \equiv E(\Pi_A\{C_1, C_2\}) \equiv \alpha[(1+\gamma(g))\Pi_M^H - \sigma(g)F_M] - c_A^C - \sigma(g)F_A. \tag{3b}$$

The system of equations defined by (1), (2) and (3) in Section 3 can be used to derive the conditions under which each of the three scenarios in the game is a *PNE*. We begin by identifying the conditions under which each scenario is a *Unique Perfect Nash Equilibrium* (*UPNE*) and then consider the case of *Multiple Perfect Nash Equilibria* (*MPNE*).

UPNE. $\{C_1, C_2\}$ From Figure 1 this corruption equilibrium requires $x_A > y_A$ and $x_M > z_M$, hence, respectively, from (1a), (2b), (3a) and (3b):

$$\varphi(\sigma) < \alpha F_M, \tag{4a}$$
$$\omega(g) > \sigma(g). \tag{4b}$$

Corollary 1. *Condition (4a) will be met and the Auditor will support Monopoly corruption iff $\sigma(g^{**}) > \sigma(g^*)$.*

UPNE. $\{C_1, H_2\}$ This equilibrium involves attempted Monopoly corruption controlled by the Auditor. In terms of Figure 1 it requires $x_A < y_A$ and $y_M > z_M$, hence, respectively, from (1a), (2a), (2b) and (3b):

$$\varphi(\sigma) > \alpha F_M, \tag{5a}$$
$$\omega(g) > 1. \tag{5b}$$

UPNE. $\{H_1, H_2\} \equiv \{H_1, C_2\}$ This 'honesty' equilibrium arises under two different sets of circumstances, if: (i) $x_A > y_A$, $z_M > x_M$, requiring, respectively (4a) and:

$$\omega(g) < \sigma(g), \tag{6a}$$

and (ii) $x_A < y_A$, $z_M > y_M$, requiring, respectively (5a) and:

$$\omega(g) < 1. \tag{6b}$$

We now consider the circumstances under which there are *MPNE*.

MPNE. $\{C_1, C_2\}$,$\{C_1, H_2\}$ From Figure 1 these corruption equilibria require $x_A = y_A$ and $x_M, y_M > z_M$, hence, respectively, from (1a), (2a), (2b), (3a) and (3b):

$$\varphi(\sigma) = \alpha F_M, \tag{7a}$$
$$\omega(g) > 1. \tag{7b}$$

MPNE. **{**C_1, C_2**}**,**{**$H_1, \ldots$**}** From Figure 1 these corruption equilibria require $x_A > y_A$ and $x_M = z_M$, hence, respectively, (4a), and from (1a) and (3a):

$$\omega(g) = \sigma(g). \tag{8}$$

MPNE. **{**C_1, H_2**}**,**{**$H_1, \ldots$**}** From Figure 1 these corruption equilibria require $x_A < y_A$ and $y_M = z_M$, hence, respectively, (5a), and from (1a) and (2a):

$$\omega(g) = 1. \tag{9}$$

MPNE. **{**C_1, C_2**}**,**{**C_1, H_2**}**,**{**$H_1, \ldots$**}** From Figure 1 these corruption equilibria require $x_A = y_A$ and $x_M = y_M = z_M$, hence, respectively, (7a), and from (8) and (9):

$$\omega(g) = \sigma(g) = 1. \tag{10}$$

Lemma 4. *MPNE4 is not feasible.*

Proof. From Lemma 1(iii) $\lim_{\sigma \to 1^-} = \infty$ and hence from Definition 4 $\sigma(g^{**}) < 1$ which contradicts (10). □

Remark 8. For completeness, note, there are no pure strategy PNE under $x_A = y_A$ where either (i) $x_M > z_M > y_M$, or (ii) $y_M > z_M > x_M$.

Remembering that g^* is not a (continuous) choice variable, there is a clear way of ranking the three *UPNE* from a public policy point of view at a given level of g^*. *UPNE3* is the most desirable outcome as this involves the guarantee of no corrupt activity. *UPNE1* is clearly the least desirable outcome as corrupt activities may be going on undetected. *UPNE2* is an improvement upon *UPNE1* inasmuch as corruption, although it is not prevented, is detected through the functioning of the Auditor. Similarly, cases where *UPNE2* supports unconstrained corruption may involve very high levels of abuse which, though not avoided, are detected, whilst unconstrained corruption under *UPNE1* may be very high and go undetected.

Labeling UPNEk ($k = 1, 2, 3$), corruption equilibria are monotonically 'worsening' ['improving'] in g^* if increasing g^* leads to smaller [larger] k for $\forall g^* \in (0, \infty)$.

4 Analysis of equilibria by Case

In this section we are interested in establishing the conditions under which corruption might be an equilibrium and even an unconstrained equilibrium. In the next Section we will address how these conclusions are affected by changes in the corruption technology and detection profiles through manipulation of Auditor or Monopolist choice variables. For now we seek to establish whether the equilibria of the model under a particular technology/detection profile combination is monotonically worsening, improving or non-monotonic in the level of g^*.[4] Intuition might suggest that corruption equilibria are monotonically improving (in accordance with Definition 10) with higher levels of g^*. We show that on the basis of the collection of Cases introduced in Definition 7, the corruption equilibria can be monotonically improving, worsening and even non-monotonic.

We begin the analysis by considering the first corruption technology $\omega_a(g)$ under each of the five Cases and then examine how the predictions of the model change by sequentially introducing technologies $\omega_b(g)$ and $\omega_c(g)$.

[4]it is important to be clear about what we are seeking to establish in this exercise. Given g^* is an exogenous variable we are not actually concerned with changes in the level of g^* as this is not in the gift of either of the players or the regulatory authority. Instead, we are asking the question, how would the nature of the equilibrium change if the prospect g^* were higher or lower?

4.1 Corruption technology *a*

In this Section we begin to examine each of the Cases under the first corruption technology $\omega_a(g)$ and the *UPNE* that are supported under them. For convenience we refer to Case ji with Case j, $j \in \{1, 2, 3, 4, 5\}$ in accordance with Definition 7 and $i \in \{a, b, c\}$ refers to the corruption technology profile as outlined in Definition 6.

Proposition 1. [5] ***Case 1a*** *supports UPNE2, UPNE3 and MPNE3 depending upon g^* according to:*

$$\left\{ \begin{array}{c} \{H,H\} \\ \{H,H\},\{C,H\} \\ \{C,H\} \end{array} \right\} if \left\{ \begin{array}{c} g^* \in (0,\bar{g}) \\ g* = \bar{g} \\ g* \in (\bar{g},\infty) \end{array} \right\}.$$

Corollary 2. ***Case 1a*** *(i) supports unconstrained $UPNE2$ corruption, and, (ii) $UPNEk$ are monotonically worsening in g^*.*

Note, that under ***Case 1a***, there is never a possibility of complete regulatory failure: *UPNE1* is never feasible. For sufficiently low g^*, there is no corruption, whilst for sufficiently high g^* corruption is chosen by the Monopolist but detected by the Auditor.

We now consider what happens if the detection profile becomes less tough (σ_1 stretches to the right) and/or the the rewards to corruption becomes steeper in accordance with the scenario in ***Case 2a***.

Proposition 2. ***Case 2a*** *supports UPNE1-3 and MPNE2 and MPNE3 depending upon g^* according to:*

$$\left\{ \begin{array}{c} \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \\ \{H,H\},\{C,H\} \\ \{C,H\} \end{array} \right\} if \left\{ \begin{array}{c} g^* \in (0, min\{g^{**},\bar{g}\}) \\ g^* = min\{g^{**},\bar{g}\} \\ g^* \in (min\{g^{**},\bar{g}\},\tilde{g}) \\ g^* = \tilde{g} \\ g^* \in (\tilde{g},\infty) \end{array} \right\}.$$

One important thing to note is that the movement from ***Case 1a*** to ***Case 2a*** has introduced the equilibrium *UPNE1* under which the regulatory system fails and the Auditor colludes in the corrupt activity. However, the following Corollary has important implications for policymakers.

Corollary 3. ***Case 2a*** *(i) supports unconstrained $UPNE2$ corruption, and, (ii) $UPNEk$ are non-monotonic in g^*: marginal adjustments in the detection or penalty regimes intended to move the equilibrium from UPNE1 (UPNE2) to UPNE3 may overshoot and result in UPNE2 (UPNE1).*

A further weakening (rightward-stretching) of the detection profile $\sigma_1(g)$ and/or improvement in the rate of return to corruption $\omega_a(g)$ results in a movement from ***Case 2a*** to ***Case 3a***.

[5] The proofs to all propositions in Section 4, whilst possible to produce mathematically, are lengthy and tedious. However, the reader should be able to readily verify the propositions using diagrams.

Proposition 3. ***Case 3a*** *supports UPNE1 and UPNE2 depending upon g^*, and may support MPNE1 or UPNE3, MPNE2, and MPNE3 depending upon g^{**} according to:*

$$\begin{array}{cc} g^{**} < \tilde{g} & g^{**} > \tilde{g} \end{array}$$
$$\left\{\begin{array}{cc} \{C,C\} & \{C,C\} \\ & \{C,C\},\{C,H\} \\ \{C,C\},\{H,H\} & \\ \{H,H\} & \\ \{H,H\},\{C,H\} & \\ \{C,H\} & \{C,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0, g^{**}) \\ \tilde{g} < g^* = g^{**} \\ \tilde{g} \geq g^* = g^{**} \\ g^* \in (min\{g^{**}, \tilde{g}\}, \tilde{g}) \\ g^{**} \leq g^* = \tilde{g} \\ g^* \in (max\{g^{**}, \tilde{g}\}, \infty) \end{array}\right\}.$$

Corollary 4. ***Case 3a*** *(i) for $g^{**} > \tilde{g}$ is monotonically improving in g; (ii) for $g^{**} \geq \tilde{g}$ is non-monotonic in g, following the same sequence of equilibria as* ***Case 2a*** *but for different reasons; (iii) like* ***Case 2a****, supports unconstrained UPNE2 corruption.*

Proposition 4. *(i) Under $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$,* ***Case 4a*** *and* ***Case 3a*** *are equivalent (they support the same equilibria under the same conditions - see Proposition 3), and (ii) Under $\lim_{g\to\infty} \sigma_2(g) < \sigma^{**}$,* ***Case 4a*** *supports only UPNE1:*

$$\left\{\ C, C\ \right\} \textit{for} \left\{\ g^* \in (0, \infty)\ \right\}.$$

Corollary 5. ***Case 4a*** *under $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ (i) is non-monotonic in g, and, (ii) supports unconstrained UPNE2 corruption. (iii)* ***Case 4a*** *under $\lim_{g\to\infty} \sigma_2(g) < \sigma^{**}$, supports unconstrained and small-scale UPNE1 corruption.*

Therefore, even though in **Case 4** the detection profile $\sigma_2(g)$ lies everywhere below probability 1, so long as g^{**} exists, the outcomes of the model with corruption technology $\omega_a(g)$ are exactly the same as under Case 3. However, under ***Case 4a*** with $\sigma_2(g) < \sigma^{**}$, $\{C_1, C_2\}$ is the only outcome.

Proposition 5. ***Case 5a*** *under (i) $\lim_{g\to\infty} \sigma_2(g) < \sigma^{**}$, supports UPNE1, UPNE3 and MPNE2 depending upon g^*, according to:*

$$\left\{\begin{array}{c} \{H,H\} \\ \{H,H\},\{C,C\} \\ \{C,C\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0, \bar{g}) \\ g^* = \bar{g} \\ g^* \in (\bar{g}, \infty) \end{array}\right\},$$

and, under (ii) $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ and $g^{**} < \bar{g}$, supports UPNE2, UPNE3 and MPNE3 depending upon g^*, and according to:

$$\left\{\begin{array}{c} \{H,H\} \\ \{H,H\},\{C,H\} \\ \{C,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0, \tilde{g}) \\ g^* = \tilde{g} \\ g^* \in (\tilde{g}, \infty) \end{array}\right\},$$

and, under (iii) $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ and $\tilde{g} > g^{**} > \bar{g}$, supports UPNE1-3 and MPNE1-3 depending upon g^*, according to:

$$\left\{\begin{array}{c} \{H,H\} \\ \{H,H\},\{C,C\} \\ \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \\ \{H,H\},\{C,H\} \\ \{C,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0, \bar{g}) \\ g^* = \bar{g} \\ g^* \in (\bar{g}, g^{**}) \\ g^* = g^{**} \\ g^* \in (g^{**}, \tilde{g}) \\ g^* = \tilde{g} \\ g^* \in (\tilde{g}, \infty) \end{array}\right\}.$$

and, under (iv) $\lim_{g\to\infty}\sigma_2(g) > \sigma^{**}$ *and* $g^{**} > \tilde{g}$*, supports UPNE1-3 and MPNE1 and MPNE2 depending upon* g^**, according to:*

$$\left\{\begin{array}{c} \{H,H\} \\ \{H,H\},\{C,C\} \\ \{C,C\} \\ \{C,C\},\{C,H\} \\ \{C,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0,\bar{g}) \\ g^* = \bar{g} \\ g^* \in (\bar{g}, g^{**}) \\ g^* = g^{**} \\ g^* \in (g^{**},\infty) \end{array}\right\}.$$

Corollary 6. ***Case 5a*** *(i) supports unconstrained UPNE1 corruption under* $\lim_{g\to\infty}\sigma_2(g) < \sigma^{**}$ *and unconstrained UPNE2 corruption otherwise, (ii) supports monotonically worsening UPNEk with* g^**, under both* $\lim_{g\to\infty}\sigma_2(g) < \sigma^{**}$ *and* $\lim_{g\to\infty}\sigma_2(g) > \sigma^{**}$ *given* $g^{**} < \bar{g}$ *and, (iii) is non-monotonic in* g^* *for* $\lim_{g\to\infty}\sigma_2(g) > \sigma^{**}$ *given* $g^{**} > \bar{g}$.

4.2 Corruption technology *b*

One of the main characteristics of corruption technology $\omega_a(g)$ is that, whilst it exhibits diminishing returns to the scale of corruption g ($\gamma(g)$ is strictly concave), the diminishing returns property is insufficiently pronounced to ever cause $\omega_a(g)$ to become decreasing in g. We now consider the case of corruption technology $\omega_b(g)$ under which, for sufficiently high levels of g^*, $\omega_a'(g) < 0$.

Proposition 6. *Moving from corruption technology* $\omega_a(g)$ *to* $\omega_b(g)$ *introduces MPNE3 and UPNE3 at the end of the sequence of equilibria in* g^* *under Cases 1 and 2 so the relevant sequence of equilibria under corruption technology* $\omega_b(g)$ *extends those in Propositions 1 and 2, and necessarily changes the interval over which UPNE2 exists, according to:*

$$\left\{\begin{array}{c} \vdots \\ \{C,H\} \\ \{C,H\},\{H,H\} \\ \{H,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} \vdots \\ g^* \in (\tilde{g}, \tilde{\tilde{g}} = \bar{\bar{g}}) \\ g^* = \tilde{\tilde{g}} = \bar{\bar{g}} \\ g^* \in (\tilde{\tilde{g}} = \bar{\bar{g}}, \infty) \end{array}\right\}.$$

Corollary 7. *Corruption technology* $\omega_b(g)$ *(i) rules out unconstrained corruption equilibria that prevailed in Cases 1 and 2 under corruption technology* $\omega_a(g)$*, (ii) makes Case 1 non-monotonic in* g^**, whereas it was monotonically worsening under corruption technology* $\omega_a(g)$.

Proposition 7. *Moving from corruption technology* $\omega_a(g)$ *to* $\omega_b(g)$ *(i) introduces MPNE3 and UPNE3 at the end of the sequence of equilibria in* g^* *under* ***Case 3*** *so the relevant sequence of equilibria under corruption technology* $\omega_b(g)$ *extends those in Proposition 3, and necessarily changes the interval over which UPNE2 exists, according to:*

$$\begin{array}{cc} g^{**} < \tilde{g} & \tilde{\tilde{g}} > g^{**} > \tilde{g} \end{array}$$
$$\left\{\begin{array}{cc} \vdots & \vdots \\ \{C,H\} & \\ & \{C,H\} \\ \{C,H\},\{H,H\} & \{C,H\},\{H,H\} \\ \{H,H\} & \{H,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} \vdots \\ g^* \in (\tilde{g}, \tilde{\tilde{g}}) \\ g^* \in (g^{**}, \tilde{\tilde{g}}) \\ g^* = \tilde{\tilde{g}} \\ g^* \in (\tilde{\tilde{g}}, \infty) \end{array}\right\}.$$

and, (ii) for $g^{**} > \tilde{\tilde{g}}$:

$$\left\{\begin{array}{c} \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0, min\{g^{**},\bar{\bar{g}}\}) \\ g^* = min\{g^{**},\bar{\bar{g}}\} \\ g^* \in (min\{g^{**},\bar{\bar{g}}\},\infty) \end{array}\right\}.$$

Corollary 8. *Corruption technology $\omega_b(g)$: (i) rules out unconstrained corruption equilibria UPNE2 that prevailed in **Case 3** under corruption technology $\omega_a(g)$, and, (ii) preserves the non-monotonicity of the UPNEk in g^* under $g^{**} < \tilde{g}$ and the monotonically improving UPNEk for $g^{**} > \tilde{g}$.*

Proposition 8. *(i) Under $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$, Case 4 and Case 3, with corruption technology $\omega_b(g)$, are equivalent (they support the same equilibria under the same conditions - see Proposition 7), and (ii) under $\lim_{g\to\infty} \sigma_2(g) < \sigma^{**}$, moving from corruption technology $\omega_a(g)$ to $\omega_b(g)$ introduces MPNE2 and UPNE3 at the end of the sequence of equilibria in g^* under **Case 4** so the relevant sequence of equilibria under corruption technology $\omega_b(g)$ extends those in Proposition 4, and necessarily changes the interval over which UPNE1 exists, according to:*

$$\left\{\begin{array}{c} \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} g^* \in (0, \bar{g} = \bar{\bar{g}}) \\ g^* = \bar{g} = \bar{\bar{g}} \\ g^* \in (\bar{g} = \bar{\bar{g}}, \infty) \end{array}\right\}.$$

Corollary 9. *Corruption technology $\omega_b(g)$: (i) rules out unconstrained corruption equilibria UPNE2 and UPNE1 that prevailed in **Case 4** under corruption technology $\omega_a(g)$, and, (ii) preserves the non-monotonicity of the UPNEk in g^* under $g^{**} < \tilde{g}$ and the monotonically improving UPNEk for $g^{**} > \tilde{g}$.*

Proposition 9. *Moving from corruption technology $\omega_a(g)$ to $\omega_b(g)$ under* **Case 5**, *and (i) $\lim_{g\to\infty} \sigma_2(g) < \sigma^{**}$, introduces MPNE2 and UPNE3 at the end of the sequence of equilibria in g^* so the relevant sequence of equilibria under corruption technology $\omega_b(g)$ extends those in Proposition 5(i), and necessarily changes the interval over which UPNE3 exists, according to:*

$$\left\{\begin{array}{c} \vdots \\ \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} \vdots \\ g^* \in (\bar{g}, \bar{\bar{g}}) \\ g^* = \bar{\bar{g}} \\ g^* \in (\bar{\bar{g}}, \infty) \end{array}\right\},$$

and, under (ii) $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ and $g^{**} < \tilde{g}$, supports UPNE3 and MPNE3 at the end of the sequence of equilibria in g^* so the relevant sequence of equilibria under corruption technology $\omega_b(g)$ extends those in Proposition 5(ii) and (iii), and necessarily changes the interval over which UPNE3 exists, according to:

$$\left\{\begin{array}{c} \vdots \\ \{C,H\} \\ \{C,H\},\{H,H\} \\ \{H,H\} \end{array}\right\} \textit{if} \left\{\begin{array}{c} \vdots \\ g^* \in (\tilde{g}, \tilde{\tilde{g}}) \\ g^* = \tilde{\tilde{g}} \\ g^* \in (\tilde{\tilde{g}}, \infty) \end{array}\right\},$$

and, under (iii) $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ and $\bar{\bar{g}} > g^{**} > \tilde{g}$, supports UPNE3 and MPNE3 at the end of the sequence of equilibria in g^* so the relevant sequence of equilibria under corruption technology $\omega_b(g)$ extends those in Proposition 5(iv), and necessarily changes *the interval over which UPNE2 exists, according to:*

$$\begin{array}{cc} \tilde{\tilde{g}} < g^{**} < \tilde{g} & \bar{\bar{g}} > g^{**} > \tilde{\tilde{g}} \end{array}$$

$$\left\{ \begin{array}{cc} \vdots & \vdots \\ \{C,H\} & \\ & \{C,H\} \\ \{C,H\},\{H,H\} & \\ & \{C,H\},\{H,H\} \\ \{H,H\} & \\ & \{H,H\} \end{array} \right\} \text{ if } \left\{ \begin{array}{c} \vdots \\ g^* \in (g^{**}, \tilde{\tilde{g}}) \\ g^* \in (g^{**}, \bar{\bar{g}}) \\ g^* = \tilde{\tilde{g}} \\ g^* = \bar{\bar{g}} \\ g^* \in (\tilde{\tilde{g}}, \infty) \\ g^* \in (\bar{\bar{g}}, \infty) \end{array} \right\}.$$

and, under (iv) $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ *and* $\bar{\bar{g}} < g^{**}$*, supports UPNE3 and MPNE3 at the end of the sequence of equilibria in* g^* *so the relevant sequence of equilibria under corruption technology* $\omega_b(g)$ *is exactly in accordance with part (i) of this Proposition.*

4.3 Corruption technology *c*

Finally, we consider corruption technology $\omega_c(g)$, which unlike technologies a b, has such strongly diminishing returns to corruption that $\omega_c(g)$ never reaches unity - which, of course, means that Auditor honesty will immediately rule out any corruption by the Monopolist.

Proposition 10. *Moving from corruption technology* $\omega_a(g)$ *or* $\omega_b(g)$ *to* $\omega_c(g)$ *under (i)* ***Case 1*** *results in universal UPNE3:*

$$\left\{ \;H,H\; \right\} for \left\{ \;g^* \in (0,\infty)\; \right\},$$

(ii) ***Case 2*** *results in the sequence of equilibria in* g^**:*

$$\left\{ \begin{array}{c} \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \end{array} \right\} if \left\{ \begin{array}{c} g^* \in (0, min\{\bar{g}, g^{**}\}) \\ g^* = min\{\bar{g}, g^{**}\} \\ g^* \in (min\{\bar{g}, g^{**}\}, \infty) \end{array} \right\}.$$

Corollary 10. *Corruption technology* $\omega_c(g)$ *(i) rules out the non-monotonic sequence of equilibria in* g^* *under* ***Case 1b****, and preserves the monotonically improving sequence of equilibria in* g^* *in* ***Case 2a*** *and* ***Case 2b****.*

Proposition 11. *Under* $\lim_{g\to\infty} \sigma_2(g) < \sigma^{**}$*,* ***Case 4c (Case 5c)*** *is equivalent to* ***Case 4a (Case 5a)*** *supporting universal UPNE1 (unconstrained UPNE1).*

Corollary 11. *Unconstrained UPNE1 is feasible with corruption technology* $\omega_c(g)$ *under Case4.*

Proposition 12. *Under* $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ *(i)* ***Case 4c*** *supports the sequence of equilibria under* g^**, according to:*

$$\left\{ \begin{array}{c} \{C,C\} \\ \{C,C\},\{H,H\} \\ \{H,H\} \end{array} \right\} \text{ if } \left\{ \begin{array}{c} g^* \in (0, g^{**}) \\ g^* = g^{**} \\ g^* \in (g^{**}, \infty) \end{array} \right\}.$$

(ii) ***Case 5c*** *supports the sequence of equilibria under g^*, according to:*

$$\begin{array}{cc} g^{**} \leq \bar{g} & g^{**} > \bar{g} \end{array}$$
$$\left\{\begin{array}{cc} \{H,H\} & \{H,H\} \\ & \{H,H\},\{C,C\} \\ & \{C,C\} \\ & \{C,C\},\{H,H\} \\ \{H,H\} & \{H,H\} \end{array}\right\} \; if \; \left\{\begin{array}{c} g^* \in (0, min\{g^{**},\bar{g}\}) \\ g^* = \bar{g} < g^{**} \\ g^* \in (\bar{g}, g^{**}) \\ g^* = g^{**} > \bar{g} \\ g^* \in (g^{**}, \infty) \end{array}\right\}.$$

Corollary 12. *For $\lim_{g\to\infty} \sigma_2(g) > \sigma^{**}$ Corruption technology $\omega_c(g)$ (i) rules out unconstrained corruption equilibrium UPNE2 under Cases 4 and 5 that prevailed under $\omega_a(g)$ (ii) eliminates non-monotonicity under Case 4 that prevailed under $\omega_a(g)$ and $\omega_b(g)$ (iii) preserves non-monotonicity under Case 5 that prevailed under $\omega_a(g)$ and $\omega_b(g)$ for $g^{**} > \bar{g}$.*

5 Policy analysis

In this section we consider how the parameters of the model may be manipulated so as to change the outcome of the game for a given prospect g^*. We begin by asking whether the Monopolist can influence the outcome of the game. Given we are assuming that the Monopolist cannot determine the level of corruption, the only other candidate for an instrument that the Monopolist might exploit is α.[6]

Proposition 13. *If $\omega(g^*) > \sigma(g^*)$ and $\sigma(g^*)$ is greater than, but sufficiently close to, $\sigma(g^{**})$ then the monopolist can increase α (the share of profit devoted to Auditor services) strategically to move from UPNE2 to UPNE1.*

Proof. Let $\omega(g^*)$ at some initial level of α be $\omega(g^*, \alpha)$ where $\omega(g^*, \alpha) > \sigma(g^*)$. Accordingly, let $\sigma(g^*) > \sigma(g^{**}, \alpha)$ so that we have UPNE2 at α. Increasing α shifts αF_M (in Figure 2) to the left raising $\sigma(g^{**})$. However, given $\omega(g^*, \alpha) > \sigma(g^*)$, it follows there exists some $\Delta\alpha > 0$ such that $\omega(g^*, \alpha + \Delta\alpha) > \sigma(g^*)$. If $\sigma(g^{**}, \alpha)$ is sufficiently close to $\sigma(g^*)$, then $\sigma(g^{**}, \alpha + \Delta\alpha) < \sigma(g^*)$, hence yielding UPNE1. □

Definition 10. If it exists, let $\underline{\Delta\alpha} > 0$ be the value of $\Delta\alpha$ which satisfies both $\sigma(g^{**}, \alpha + \Delta\alpha) < \sigma(g^*)$ and $\omega(g^*, \alpha + \Delta\alpha) > \sigma(g^*)$, where $\omega(g^*, \alpha) > \sigma(g^*)$ and $\sigma(g^*) > \sigma(g^{**}, \alpha)$.

Hence, if $\underline{\Delta\alpha}$ exists then it is possible for the Monopolist to move the game from UPNE2 to UPNE1. It follows that the Monopolist may be able to exploit consultancy fees to 'bribe' the Auditor to be complicit in its corruption. However, although UPNE1 may be 'better' than UPNE2 for the Monopolist, inasmuch as it moves the Monopolist from a situation of incurring the fine F_M with certainty, to incurring it with some positive probability $\sigma(g^*) < 1$,[7] the above Proposition only establishes that there are circumstances under which it might bring about such manipulation of the Auditor. We now address the question regarding the conditions under which such manipulation would be in the interests of the Monopolist.

[6] It is conceivable that the Monopolist might be able to influence the profile $\gamma(g)$. However, in order to analyse this we would require a formal specification of the costs involved and this lies beyond the scope of the current work.

[7] By definition, under UPNE1, $\sigma(g^*) < \sigma(g^{**}) < 1$.

Proposition 14. *The Monopolist optimally selects to increase α by an amount $\Delta\alpha$ in order to bring about a move from UPNE2 to UPNE1 if:*

$$\Delta\alpha < \frac{(1-\alpha)(1-\sigma(g))F_M}{\{(1+\gamma(g))\Pi_M^H - \sigma(g)F_M\}} \tag{11}$$

Proof. It is required to show that the (risk-neutral) Monopolist's expected profit under UPNE1 with $\alpha + \Delta\alpha$ is greater than the Monopolist's profit under UPNE2 with α. Replacing α in (3a) with $\alpha + \Delta\alpha$ and comparing with (2a) we have (11). $\square$

Definition 11. Let $\overline{\Delta\alpha} \equiv \frac{(1-\alpha)(1-\sigma(g))F_M}{(1+\gamma(g))\Pi_M^H - \sigma(g)F_M}$.

Lemma 5. *Although it is possible for the denominator of (11) to be non-positive, for $\{C_1, C_2\}$ to be a UPNE requires that $(1+\gamma(g))\Pi_M^H - \sigma(g)F_M > 0$, hence where the strategy of using α to move from UPNE2 to UPNE1 is feasible, then the denominator of (11) is positive.*

Proof. From (4b) UPNE1 requires that $\omega(g) > \sigma(g)$, hence $\frac{\Pi_M^H}{F_M}\gamma(g) > \sigma(g)$. Multiplying by F_M and rearranging, we have $\gamma(g)\Pi_M^H - \sigma(g)F_M > 0$, hence $1 + \gamma(g)\Pi_M^H - \sigma(g)F_M > 0$. $\square$

Remark 9. If $\underline{\Delta\alpha} \in (0, \overline{\Delta\alpha})$ then the Monopolist can and will optimally raise α to move the game from UPNE2 to UPNE1.

Proposition 15. *The range of values of $\Delta\alpha$ which are consistent with the Monopolist optimally choosing to stimulate a move from UPNE2 to UPNE1, $\Delta\alpha \in (0, \overline{\Delta\alpha})$, is (i) decreasing in α, Π_M^H and $\gamma(g)$, (ii) increasing in F_M and (iii) may be increasing or decreasing in $\sigma(g)$.*

Proof. (i) This follows directly from the observation that $-\alpha$ appears only in the numerator of (11) whilst $\gamma(g)$ and Π_M^H both appear only in the denominator of (11) with positive coefficients, hence the respective partial derivatives of $\overline{\Delta\alpha}$ in each Case are negative. (ii) This follows given, after some manipulation:

$$\frac{\partial\overline{\Delta\alpha}}{\partial F_M} = \frac{(1-\alpha)(1-\sigma(g))[(1+\gamma(g))\Pi_M^H]}{\{.\}^2} > 0,$$

where $\{.\}$ is the denominator in (11), and given the assumptions of the model, the numerator of the derivative is positive. (iii) Given:

$$\frac{\partial\overline{\Delta\alpha}}{\partial\sigma(g)} = \frac{(1-\sigma(g)) - [(1+\gamma(g))\Pi_M^H - \sigma(g)F_M]}{\{.\}^2},$$

the first term in the numerator $(1-\sigma(g))$ is non-negative by the assumptions of the model and [.] is also positive from Lemma 5. $\square$

It follows that subject to UPNE1 and UPNE2 both being feasible following an increase in F_M, such an increase in the fine to the Monopolist will increase the range of values of $\Delta\alpha$ which would make a move from UPNE2 to UPNE1 attractive to the Monopolist. As we will see later, such an increase in F_M will also have a perverse effect on the Auditor which reinforces the likelihood of a move from UPNE2 to UPNE1 being feasible and optimal.

We now ask whether the regulatory body can influence the outcome of the game. The two obvious factors that the regulator can manipulate are the fines (to the Auditor (F_A) and the Monopolist (F_M) in the scenario where corruption is detected) and the probability of detection (by investing in the detection framework). We begin by examining the impact upon the game of raising the penalty to the Monopolist, F_M.

Proposition 16. *Increasing the Monopolist's fine under detected corruption, F_M (i) can eliminate all corruption with a sufficiently high fine, (ii) can, perversely, incentivise UPNE1 over UPNE2.*

Proof. (i) For $\{C_1, C_2\}$ to be UPNE requires, from (4a), that $\omega(g) \equiv \frac{\gamma(g)\Pi_M^H}{F_M} > \sigma(g)$ and for $\{C_1, H_2\}$ to be UPNE requires, from (5b), that $\omega(g) \equiv \frac{\gamma(g)\Pi_M^H}{F_M} > 1$. Hence, to rule out UPNE1 and UPNE2, respectively requires that $\sigma(g)F_M > \Pi_M^H$ and $F_M > \pi_M^H$. (ii) Let $\omega(g)$ at some initial level of F_M be $\omega(g, F_M)$, where $\omega(g, F_M) > \sigma(g)$. Accordingly, let $\sigma(g^*) > \sigma(g^{**}, F_M)$ so that we have UPNE2. Increasing F_M shifts αF_M in Figure 2 to the left raising $\sigma(g^{**})$. However, given $\omega(g^*, F_M) > \sigma(g^*)$, it follows there exists some $\Delta F_M > 0$ such that $\omega(g^*, F_M + \Delta F_M) > \sigma(g^*)$. If $\sigma(g^{**}, F_M)$ is sufficiently close to $\sigma(g^*)$, then $\sigma(g^{**}, F_M + \Delta F_M) < \sigma(g^*)$, hence yielding UPNE1. $\square$

Essentially, Proposition 16(i) refers to a case where $\omega(g)$ is lowered sufficiently that the corruption profile resembles **Case 1c**: for $g \in (0, \infty)$, $\omega(g) < \sigma(g)$.

Corollary 13. *UPNEk can be non-monotonic in F_M.*

Corollary 18 is a warning that increasing the fine to the Monopolist on detection of corruption may have perverse effects if the fine is not set sufficiently high.

Corollary 14. *The regulatory authority can bring about a move from UPNE1 to UPNE2, causing the Auditor to be honest instead of supporting Monopoly corruption, by decreasing the monopoly penalty, F_M.*

We now examine the implications for the game of the regulator increasing the fine to the Auditor with corruption detected under UPNE1.

Proposition 17. *Increasing the fine to the Auditor, F_A, on detection of UPNE1 corruption (i) unambiguously reduces the range of g^* over which the Auditor will choose to be complicit in corrupt activities, promoting UPNE2 over UPNE1, (ii) cannot eliminate UPNE2.*

Proof. (i) This follows straightforwardly from Definition 2. Increasing F_A raises $\varphi(\sigma)$ for $\forall\sigma \in (0, 1)$. Since, from (4a), UPNE1 requires that $\varphi(\sigma) < \alpha F_M$, increasing $\varphi(\sigma)$ reduces $\sigma(g^{**})$, the supremum of the set of $\sigma(g)$ for which the Auditor would support Monopoly corruption. (ii) This follows straightforwardly from the observation that F_A does not feature in the Monopolist's condition for UPNE2. $\square$

Finally, we consider the possibility that the regulator could invest in improving the corruption detection framework, raising $\sigma(g)$.

A 13. *We assume, for simplicity, that investments in improving the corruption detection framework cause the profile $\sigma(g)$ to rise $\forall g \in (0, \hat{g})$ [$\forall g \in (0, \infty)$] in the case of σ_1 [σ_2] so that the properties of the profile under A 10 are preserved.*

Corollary 15. *(i) If $T > \sigma^{**}$ so that g^{**} does not exist, then a sufficiently large investment in improving detection will eventually yield $T < \sigma^{**}$ for which there will exist an associated g^{**}. (ii) Investment in improving detection cannot convert a $\sigma_2(g)$ detection profile into a $\sigma_1(g)$ profile.*

Lemma 6. *Under σ_1 and also σ_2 for $T > S$, g^{**} exists and any investment in improving the detection of corruption in accordance with A 10 will lower the level of g^{**}.*

Proof. For this proof it is convenient to exploit the strict monotonicity of $\sigma(g)$ ($\sigma'(g) > 0$) for $\sigma \in [0, 1)$ [$\sigma \in (0, \infty)$] under σ_1 [σ_2]. This allows us to invert the function giving $g(\sigma)$ for $\sigma_1 \in [0, 1)$ and $\sigma_2 \in [0, T)$. Under σ_1, $\sigma(g^{**}) \in (0, 1)$ exists and under σ_2 with $T > S$, $\sigma(g^{**}) \in (0, T)$ exists . Hence, inverting the function we can say in each case $g(\sigma^{**})$ exists. Given σ^{**} is determined by the interaction of $\varphi(\sigma)$ and αF_M, neither of which are affected by raising the $\sigma(g)$ profile, then σ^{**} is constant. However, an upward shift in $\sigma_1(g)$ for $\sigma \in (0, 1)$ implies $g(\sigma^{**})$, and hence g^{**}, falls. A similar argument holds for an upward shift in σ_2 for $\sigma \in (0, T)$. □

We begin by considering the impact of investing in improved detection upon the Auditor.

Proposition 18. *Investment in corruption detection (i) under σ_1, and also σ_2 for $T > S$, unambiguously reduces the range of g^* for which the Auditor will choose to be complicit in corrupt activities, promoting UPNE2 over UPNE1, (ii) under σ_2 in the case of $T \leq S$ will reduce the range of g^* for which the Auditor will choose to be complicit if the shift in σ_2 is sufficiently large.*

Proof. (i) Given Lemma 6 Since the Auditor's complicity in corruption requires that $g^* \in (0, g^{**})$ the range of values of g^* consistent with Auditor complicity has fallen. (ii) It is sufficient to note that under σ_2 in the case of $T \leq S$, σ^{**} lies strictly above σ_2 $\forall g \in [0, \infty)$, hence g^{**} does not exist. However, since σ^{**} is fixed and lies in the open interval $(0, 1)$ there always exists a $\sigma > \sigma^{**}$ in the interval $(0, 1)$. Hence, a sufficiently large investment in improving detection will eventually shift σ_2 upwards raising T above S so that g^{**} exists. This reduces the interval of g^* under which the Auditor will be complicit in corruption from $(0, \infty)$ to $(0, g^{**})$. Further improvements in corruption detection will then have the effect described in (i). □

It follows that investments in improving corruption detection may have no effect upon the Auditor unless they are sufficiently large, hence local adjustments in the detection may not have any impact upon the the range of g^* supporting UPNE2. We now turn our attention to the impact of investments in corruption detection on the Monopolist.

Proposition 19. *Investments in improving corruption detection, however large, are completely ineffective at eliminating Monopoly corruption or even reducing the range of g^* for which the Monopolist is corrupt where corruption arises under technologies a and b in the region $\omega_a > 1$ or $\omega_b > 1$.*

Proof. This follows straight forwardly from the observation that UPNE2 requires $\omega > \sigma$ but since $\omega > 1$ and σ is constrained to lie at or below 1, any feasible increase in σ will not be enough to reverse the inequality between σ and ω. □

Corollary 16. *Investments in improving corruption detection are completely ineffective at addressing unconstrained UPNE2 under technology ω_a.*

Thus, whilst improving detection may deter the Auditor from being complicit in corrupt activities, on its own, this policy cannot eliminate all corruption, including possible unconstrained corruption. Also, we know from Proposition 18 that such investments will eventually deter the Auditor from supporting corrupt activities, hence the most that could be achieved with this policy of improving corruption detection is to eliminate UPNE1. UPNE2 cannot be eliminated in this case, however much investment is undertaken.

Remark 10. In line with A 10, sufficiently large investments in improving corruption detection will eventually raise $\sigma_1(g)$ transforming Case 3 into Case 2 and Case 2 into Case 1. Similarly, investments will eventually raise $\sigma_2(g)$ transforming Case 4 into Case 5.

Proposition 20. *If investments in improving corruption detection, required to bring about a change in Case as described in Remark 6, are prohibitively expensive, improving corruption detection will not eliminate small-scale UPNE1 in Case 2, Case 3 and Case 4.*

Proof. The proof follows from the definition of small-scale corruption and the observation that Cases 2-4 support UPNE1 small-scale corruption since in each case $\sigma'(0) < \omega'(0)$. □

We now examine some of the characteristics of the five Cases in terms of the role that investments in detection improvement can have on deterring Monopoly corruption. We use the idea of arbitrarily small changes in corruption detection investment in order to emphasise that after the investment the local properties of the model are unchanged and we have not made a shift from one Case to another.

Proposition 21. *(i) Investments in improving corruption detection are completely ineffective in dealing with Monopolist corruption in Case 1. (ii) Under Case 2, arbitrarily small investments in improving corruption technology will always reduce the range of g^* for which the Monopolist chooses to be corrupt.*

Proof. (i) This follows directly from the fact that under Case 1 the only corrupt equilibrium is UPNE2 where $\omega_a > 1$ or $\omega_b > 1$, which, from Proposition 19, we know cannot be affected by detection investments. (ii) First, if $g^{**} > \bar{g}$ then Monopolist corruption occurs if $g^* \in (0, \bar{g})$. Investing in improving corruption detection will raise $\sigma_1(g)$ hence reducing $\bar{g}$ and with it the upper limit of g^* consistent with Monopolist corruption. Second, if $g^{**} \leq \bar{g}$ then Monopolist corruption occurs if $g^* \in (0, g^{**})$. Investing in improving corruption detection raises $\sigma_1(g)$, which by Lemma 6 reduces g^{**}, and with it the upper limit of g^* consistent with Monopolist corruption. □

Finally, we note that unlike Case 1 where corruption detection was completely ineffective at deterring Monopoly corruption, and Case 2 where, regardless of the corruption technology, such investments would always reduce the range of g^* under which the Monopolist would be corrupt, we have that Cases 3-5 each have conditions under which improving corruption detection would and would not have benefits in terms of reducing the range of g^* consistent with Monopolist corruption. For brevity, the following Proposition identifies the Cases where local improvements in the corruption detection do not impact upon Monopolist corruption.

Proposition 22. *Arbitrarily small improvements in corruption detection do not reduce the range of* g^* *under which the Monopolist is corrupt (i) under Case 3a and Case 3b if* $\tilde{g} < g^{**} \leq \tilde{\tilde{g}}$, *(ii) under Case 4a and Case 4c if* $T < \sigma^{**}$ *and* $T < S < \sigma^{**}$, *respectively, (iii) under Case 4a and Case 4b if* $T > \sigma^{**}$ *and respectively* $g^{**} > \tilde{g}$, $g^{**} > \tilde{g}$, *(iv) under Case 5a and Case 5b if* $T > \sigma^{**}$ *and* $\bar{g} > g^{**}$.

Proof. (i) Under Case 3a with $g^{**} > \tilde{g}$, a reduction in the range of g^* under which Monopoly corruption is an equilibrium requires a sufficiently large improvement in corruption detection, and by Lemma 6 associated reduction in g^{**}, such that $g^{**} < \tilde{g}$. Hence, arbitrarily small improvements in corruption detection yield $g^{**} > \tilde{g}$, leaving the range of g^* under which the Monopolist is corrupt unchanged. Under Case 3b a further argument is required. Given $g^{**} \leq \tilde{\tilde{g}}$, where under Case 3b, by Definition 6 and Definition 7, $\tilde{\tilde{g}} < \bar{\bar{g}}$, arbitrarily small improvements in corruption detection which reduce $\hat{g}$ but yield $\tilde{\tilde{g}} < \bar{\bar{g}}$ leave unchanged the range of g^* under which Monopoly corruption is an equilibrium. (ii) Under Case 4a [Case 4c] with $T < \sigma^{**}$ [$T < S < \sigma^{**}$], $\sigma_2(g)$ lies strictly below σ^{**} and $\omega_a(g)$ [$\omega_c(g)$] $\forall g \in (0, \infty)$. Hence improvements in corruption detection which raise $\sigma_2(g)$ by sufficiently small amounts such that $\sigma_2(g) < \sigma^{**}$ and $\sigma_2(g) < \omega_a(g)$ [$\sigma_2(g) < \omega_c(g)$] $\forall g \in (0, \infty)$ are preserved leaves the range of g^* under which the Monopolist is corrupt unchanged. (iii) The proof is obtained by replacing Case 3a and Case 3b in (i) with Case 4a and Case 4b, respectively. (iv) Under Case 5a and Case 5b with $g^{**} < \bar{g}$, improving corruption detection reduces g^{**} and raises $\sigma_2(g)$ shifting $\bar{g}$ to the right. However, since honesty is the equilibrium for the Monopolist $\forall g^* \in (0, \tilde{g})$ reductions in g^{**} have no effect on the Monopolist's equilibrium and given $\bar{g} < \tilde{g}$ under detection profile σ_2, investments in improving corruption detection do not extend upwards the range of g^* that yield Monopolist honesty. □

6 Conclusions

This paper has had two broad objectives. First, to develop a model of firm corruption, taking account of auditor interaction, and to use this model to identify the possibility of stable corruption, where stability is viewed as an equilibrium in the game. The key driver to the relationship between the firm and the auditor is that increasing firm profitability, from corruption, indirectly increases the demand for consultancy services that the auditor provides in addition to auditing services. It has been shown here that a variety of equilibria are possible in the game, depending on particular parameterisations: corruption by both the firm and the auditor; firm corruption that is controlled by an honest auditor; multiple equilibria involving both corruption and honesty; honesty by both actors in the model. The multiplicity of possible equilibria in the model is interesting in its own right but is particularly useful in terms of the analysis of possible policy interventions that are considered in the final substantive section. This analysis of policy is the second broad objective of the discussion. In general terms some of the policy conclusions confirm what might be considered intuitively obvious anti-corruption policies. But some of the conclusions are less intuitively obvious and reflect firm-auditor interaction. Amongst other things, we show that corruption is indeed an equilibrium of the game under some scenarios and also that in general it is not possible to say anything about whether a corrupt or honest equilibrium is likely to occur for higher or lower levels of corruption activity on offer to the Monopolist: under some scenarios the honest (corrupt) equilibrium prevails where the corrupt prospect is small (large) and vice versa. In particular, we show that the Monopolist might be able to profitably manipulate the consultancy fee it pays to the Auditor to bring about a corrupt equilibrium in which the Auditor is complicit. We also show that sufficiently high fines on the Monopolist can eliminate corruption but that generally raising the fine incurred by the Monopolist can have perverse effects, too. Fining the Auditor, on the other hand, cannot eliminate all corruption. Finally, we show that investments in corruption detection (raising the probability that corrupt activity is detected and penalised) may be effective at deterring Auditor complicity in corrupt activities but may be completely ineffective at addressing Monopoly corruption. First, the monopolist can, in principle, 'bribe' the auditor by increasing consultancy payments. The result here is that the equilibrium of the game can, in principle, be shifted from 'firm corruption that is controlled by an honest auditor' to 'corruption by both the firm and the auditor'. Secondly, even without the firm strategically buying consultancy services, increasing penalties on corrupt firms can be shown to undermine auditor honesty; a conclusion that follows from the interactions in the model. It follows that the efficiency of the auditing system may be improved by reducing penalties on corrupt firms.

It follows from these conclusions that imposing penalties on corrupt firms may be an inefficient policy option and should be used in combination with, or replaced by, other policy options. First there is the obvious option of punishing auditors. It has been shown here that this unambiguously promotes auditor honesty and does not have the perverse effects that can be identified when corrupt monopolists are punished. But auditor punishment does not remove firm corruption instead it results in a more effective auditing system. It follows that possible anti-social effects of corruption not considered here (for instance on consumers or other economic actors) still exist. A similar conclusion follows from investment in the detection of firm corruption. This can be shown to not eliminate corruption instead it promotes auditor honesty.

It is appropriate to mention, here in the conclusion, various policy options that appear intuitively plausible but go beyond the confines of the model presented here. First, there is the possibility of making penalties endogenous and hence increasing with corrupt gains. This might eventually eliminate large scale corruption, but depending on the function used to define the penalties need not eliminate the perverse impacts of firm penalties in general. An interesting issue is when dual equilibria exist. This suggests that corruption might be understood as a focal point; the fact that it exists does not imply that non-corruption can also exist even with the same Monopoly and Auditor payoff structures. This possibility suggests anti-corruption policies that are beyond the framework developed here and might revolve round the expectations of the actors. One final issue that can be highlighted involves the non-monotonicity of the equilibria. Without a detailed picture of the relevant corruption detection and technology profiles it is not possible to say whether policies aimed at 'getting tough' on corruption are necessary, productive or indeed, counterproductive.

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Figure 1: **Extensive form representation of the corruption game**

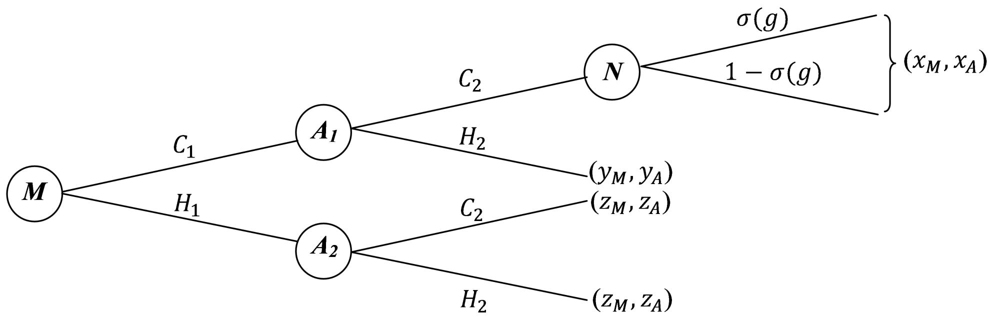

Figure 2: **Auditor's Decision**

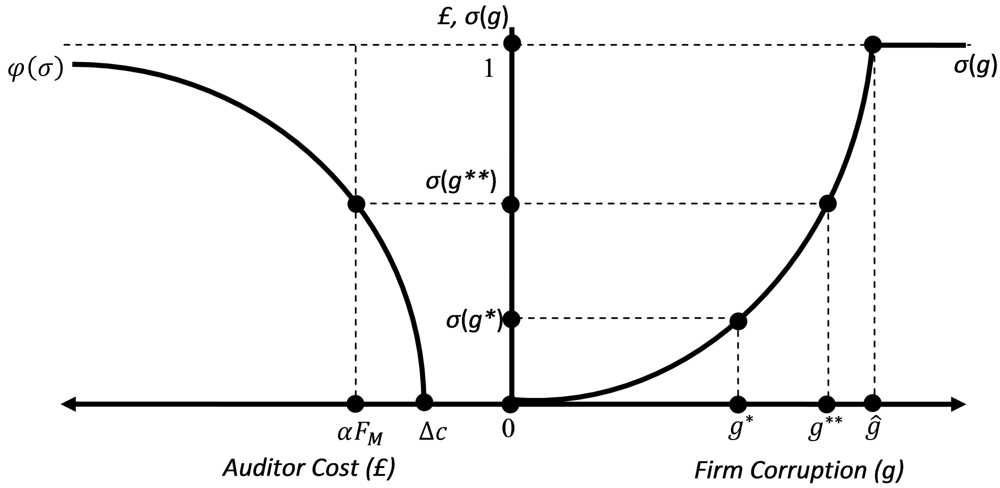

Figure 3: **Three Corruption Technologies** $\omega(g)$

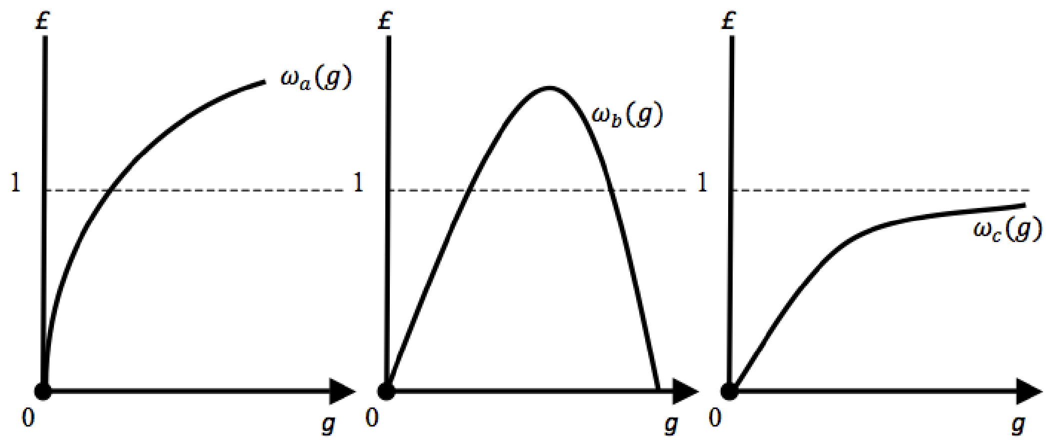

Figure 4: **Examples of the of Cases 1-3 the Relationship between Corruption Technology $\omega(g)$ and the Corruption Detection Profile $\sigma(g)$**