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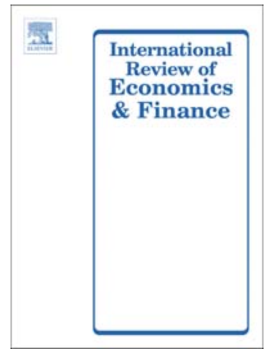

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Managerial compensation, product market competition and fraud*

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Abstract

We study a model in which a manager can engage in unobservable cost-cutting effort, possesses private information about firm profits and where shareholders employ stock and stock option-based compensation packages to align the manager's interests with theirs. Stock-based incentives may induce the manager to misrepresent profits with the aim to increase the firm's stock price and hence her compensation. Common wisdom holds that competition disciplines the manager. We investigate how product market competition affects the shareholders' trade-off between fraud and effort and hence incentive provision.

Keywords: executive compensation; fraud; incentives; product market competition; stock and stock options

Jel: D82, G30, J33, L1

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1 Introduction

In the presence of separation of ownership and management stock and stock option-based compensation schemes are employed to align shareholders' and managers' incentives (Jensen and Meckling, 1976). Accounting scandals, such as Enron, WorldCom and Xerox, during the 1990s have brought CEO compensation practices under close scrutiny suggesting that stock-based compensation may induce managers to misrepresent the firm's performance with the aim to increase their personal wealth (see, for example, Goldman and Slezak, 2006; Burns and Kedia, 2006; Bergstresser and Philippon, 2006; Efendia, Srivastavab and Swanson, 2007). Common wisdom holds that product market competition (PMC) disciplines the manager and helps aligning shareholders' and manager's incentives (see, for example, the discussion in Schmidt, 1997 and Raith, 2003) and thus raises the question of how PMC affects managerial incentive provision if she can engage in fraudulent behavior.

In this paper we consider a model in which a manager can exert unobservable cost-cutting effort (hidden action) and has private information about firm profits (hidden information) which she can use to fraudulently inflate her compensation. Fraudulent behavior can affect long-term firm profits positively if, for example, the firm is in need of funds from investors as in Povel et al. (2007), or negatively if, for example, real resources are wasted (see Jensen, 2003; Karpoff, Lee and Martin, 2008b; Kedia and Philippon, 2009). If fraud is costly for the firm, then shareholders trade off gains from managerial effort against costs due to fraudulent behavior and we investigate how the degree of PMC affects this trade-off and hence managerial incentive provision.

We assume that shareholders cannot observe firm profits and that at the beginning of the game they offer the manager privately a stock-based incentive contract. After accepting the contract, the manager exerts unobservable cost-cutting effort, firms compete in quantities or prices and profits are realized. We assume that with a positive probability, some consumers do not fulfill their debt obligation which leads to negative profit shocks. This information is private to the manager who may hide it from shareholders in order to boost the stock price and hence her compensation. Before pocketing the compensation package, the manager writes a profits report and the firm is audited by an external auditor. The auditor states whether the profits report is truthful or not. We assume that the audit technology is imperfect and that the fraud detection probability is lower than one, which may be due to mistakes by the auditor, but may also be due to collusion between the manager and the auditor (Baglioni and Colombo, 2011). The manager's compensation depends thus on her profits report and on the auditor's announcement, which may lead to distorted incentives.[1] In particular, the manager of a firm that does not experience negative profit shocks has an incentive to truthfully report profits with the aim to increase her compensation, whereas the manager of a firm that does suffer a negative profit shock has to decide whether to report profits truthfully or not. We consider the case of managerial myopia (see, for example, Tirole, 2006, chapter 7.2). Stock and stock options are granted to induce managerial effort, but they may also encourage the manager to inflate through fraudulent reporting the firm's stock price and hence her compensation. We assume that if caught reporting fraudulently the manager gets punished (see Karpoff, Lee and Martin, 2008a for empirical evidence on personal costs to managers).

In the first part, we consider only stock-based compensation packages and show that since the manager's benefits of fraudulent reporting depend positively on her pay-for-performance sensitivity (PPS), a separating equilibrium, where a manager always truthfully reports profits, can be obtained if the PPS is sufficiently low. We argue that this may not be optimal from the shareholder's viewpoint since it may induce a too low effort level and that in some cases shareholders prefer a pooling equilibrium, where a manager of a firm hit by a negative profit shock reports high profits with a positive probability, in order to induce strong managerial effort. We find conditions on the profit function such that the stronger PMC, the greater marginal gains from incentive provision compared with its marginal costs. We show that these conditions are satisfied in linear demand models with price and quantity competition if the positive effect of effort on output is stronger when competition is fierce, which, for example, is true in the case of Cournot competition and in Salop's model, and in a duopoly with price competition if consumers are endowed with CES utility functions. As a consequence, we find that if the fraud detection probability is sufficiently large and PMC is sufficiently strong, then gains from managerial cost-cutting effort are large compared with costs due to fraudulent behavior; thus a pooling equilibrium, where managers' PPS is large, is optimal for shareholders. In this case, PMC is positively related both to PPS and fraudulent behavior. If the fraud detection probability is low and PMC is weak, then gains from cost-cutting effort are low compared with costs due to fraudulent behavior and thus a separating equilibrium, where managers' PPS is low, is optimal for shareholders.

In the second part, we consider stock and stock option-based compensation packages. Stock options give the manager the right to buy the firm's stock at a predetermined price (strike price). The value of the option is positive if the stock price is larger than the strike price, otherwise the option is

[1]See also Baker (1992, 2002) who shows how incentive schemes based on alternative performance measures can lead to distorted incentives.

worthless. We show that the non-linearity of stock options allows shareholders to make the manager's remuneration report-dependent by setting the strike price in such a way that options are out-of-the money, that is, their value is zero, in some states, and in-the-money, that is, their value is positive, in others. Thus, at the equilibrium, even though the contract signed at the beginning of the game is the same for all managers, the PPS will be different since it will depend on the profits report. Labelling profits of firms hit and not hit by a negative shock as "low" and "high", respectively, we find that shareholders can eliminate fraudulent behavior if options are in-the-money for a manager reporting high profits and out-of-the-money for a manager reporting low profits. As a result, the PPS of a manager reporting high profits is larger than the PPS of a manager reporting low profits. Compared with only stock grants, the use of stock and stock options allows shareholders to elicit stronger effort when eliminating fraud, but akin to stock grants, shareholders face a trade-off between fraud and effort since eliminating fraud requires a low PPS for a manager reporting low profits. We characterize situations where shareholders prefer to use options and to eliminate fraud, and where they prefer to provide a manager with strong incentives independently of profits reported and to endure some fraudulent behavior.

Our results are consistent with the empirical evidence on the relationship between fraudulent behavior and PMC and the relationship between managerial PPS and PMC. Datta et al. (2013), measuring product market pricing power using the Lerner Index, and Karuna et al. (2012), using the degree of product substitutability, market size and entry costs as proxies for competition, find a positive relationship between PMC and fraudulently reported profits. Cuñat and Guadalupe (2005), exploiting the quasi-natural experiment of the pound sterling appreciation in 1996, Cuñat and Guadalupe (2009a), using the deregulation of the banking and financial sectors in the 1990s, and Cuñat and Guadalupe (2009b), analyzing the degree of import penetration, evidence that an increase in the strength of competition is associated with an increase in managerial PPS. Karuna (2007) considers a multi-dimensional characterization of competition, encompassing product substitutability, market size and entry costs, and finds a positive relationship between PMC and PPS.

A number of papers suggest that managers engage in opportunistic profits manipulation to increase their personal wealth.[2] Burns and Kedia (2006), Bergstresser and Philippon (2006), Efendia, Srivastavab and Swanson (2007) and Peng and Röell (2008a), find that stock-based compensation increases

[2]Among other motives for fraudulent behavior are the attraction of funds as evidenced in Teoh et al. (1998), Povel, Singh and Winton (2007) and Wang, Winton and Yu (2010) and Shu and Chiang (2014) and the stock price manipulation before share repurchases as discussed in Gong, Louis, and Sun (2008) and Chiu and Liang (2015).

the likelihood of observing fraudulent behavior. Goldman and Slezak (2006) consider a principal/agent model with hidden action and show that the potential for information manipulation affects the equilibrium level of pay-for-performance sensitivity. Crocker and Slemrod (2007) study managerial incentive provision and profits manipulation in a model with hidden action and hidden information and show that compensation contracts contingent on reported profits cannot induce the manager both to maximize profits and to report profits truthfully. Peng and Röell (2008b, 2014) study optimal managerial incentive provision if the manager's cost of manipulating is uncertain.[3] These papers do not consider how PMC affects the shareholders' trade-off between effort and fraud. We study the problem of incentive provision taking the market structure explicitly into account. In particular, our model expands on Andergassen (2010), where the relationship between fraudulent behavior and managerial incentives in the presence of hidden action and hidden information is studied, in three majors ways. In Andergassen (2010) the strength of PMC is modeled in a reduced form as the ability of firms to collude. In the present paper we consider price and quantity competition under general conditions on the profit function which we show to hold in a wide range of models. Secondly, instead of demand-boosting effort, we examine the effects of cost-reducing managerial effort. We find that in the case of cost-cutting effort shareholders prefer to avoid fraud if PMC is weak, while they prefer strong managerial incentives if PMC is strong, which is the opposite of what happens in the case of demand-boosting effort. Thirdly, we consider a more general non-linear stock and stock option-based compensation scheme. We show that shareholders prefer to use stock and stock option grants if they want to eliminate fraud since it increases managerial effort, thereby enabling us to predict the structure of compensation packages in industries as their PMC differs.

The paper is also related to the literature on managerial effort and PMC (see, for example, Schmidt, 1997; Graziano and Parigi, 1998; Boone, 2000; Stennek, 2000; Raith, 2003; Vives, 2008; Piccolo, D'Amato and Martina, 2008; Beiner, Schmid and Wanzenried, 2011).[4] While this literature focuses on how a change in the degree of PMC affects managerial effort, in the present paper we investigate how PMC affects the PPS of the manager's compensation package if she can exert cost-cutting effort and engage in fraudulent behavior.

The remaining part of the paper is organized as follows. In Section 2 the model is presented and

[3] The shareholders' trade-off between stock- and stock option-based compensation if the manager can exert unobservable effort and fraudulently inflate the firm's stock price is analyzed in Andergassen (2008), Wu (2011), Santore and Tackie (2013), Wilson and Wu (2014), while Baglioni and Colombo (2009, 2011) and Robison and Santore (2011) investigate how monitoring affects incentive contracts.

[4] The effects of competition on the information structure of the agency problem and hence on managerial incentives have been investigated by Hart (1983), Scharfstein (1988), Hermalin (1992), Martin (1993) and Bertoletti and Poletti (1997) showing an ambiguous relationship between competition and incentives.

the shareholders' trade-off between fraud and effort is solved if managerial compensation consists of cash and stock grants. In Section 3 we consider the case where managerial compensation includes also stock options. Section 4 contains some concluding remarks. Proofs are in the Appendix.

2 Stock-based compensation and fraud

We consider n firms competing in an industry; we consider both Cournot and Bertrand competition. Average production costs of firm i are $C_i = c - e_i$, where $e_i > 0$ is unobservable managerial cost-cutting effort, $i = 1, ..., n$. We assume that c is sufficiently large such that $C_i > 0$. Each firm, represented as a group of shareholders, hires a single manager. The model is characterized by moral hazard in that managers are identical but undertake cost-cutting effort, which is unobservable to the firm's shareholders and all other firms. For the following we omit index i wherever this does not lead to confusion and consider the problem of a representative firm.

2.1 Timing of the game

At T_0 managers and firms are randomly matched and shareholders offer privately an incentive contract. The contract is accepted by the manager if it yields an expected utility at least as large as the outside-option utility, which is normalized to 0. At T_1 the manager exerts unobservable cost-cutting effort and at T_2 she chooses quantities or prices. Products are sold at T_3 and profits observed only by the manager. With probability $\frac{1}{2}$ a firm is hit by a negative profit shock (for example, some consumers default on their debt)[5], in which case, for simplicity's sake, we assume that half of its profits are lost. We normalize the risk-free interest rate to zero. Let H denote a firm that does not experience profit losses (a high profits firm) and L a firm that does (a low profits firm), with $\Pi_H = \hat{\pi}$ and $\Pi_L = \frac{1}{2}\hat{\pi}$ total profits of a firm without ($H-$type) and with ($L-$type) profit losses for a given price/quantity and effort choice.[6]

Only the manager observes realized profits and thus knows the firm's type. At T_4, the manager writes a profits report. In particular, the manager has to choose whether to report profits truthfully

[5] The model could be straightforwardly extended by assuming that all firms are hit by negative profit shocks, but some are hit more severely than others or that the negative shock occurs with some probability different from $\frac{1}{2}$, without altering our qualitative results.

[6] It would be interesting to extend the model to the case where instead of only two states, negative profit shock or no negative profit shock, there are a finite number of states (or even a continuum of states), each corresponding to a different size of profit shock. In this case, in addition to the choice of reporting profits truthfully or not, the manager, if she decides to report untruthfully, has also to decide the extent of fraudulent reporting. This issue is left for further research. We are grateful to an anonymous referee for pointing this out.

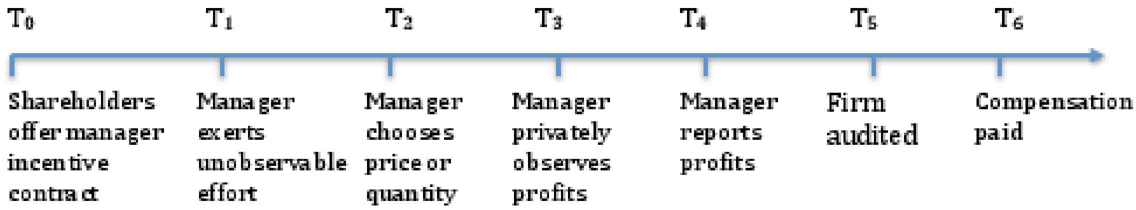

Figure 1: Timing of the game.

or not. The manager of an H type firm has an incentive to write a truthful profits report since she wants to separate herself from managers of firms that experienced negative shocks, while a manager of an L type firm has to decide whether to report profits truthfully or not (fraud choice). At T_5 the firm is audited by an external auditor. At T_6 the manager receives her compensation as specified by the contract in T_0. For simplicity's sake we assume that the manager receives the money equivalent of stock and stock option grants. We assume that the auditing technology is imperfect. In particular, the auditor perfectly verifies a truthful report, either $\hat{L}$ when profits are L, or $\hat{H}$ when profits are H, or imperfectly identifies a fraudulent report. Specifically, if the manager misreports $\hat{H}$, then the auditor (incorrectly) verifies it, announces V, with probability $1-\eta$, but accurately detects the fraud, announces F, with probability η.[7]

Fraudulent behavior can affect long-term firm profits positively (for example, if the firm is in need of funds from investors as in Povel et al., 2007) or negatively (for example, if real resources are wasted as in Kedia and Philippon, 2009). Let the benefit or cost of fraudulent reporting to the firm if it is not discovered by the auditor be $\delta\frac{1}{2}\hat{\pi}$, $\delta \in (-1,1)$. For $\delta \in (-1,0)$ fraudulent behavior benefits the firm, while for $\delta \in (0,1)$ it harms the firm. If the manager of an L type firm writes an untruthful profits report $\hat{H}$ and it is not discovered by the auditor, then firm profits are $\Pi_L - \delta\frac{1}{2}\hat{\pi} = \frac{1}{2}\hat{\pi}(1-\delta)$. If the auditor discovers fraudulent behavior, then firm profits are $\frac{1}{2}\hat{\pi}$.

Shareholders are risk-neutral and managers are risk-neutral but effort-averse. In Figure 1 we depict the timing of the game.

2.2 The shareholders' problem

In this section we assume that managerial pay consists of w_0 units of cash and w_1 shares of stock. The shareholders' problem is to choose at T_0 a compensation contract (w_0, w_1) that maximizes the expected firm value, taking into account the auditing technology, the equilibrium fraud probability,

[7] See Baglioni and Colombo (2011) for a similar setup.

the participation and the incentive compatibility constraint.

Let S_{T_0} and U_{T_0} denote the stock price of a firm and the expected utility of its manager at T_0, respectively. As shown below, S_{T_0} and U_{T_0} are calculated given the fraud probability λ that a manager of an L type firm reports $\hat{H}$ and taking expectation over types, auditing and fraud events. The shareholders' problem at T_0 can thus be formally stated as follows:

$$max_{w_0,w_1} S_{T_0} \tag{1}$$

$$\text{s.t. } e^* = argmax_e U_{T_0} \tag{2}$$

$$U_{T_0} \geq 0 \tag{3}$$

$$\lambda = \lambda^* \tag{4}$$

(2) and (3) are the incentive compatibility and participation constraints, respectively, and λ^* in (4) is the equilibrium fraud probability. Problem (1) - (4) is solved backwards.

2.2.1 Manager's report choice at T_4

Consider T_4 when the manager chooses whether to report profits truthfully or not. Let us first calculate for given profits and realization of types the value of her compensation package and the corresponding utility. At T_6, the company's stock price depends on the type of report written ($\hat{H}$ or $\hat{L}$) and on the auditor's announcement. Let $S_{T_6,\sigma,A}$ be the stock price of the company at T_6 if the manager at T_4 has written a profits report of type $\sigma \in \left\{\hat{L}, \hat{H}\right\}$ and the auditor announces $A \in \{V, F\}$.

The manager's compensation package at T_6 can be written as

$$W_{T_6,\sigma,A} = w_0 + w_1 S_{T_6,\sigma,A}. \tag{5}$$

Normalizing without loss of generality to 1 the number of already existing shares, the value of a single share (stock price) at T_6 if the manager writes a profits report $\sigma \in \left\{\hat{L}, \hat{H}\right\}$ and if the auditor announces $A \in \{V, F\}$ is

$$S_{T_6,\sigma,A} = E\left(\Pi | \, \sigma, A\right) - W_{T_6,\sigma,A}. \tag{6}$$

where $E\left(\Pi | \, \sigma, A\right)$ are expected firm profits, given the manager's report and the auditor's announcement. Using (5), stock price (6) reads, after rearranging terms,

$$S_{T6,\sigma,A} = (1-\alpha)\left[E\left(\Pi|\,\sigma,A\right) - w_0\right] \tag{7}$$

where $\alpha = \frac{w_1}{1+w_1} \in [0,1]$ is the percentage of total shares the manager is granted. Using (7) the manager's compensation package can be written as $W_{T6,\sigma,A} = (1-\alpha)\,w_0 + \alpha E\left(\Pi|\,\sigma,A\right)$, and thus α captures the pay-for-performance sensitivity (PPS) since it measures how managerial compensation changes as expected firm profits vary.

The manager of an H type firm has never an incentive to report $\hat{L}$. Thus, if the report is $\hat{L}$, in which case the auditor always announces V, $E\left(\Pi|\,\sigma=\hat{L}, A=V\right) = \Pi_L = \frac{1}{2}\hat{\pi}$. If the manager's report is $\hat{H}$ and the auditor announces V, then, using Bayes law and given the fraud probability λ, $prob\left(t=H\,\middle|\sigma=\hat{H}, A=V\right) = \frac{1}{1+\lambda(1-\eta)}$ and $prob\left(t=L\,\middle|\sigma=\hat{H}, A=V\right) = \frac{\lambda(1-\eta)}{1+\lambda(1-\eta)}$ are the probabilities that the firm's true type is H and L, respectively, and thus expected firm profits are

$$E\left(\Pi|\,\sigma=\hat{H}, A=V\right) = \frac{1}{1+\lambda(1-\eta)}\hat{\pi} + \frac{\lambda(1-\eta)}{1+\lambda(1-\eta)}\frac{1}{2}\hat{\pi}(1-\delta)$$

Thus, if at the equilibrium $\lambda > 0$ for some firms, then the market undervalues them if their true type is H and overvalues them if their true type is L. If the manager's report is $\hat{H}$ and the auditor announces F, then, using Bayes law, $prob\left(t=L\,\middle|\sigma=\hat{H}, A=F\right) = 1$ and $E\left(\Pi|\,\sigma=\hat{H}, A=F\right) = \frac{1}{2}\hat{\pi}$.

We assume that a manager caught reporting fraudulently gets punished. Let the expected (monetary and the money-equivalent of non-monetary) costs for the fraudulently reporting manager[8] be $\gamma\frac{1}{2}\hat{\pi}$, where $\gamma \in (0,1]$.

Let $U_{T_4,t,\sigma,A}$ be the manager's expected utility at T_4 if the firm's true type is t, the manager reports profits σ, where $t \in \{L,H\}$ and $\sigma \in \left\{\hat{L},\hat{H}\right\}$, then

$$U_{T_4,t,\sigma} = w_0 + w_1\left[prob\left(A=V\,|t,\sigma\right)S_{T6,\sigma,V} + prob\left(A=F\,|t,\sigma\right)S_{T6,\sigma,F}\right] - \frac{1}{2}e^2 - prob\left(A=F\,|t,\sigma\right)\gamma\frac{1}{2}\hat{\pi} \tag{8}$$

$\frac{1}{2}e^2$ is the disutility of effort, where the quadratic function has been chosen to obtain a closed-form solution, $\frac{1}{2}$ is a normalization constant, and $\gamma\frac{1}{2}\hat{\pi}$ is the expected disutility due to monetary and non-monetary punishments for the fraudulently reporting manager if she gets caught.

[8] Karpoff, Lee and Martin (2008a) analyze personal monetary costs and non-monetary costs to managers found responsible for fraudulent behavior and show that the likelihood of such individuals being removed from the job is positively linked to the size of the harm caused to the shareholders, which is in keeping with the expected penalty function employed in our paper.

Expected managerial utilities (8) at T_4 are

$$U_{T_4,L,\hat{H}} = (1-\alpha)\,w_0 + (1-\eta)\,\alpha\hat{\pi}\left[1-(1+\delta)\,\frac{\lambda\,(1-\eta)}{1+\lambda\,(1-\eta)}\frac{1}{2}\right] + \eta\alpha\frac{1}{2}\hat{\pi} - \frac{1}{2}e^2 - \eta\gamma\frac{1}{2}\hat{\pi} \tag{9}$$

$$U_{T_4,L,\hat{L}} = (1-\alpha)\,w_0 + \alpha\frac{1}{2}\hat{\pi} - \frac{1}{2}e^2 \tag{10}$$

$$U_{T_4,H,\hat{H}} = (1-\alpha)\,w_0 + \alpha\hat{\pi}\left[1-(1+\delta)\,\frac{\lambda\,(1-\eta)}{1+\lambda\,(1-\eta)}\frac{1}{2}\right] - \frac{1}{2}e^2. \tag{11}$$

Comparing expected utilities of a manager reporting untruthfully $\hat{H}$ with those of one truthfully reporting $\hat{L}$, we observe that the former benefits from a larger expected compensation, but faces an expected disutility of punishment because of fraudulent reporting.

The manager of a firm of type L chooses to report fraudulently as long as $U_{T_4,L,\hat{H}} \geq U_{T_4,L,\hat{L}}$. Since $U_{T_4,L,\hat{H}}$ is decreasing in λ, using (9) and (11) and rearranging terms, the probability that a manager engages in fraudulent behavior is: [9]

$$\lambda^* = \begin{cases} 0 & \text{for} \quad \alpha \leq \hat{\gamma} \\ \frac{1}{1-\eta}\frac{\alpha-\hat{\gamma}}{\delta\alpha+\hat{\gamma}} & \text{for} \quad \hat{\gamma} < \alpha < \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} \\ 1 & \text{for} \quad \alpha \geq \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} \end{cases} \tag{12}$$

where $\hat{\gamma} = \frac{\eta}{1-\eta}\gamma$.

If α is lower than $\hat{\gamma}$, then we are in a separating equilibrium, where every manager truthfully reports the firm's type, and hence the equilibrium fraud probability is nil. If α is larger than $\hat{\gamma}$, then we are in a pooling equilibrium where a manager of an L type firm writes a report $\hat{H}$ with probability $\lambda^* > 0$. The intuition for this result is that the manager's benefits from fraudulent reporting are increasing in α and as a result λ^* is increasing in the PPS. Below we show that managerial effort depends positively on α and hence if fraud is costly for the firm, which, as shown below, depends on the magnitude of direct benefits or costs of fraudulent behavior for the firm (δ), then shareholders have to trade off gains from managerial effort against costs of fraudulent behavior.[10] Note also that the probability that there is fraudulent behavior at the equilibrium is $(1-\eta)\,\lambda^*$, which is the product of two probabilities: the probability that the manager engages in fraudulent behavior and that fraud is not detected.

[9] For $\delta > 0$, solving $U_{T_4,L,\hat{H}} = U_{T_4,L,\hat{L}}$ yields $\lambda^* = \frac{1}{1-\eta}\frac{\alpha-\hat{\gamma}}{\delta\alpha+\hat{\gamma}}$ as long as $\hat{\gamma} < \alpha < \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}$. Hence, if $\alpha \leq \hat{\gamma}$, then $\lambda^* = 0$. If $\delta < 0$, then $\delta\alpha + \hat{\gamma} > 0$ as long as $\alpha < -\frac{\hat{\gamma}}{\delta}$. Since $\frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} < -\frac{\hat{\gamma}}{\delta}$ if follows that for $\alpha \geq \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}$, $\lambda^* = 1$.

[10] The real-world relevance of pooling equilibria is demonstrated by the empirical evidence that stock prices react strongly to profits restatement announcements (see, for example, Karpoff, Lee and Martin, 2008b, and Kedia and Philippon, 2009).

2.2.2 Manager's price or quantity choice at T_2

At T_2 the manager has to choose for a given effort level the price or quantity not knowing the firm's true type. Taking the expectation over firm types and fraud events, the manager's expected utility is

$$U_{T_2} = \frac{1}{2} U_{T_4,H,\hat{H}} + \frac{1}{2} \lambda U_{T_4,L,\hat{H}} + \frac{1}{2} (1-\lambda) U_{T_4,L,\hat{L}} \tag{13}$$

The first term in (13) represents expected utility of a manager of an $H-$type firm; the second and third term represent expected utility of a manager of an $L-$ type firm that with probability λ engages and with probability $1-\lambda$ does not engage in fraudulent reporting, respectively. Using (8), (9), (10), (11) and (12) we obtain after rearranging terms

$$U_{T_2} = (1-\alpha) w_0 + \alpha \frac{3}{4} \hat{\pi} - (1-\eta)(\alpha\delta + \hat{\gamma}) \lambda^* \frac{1}{4} \hat{\pi} - \frac{1}{2} e^2. \tag{14}$$

The first two terms in (14) represent expected managerial compensation if the manager does not engage in fraudulent reporting. The third term is the expected cost of fraudulent behavior for the manager and the fourth term is the disutility of managerial effort.

For given α, w_0 and e, the manager chooses the price or quantity maximizing (14), which corresponds to maximizing expected firm profits. Let $\tilde{\pi}(e)$ be firm profits if its manager exerts effort e, once the price or quantity game has been solved. We assume that firm profits increase as its manager increases effort, $\frac{\partial \tilde{\pi}}{\partial e} > 0$, and that $1 > \frac{\partial^2 \tilde{\pi}}{\partial e^2}$, which guarantees that the second order condition for the manager's effort maximization problem at T_1 is satisfied.

2.2.3 Manager's effort choice at T_1 and participation decision at T_0

At T_1 the manager chooses effort maximizing expected utility

$$U_{T_1} = (1-\alpha) w_0 + \alpha \frac{3}{4} \tilde{\pi}(e) - (1-\eta)(\alpha\delta + \hat{\gamma}) \lambda^* \frac{1}{4} \tilde{\pi}(e) - \frac{1}{2} e^2. \tag{15}$$

From the FOC of this problem we obtain

$$\begin{array}{lcr} \alpha \frac{3}{4} \frac{\partial \tilde{\pi}}{\partial e} - e = 0 & \text{for} & \alpha \leq \hat{\gamma} \\ \frac{\partial \tilde{\pi}}{\partial e} \left[\alpha \frac{3}{4} - (1-\eta)(\alpha - \hat{\gamma}) \frac{1}{4} \right] - e = 0 & \text{for} & \hat{\gamma} < \alpha < \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} \\ \frac{\partial \tilde{\pi}}{\partial e} \left[\alpha \frac{3}{4} - (1-\eta)(\delta\alpha + \hat{\gamma}) \frac{1}{4} \right] - e = 0 & \text{for} & \alpha \geq \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} \end{array} \tag{16}$$

which implicitly define optimal effort e^*. Applying the implicit function theorem we obtain $\frac{de^*}{d\alpha} > 0$.

At T_0 the manager accepts the compensation contract if the expected utility is greater than the outside-option utility, which is normalized to 0. Since the compensation contract is designed to maximize the shareholders' value, w_0 is chosen such that the manager's participation constraint (3) is binding: $U_{T_0} = 0$. Using U_{T_0}, which can be obtained from (15) evaluated at e^*,[11] w_0 is

$$w_0 = -\frac{1}{1-\alpha}\left[\alpha\frac{3}{4}\pi^* - (1-\eta)(\alpha\delta + \hat{\gamma})\lambda^*\frac{1}{4}\pi^* - \frac{1}{2}e^{*2}\right] \tag{17}$$

where $\pi^* = \tilde{\pi}(e^*)$

2.2.4 Shareholder's problem at T_0

At T_0 shareholders have to choose an incentive contract (w_0, α) that maximizes the company's stock price:

$$S_{T_0} = \sum_{t,\sigma}\left[prob(t)\,prob(\sigma\,|t)\,prob(A = V\,|t,\sigma)\,S_{T_6,\sigma,V} + prob(t)\,prob(\sigma\,|t)\,prob(A = F\,|t,\sigma)\,S_{T_6,\sigma,F}\right]$$

or, after substituting values,

$$S_{T_0} = \frac{1}{2}S_{T_6,\hat{H},V} + \frac{1}{2}\left[\lambda(1-\eta)S_{T_6,\hat{H},V} + \lambda\eta S_{T_6,\hat{H},F} + (1-\lambda)S_{T_6,\hat{L},V}\right] \tag{18}$$

Substituting (7), (17) and (12) into the expression and rearranging terms we obtain

$$S_{T_0} = \left[\frac{3}{4} - (1-\eta)(\delta + \hat{\gamma})\lambda^*\frac{1}{4}\right]\pi^* - \frac{1}{2}e^{*2} \tag{19}$$

where e^* is optimal effort that satisfies (16). In (19), $\frac{3}{4}\pi^*$ are expected firm profits if there is no fraud and $(1-\eta)\lambda^*(\delta + \hat{\gamma})\frac{1}{4}\pi^*$ are expected costs of fraudulent behavior for shareholders: $\delta\frac{1}{2}\pi^*$, if δ is positive, represents the direct long-term cost of fraud for the firm, while if δ is negative, represents long-term benefits; $\hat{\gamma}\frac{1}{2}\pi^*$ represents indirect costs for shareholders of fraudulent behavior, since, because of the binding participation constraint, the manager has to be compensated for the expected punishment if she is induced to engage in fraud. If $-\delta < \hat{\gamma}$, then the cost of fraud is larger than its benefits and thus fraudulent behavior reduces the firm value, while if $-\delta > \hat{\gamma}$, then the opposite is true.

[11] Note that, given (17), since effort is a sunk cost and since it has been exerted before uncertainty about the firm's type gets resolved and before stock grants vest, the manager has never an incentive to walk away before the game is over.

The shareholders' problem (1) - (4) simplifies to the one of finding the PPS α that maximizes the expected firm value S_{T_0} in (19). Since managerial effort depends on the PPS α, and, because of competition, firm profits depend on managerial effort of all firms, the expected value of a firm is a function of the PPS of the manager of each firm. A priorily these PPS are different. Shareholders of each firm choose non-cooperatively the PPS that maximizes the expected firm value and we characterize the symmetic Nash equilibrium. For the sake of clarity, let S_{i,T_0} be the expected value of firm i and $\tilde{\pi}_i = \tilde{\pi}_i (e_1, ..., e_i, ..., e_n)$ be its profits, then the shareholders' problem is

$$max_{\alpha_i} S_{i,T_0} \tag{20}$$

where α_i is the PPS of the manager of firm i. Let us define $\alpha^i_{max} = argmax_{\alpha_i} S_{i,T_0}$.

We define the following properties of profits $\tilde{\pi}_i$.

Condition 1 *Let $\theta > 0$ be a measure of PMC, where a larger value of θ corresponds to stronger PMC. Then, at the symmetric equilibrium where $e_i = e_i^* = e^*$, let $\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2\Big|_{e_i=e^*}$ and $\frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2}\Big|_{e_i=e^*}$ be increasing in θ.*

If PMC is weak, then the firm's per-unit profit and quantity produced are larger than if PMC is strong, leading under Condition 1 to smaller gains from cost-cutting effort. In Appendix II we show that Condition 1 holds in symmetric equilibria of price and quantity competition with linear demand functions if a larger PMC leads to a stronger business-stealing effect, and in the case of price competition between two firms if consumers have a CES utility function. We also provide a more precise interpretation of Condition 1 in these particular cases. The following proposition characterizes α^i_{max}.

Proposition 1 *(i) If $\hat{\gamma} \geq 1$ or $-\delta \geq \hat{\gamma}$, then $\alpha^i_{max} = 1$; (ii) if $\hat{\gamma} < 1$ and $-\delta < \hat{\gamma}$, then there exists a critical fraud detection probability $\eta' \in [0, 1)$ such that for $\eta > \eta'$, $\alpha^i_{max} = \alpha^*$ where $\alpha^* \in (\hat{\gamma}, 1]$, while for $\eta < \eta'$, $\alpha^i_{max} = \hat{\gamma}$; under Condition 1, η' is decreasing in θ.*

If the expected punishment is very strong, that is, $\hat{\gamma} \geq 1$, then, since $\alpha \leq 1$, $\lambda^* = 0$, and thus the PPS affects the firm's stock price only through managerial effort. If long term benefits of fraud are larger than its costs, that is, $-\delta \geq \hat{\gamma}$, then the firm's stock price is increasing in the PPS. Consequently, in both cases it is optimal to provide the manager with the largest possible PPS, that is, $\alpha^i_{max} = 1$, which is to say that the manager owns the firm. On the other hand, if $\hat{\gamma} < 1$ and fraud is costly for the firm (i.e. $-\delta < \hat{\gamma}$) , then shareholders face a trade-off between fraud and managerial effort. Condition 1 implies that the stronger is PMC the larger shareholders' marginal gains from incentive provision compared with its costs. Hence, if η, the probability that the auditor detects fraudulent behavior, is sufficiently large and PMC is sufficiently strong, then gains from managerial cost-cutting effort are large compared with costs due to fraudulent behavior and thus shareholders prefer to provide the manager with strong incentives even though this may lead to some fraudulent behavior. If the fraud detection probability is sufficiently small and PMC is sufficiently weak, then costs of fraudulent behavior are large compared with gains from managerial cost-cutting effort and thus shareholders prefer avoiding fraudulent behavior by setting a low PPS.

The next proposition characterizes the PPS α^* in Proposition 1 and the probability of fraudulent behavior of a firm $\frac{1}{2}(1-\eta)\lambda^*$ as PMC θ varies.

Proposition 2 *Under condition 1, the α^* and λ^* are increasing in θ.*

Proposition 2 states that the stronger PMC, the larger the PPS and the fraud probability, thereby establishing a positive link between PMC and fraud. The intuition for this result is that the stronger PMC, the stronger the sharholders' gains from cost-cutting managerial effort and thus the larger the PPS. A larger PPS induces also more fraudulent behavior, establishing a positive relationship between PMC and fraudulent behavior.

3 Stock-based and stock option-based compensation

In this section we study how stock option-based managerial compensation packages can be used to increase the shareholder value if fraudulent behavior is costly to the firm. We consider the following compensation contract

$$W_{T_6,\sigma,A} = w_0 + w_1 S_{T_6,\sigma,A} + w_2 max\left\{S_{T_6,\sigma,A} - K, 0\right\} \tag{21}$$

where w_1 and w_2 are stock and stock option grants, respectively, and K is the option's strike price. Substituting (21) into the definition of the stock price (6), we obtain the stock price and the value of the compensation package at T_6 for a representative firm

$$S_{T_6,\sigma,A} = \begin{cases} (1-\alpha_1-\alpha_2)\left[E\left(\Pi|\,\sigma,A\right)-w_0\right]+\alpha_2 K & \text{for} \quad S_{T_6,\sigma,A} \geq K \\ \left(1-\frac{\alpha_1}{1-\alpha_2}\right)\left[E\left(\Pi|\,\sigma,A\right)-w_0\right] & \text{for} \quad S_{T_6,\sigma,A} < K \end{cases} \tag{22}$$

$$W_{T_6,\sigma,A} = \begin{cases} (1-\alpha_1-\alpha_2)\, w_0 + \alpha_1 E\left(\Pi|\, \sigma, A\right) + & \text{for} \quad S_{T_6,\sigma,A} \geq K \\ \quad +\alpha_2 \left[E\left(\Pi|\, \sigma, A\right) - K\right] & \\ w_0 \left(1 - \frac{\alpha_1}{1-\alpha_2}\right) + \frac{\alpha_1}{1-\alpha_2} E\left(\Pi|\, \sigma, A\right) & \text{for} \quad S_{T_6,\sigma,A} < K \end{cases}$$

where $\alpha_1 = \frac{w_1}{1+w_1+w_2}$, $\alpha_2 = \frac{w_2}{1+w_1+w_2}$ and $\alpha_1 + \alpha_2 \in [0,1]$. α_1 and α_2 are the fractions of profits the manager is granted through stock and stock options, respectively.

Expected managerial utility at T_4 is

$$U_{T_4,t,\sigma} = w_0 + w_1 \left[\sum_{A=V,F} prob\left(A\,|t,\sigma\right) S_{T_6,\sigma,A}\right] + \\ w_2 \left[\sum_{A=V,F} prob\left(A\,|t,\sigma\right) max\left\{S_{T_6,\sigma,A} - K, 0\right\}\right] - \frac{1}{2}e^2 - prob\left(A = F\,|t,\sigma\right)\gamma\frac{1}{2}\hat{\pi} \tag{23}$$

We next show how stock options can be used to make managerial compensation report dependent and to induce truthful revelation of types. Since $S_{T_6,\hat{H},V} \geq S_{T_6,\hat{H},F} = S_{T_6,\hat{L},V}$ (this result is formally shown in the Appendix), depending on the value of the strike price K we have three cases:

1. $S_{T_6,\hat{H},F} \geq K$ where all options are in-the-money;

2. $S_{T_6,\hat{H},V} \geq K > S_{T_6,\hat{H},F}$ where options of an $\hat{H}$ reporting manager and with auditor announcement V are in-the-money while those of an $\hat{H}$ reporting manager with auditor announcement F and options of an $\hat{L}$ reporting manager with auditor announcement V are out-of-the-money;

3. $K > S_{T_6,\hat{H},V}$ where all options are out-of-the-money.

The strike price K can thus be used to render managerial pay report-dependent and to induce truthful reporting.

Below we show that truthful revelation of types can be obtained if stock options are in-the-money only for an $\hat{H}$ reporting manager with auditor announcing V, while they are out-of-the-money in all other cases. In this way a manager who reports $\hat{H}$ benefits from the stock and the stock option component, an $\hat{L}$ reporting manager benefits only from the stock component, while the cash component w_0 is used to make the manager's participation constraint binding. In case 1) and 3) where all options are in-the-money and out-of-the-money, respectively, they are in- or out-of-the-money independently of the manager's profits report and hence the strike price cannot be used to induce truthful revelation of types. As a consequence, the solution to the shareholders' problem in these cases is identical to the one described in the previous section.[12]

[12] To see this, consider first case 1) where all options are in-the-money. Since the strike price neither affects managerial effort nor the fraud probability, an increase in K simply reduces managerial rents and hence increases the shareholder

For the remainder of this section we focus on case 2) where options of an $\hat{H}$ reporting manager and with auditor announcement V are in-the-money, while options are out-of-the-money in all other cases.

Using (23) and results seen in the previous section, expected utility of a manager of an $L-$type firm at T_4 is

$$U_{T_4,L,\hat{L}} = w_0 + \frac{\alpha_1}{1-\alpha_2}\left(\frac{1}{2}\hat{\pi} - w_0\right) - \frac{1}{2}e^2$$

if she reports truthfully, and, since $1-\alpha_1-\alpha_2 = \frac{1}{1+w_1+w_2}$ and $w_1\left(1-\frac{\alpha_1}{1-\alpha_2}\right) = \frac{\alpha_1}{1-\alpha_2}$,

$$U_{T_4,L,\hat{H}} = w_0 + (1-\eta)(\alpha_1+\alpha_2)\left[\hat{\pi} - w_0 - (1+\delta)\tfrac{\lambda(1-\eta)}{1+\lambda(1-\eta)}\tfrac{1}{2}\hat{\pi}\right] + \eta\tfrac{\alpha_1}{1-\alpha_2}\left(\tfrac{1}{2}\hat{\pi} - w_0\right) + \\ -\alpha_2(1-\eta)K - \tfrac{1}{2}e^2 - \eta\gamma\tfrac{1}{2}\hat{\pi}$$

if she does not report truthfully.

For values of $\lambda^* \in (0,1)$, equilibrium fraud probability λ^* solves $U_{T_4,L,\hat{H}} = U_{T_4,L,\hat{L}}$ and is implicitly defined by

$$(\alpha_1+\alpha_2)\tfrac{\lambda^*(1-\eta)}{1+\lambda^*(1-\eta)}(1+\delta)\tfrac{1}{2}\hat{\pi} = \\ max\left\{(\alpha_1+\alpha_2)(\hat{\pi}-w_0) - \tfrac{\alpha_1}{1-\alpha_2}\left(\tfrac{1}{2}\hat{\pi}-w_0\right) - \alpha_2 K - \hat{\gamma}\tfrac{1}{2}\hat{\pi}, 0\right\}. \quad (24)$$

It is easy to see that an increase in K reduces λ^*. If fraud is costly for the firm, then it reduces the shareholders' wealth and it is therefore optimal to increase K as much as possible. From (24), fraud probability is nil if $K = K_{NF}$, where

$$K_{NF} \equiv \frac{1}{\alpha_2}\left[(\alpha_1+\alpha_2)(\hat{\pi}-w_0) - \frac{\alpha_1}{1-\alpha_2}\left(\frac{1}{2}\hat{\pi}-w_0\right) - \hat{\gamma}\frac{1}{2}\hat{\pi}\right]. \quad (25)$$

Since shareholders want to induce strong effort, which corresponds to large values of α_1 and α_2, K_{NF} at the equilibrium will always be positive (see the proof of Lemma 1 in the Appendix). The increase in K is constrained by the condition $S_{T_6,\hat{H},V} \geq K$, that is, options of an $\hat{H}$ reporting manager with auditor announcement V are in-the-money.

Let us define K_σ such that $S_{T_6,\sigma,V} \gtreqless K$ for each $K \lesseqgtr K_\sigma$ and $\sigma = \hat{H}, \hat{L}$, then the shareholders'

value. Note that w_0 plays the same role and thus K can be set to zero. Hence, by setting $\alpha_1+\alpha_2 = \alpha$, the solution is the same as the one described in Proposition 1. In case 3) all options are out-of-the-money, that is, they are all worthless. Hence, without loss of generality, we can set w_2 to zero, and by setting $\alpha = \alpha_1$, the problem reduces to the same as the one described in the previous section and therefore the solution is the same.

problem at T_0 can be written as follows

$$\begin{aligned} & max_{\alpha_1,\alpha_2,K,w_0} S_{T_0} \\ & \text{s.t. } K_{\hat{H}} \geq K > K_{\hat{L}} \\ & e^* = argmax_e U_{T_0} \\ & U_{T_0} \geq 0 \\ & \lambda = \lambda^* \end{aligned} \tag{26}$$

In (26) the shareholder maximizes at T_0 the firm's stock price choosing the pay-for-performance sensitivities α_1 and α_2, the strike price K and cash w_0 under the condition that options of an $\hat{H}$ reporting manager with auditor announcement V are in-the-money while those of an $\hat{L}$ reporting manager with auditor announcement V are out-of-the-money, taking into account the manager's incentive compatibility and her participation constraint, and given the equilibrium fraud probability.

Let $(\alpha_{1,max}, \alpha_{2,max})$ denote the arguments of the maximum in problem (26). The following result holds.

Lemma 1 *For $\hat{\gamma} < 1$, the stock and stock-option based compensation package that solves problem (26) in the case where $\lambda^* = 0$ is $K = K_{NF}$, $\alpha_{1,max} = 0$, $\alpha_{2,max} = 1$ and $\frac{\alpha_{1,max}}{1-\alpha_{2,max}} = \hat{\gamma}$.*

The compensation package described in Lemma 1 corresponds to one that grants $w_1 = \frac{\hat{\gamma}}{1-\hat{\gamma}}$ units of stock to an $\hat{L}$ reporting manager and that grants an option on all expected firm profits at a strike price K_{NF} to an $\hat{H}$ reporting manager. Even though the compensation package is the same for all managers, the PPS is different since it depends on the report and, since we are in a separating equilibrium, on the type of the firm. Compared with the case of only stock-based compensation where fraud is eliminated if the PPS of all managers is sufficiently low, by using stock options fraud can be successfully eliminated if incentives provided to an $\hat{L}$ reporting manager, whose stock options are out-of-the-money and who gains only from stock grants, are sufficiently weak, while those of an $\hat{H}$ reporting one, whose stock options are in-the-money, is strongest. As a consequence, effort elicited from the former manager is small and we show next that, akin to the previous section, this leads to a trade-off between fraud with strong incentives for all managers and no-fraud with weak incentives for $\hat{L}$ reporting managers.

We have to find conditions for which it is optimal for shareholders to increase the PPS of an $\hat{L}$ reporting manager $(\frac{\alpha_1}{1-\alpha_2})$ beyond the threshold $\hat{\gamma}$ even though this may lead to some fraudulent behavior. In this case, as shown in the proof of Lemma 1, the shareholders' problem and hence its solution is identical to the one described in the previous section and in particular in Proposition 1. Following the reasoning in the proof of Proposition 1, for a sufficiently large fraud detection probability η and a sufficiently strong PMC, shareholders prefer to provide the manager, independently of the profits report, with strong incentives and to endure some fraudulent reporting. Compared with the case where only stock grants are employed, eliminating fraudulent behavior through stock options leads, since incentives for an $\hat{H}$ reporting manager are stronger, to a larger effort level and to a larger shareholder value. As a consequence, the threshold level for η above which it is optimal for shareholders to provide the manager, independently of the profits report, with strong incentives is larger if the compensation package consists of both stock and stock options. These results are summarized in the following Proposition.

Proposition 3 *If $\hat{\gamma} < 1$ and $-\delta < \hat{\gamma}$, then there exists a critical fraud detection probability $\eta'' \in [0, 1)$, where $\eta'' > \eta'$, such that for $\eta > \eta''$, $\alpha_{1,max} = \alpha^*$ where $\alpha^* \in (\hat{\gamma}, 1]$ and $\alpha_{2,max} = 0$, while for $\eta < \eta''$, shareholders prefer to eliminate fraudulent behavior by employing the compensation package $K = K_{NF}$, $\alpha_{1,max} = 0$, $\alpha_{2,max} = 1$ and $\frac{\alpha_{1,max}}{1-\alpha_{2,max}} = \hat{\gamma}$; under Condition 1, η'' is decreasing in θ and α^* is increasing in θ.*

Akin to the results in Proposition 1, if the fraud detection probability is large and PMC is strong, then the cost of eliminating fraud, that is, weak incentives elicited from an $\hat{L}$ reporting manager, is larger than the benefit and thus shareholders prefer a pooling equilibrium, that is, they prefer to induce strong managerial cost-cutting effort at the expense of provoking some fraudulent behavior. If the fraud detection probability is low and PMC is weak then shareholders prefer a separating equilibrium.

4 Conclusion

We considered a model where managers take a cost-cutting unobservable action and obtain private information which they can use to fraudulently inflate their wealth. We argued that if fraud is costly for the firm, then shareholders face a trade-off between inducing cost-cutting managerial effort and fraudulent behavior, and we investigated how this trade-off changes as the degree of PMC varies. We showed that by granting the manager stocks and stock options, shareholders can secure a separating equilibrium by setting the strike price in such a way that options are out-of-the-money for a manager reporting low profits and in-the-money for a manager reporting high profits. As a consequence, incentives provided to the former manager are weak and thus eliminating fraudulent reporting may not be optimal for shareholders since it may lead to a too low effort level. Shareholders compare the firm value in the separating equilibrium with the one in the pooling equilibrium where a high profit report is fraudulent with a positive probability. Shareholders prefer the latter equilibrium and thus to endure some fraudulent behavior if this is the price they have to pay to elicit strong managerial effort.

Our model predicts that fraudulent behavior is likely to occur in industries where PMC is sufficiently strong. In these industries we find a positive relationship between PPS and PMC consistent with empirical evidence found in Cuñat and Guadalupe (2005, 2009a, 2009b) and Karuna (2007), and a positive relationship between fraud and PMC in keeping with empirical results in Datta et al. (2013) and Karuna et al. (2012). Our model further predicts that stock options are employed in industries where PMC is weak, with the aim to eliminate fraudulent behavior.

In our model the perverse incentive effect is due to the assumption that the manager writes the profits report and exerts unobservable cost-cutting effort. This provides an important reason, in addition to expertise, for firms to separate these functions. However, even though the CEO did not produce the profits report, the CEO must sign off on the report. The possibility of gains that accrue to the CEO if the report states high profits afford the opportunity for the CEO and the accountant to share in these gains by colluding to falsely report high profits, leading, as a consequence, to the same perverse incentive effect studied in this paper.[13]

Appendix I

Proof of Proposition 1. Consider the following three cases: (i) $\alpha_i < \hat{\gamma}$; (ii) $\hat{\gamma} \leq \alpha_i < \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}$ and (iii) $\alpha_i \geq \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}$. (i) If $\alpha_i < \hat{\gamma}$, then the FOC for (20), using (16), reads $\frac{\partial e_i}{\partial \alpha_i} \frac{\partial \tilde{\pi}_i(e_i)}{\partial e_i} \frac{3}{4} (1 - \alpha_i) = 0$ which leads to $\alpha_i = 1$. As a consequence, if $\hat{\gamma} \geq 1$, then the solution to (20) is $\alpha^i_{max} = 1$; but if $\hat{\gamma} < 1$, then $\alpha_i = 1$ induces some fraudulent behavior and hence we have to study the case where $\alpha_i \geq \hat{\gamma}$. Consider case (ii). Using the implicit function theorem we obtain from the FOC (16)

$$\frac{de_i^*}{d\alpha_i} = \frac{\frac{\partial \tilde{\pi}_i}{\partial e_i} \left[\frac{3}{4} - (1 - \eta) \frac{1}{4}\right]}{1 - \frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2} \left[\alpha_i \frac{3}{4} - (1 - \eta) (\alpha_i - \hat{\gamma}) \frac{1}{4}\right]}$$

After using this latter expression, (16) and rearranging terms, the FOC for (20) can be written as

[13] The author is grateful to an anonymous referee for this point.

$$\Phi(\alpha_i) \equiv \frac{\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2 \left[\frac{3}{4} - (1-\eta)\frac{1}{4}\right]}{1 - \frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2}\left[\alpha_i \frac{3}{4} - (1-\eta)(\alpha_i - \hat{\gamma})\frac{1}{4}\right]}(1-\alpha_i)\left[\frac{3}{4} - \frac{1}{4}(1-\eta)\delta\lambda_i^*\right] - \frac{1}{4}(1-\eta)(\delta+\hat{\gamma})\frac{(1+\delta)\hat{\gamma}}{(\delta\alpha_i + \hat{\gamma})^2} = 0$$

where $\lambda_i^* = \frac{1}{1-\eta}\frac{\alpha_i - \hat{\gamma}}{\delta\alpha_i + \hat{\gamma}}$. Note that $\Phi_\eta > 0$ and, under Condition 1, $\Phi_\theta > 0$.

For a sufficiently low γ, it is always possible to find a sufficiently large η such that $\hat{\gamma} < 1$ and $\Phi(\hat{\gamma}) > 0$. Suppose $\frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} > 1$, then since $\Phi(1) < 1$, an α^* where $\alpha_{max}^i = \alpha^* > \hat{\gamma}$ exists. Decreasing η decreases $\Phi(\alpha_i)$ and thus for sufficiently low values of η and, under Condition 1, low values of θ, $\Phi(\alpha_i) < 0$ for each $\alpha_i \in [\hat{\gamma}, 1]$ and as a consequence $\alpha_{max}^i = \hat{\gamma}$. Since under Condition 1 $\Phi(\alpha_i)$ is increasing in θ the result follows. If $\frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)} < 1$, then for $\alpha_i = \frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}$, $\lambda^* = 1$ and thus if $\Phi\left(\frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}\right) > 0$ then $\alpha^* = 1$, while if $\Phi\left(\frac{\hat{\gamma}(2-\eta)}{1-\delta(1-\eta)}\right) < 0$, then $\alpha_{max}^i < 1$. ■

Proof of Proposition 2. Since under Condition 1 $\Phi_\theta > 0$, and because of the second order condition for the maximum $\Phi_\alpha < 0$, from the implicit function theorem $\frac{\partial \alpha^*}{\partial \theta} = -\frac{\Phi_\theta}{\Phi_\alpha} > 0$. Since λ^* is increasing in θ the result follows. ■

Proof of Lemma 1. Let us first find conditions on α_1 and α_2 such that $K_{\hat{H}} \geq K_{NF} > K_{\hat{L}}$ in which case a separating equilibrium can be obtained, i.e. fraud can be eliminated. Consider the incentive compatibility and the participation constraint in problem (26). If $K = K_{NF}$ and at the same time $K_{\hat{H}} \geq K_{NF} > K_{\hat{L}}$, then U_{T_0} reads

$$\begin{aligned} U_{T_0} &= \tfrac{1-\alpha_2-\alpha_1}{1-\alpha_2} w_0 - \tfrac{1}{2}e^2 + \tfrac{\alpha_1}{1-\alpha_2}\tfrac{1}{4}\hat{\pi} + \\ &+ \tfrac{1}{2}\left[(\alpha_1+\alpha_2)\hat{\pi} - \alpha_2 \tfrac{1-\alpha_2-\alpha_1}{1-\alpha_2} w_0 - \alpha_2 K_{NF}\right]. \end{aligned} \tag{27}$$

Hence, the incentive compatibility constraint is $e^* = argmax_e U_{T_0}$, where U_{T_0} is given by (27). Substituting the strike price (25) into (27) and rearranging terms, the manager's binding participation constraint (since shareholders maximize their value, at the equilibrium, w_0 is chosen such that the manager's participation constraint is binding) is

$$U_{T_0} = \left(1 - \frac{\alpha_1}{1-\alpha_2}\right) w_0 - \frac{1}{2}e^{*2} + \frac{\alpha_1}{1-\alpha_2}\frac{1}{2}\hat{\pi} + \hat{\gamma}\frac{1}{4}\hat{\pi} = 0 \tag{28}$$

from which w_0 can be obtained.

We have to find conditions such that $K_{\hat{H}} \geq K_{NF} > K_{\hat{L}}$, that is, where fraud can be eliminated

($K = K_{NF}$) and at the same time options of an $\hat{H}$ reporting manager are not out-of-the-money ($K \leq K_{\hat{H}}$) while those of an $\hat{L}$ reporting one are out-of-the-money ($K > K_{\hat{L}}$). Given that fraud is eliminated, the firm's stock price at T_4 in case of an $\hat{H}$ and $\hat{L}$ profits report is, respectively

$$S_{T_6,\hat{H},V} = (1-\alpha_1-\alpha_2)(\hat{\pi}-w_0)+\alpha_2 K$$

$$S_{T_6,\hat{L},V} = \left(1-\frac{\alpha_1}{1-\alpha_2}\right)\left(\frac{1}{2}\hat{\pi}-w_0\right).$$

Using w_0 from the binding participation constraint (28) we obtain

$$S_{T_6,\hat{L},V} - K < 0 \Longleftrightarrow K > K_{\hat{L}} \equiv -\frac{1}{2}e^{*2}+\frac{1}{2}\hat{\pi}+\hat{\gamma}\frac{1}{4}\hat{\pi}$$

and

$$S_{T_6,\hat{H},V} - K \geq 0 \Longleftrightarrow \left(1-\frac{\alpha_1}{1-\alpha_2}\right)\frac{1}{2}\hat{\pi}-\frac{1}{2}e^{*2}+\frac{1}{2}\hat{\pi}+\hat{\gamma}\frac{1}{4}\hat{\pi} \equiv K_{\hat{H}} \geq K.$$

Note that for $\frac{\alpha_1}{1-\alpha_2} < 1$, $K_{\hat{H}} > K_{\hat{L}}$ and thus $S_{T_6,\hat{H},V} > S_{T_6,\hat{L},V}$. Substituting w_0 from the binding participation constraint into the strike price K_{NF} (25) we obtain

$$K_{NF} = \frac{1}{\alpha_2}\left[\alpha_2\left(-\frac{1}{2}e^2+\frac{1}{2}\hat{\pi}+\hat{\gamma}\frac{1}{4}\hat{\pi}\right)+(\alpha_1+\alpha_2)\frac{1}{2}\hat{\pi}-\hat{\gamma}\frac{1}{2}\hat{\pi}\right]$$

or, since $\alpha_1+\alpha_2 = \frac{\alpha_1}{1-\alpha_2}(1-\alpha_2)+\alpha_2$,

$$K_{NF} = K_{\hat{H}} + \frac{1}{\alpha_2}\left(\frac{\alpha_1}{1-\alpha_2}-\hat{\gamma}\right)\frac{1}{2}\hat{\pi}$$

from which follows that

$$K_{\hat{H}} \geq K_{NF} \Longleftrightarrow \frac{\alpha_1}{1-\alpha_2} \leq \hat{\gamma}$$

and

$$K_{NF} > K_{\hat{L}} \Longleftrightarrow \alpha_1+\alpha_2 > \hat{\gamma}$$

Thus, condition $K_{\hat{H}} \geq K_{NF} > K_{\hat{L}}$ holds if and only if $\frac{\alpha_1}{1-\alpha_2} \leq \hat{\gamma} < \alpha_1+\alpha_2$.

If $\frac{\alpha_1}{1-\alpha_2} > \hat{\gamma}$, then $K_{NF} > K_{\hat{H}}$ and thus for $K \geq K_{\hat{H}}$, options of an $\hat{H}$ reporting manager are out-of-the-money. But in this case options cannot be used to induce truthful revelation. They can only be employed to provide rents to managers, which can be done also through w_0 and thus the problem is identical to the one without options.

For the remaining part of the proof we focus on $\frac{\alpha_1}{1-\alpha_2} \leq \hat{\gamma}$ and we solve the shareholder's problem under the constraint that $K = K_{NF}$. For the sake of clarity, let S_{i,T_0} be the expected value of firm i, $\tilde{\pi}_i = \tilde{\pi}_i\left(e_1, ..., e_i, ..., e_n\right)$ be its profits and e_i effort exerted by the manager of firm i, then, using (18), the expected shareholder, once the price/quantity choice has been made, reads

$$S_{i,T_0} = \frac{3}{4}\tilde{\pi}_i - \frac{1}{2}e_i^2. \tag{29}$$

Note that the shareholders' value is increasing in effort as long as $\frac{3}{4}\frac{\partial \tilde{\pi}_i}{\partial e_i} - e_i > 0$.

From (27), the FOC for managerial effort is

$$\frac{1}{4}\frac{\alpha_{i,1}}{1-\alpha_{i,2}}\frac{\partial \tilde{\pi}_i}{\partial e_i} + \frac{1}{2}\left(\alpha_{i,1} + \alpha_{i,2}\right)\frac{\partial \tilde{\pi}_i}{\partial e_i} - e_i^* = 0 \tag{30}$$

where $\alpha_{i,1}$ and $\alpha_{i,2}$ are the fraction of profits the manager of firm i is granted through stock and stock options, respectively. Because of the second order condition, e_i^* is increasing in $\alpha_{i,1}$ and $\alpha_{i,2}$. Choosing the strongest possible incentives compatible with the no-fraud equilibrium $\frac{\alpha_{i,1}}{1-\alpha_{i,2}} = \hat{\gamma}$, it follows that the FOC (30) reads

$$\frac{1}{4}\gamma\frac{\partial \tilde{\pi}_i}{\partial e_i} + \frac{1}{2}\left[\hat{\gamma}\left(1-\alpha_{i,2}\right) + \alpha_{i,2}\right]\frac{\partial \tilde{\pi}_i}{\partial e_i} - e_i^* = 0$$

As a consequence, as long as $\hat{\gamma} < 1$, the contract that maximizes the shareholder value is $\alpha_{i,1} = \alpha_{1,max} = 0$, $\alpha_{i,2} = \alpha_{2,max} = 1$ and $\frac{\alpha_{i,1}}{1-\alpha_{i,2}} = \frac{\alpha_{1,max}}{1-\alpha_{2,max}} = \hat{\gamma}$.

Finally, we show that at the equilibrium $K_{\hat{H}} = K_{NF} > 0$. For $\frac{\alpha_1}{1-\alpha_2} = \hat{\gamma}$, $\alpha_2 = 1$, $\alpha_1 = 0$ and $e_i = e^*$ we obtain

$$K_{NF} = \frac{3}{4}\pi_i^* - \frac{1}{2}e^{*2} + \left(1-\hat{\gamma}\right)\frac{1}{4}\pi_i^*$$

Since $S_{i,T_0} > 0$ in (29), it follows that $K_{NF} > 0$. ■

5 Appendix II

In this Appendix we discuss examples that satisfy Condition 1. In particular, we show that Condition 1 holds in symmetric equilibria of price and quantity competition with linear demand functions if stronger PMC leads to a stronger business-stealing effect and in the case of price competition between two firms if consumers have a CES utility function.

Linear demand function The first case we consider is the case of price and quantity competition with linear demand functions.

Let $q_i = \tilde{f}(p_1, ..., p_n)$ be firm i's demand in the case of price competition, where p_j, for $j = 1, ..., n$, is the price charged by firm j, and let $p = \hat{f}(q_1, ..., q_n)$ be the industry price in the case of quantity competition, where q_j, for $j = 1, ..., n$, is the quantity produced by firm j. We assume that $\left(\frac{\partial \tilde{f}}{\partial p_i}\right)^{-1} = \frac{\partial \hat{f}}{\partial q_i} = -f$, while $\frac{\partial^j \tilde{f}}{\partial p_i^j} = \frac{\partial^j \hat{f}}{\partial q_i^j} = 0$ for each $i = 1, .., n$ and $j \geq 2$.

Lemma 2 *$\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2\Big|_{e_i=e^*}$ and $\frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2}\Big|_{e_i=e^*}$ are increasing in θ if and only if $\frac{\partial q_i}{\partial e_i}\Big|_{e_i=e^*}$ is increasing in θ.*

Proof of Lemma 2. In the case of quantity competition, the problem is $max_{q_i}\pi_i = (p - c_i)\, q_i$, where $p = \hat{f}(q_1, ..., q_n)$ and the FOC is $p - c_i = q_i f$. In the case of price competition, the problem is $max_{p_i}\pi_i = (p_i - c_i)\, q_i$, where $q_i = \tilde{f}(p_1, ..., p_n)$ and the FOC is $p_i - c_i = q_i f$. Substituting the FOC back into the profit function, firm profits in both cases are $\tilde{\pi}_i = q_i^2 f$. Taking the first and second derivative of $\tilde{\pi}_i$ with respect to e_i, we obtain $\frac{\partial \tilde{\pi}_i}{\partial e_i} = 2q_i f \frac{\partial q_i}{\partial e_i}$ and $\frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2} = -2f\left(\frac{\partial q_i}{\partial e_i}\right)^2$, respectively, and thus $\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2 = -4f\left(\frac{\partial q_i}{\partial e_i}\right)^2$. ■

Lemma 2 implies that if demand functions are linear and firms compete in quantity or prices, then Condition 1 is equivalent to assuming that $\frac{\partial q_i}{\partial e_i}\Big|_{e_i=e^*}$ is increasing in θ, that is, the positive effect of effort on output is stronger when competition is fiercer, corresponding to a stronger business-stealing effect.

In the following we discuss two particular examples: Cournot competition with linear demand functions and price competition with horizontal product differentiation (Salop, 1979).

Example 1 (Cournot competition) *Consider the case of Cournot competition with linear demand function $p = a - \sum_{j=1}^{n} q_j$, then solving the model we obtain*

$$q_i = \frac{a-c}{1+n} + \frac{ne_i - \sum_{j\neq i} e_j}{1+n}$$

and thus $\frac{\partial q_i}{\partial e_i} = \frac{n}{1+n}$, which is increasing in θ, where $\theta = n$ measures the degree of PMC.

Example 2 (Horizontal production differentiation with quadratic transportation costs) *Consider n firms symmetrically distributed on a unit circle and a mass m of consumers uniformly distributed around the circle. The utility function of a consumer positioned at l and buying from producer i positioned at z_i is $V_i(l) = s - p_i - \tau (l - z_i)^2$. We assume that the gross surplus s is sufficiently large such* *that the market is always covered. τ is the transportation cost: the lower is τ, the greater the degree of product substitutability. A consumer positioned at l_{i+} is indifferent between buying from producer i or $i+1$ if $V_i(l_{i+}) = V_{i+1}(l_{i+})$.*[14] *Since what matters for consumers (apart from prices p_i and p_{i+1}) is the distance between producer i and $i+1$, which is $\frac{1}{n}$, we can, without loss of generality, position producer i in 0 and $i+1$ in $\frac{1}{n}$. Consequently, for given prices p_i and p_{i+1}, the marginal consumer on the right-hand-side market of firm i is l_{i+}, which is implicitly defined by $s - p_i - \tau l_{i+}^2 = s - p_{i+1} - \tau\left(\frac{1}{n} - l_{i+}\right)^2$; l_{i-} is defined in a similar way. Since m is the mass of consumers of a given type (i.e. position) buying product i, demand of firm i is*

$$q_i = m\left(l_{i+} + l_{i-}\right) = m\left[\frac{E(p_i) - p_i}{\tau\frac{1}{n}} + \frac{1}{n}\right] \tag{31}$$

where $E(p_i) = \frac{1}{2}(p_{i+1} + p_{i-1})$. Maximizing firm profits π_i with respect to prices yields $p_i = \frac{E(p_i)+C_i}{2} + \frac{\tau}{2n^2}$. At the Bayesian equilibrium where $E(p_j) = E(p_i)$ we have $E(p_j) = E(C) + \frac{\tau}{n^2}$, where $E(C)$ is calculated in a consistent way, that is, $E(C_i) = E(C)$. From this expression follows that

$$q_i = m\left\{\frac{\frac{1}{2}\left[E(C) - C_i\right]}{\tau\frac{1}{n}} + \frac{1}{n}\right\}$$

and thus, since $C_i = c - e_i$, $\frac{\partial q_i}{\partial e_i}$ is increasing in θ, where $\theta = \frac{mn}{\tau}$ measures the degree of PMC.

CES utility function and price competition Consider the case of $n = 2$ and let the consumers' utility if they buy q_j units of product j, $j = 1, 2$, be $V(q_1, q_2) = (q_1^\rho + q_2^\rho)^{\frac{1}{\rho}}$. We assume that $0 < \rho < 1$ and thus the larger is ρ the greater the degree of product substitutability. We normalize the consumers' income to 1. Solving the consumers' problem the demand function of firm i reads

$$q_i = \frac{p_i^{\frac{1}{\rho-1}}}{p_1^{\frac{\rho}{\rho-1}} + p_2^{\frac{\rho}{\rho-1}}}$$

Firms maximize profits choosing prices. From the FOC we obtain[15]

[14] Indexes $i+1$ and $i-1$ indicate the nearest neighbor of firm i on the right-hand-side and left-hand-side market, respectively.

[15] The FOC yields $\frac{p_i - c_i}{p_i} = \frac{1-\rho}{\rho}\frac{p_i^{\frac{\rho}{\rho-1}} + p_j^{\frac{\rho}{\rho-1}}}{p_j^{\frac{\rho}{\rho-1}}}\frac{c_i}{p_i}$, which can also be written as $\frac{c_i}{p_i} = \frac{1}{1+\frac{1-\rho}{\rho}y^{\frac{\rho}{\rho-1}}}$ and from which equation (32) and the price-cost margin $\frac{p_i - c_i}{p_i} = \frac{\frac{1-\rho}{\rho}y^{\frac{\rho}{\rho-1}}}{1+\frac{1-\rho}{\rho}y^{\frac{\rho}{\rho-1}}}$ can be obtained.

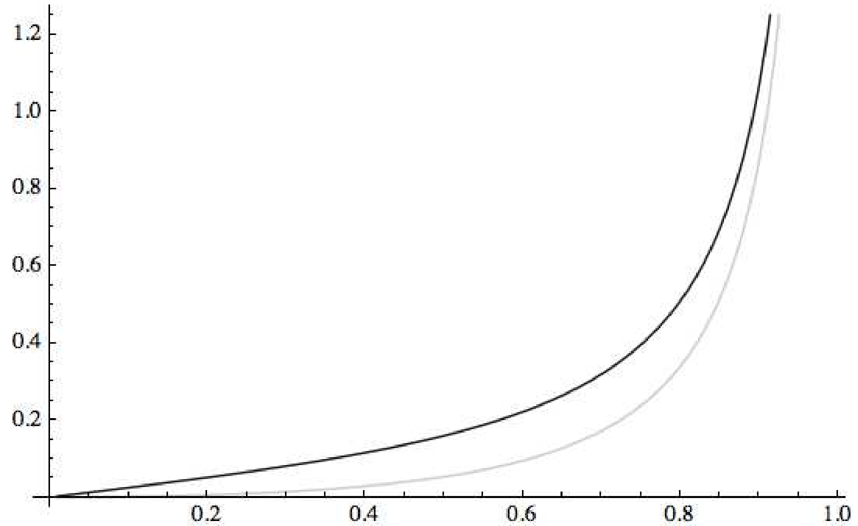

Figure 2: $\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2\Big|_{e_i=e^*}$ (gray line) and $\frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2}\Big|_{e_i=e^*}$ (black line) as a function of ρ.

$$y = z\frac{\frac{1}{\rho} + \frac{1-\rho}{\rho} y^{\frac{\rho}{\rho-1}}}{\frac{1}{\rho} + \frac{1-\rho}{\rho} y^{-\frac{\rho}{\rho-1}}} \tag{32}$$

where $y = \frac{p_i}{p_j}$ and $z = \frac{c_i}{c_j}$ and thus the profit function is

$$\tilde{\pi}_i = \frac{\frac{1-\rho}{\rho} y^{\frac{\rho}{\rho-1}}}{\frac{1}{\rho} + \frac{1-\rho}{\rho} y^{\frac{\rho}{\rho-1}}} \tag{33}$$

At the symmetric equilibrium where $z = y = 1$, the price-cost margin is $\frac{p_i - c_i}{p_i} = 1 - \rho$ and firm profits are $\tilde{\pi}_i = \frac{1-\rho}{2-\rho}$, which both are decreasing in ρ and thus $\theta = \rho$ is a measure of PMC. We simulate $\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2\Big|_{e_i=e^*}$ and $\frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2}\Big|_{e_i=e^*}$ numerically as functions of ρ. In particular, we analyze numerically the impact of a small change in effort (z) on equilibrium prices (y) in (32) and its effect on firm profits (33). In Figure 2 we plot $\frac{1}{\tilde{\pi}_i}\left(\frac{\partial \tilde{\pi}_i}{\partial e_i}\right)^2\Big|_{e_i=e^*}$ (gray line) and $\frac{\partial^2 \tilde{\pi}_i}{\partial e_i^2}\Big|_{e_i=e^*}$ (black line) as functions of ρ and observe that both are increasing in ρ.

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Research Highlights

- Managers have private information about profits and can exert cost-cutting effort
- Stock based compensation is employed to align manager's and shareholders' incentives
- We study shareholders' trade-off between fraud and effort as the degree of PMC varies
- We find a positive relationship between PMC and fraudulent reporting