The Corporate Governance Role of Information Quality and Corporate Takeovers *

Jing Li[†], Lin Nan [‡], Ran Zhao [§]

November, 2013

Abstract

This paper examines the corporate governance role of firms' information quality and the takeover market in disciplining management. We consider a model where the takeover market plays a disciplinary role in replacing the inefficient incumbent manager to increase firm value. Increasing the information quality improves the takeover efficiency, but more precise information also discourages the manager from working hard. We find that current shareholders prefer a higher information quality level than the one that maximizes firm value. This is because the current shareholders may obtain an overbidding premium by increasing the information quality to induce a higher likelihood of receiving a high-price bid for a low-value firm. We also analyze the effect of antitakeover laws or provisions. We find that the optimal information quality is higher after the adoption of antitakeover law or antitakeover provisions. Moreover, the adoption of antitakeover laws always increases the firm value, but increases the current shareholders' payoff only when the manager's private benefit is large and the value enhancement from takeover is small.

*We would like to thank Tim Baldenius, Anne Beyer, Judson Caskey, Carlos Corona, Jon Glover, Mirko Heinle, John Hughes, Bjorn Jorgensen, Pierre Liang, John O'Brien, Ram Ramanan, Stefano Sacchetto, Jack Stecher, seminar participants at Carnegie Mellon University, and participants at 2012 Junior Accounting Theory Conference and 2013 Financial Accounting and Reporting Section meeting for helpful comments.

†Carnegie Mellon University, jlill@andrew.cmu.edu.

‡Purdue University, lnan@purdue.edu.

§Carnegie Mellon University, ranzhao@andrew.cmu.edu.

1 Introduction

Financial accounting information provides direct input in the design of corporate governance mechanisms to facilitate the monitoring of managers (Bushman and Smith, 2001; Armstrong, et al., 2010). A large body of accounting research in corporate governance examines the interaction between a firm's information environment and a variety of corporate governance mechanisms. However, it is difficult to establish a precise link between the information environment and governance structures, because these two constructs are both endogenously chosen by firms (Armstrong, et al., 2010; Defond et al., 2005). In this paper, we provide a theoretical model to examine the governance roles of endogenous information quality and an important external governance mechanism, the corporate takeover market, in which a third party (a raider) can take control of the firm and replace inefficient managers (Jensen, 1988; Scharfstein, 1988).

Recently the role of financial reporting in facilitating takeover markets has gained attention from researchers. For example, several empirical studies examine whether the information quality of the acquirer or target firm influences the profitability and efficiency of acquisitions (Francis and Martin, 2010; Ramen et al., 2010; McNichols and Stubben, 2011; Martin and Shalev, 2009). In general, these studies focus on the acquirers' perspective, and find that acquisition decisions are more efficient in terms of ex-post profitability and synergies when acquirers or targets have more transparent financial reporting. The reason is that higher quality accounting information reduces the information asymmetry between the target and the acquirer company, and allows the acquirer to value the target with great precision and bid more efficiently (McNichols and Stubben, 2011). However, it is not clear whether target firms have the incentive to improve their information quality to facilitate the takeover market efficiency. Moreover, despite the growing interest of empirical studies in this area, no existing theoretical models provide analysis of the role of financial information in takeover. Our study provides analytical analysis to better understand the interaction between the information quality and the takeover market as corporate governance mechanisms.

We model the endogenous choice of information quality of a target firm in the presence of a potential raider who may take over the firm and replace the incumbent manager. Consistent with the typical view of economic and legal scholars, the takeover market in our model serves two important functions for shareholders' value maximization. First, takeover can enhance firm value due to the raider's efficient management skills or superior knowledge about new environment (Scharfstein, 1988; Jensen, 1986). Second, the incumbent manager loses his private benefit of control after a successful takeover, which occurs more likely if the manager shirks. Thus the takeover market serves as a disciplinary mechanism to motivate the incumbent manager. However, an active takeover market may have a negative effect on the manager's incentive, because the manager's position is highly insecure when the takeover is highly efficient (Stein, 1988). The shareholders of the target firm need to take into consideration all these different effects of the takeover market in their decisions.

The takeover bid in our model is in the form of a tender offer, in which a raider makes a price offer and shareholders individually decide whether to tender their shares. Information asymmetry exists in the takeover bidding, as the raider only observes the target firm's financial information, whereas the current shareholders in the target firm have better information about firm value.[1] The manager's effort determines the firm value and he enjoys a private benefit of control. The manager loses his private benefit if takeover succeeds.[2] We assume that the private benefit is the only payoff for the manager in order to focus on the disciplinary role of takeover market when other disciplinary mechanisms such as incentive contracts are not effective.[3] Later on, we relax this assumption in an extension of the model.

[1] In reality, acquirers may perform due diligence to obtain and verify information about the target before signing the final agreement. Due diligence is usually done by an independent third party such as an investment bank, attorney or accountant. More information may be obtained through due diligence and the raider may withdraw his offer or lower the price after the due diligence. However, our model's implications still apply as long as the information obtained through due diligence is imperfect. In addition, the quality of information system of the target, such as the effectiveness of internal control system, also determines whether or not the independent party obtains high quality information in due diligence. A low quality information system increases the raider's cost to conduct due diligence. As a matter of fact, empirical evidence shows it is common for bidding firms to overpay in acquisitions, despite the compliance with the due diligence process (Moeller et al., 2005).

[2] The manager may either be fired or simply lose his decision power in the firm, because the raider takes control after the takeover. Previous studies (Kini et al., 1995, 2004; Martin and McConnell, 1991) document a significant CEO turnover during takeovers, and also find a negative relation between the pre-takeover performance and post-takeover CEO turnovers. Moreover, this negative relation is more pronounced when a more active and less friendly takeover market plays an important role in managerial disciplining (Kini et al., 2004).

[3] Takeover market is considered as an external governance mechanism, which is often viewed as a "court of last resort" and is applied when internal governance mechanisms are weak or ineffective (Jensen, 1986). A primary motive for relying on the takeover market as a disciplinary mechanism is to replace entrenched

In equilibrium, the raider's bidding strategy is based on her belief about the manager's effort given the accounting information; the manager maximizes his own expected payoff given the anticipated bidding strategy. We find that when the incumbent manager's private benefit is small and the information quality is low, the raider bids conservatively and follows a low-price-bidding strategy regardless of accounting signals. When the manager's private benefit is large, or the information quality is high, the raider updates her belief upon observing accounting signals and tends to bid more aggressively upon a good signal.

We examine the optimal levels of information quality that maximize the current shareholders' expected payoff and the expected firm value respectively. The expected firm value consists of two parts: the expected firm value without takeover (which depends on the manager's effort level) and the expected value enhancement from takeover. For the current shareholders, their expected payoff is the expected firm value plus the expected overbidding premium. Increasing information quality enhances the overall takeover efficiency because the raider now bids upon more precise signals. As a result, higher information quality directly increases the expected value enhancement from takeover market. However, a more efficient takeover market also discourages the manager's effort and leads to a lower expected firm value without takeover. Because of this negative effect on the manager's effort when increasing the information quality, we find that a perfectly informative information system is never optimal for either the current shareholders' expected payoff maximization or the expected firm value maximization.[4]

From the current shareholders' perspective, however, they care not only about the expected firm value, but also the overbidding premium from the takeover. The overbidding premium in our model depends on the probability of a low-value firm generating a good signal and the aggressiveness of the raider's bidding strategy upon a good signal. The overall incremental overbidding premium is positive from increasing the information quality above the

and inefficient managers who cannot be motivated effectively otherwise (Kini et al., 2004).

[4]This result of the imperfect optimal information precision echoes other studies with similar conclusions in different settings that more information or higher quality information may not always be better. For example, Kanodia, et al. (2005) show that some degree of accounting imprecision can be value enhancing in a setting with information asymmetry regarding investment profitabilities; Arya, et al. (2004) show that additional information may not always be helpful when existing information is inter-temporally aggregated; Arya and Mittendorf (2011) find that more detailed information may not always be beneficial in evaluating managers' performance given career concerns.

level that maximizes the expected firm value. We thus find that current shareholders prefer a higher level of information quality than the one that maximizes the expected firm value, especially when the value enhancement from takeover is relatively large. The result sounds counterintuitive that the optimal information quality that maximizes firm value is lower than the one preferred by the current shareholders, because the common view is that increasing financial reporting quality is always beneficial for investors who care about the fundamental firm value. In takeover market, when there exists discrepancy of interests between current shareholders and future shareholders, a lower level of information quality actually maximizes firm value. Notice that increasing information quality indeed always improves the overall takeover efficiency; however, this does not imply a higher firm value.

We also examine the impact of antitakeover law adoption on the information quality of the firm, assuming that antitakeover laws make takeovers more difficult and decreases the private benefit that the raider receives after takeover.[5] We find that after the adoption of antitakeover laws, the optimal information quality levels that maximize the current shareholders' expected payoff and the expected firm value are both higher. In addition, antitakeover laws always improve the firm value, but improve the current shareholders' expected payoff only when the value enhancement from takeover is small and the manager's private benefit is large. Our model therefore may provide an explanation for the recent empirical finding that the informativeness of financial statements increases after the passage of antitakeover laws or antitakeover provisions (Armstrong, et al., 2012; Fu and Liu, 2008).

In our main model, in order to focus on the disciplinary role of the takeover market instead of other incentive mechanisms, we assume that the incumbent manager is compensated through his private benefit of staying in his position. We also examine an extension of the main model which allows the current shareholders to offer a compensation contract to the manager in addition to his private benefit of control.[6] We then consider the optimal compen-

[5]In the 1980s, many states passed anti-takeover laws which increased the legal barriers to takeovers as a response to an active takeover market in the 1980s. Many firms also adopted antitakeover provisions to reduce the threat of takeovers to protect managers from the pressure to make short-horizon investments. However, there have been controversies whether antitakeover laws or provisions enhance or destroy shareholders' value (DeAngelo and Rice, 1983; Jarrell and Poulsen, 1988; Malatesta and Walkling, 1988; Mahoney and Mahoney, 1993; Ryngaert, 1988; etc.)

[6]In related studies, Cyert, et al. (2002) examine the interaction between the top-management compensation and takeover threats by a large shareholder. Bertrand and Mullainathan (1998) consider the interaction

sation contract and information quality that maximize the current shareholders' expected payoff and the expected firm value in this extension. The compensation contract provide an alternative mechanism to motivate the manager to maximize these expected payoffs.[7] We find that in this extension, our main results still hold when the manager's private benefit of control is relatively large. This suggests that when the manager is more entrenched and the compensation contract is not effective enough to motivate the manager to work hard, the information quality plays a similar role to that in the main setting. On the other hand, when the manager's private benefit of control is small, the current shareholders rely more on the compensation contract to motivate the manager, and correspondingly the raider's bidding strategy depends less on the information quality as she can infer from the compensation contract about the manager's effort level. Therefore current shareholders prefer lowering the information quality to produce more noisy signals to take advantage of the overbidding premium.

Most theoretical studies on the role of accounting information in corporate governance have been done in the area of executive compensation and performance measures in agency-based models.[8] Not many studies examine the role of accounting information with respect to other corporate governance mechanisms.[9] Our paper establishes the link between financial

between executive compensation and takeover as disciplinary mechanisms, and examine the impact of changes in states' anti-takeover legislation on executive compensation.

[7]Sometimes managers may receive golden parachutes, which refer to special benefits (including salaries, stock options, etc.) they can receive if they are fired in the event the company is taken over by another firm. The benefit of golden parachutes is to align the interests of the manager and shareholders in takeover bids and reduce managers' resistance to takeover, especially in negotiated takeover cases (Lambert and Larcker, 1985). The cost of golden parachutes, however, is to decrease the disciplinary role of takeover market on management and to potentially adversely impact shareholders' interest (Lambert and Larcker, 1985). Since the takeover market serves mainly as a disciplinary mechanism to motivate managers to work in our model, introducing the contract through golden parachutes may not be beneficial to the shareholders. To examine the robustness of our results, we examine a setting in which the manager receives a golden parachute payment after the firm is taken over. We can show numerically that it is not optimal to give any payment in such form either for current shareholders or for firm value maximization. In our model the cost of allowing golden parachutes (i.e., decreased disciplinary role of takeovers) has a much stronger effect than the benefit of golden parachutes (i.e., reducing the pressure on management due to active takeovers to motivate more managerial effort). This is partially because that the current shareholders can alleviate the negative effect of active takeover markets through changing information quality, hence the benefit of golden parachutes is not critical in such a setting. In addition, a commitment to a golden parachute can be problematic, as the current shareholders may have incentive to avoid the parachute obligations. For example, the manager may be fired for fault, or the firm can informally reduce the manager's influence on the firm's decision making without firing him.

[8]Bushman and Smith (2001) and Armstrong, et al. (2010) both provide detailed reviews of this literature.

[9]For example, Laux and Laux (2009) examine the board of directors' strategies for setting CEO incentive

disclosure and the takeover mechanism in corporate governance of the target firm.[10]

Our paper adds to the literature on the endogenous choice of information quality or precision of public signals in various settings. For example, Penno (1997) shows the effect of ex-ante information quality on the firm's voluntary disclosure choice. Fan and Zhang (2011) study optimal accounting policies such as aggregation and conservatism when a firm can control the quality of accounting information with some cost. Nan and Wen (2012) investigate the effect of accounting biases on firms' financing decisions and the role of accounting biases in endogenous information quality.

Our paper also contributes to the broad literature that examines how financial reporting facilitates disciplining the management or other parties through capital market in general. For example, Kanodia and Lee (1998) examine the optimal information precision when the capital market relies on the accounting information to discipline the manager's investment choice. Huddart, et al. (1999) examine how public disclosure requirements influence listing decisions by corporate insiders. Dye and Sridar (2007) study the allocational effects associated with the precision of accounting estimates when the precision of estimates is a choice variable for firms.

The remainder of the paper proceeds as follows: Section 2 presents the main model setup and the raider's bidding strategy, Section 3 examines the equilibria and analyzes the optimal information quality levels that maximize the current shareholders' expected payoff and the expected firm value, Section 4 provides an extended model with compensation contract, and Section 5 concludes the paper.

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pay and overseeing financial reporting and their effects on the level of earnings management.

[10] Prior studies examine the role of information and disclosure in takeovers in other settings. For example, Grossman and Hart (1980b) show that when the raider has more information about the firm value after takeover, imposing a more stringent disclosure law can reduce the level of dilution by the raider, which may overly hinder the takeover bid process and have an adverse effect on managerial efficiency. Marquez and Yilmaz (2008) analyze tender offers where privately informed shareholders are uncertain about the raider's ability to improve firm value and only shareholders with bad information will tender. They show that private information affects not only the efficiency of the takeover process, but also the surplus allocation between the raider and the shareholders.

2 The Main Model

2.1 Model Setup

We consider a two-period model with dates $t = 0, 1, 2$. All agents are risk-neutral. At date 0, the current shareholders choose the quality of the financial reporting system, $d \in [\frac{1}{2}, 1]$. d determines the precision of the noisy signals generated by the financial reporting system, which we will elaborate in the next paragraph. After d is determined, an incumbent manager makes an effort e that will affect the firm's future value v. For convenience, we refer to the manager as "he." The manager's effort is not contractable. For simplicity, we assume that the effort $e \in [0, 1]$. The cost of the manager's effort is a convex function, $\frac{1}{2}e^2$. We assume that the firm value is binary, $v \in \{0, 1\}$. If the manager shirks, the expected value of the firm will be lower. Specifically, we assume that the probability of generating a high firm value ($v = 1$) is e (i.e., $prob(v = 1|e) = e$), and the probability of generating a low firm value ($v = 0$) is $1 - e$ (i.e., $prob(v = 0|e) = 1 - e$). The manager enjoys a private benefit of m if the firm is not taken over. It is reasonable to assume that the private benefit of the manager is smaller than the maximum firm value; i.e., $0 < m < 1$. We assume that m is the only benefit of the manager to compensate for his effort, because we want to concentrate on the disciplinary role of the takeover market instead of other incentive mechanisms. Current shareholders can discipline the incumbent manager through the threat of takeover market. If the takeover succeeds, the incumbent manager is deprived of his private benefit.[11]

At time 1, the firm value v is privately observed by the current shareholders. The outsiders do not observe the firm value, but receive a noisy signal y about the firm value, which is generated from the financial reporting system.[12] We assume that the signal is binary, $y \in \{G, B\}$, where G represents a good signal and B represents a bad signal. The information quality of the financial reporting system, d, determines the information properties of the

[11] In the main setup, we assume no performance-based compensation is paid to the manager in order to focus on the disciplinary role of the takeover market in replacing the entrenched manager. In the later section we relax this assumption, and allow a more general design of the managerial compensation contract.

[12] We assume that the current shareholders obtain the perfect information about firm value for simplicity. A variation of our model could assume that shareholders observe a noisy signal about firm value, but the raider receives a noisier signal than what shareholders observe. This variation will lead to similar results to our current model.

signals. We assume that:

$$prob(y = G|v = 1) = prob(y = B|v = 0) = d, \tag{1}$$
$$prob(y = B|v = 1) = prb(y = G|v = 0) = 1 - d.$$

That is, a higher-quality information system produces more informative signals.

At time 2, there is a potential raider in the market that makes a tender offer to the current shareholders. For convenience, we use "she" to refer to the raider. The raider can improve firm value after taking control of the firm. We assume that the value enhancement, v_0, is smaller than the maximum firm value before takeover (i.e., $0 < v_0 < 1$), and v_0 is common knowledge.[13] After observing the signal y, the raider may make a tender offer p. If the takeover succeeds, the incumbent manager is replaced and the new firm value becomes $v + v_0$. If the takeover fails, the firm value remains as v. We assume that the raider enjoys some private benefit after taking control of the firm, and assume that her private benefit is b.[14] We also assume that the bidder's private benefit is smaller than the maximum firm value; i.e., $0 < b < 1$.[15] The private benefit is common information.

In our model shareholders are rational and no shareholder can affect the outcome of the takeover bid.[16] Therefore the bidding price needs to be at least greater or equal to the firm's

[13]The value enhancement assumption is consistent with the view that the takeover market enables a control shift to a new management team that can run the firm more efficiently or has new ideas that improve the firm value when the environment changes (Scharfstein, 1988; Shleifer and Vishny, 1986).

In our model, the value enhancement from takeover is independent of the manager's effort. If we allow the value enhancement varies with the firm value, for example, the value enhancement is smaller for the high-value firm, our main results qualitatively remain. The reason is that when takeover adds less value to the high-value firm, increasing information quality benefits less in terms of encouraging more aggressive bidding in order to realize the value enhancement from successful takeover, and on the other hand, increasing information quality may weaken the manager's effort significantly.

[14]Without private benefit from the takeover, the raider does not have any incentive to make the offer because of the free-rider problem described by Grossman and Hart (1980a). Our assumption of private benefit of the raider is consistent with Grossman and Hart (1980a) and other studies which assume the raider can divert the firm value after takeover and thus the minority shareholders cannot receive the whole firm value. Our assumption is a simplified version that makes the raider willing to make the takeover bid. There are other models that resolve the free-rider problem without assuming such a divergence of payoff after takeover, for example, Shleifer and Vishny (1986), Bagnoli and Lipman (1988), etc.

[15]If the raider's private benefit is too large ($b > 1$), the raider would always bid high price regardless of accounting signals in order to capture the large private benefit from successful takeover. In that case, accounting information quality becomes irrelevant.

[16]In our model, shareholders only accept or reject the bidding price. Although no shareholders in our model are influential enough to affect the takeover outcome, they can be blockholders that have access to

post-takeover value $v+v_0$. Otherwise, a single shareholder could always hold on to his or her shares and obtain the value enhancement, assuming his or her tender decision will not affect the outcome of the takeover bid. The takeover is successful if more than 50% of shareholders tender the offer. Given that shareholders in our model are identical, either 100% of them tender or none tenders.

Figure 1 summarizes the timeline of our model.

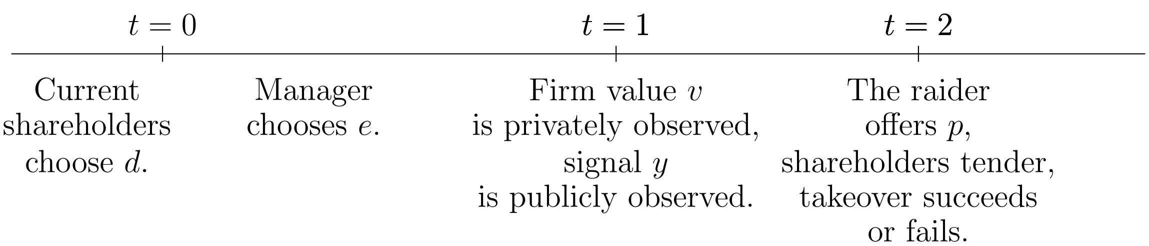


Figure 1: Timeline

2.2 The Raider's Bidding Strategy

We first look at the raider's bidding strategy $p(y)$ upon an imperfect signal y. The raider updates her belief about the true value of the firm after observing y and makes an offer. Since the raider does not have perfect information about the current firm value, she is likely to overbid.

We denote the posterior probability of a high firm value given y to be:

$$h(y) \equiv Prob(v = 1|y). \tag{2}$$

The raider's payoff from the takeover, if successful, is $v + v_0 + b - p$. We use $\pi_r(p, y)$ to represent the raider's expected payoff by bidding at price p after observing signal y.

With the firm's value v being binary (v is either 0 or 1), it is easy to verify that the tender offer should be either v_0 or $1 + v_0$ (any other offer is dominated). When $p = v_0$, only if firm

more information than outsiders. In reality, for example, holding 5% of shares is sufficient to get some access to insider information, but not enough to determine the takeover outcome. Our model may fit best for takeovers of private targets or small targets with high information asymmetry. Empirical evidence shows that acquisitions of private targets are prevalent in corporate takeovers (Fuller, et al., 2002).

value is low will the shareholders tender and the takeover succeeds; otherwise if firm value is high, shareholders do not tender and the takeover fails. When $p = 1+v_0$, shareholders always tender regardless of firm value and the takeover always succeeds. However, when $p = 1+v_0$, the raider may overbid for a low-value firm and incur a loss. The raider's expected payoffs from bidding v_0 and $1+v_0$ are, respectively,

$$\pi_r(v_0, y) = [1 - h(y)]b,$$

$$\pi_r(1 + v_0, y) = h(y)b + [1 - h(y)](b - 1).$$

It is easy to see that $\pi_r(1 + v_0, y) > \pi_r(v_0, y)$ if and only if $h(y) > \dfrac{1}{1+b}$. Essentially, the raider considers the tradeoff between the marginal benefit and marginal cost of bidding a high price after observing the signal. The marginal benefit of bidding a high price is that takeover succeeds for the high-value firm and allows the raider to enjoy her private benefit. On the other hand, the marginal cost of bidding a high price is the expected overbidding loss from the low-value firm. The raider is more willing to offer a high price when $h(y)$ increases.

We define the raider's bidding strategy as a pair of probabilities (α, β), where α is the probability of offering a high price $(1+v_0)$ after observing a good signal (i.e., $y = G$), and β is the probability of offering a high price after observing a bad signal (i.e., $y = B$). Lemma 1 summarizes the raider's bidding strategy, (α, β):

Lemma 1 *The raider's bidding strategy depends on her posterior belief of facing a high-value firm upon the signal:*

- ***S1***: $\alpha = \beta = 1$, *if* $\frac{1}{1+b} < h(B) < h(G)$.
- ***S2***: $\alpha = 1$, $0 < \beta < 1$, *if* $h(B) = \frac{1}{1+b}$.
- ***S3***: $\alpha = 1$, $\beta = 0$, *if* $h(B) < \frac{1}{1+b} < h(G)$.
- ***S4***: $0 < \alpha < 1$, $\beta = 0$, *if* $h(G) = \frac{1}{1+b}$.
- ***S5***: $\alpha = \beta = 0$, *if* $h(B) < h(G) < \frac{1}{1+b}$.

Lemma 1 suggests that the informativeness of signals is critical in determining a raider's bidding strategy. $h(G)$ and $h(B)$ are the raider's posterior beliefs about the probability of facing a high-value firm upon good and bad signals respectively. Since the signal is informative ($d > \frac{1}{2}$), the probability of a high firm value is higher upon a good signal than upon a bad signal (i.e., $h(G) > h(B)$). The raider's probability of bidding a high price upon observing a signal increases with the updated belief about the likelihood of a high-value firm. When the raider's posterior beliefs upon both signals are high enough, the raider always offers a high price ($S1$). When the raider's posterior beliefs are both low, the raider always offers a low price ($S5$). When the raider's posterior belief is high upon a good signal and low upon a bad signal, the raider follows a separating bidding strategy ($S3$). In the other two cases, the raider's posterior belief on either a good signal or a bad signal is on the edge ($h(y) = \frac{1}{1+b}$), the raider is indifferent between a high price and a low price, and thereby follows a mixed strategy upon the signal ($S2$ and $S4$).

Although there are five cases in Lemma 1, as we will show in the next section, not all of them are in equilibrium. This is because the posterior probability $h(y)$ depends on the raider's conjecture of the manager's effort, whereas her conjecture has to be consistent with the manager's optimal choice of effort to make the case sustainable in equilibrium.

3 Equilibrium and optimal information quality

In our model, the information quality d is determined first. The manager then chooses his effort level that affects the expected firm value. However, he may lose his incumbent private benefit if the firm is later successfully taken over by a raider. The raider does not observe the manager's effort. When offering the bidding price upon the imperfect signals, the raider needs to conjecture the manager's effort level to update her belief about the firm value. We will first define and fully characterize the manager's equilibrium effort and the equilibrium bidding strategy of the raider, taking as given the information quality d.

3.1 Manager's effort and raider's bidding strategy in equilibrium

A perfect Bayesian equilibrium of the manager's and the raider's strategies, given any information quality, is defined as the following:

Definition 1 *A set of strategies (e^*, α^*, β^*) forms a perfect Bayesian equilibrium such that:*

(i) The raider forms her belief about the manager's effort, $\hat{e}$, and her optimal bidding strategy, $(\alpha^*(\hat{e}), \beta^*(\hat{e}))$, satisfies the bidding strategies as specified in Lemma 1.

(ii) The manager's optimal effort, e^*, maximizes his own expected payoff, $\Pi_m(e, \alpha^*(\hat{e}), \beta^*(\hat{e}))$, given the anticipated optimal bidding strategy of the raider, $(\alpha^*(\hat{e}), \beta^*(\hat{e}))$.

(iii) The raider's belief in (ii) is consistent with the manager's optimal effort, $\hat{e} = e^*$.

For any bidding strategy, the takeover always succeeds for a low-value firm. For a high-value firm, the takeover succeeds only when the price is high (i.e., $\alpha = 1$ or $\beta = 1$). A takeover fails when the raider offers a low bidding price and the true value of the firm is high. Recall that the probability of a high firm value given the manager's effort e is $prob(v = 1|e) = e$. Therefore, the probability of takeover success is calculated as

$$\begin{aligned} Prob[T] &= 1 - e + e(\alpha Prob[y = G|v = 1] + \beta[Prob[y = B|v = 1]) \\ &= 1 - e + e[d\alpha + (1 - d)\beta]. \end{aligned} \quad (3)$$

The manager's expected payoff for choosing an effort level of e given the raider's bidding strategy, $\Pi_m(e, \alpha, \beta)$, is thus given by:

$$\Pi_m(e, \alpha, \beta) = (1 - Prob[T])m - \frac{e^2}{2} = e[1 - d\alpha - (1 - d)\beta]m - \frac{e^2}{2}. \quad (4)$$

Given any raider's strategy (α, β), the manager's optimal effort that maximizes his expected payoff in (4) is

$$e^*(\alpha, \beta) = [1 - d\alpha - (1 - d)\beta]m. \quad (5)$$

We now discuss the raider's belief. The raider's belief about the manager's effort is $\hat{e}$, which means her ex-ante belief on the probability of a high firm value ($v = 1$) is $\hat{e}$. After observing the signal y, the raider updates her belief about the probability of a high firm value given the information structure in (1):

$$h(G,\hat{e}) = \frac{\hat{e}d}{\hat{e}d+(1-d)(1-\hat{e})}, \tag{6}$$
$$h(B,\hat{e}) = \frac{\hat{e}(1-d)}{\hat{e}(1-d)+(1-\hat{e})d}.$$

With the updated belief, the raider chooses her optimal bidding strategy (α^*, β^*) to maximize her expected payoff. The raider's belief about the manager's effort in equilibrium is consistent with the manager's optimal effort in (5).

For the five cases in Lemma 1, it turns out that the first three bidding strategies, $S1-S3$, will not be equilibrium cases. In these three cases, the raider is more likely to bid a high price based on a conjecture of high firm value. However, the higher likelihood of takeover success makes the manager's position more insecure and discourages the manager from working hard. As a result, the manager's optimal effort is lower, inconsistent with the raider's conjecture. The bidding strategies that are sustainable in equilibrium are $S4$ and $S5$. That is, the raider either always bids a low price when the raider conjectures a sufficiently low effort level, or bids a low price upon a bad signal and follows a mixed strategy upon a good signal.

Proposition 1 characterizes the full equilibrium:

Proposition 1 *Given the information quality d, there exist two mutually exclusive, commonly exhaustive conditions, $C1$ and $C2$, such that:*

- *if C1 holds, the manager chooses $e^* = m$, and the raider chooses $\alpha^* = 0$ and $\beta^* = 0$ **(low-price-bidding equilibrium)**;*
- *if C2 holds, the manager chooses $e^* = \frac{1-d}{1-d+db}$, and the raider chooses $\alpha^* = \frac{1}{d}\frac{bdm-(1-d)(1-m)}{(1-d)m+bdm}$ and $\beta^* = 0$ **(mixed-price-bidding equilibrium)**.*

C1 and C2 are conditions about m and d:
C1: $m \leq \frac{1}{1+b}$ and $d < \frac{1-m}{1-(1-b)m}$,
C2: $m > \frac{1}{1+b}$, or $m \leq \frac{1}{1+b}$ and $d \geq \frac{1-m}{1-(1-b)m}$.

Proof. See Appendix. ■

Although there are two possible cases (that is, the case when C1 holds and the case when C2 holds), in each case there exists only one equilibrium.

To understand the intuition of Proposition 1, notice that the manager's marginal benefit of increasing effort depends on m and the probability of unsuccessful takeover, as shown below:

$$\frac{\partial \Pi_m}{\partial e} = \underbrace{[1 - d\alpha - (1-d)\beta]m}_{Marginal\ Benefit} - e. \tag{7}$$

When m is relatively small ($m < \frac{1}{1+b}$), the manager's marginal benefit of increasing his effort is small. In this case, the raider's bidding strategy depends on the information quality. If the information quality is low ($d < \frac{1-m}{1-(1-b)m}$), the raider's best strategy is to offer a low price to avoid overbidding loss (i.e., $\alpha^* = 0$, $\beta^* = 0$). The manager enjoys the full marginal benefit of increasing effort, m, and sets his optimal effort level at $e^* = m$. On the other hand, if the information quality is high ($d > \frac{1-m}{1-(1-b)m}$), the raider is willing to bet on the high value by following a mixed strategy when the signal is good (i.e., $\alpha > 0$ and $\beta = 0$). The manager's marginal benefit of increasing effort then becomes $(1-d\alpha)m$, where $d\alpha$ is the probability that the takeover succeeds when the signal is good and the bidding price is high. The possibility of takeover success reduces the manager's effort incentive and the manager lowers the optimal effort to $e^* = \frac{1-d}{1-d+db} < m$, consistent with the raider's belief.

When m is relatively large ($m > \frac{1}{1+b}$), the raider knows that the manager's marginal benefit of increasing effort is large and thus the probability of a high firm value is high. The raider thus follows a mixed strategy when the signal is good. The manager's marginal benefit of increasing effort again becomes $(1 - d\alpha)m$. Therefore the manager chooses an effort level $e^* = \frac{1-d}{1-d+db}$, consistent with the raider's belief.

Our result echoes the view of the takeover market as an effective corporate governance mechanism. Without the takeover threat, the manager is entrenched as he has no incentive to work. The takeover market here serves as a disciplinary device to motivate the manager to choose higher effort (Jensen, 1988). If the manager shirks, it is likely that the firm value will be low and in equilibrium a low-value firm will be taken over for sure. However, our analysis also shows another effect of takeover market on the manager's effort decision. That is, if the takeover market is very efficient so that the takeover always succeeds, the manager will lose his incentive to exert effort since his position is highly insecure. This second effect is consistent with some regulators' and academics' concerns that an active takeover market may place too much pressure on the management and the manager will not pursue the best interest of shareholders (Stein, 1988).

It is also interesting to analyze how the information quality, d, affects the equilibrium. Intuitively, when the information quality increases, the signal y becomes more informative. As a consequence of higher information quality, the raider is more likely to follow a mixed strategy instead of always offering a low price. However, as long as the equilibrium stays in the low-price-bidding equilibrium (given $C1$ holds), a change in the information quality does not affect the equilibrium effort and bidding strategy directly. On the other hand, when $C2$ holds, the information quality d affects the mixed-price-bidding equilibrium in two ways: it changes both the equilibrium managerial effort and the raider's bidding strategy. The probability of bidding a high price increases because the raider expects a lower probability to overbid upon a good signal. As a result, the probability of takeover success increases and the takeover market becomes more efficient. However, this reduces the manager's incentive to work since his marginal benefit of effort decreases. We summarize these results in the following corollary:

Corollary 1 *The equilibrium manager effort (e^*) is non-increasing in the information quality, and the probability of bidding a high price (α^*) in equilibrium is increasing in the information quality; i.e.,*

$$\frac{\partial e^*}{\partial d} \leq 0, \quad \frac{\partial \alpha^*}{\partial d} > 0.$$

3.2 Optimal information quality

So far we have analyzed the equilibrium taking the information quality as given. In this section we examine the optimal choice of information quality. The choice of information quality not only affects the probability of successful takeover and the overbidding premium, but also affects the disciplinary role of the takeover market.

In our model, as we will illustrate soon, the firm value and the current shareholders' expected payoff are not fully aligned in the presence of the takeover market. As a consequence, the optimal information quality to maximize the firm value, denoted by d_v^*, is different from the optimal quality that maximizes the current shareholders' payoff, denoted by d_s^*. We will analyze both optimal information quality levels. The maximization of the firm value, in our view, is more consistent with regulators' perspective of protecting the interest of firms' investors, including both current shareholders and future shareholders.

To see this, let's denote $\Pi_s(e^*, p^*(y))$ to be the current shareholders' expected payoff and $\Pi_v(e^*, p^*(y))$ to be the expected firm value. The shareholders' expected payoff includes the expected value of the firm if the firm is not taken over (we denote this event as NT) and the expected price the shareholders can receive from the raider if the firm is taken over (we denote this event as T). The firm value is the expected value of the firm regardless of whether the firm is taken over or not. Formally, the expected firm value and the current shareholders' expected payoff are, respectively,

$$\begin{aligned}\Pi_v(e^*, p^*(y)) &= [1 - Prob(T)]E[v|e^*, NT] + Prob(T)E[v + v_0|e^*, T] \\ &= E[v|e^*] + Prob(T) \cdot v_0, \qquad (8)\end{aligned}$$

$$\begin{aligned}\text{and}\ \ \Pi_s(e^*, p^*(y)) &= [1 - Prob(T)]E[v|e^*, NT] + Prob(T)E[p^*(y)|e^*, T] \\ &= E[v|e^*] + Prob(T) \cdot v_0 + Prob(OT) \cdot 1, \qquad (9)\end{aligned}$$

where $Prob(T)$ is the probability of takeover success, and $Prob(OT)$ is the probability of takeover success with overbidding price.

The expected firm value consists of two parts: the expected firm value $E[v|e]$ when there is no takeover, and the expected value enhancement from the takeover, $Prob(T) \cdot v_0$. The current shareholders' expected payoff equals the expected firm value plus the expected overbidding premium, $Prob(OT) \cdot 1$. The current shareholders receive a higher payoff when there is overbidding from the raider. However, the overbidding premium is only a wealth transfer from the raider (the future shareholder) to the current shareholders and should not be considered as part of the expected firm value.

In the low-price-bidding equilibrium, $E[v|e^*] = e^* = m$. Given the raider's low-price bidding strategy, $\alpha^* = \beta^* = 0$, only the low-value firm can be taken over. Thus the probability of takeover success is $Prob(T) = 1 - e^*$ and there is no overbidding. In this case, the current shareholders' expected payoff and the expected firm value are the same. The change in information quality does not affect the current shareholders' expected payoff or the expected firm value. As a result, the optimal information quality that maximizes both the shareholders' expected payoff and the expected firm value in the pooling equilibrium can be of any value, as long as the low-price-bidding equilibrium condition is satisfied; i.e., d_s^* and d_v^* is any value in the range of $[\frac{1}{2}, \frac{1-m}{1-(1-b)m}]$.

In the mixed-price-bidding equilibrium, $E[v|e^*] = e^* = \frac{1-d}{1-d+db}$. Given the raider's mixed strategy upon a good signal, when the realized value is low the takeover is always successful, while when the realized value is high the takeover succeeds only when a good signal is generated and at the same time the bidding price is high. The probability of takeover success in this case is $Prob(T) = 1 - e^* + e^* d\alpha^*$. Here, the overbidding premium occurs only when a low-value firm obtains a good signal and the bidding price is high. Therefore, the probability of successful takeover with overbidding is $Prob(OT) = (1 - e^*)(1 - d)\alpha^*$. In contrast to the case of low-price-bidding equilibrium, now the information quality affects both the current shareholders' expected payoff and the expected firm value through its impacts on both the optimal effort level of the manager and the raider's bidding strategy. The optimal level of information quality that maximizes firm value is $d_v^* = \frac{2v_0-m}{2v_0-m+bm}$. The optimal information quality that maximizes the current shareholders' expected payoff is $d_s^* = \frac{2v_0-m+b(2-m)}{2v_0-m+b(2+bm)}$, which is different from d_v^* because the current shareholders' expected payoff includes the overbidding premium.

As shown in Proposition 1, when the manager's private benefit is large ($m > \frac{1}{1+b}$), only the mixed equilibrium is possible. When the manager's private benefit is small ($m \leq \frac{1}{1+b}$), the equilibrium is contingent on d. Comparing the expected payoffs of current shareholders and the expected firm value in each equilibrium, we have the following proposition:

Proposition 2 *There exist interim levels of information quality, $\frac{1}{2} \leq d_s^* < 1$ and $\frac{1}{2} \leq d_v^* < 1$, that maximize the current shareholders' expected payoff and the expected firm value, respectively. Specifically,*

- *when* $0 < m < \frac{1}{1+b}$,

$$d_s^* = \begin{cases} [\frac{1}{2}, \frac{1-m}{1-(1-b)m}], & if \;\; 0 < v_0 \leq \frac{1-b}{2}, \\ \frac{2v_0 - m + b(2-m)}{2v_0 - m + b(2+bm)}, & if \;\; \frac{1-b}{2} < v_0 < 1, \end{cases}$$

$$d_v^* = \begin{cases} [\frac{1}{2}, \frac{1-m}{1-(1-b)m}], & if \;\; 0 < v_0 \leq \frac{1}{2}, \\ \frac{2v_0 - m}{2v_0 - m + bm}, & if \;\; \frac{1}{2} < v_0 < 1; \end{cases}$$

- *when* $\frac{1}{1+b} \leq m < 1$,

$$d_s^* = \begin{cases} \frac{1}{2}, & if \;\; 0 < v_0 \leq \frac{(1+b)^2 m}{2} - b, \\ \frac{2v_0 - m + b(2-m)}{2v_0 - m + b(2+bm)}, & if \;\; \frac{(1+b)^2 m}{2} - b < v_0 < 1, \end{cases}$$

$$d_v^* = \begin{cases} \frac{1}{2}, & if \;\; 0 < v_0 \leq \frac{(1+b)m}{2}, \\ \frac{2v_0 - m}{2v_0 - m + bm}, & if \;\; \frac{(1+b)m}{2} < v_0 < 1. \end{cases}$$

Proof. See Appendix. ■

Proposition 2 shows that regardless of whether the objective is to maximize the current shareholders' payoff or to maximize the firm value, a perfect information system is never optimal. The intuition follows directly from our analysis of the equilibrium. Specifically, the information quality has the following properties:

- $\dfrac{\partial e^*}{\partial d} < 0$,
- $\dfrac{\partial Prob(T)}{\partial d} > 0$,
- $\dfrac{\partial^2 Prob(OT)}{\partial d^2} < 0$, and $Prob(OT)$ is maximized at $d = \dfrac{2-m}{2-m+bm}$.

More informative signals make the takeover market more efficient as the probability of takeover success increases. However, increasing information quality weakens the managerial effort incentive. Increasing information quality up to a certain level is good for both the current shareholders' payoff and the firm value, as the takeover market becomes more efficient and can improve the firm value through efficient takeover. However, perfectly informative signals are not in the best interest of maximizing current shareholders' payoff or the firm value, since the takeover market's disciplinary role on managerial effort will be weakened when the takeover market becomes very efficient. The manager's incentive to make an effort is reduced if he anticipates a higher probability of takeover success in a better-quality information system. The results in Proposition 2 show that the potential value enhancement (v_0) is a key determinant of these tradeoffs in determining the optimal information quality. When the value enhancement is small, it is more important to motivate the incumbent manager to work hard to improve the current firm value than to grab the potential value enhancement (as well as the overbidding premium) from an efficient takeover market. Thus for both current shareholders' payoff and firm value maximization, the optimal information quality is relatively low. When the value enhancement is large, the incentive to benefit from a successful takeover becomes greater, and as a result, the optimal information quality is higher to improve the takeover efficiency.

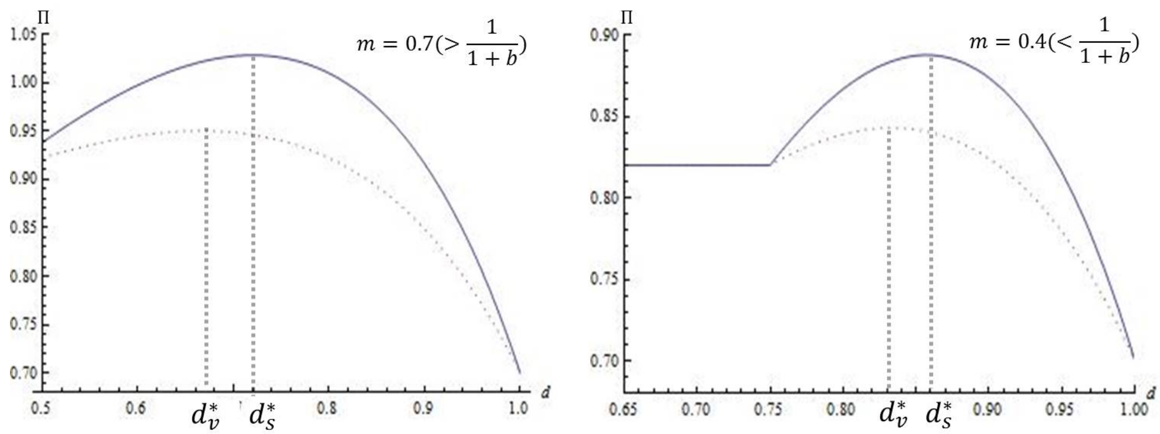
We compare these two levels of optimal information quality in Proposition 2 and have the following results:

Corollary 2 *The optimal information quality that maximizes current shareholders' expected payoff is weakly higher than the information quality that maximizes the firm value; i.e.,*

$$d_s^* \geq d_v^*.$$

In all scenarios, the current shareholders prefer an information quality level which is never lower than the one that maximizes the expected firm value. In addition, as the value enhancement from takeover gets larger, the current shareholders prefer a strictly higher level of information quality. This difference is driven by the overbidding premium that current shareholders may receive from the raider. The overbidding premium in our model depends on two factors: the probability of a low-value firm generating a good signal and the aggressiveness of the raider's bidding strategy upon a good signal. On the one hand, increasing the information quality directly increases the probability of low firm value due to the negative effect on the manager's effort level; however, it also decreases the probability of generating an imprecise signal for the low-value firm. Thus the overall effect of information quality level on the probability of low-value firm generating a good signal is ambiguous. On the other hand, increasing the information quality reduces the raider's uncertainty about the firm value and allows the raider to bid more aggressively, which increases the overbidding premium. When the information quality is at the level of $d_v^* = \frac{2v_0-m+b(2-m)}{2v_0-m+b(2+bm)}$ which maximizes the expected firm value, the marginal overbidding premium from increasing information quality is positive since $\frac{2v_0-m+b(2-m)}{2v_0-m+b(2+bm)} < \frac{2-m}{2-m+bm}$. Therefore the current shareholders are better off by further increasing the information quality.

Figure 2 illustrates how information quality affects the current shareholders' payoff and the expected firm value when the value enhancement is relatively large.



_____ is shareholders' expected payoff Π_s

……... is the firm's expected value Π_v

$v_0 = 0.7; b = 0.5$

Figure 2: The effect of information quality on the current shareholder's expected payoff (Π_s) and the expected firm value (Π_v).

This result may be counterintuitive as the common perception is that increasing the quality of financial reporting or information is always beneficial for investors who care about the fundamental firm value. Contrary to the common perception, our analysis indicates that to maximize the interests of all investors, or to maximize the expected firm value, a more stringent requirement for information quality may not be efficient in the context of takeover market, where there exists conflict of interests between current shareholders and future shareholders. Our analysis also stresses the fact that the current shareholders' interest may not fully align with the maximization of firm value.

3.3 Anti-takeover laws and information quality

In our model, the takeover market functions as an external disciplinary corporate governance device and the current shareholders choose the optimal information quality given the exogenous takeover market. In practice, the current shareholders or regulators may also influence the takeover market through takeover defense tools. In the 1980s, many states passed anti-takeover legislation that made takeovers more difficult and costly in response to an active takeover market of the 1980s. The anti-takeover laws usually limit acquirers' voting rights in takeovers, require acquirers to pay a fair price, or prohibit takeover activities for some period (Cheng et al., 2004). Following the adoption of anti-takeover laws, the takeover market declined in the 1990s. Besides antitakeover legislation, a firm can also adopt anti-takeover provisions to increase the difficulty of launching a takeover bid for the firm. These antitakeover defenses typically include corporate charter antitakeover amendments and poison-pill securities.[17]

In this section we examine how the adoption of antitakeover laws (or antitakeover provisions) influences the information quality of the firm. Since antitakeover laws make a takeover more difficult and costly for the raider, in our model we simply represent the effect of anti-takeover laws by a decrease of the private benefit of the raider from the successful takeover, b.[18] Recall that in our model the raider's expected payoff from takeover depends on his private benefit, and therefore the private benefit of the raider will affect her bidding strategy. The raider is more likely to bid a low price when her private benefit is small. This in turn will change the manager's effort incentive, as it affects the manager's conjecture about the raider's bidding strategy and the takeover success probability. In equilibrium, a smaller private benefit of the raider implies that the low-price-bidding equilibrium exists in a larger parameter space. In the mixed-price-bidding equilibrium we have the following results:

- $\dfrac{\partial e^*}{\partial b} < 0,$
- $\dfrac{\partial Prob(T)}{\partial b} > 0,$

[17] See Sundaramurthy (2000) for a review of literature related to antitakeover provisions.

[18] Sundaramurthy (2000) discusses how each type of antitakeover provisions can raise takeover costs for the raider.

- $\frac{\partial Prob(OT)}{\partial b} > 0$.

From these results, we see that a decrease in b increases the manager's effort in equilibrium. Since the raider's private benefit is smaller, the manager expects that the raider's expected payoff from bidding a high price is lower and the chance that the raider bids a high price when observing a good signal is lower.[19] Therefore, the manager is more willing to exert his effort. As a result of less aggressive bidding by the raider and the increased probability of being a high-value firm when the manager increases the effort, the overall probability of takeover success is reduced. Moreover, the overbidding likelihood is lower, since the probability of being a low-value firm is lower as a result of a higher manager's effort and a lower probability of bidding high price.

In Proposition 3, we show the optimal information quality levels to maximize the shareholders' payoff and the expected firm value, separately, after the adoption of antitakeover laws:

Proposition 3 *After the adoption of antitakeover laws, the optimal information quality levels, d_s^{**} and d_v^{**}, are both higher.*

Proof. See Appendix. ∎

Intuitively, when the raider's private benefit is smaller, the expected current shareholders' payoff and firm value are reduced due to the decreased probabilities of takeover success and overbidding. To maximize the current shareholders' payoff and firm value, it turns out to be optimal to increase the information quality. This is because increasing the information quality reduces the raider's uncertainty about the true value of the firm and encourages more aggressive bidding from the raider. The implication of Proposition 3 is consistent with the empirical evidence that financial information quality improves after the adoption of antitakeover laws or antitakeover provisions (Armstrong et al., 2012; Fu and Liu, 2008).

It is also interesting to analyze the impacts of antitakeover laws on the firm value and shareholder's welfare when current shareholders optimally choose the information quality.

[19]It is sometimes argued that antitakeover laws make it easier for entrenched managers to shirk and pursue private benefit of control instead of shareholders interest. In our model, although we do not assume a direct impact from antitakeover laws on the managers private benefit, we can show that the managers expected payoff does increase after the adoption of antitakeover laws with the endogenous information quality change.

We compare these two objective functions at the optimal information quality d_s^* and d_s^{**} respectively. The following proposition summarizes the effects:

Proposition 4 *Given that the current shareholders optimally choose the information quality before and after the passage of antitakeover laws, we have the following results:*

- *antitakeover laws have no impact on the expected firm value when* $m < \frac{1}{1+b}$ *and* $0 < v_0 < \frac{1-b}{2}$*, and always improve the expected firm value otherwise;*
- *antitakeover laws have no impact on the current shareholders' expected payoff when* $m < \frac{1}{1+b}$ *and* $0 < v_0 < \frac{1-b}{2}$*, otherwise antitakeover laws improve the current shareholders' expected payoff when* $\frac{1}{1+b} < m < 1$ *and* $1 < v_0 < \frac{1-b}{2}$*, and decrease the current shareholders' expected payoff when* $v_0 > \frac{1-b}{2}$*.*

Proof. See Appendix. ■

When the value enhancement and the manager's private benefit are both very small ($0 < m < \frac{1}{1+b}$ and $0 < v_0 < \frac{1-b}{2}$), we remain in the low-price-bidding equilibrium; thus there is no direct effect on the equilibrium effort or takeover probability by adopting antitakeover laws, as shown in Proposition 1. Both the current shareholders' expected payoff and the expected firm value remain unchanged after the adoption of antitakeover laws.

Otherwise, we are in the mixed-price-bidding equilibrium. In the mixed-price-bidding equilibrium, reducing the raider's private benefit has a positive effect on the manager's effort and a negative effect on the takeover probability. For the expected firm value, the positive effect always dominates the negative effect and the firm value increases with the antitakeover laws. But for the current shareholders, antitakeover laws may either improve or reduce their expected payoff, as reducing the raider's private benefit also reduces the probability of overbidding takeovers. When the manager's private benefit is large but the potential value enhancement is small ($\frac{1}{1+b} < m < 1$ and $0 < v_0 < \frac{1-b}{2}$), the current shareholders care more about motivating the manager to exert higher effort to increase the current firm value than the potential value enhancement they receive from the takeover. Thus antitakeover laws improve the current shareholders' payoff as they strengthen the manager's motivation to work. However, when the value enhancement is big ($v_0 > \frac{1-b}{2}$), the two negative effects of lower takeover efficiency and lower overbidding premium together dominate the positive effect of the manager's effort, therefore the current shareholders' overall welfare is reduced.

Our results provide one justification for the adoption of antitakeover laws, as regulators care more about the fundamental firm value rather than the interest of the current shareholders. Our results also suggest that firms are more likely to adopt antitakeover provisions when managers are entrenched and the takeover value enhancement is not large. Otherwise, antitakeover provisions do not serve the shareholders' interests.

4 Extension: manager compensation contract

In the main setting, we assume that the private benefit of control (m) is the only payoff that the manager receives to magnify the role of takeover market in disciplining management. In this section we extend our main model to incorporate a more general compensation structure for the manager, in which the manager also receives wage compensation in addition to his private benefit of control.

We now assume that at time 0, the current shareholders offer a compensation contract to the manager, $w(v)$, and this contract is publicly observed. The compensation is based on the firm value v.[20] We assume that the compensation contract takes the form that $w(1) = w$ and $w(0) = 0$, where w is a fixed wage offered by the current shareholders to the manager.[21] The compensation is paid out when the firm value is observed but before the raider offers the bidding price. Figure 3 presents the new timeline with the compensation contract.

The raider doesn't observe the firm value or the actual payment of the compensation to the manager, and she conjectures the firm value when bidding. The compensation expense reduces the firm's value by $w(v)$, therefore, the raider's optimal bidding strategy at time 1 is either a low price $\underline{p} = v_0$, or a high price $\bar{p} = 1 + v_0 - w$. Again the raider's bidding strategy depends on the raider's belief about the probability of a high firm value ($v = 1$)

[20] In an alternative setting, we allow the compensation contract to be based on the observed signal y, instead of the firm value directly, and we obtain similar results.

[21] In a risk-neutral single-period model with a binary setting, this specific contract can be shown to be optimal. The reason is that in equilibrium both the manager's effort and the raider's bidding strategy only depend on the difference of the two compensation schemes, $w(1) - w(0)$. Therefore the current shareholders can always lower $w(0)$ to zero to maximize their expected payoff, yet keeping the manager's effort and the raider's bidding strategy in the same equilibrium.

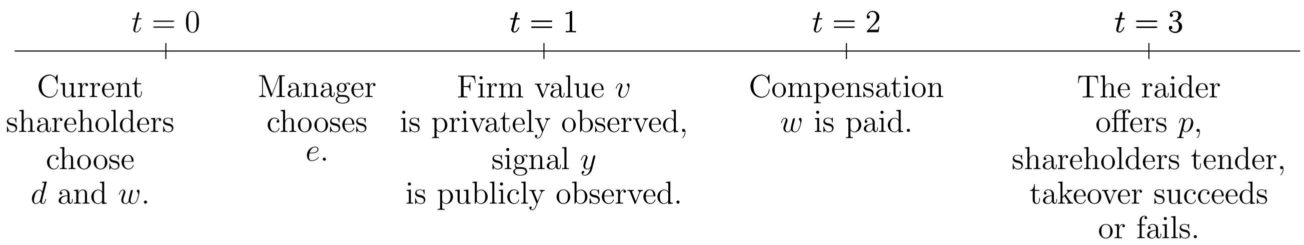


Figure 3: Timeline with compensation.

after observing the signal y ($h(y)$). The raider's expected payoffs become:

$$\begin{aligned} \pi_r(\underline{p}, y) &= [1 - h(y)]b, \\ \pi_r(\bar{p}, y) &= [1 - h(y)](b - 1 + w) + h(y)b. \end{aligned} \tag{10}$$

Comparing the two payoffs in (10), the raider bids a high price if $h(y) > \frac{1-w}{1-w+b}$, bids a low price if $h(y) < \frac{1-w}{1-w+b}$, and is indifferent between the high and low prices if $h(y) = \frac{1-w}{1-w+b}$. As w increases, $\frac{1-w}{1-w+b}$ decreases; i.e., the raider is more likely to bid a high price when the current shareholders increase the compensation incentive to motivate the manager to exert higher effort.

We denote α' to be the probability of offering a high price upon a good signal, and denote β' to be the the probability of offering a high price upon a bad signal. Following similar analysis in Lemma 1, we find that there are five cases of the raider's bidding strategy, **S1´-S5´**, depending on the raider's belief about the manager's effort level, $\hat{e}$:

- **S1´**: $\alpha' = \beta' = 1$, if $\hat{e} < \frac{d(1-w)}{d(1-w)+b-db}$;
- **S2´**: $\alpha' = 1$, $0 < \beta' < 1$, if $\hat{e} = \frac{d(1-w)}{d(1-w)+b-db}$;
- **S3´**: $\alpha' = 1$, $\beta' = 0$, if $\frac{(1-d)(1-w)}{(1-w)(1-d)+db} \leq \hat{e} \leq \frac{d(1-w)}{d(1-w)+b-db}$;
- **S4´**: $0 < \alpha' < 1$, $\beta' = 0$, if $\hat{e} = \frac{(1-d)(1-w)}{(1-w)(1-d)+db}$;
- **S5´**: $\alpha' = \beta' = 0$, if $\hat{e} \leq \frac{(1-d)(1-w)}{(1-w)(1-d)+db}$.

The manager's expected payoff given a bidding strategy becomes:

$$\Pi_m(e, \alpha', \beta') = ew + e[1 - d\alpha' - (1-d)\beta']m - \frac{e^2}{2}. \tag{11}$$

The manager is compensated for his effort through both the wage compensation and the private benefit of staying in his position. The incentive induced by wage compensation directly motivates the manager to work hard. The private benefit also disciplines the manager to work in the same way as in the main setting, because the manager receives the private benefit only when the firm value is high and the firm is not taken over. Compared with our main setting, the incentive through the private benefit is now lower because the raider is more likely to offer a higher price when she conjectures a higher effort induced by the compensation contract. The manager chooses his optimal effort level, e^*, to maximize $\Pi_m(e)$, given the anticipated bidding strategy of the raider, α' and β'. In equilibrium, the manager's optimal effort is consistent with the raider's belief, $e^* = \hat{e}$. The equilibrium manager's effort, e^*, and the raider's bidding strategy, (α'^*, β'^*), given the pre-specified information quality and the compensation contract at time 0, are presented in the following proposition. Notice that, as in the main setting without compensation, although there are multiple cases, there is only one equilibrium in each case.

Proposition 5 *Given the information quality d and the compensation contract $w(v)$,*

- ***E1**: if $w_1 \leq w < 1$, then $\alpha'^* = \beta'^* = 1$, and $e^* = w$;*
- ***E2**: if $w_2 < w < w_1$, then $\alpha'^* = 1$, $\beta'^* = \beta_1$, and $e^* = w + (1-d)(1-\beta_1)m$;*
- ***E3**: if $w_3 \leq w \leq w_2$, then $\alpha'^* = 1$, $\beta'^* = 0$, and $e^* = w + (1-d)m$;*
- ***E4**: if $w < w_3$ and $C2$ in Proposition 1 holds, or $w_4 < w < w_3$ and $C1$ in Proposition 1 holds, then $\alpha'^* = \alpha_1$, $\beta'^* = 0$, and $e^* = w + d(1-\alpha_1)m$;*
- ***E5**: if $0 \leq w \leq w_4$ and $C1$ in Proposition 1 holds, then $\alpha'^* = \beta'^* = 0$, and $e^* = w + m$,*

where w_1, w_2, w_3, and w_4 are thresholds that depend on d, b, and m; and α_1 and β_1 depend on d, m, b, w and v_0.

Proof. See Appendix. ■

In our main setting, only two of the five bidding strategy cases are in equilibrium: a mixed-price-bidding equilibrium similar to $E4$ and a low-price-bidding equilibrium similar to $E5$. In this extension, however, all five cases are possible. Both the wage compensation and the private benefit motivate the manager to work hard and thus affect the belief of the raider about the firm value. In general, when w motivates the manager very efficiently, the raider is more likely to offer a higher bidding price.

4.1 Optimal disclosure policy and compensation contract

We now examine the optimal disclosure policy and compensation contract that maximize the current shareholders' expected payoff, $\Pi_s(e^*, \alpha'^*, \beta'^*)$, and the expected firm value, $\Pi_v(e^*, \alpha'^*, \beta'^*)$, separately. Information quality plays a similar role to its role in the main setting. Increasing the information quality, on the one hand, improves the takeover efficiency; on the other hand, it might weaken the manager's incentive to work when the manager is more concerned about losing his private benefit when the takeover market is efficient. In contrast to the main setting, here, the compensation contract provides another mechanism for disciplining the manager. Increasing the compensation incentive motivates the manager to choose higher effort without sacrificing the takeover market efficiency by lowering the information quality. However, the wage compensation reduces the firm value after the takeover, and thus directly reduces the expected payoff of the current shareholders.

The optimal information quality and compensation contract for the current shareholders and the firm value are determined by comparing all five equilibria. Due to the complexity of the problem considering all five equilibria, we do not obtain close-form solutions for the optimal d_v^*, d_s^*, w_v^* and w_s^*. However, we are able to get simulation results by varying the parameter values. We will focus on the discussion of two special cases: (i) when m is relatively large, and (ii) when m is relatively small.

When m is relatively large, Figure 4 shows the simulation result of how the optimal d and w for both the current shareholders and the firm value vary with the bidder's private benefit b when $m = 0.8$ and $v_0 = 0.5$. The current shareholders prefer higher information quality than that which maximizes the firm value, $d_s^* \geq d_v^*$. In addition, Figure 4 shows that as b

gets smaller, the optimal information quality increases. These results are consistent with our results in the main setting. Moreover, the current shareholders prefer to offer higher wage incentives to the manager than that which maximizes the firm value, $w_s^* \geq w_v^* = 0$.

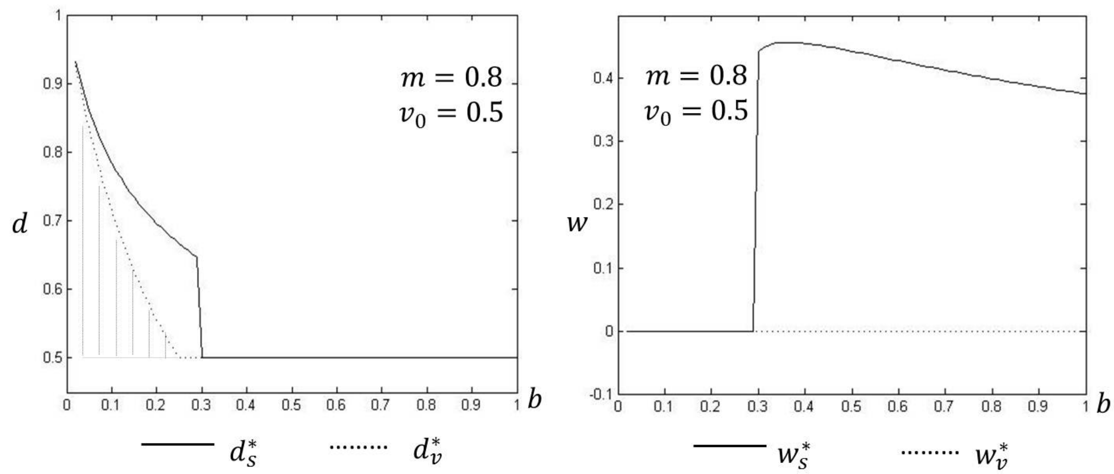


Figure 4: Simulation results of optimal d and w when m is large.

With a large m, there are two possible equilibria: a mixed-price equilibrium with the mixed-strategy bidding upon the bad signal ($E2$) and a mixed-price equilibrium with the mixed-strategy bidding upon the good signal ($E4$). To maximize the expected firm value, only equilibrium $E4$ is optimal, but for the current shareholders, either equilibrium can be optimal. In the equilibrium $E4$, the direct negative effect of increasing wage compensation on the expected firm value dominates the positive effect on the manager's effort and the raider's bidding strategy. The optimal wages for both the current shareholders' payoff and the expected firm value maximization are therefore set to the minimum level, $w_v^* = w_s^* = 0$. Thus the information quality becomes a more effective mechanism to maximize the current shareholders' expected payoff and the expected firm value. The effect of information quality in $E4$ is similar to that in the main setting, and the optimal information quality for the current shareholders is higher than that maximizes the expected firm value due to the overbidding premium.

Further increasing the wage incentive to a certain level changes the raider's belief about the manager's effort and makes high-price bidding more likely, which essentially moves the equilibrium to the other mixed-price equilibrium, $E2$. For the current shareholders, due to the overbidding premium, such a change in equilibrium can be optimal when b is relatively large, as the raider is more likely to bid aggressively and more willing to offer a high price. In the equilibrium $E2$, there is no incentive for the current shareholders to increase the information quality beyond the minimum level, as increasing the information quality only reduces the overbidding premium given that the raider already follows a high-price bidding strategy.

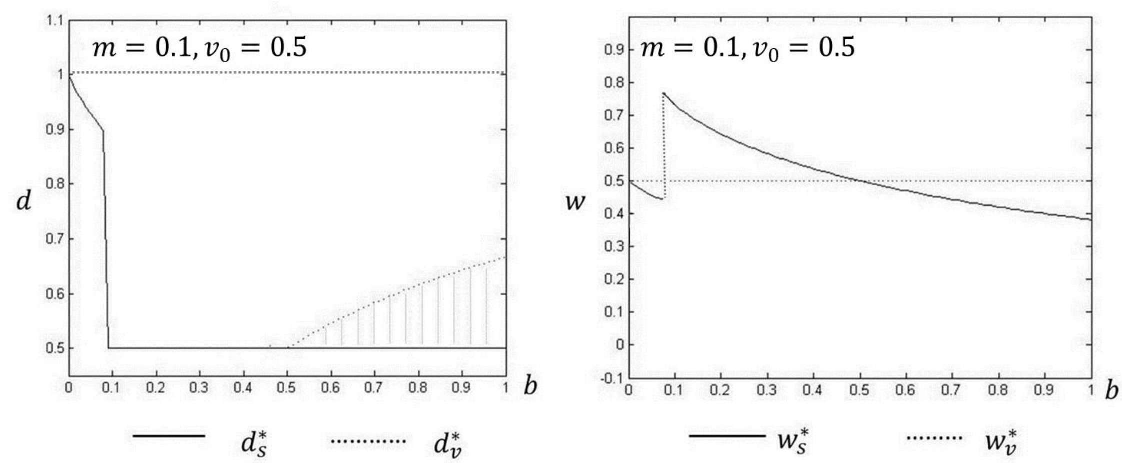


Figure 5: Simulation results of optimal d and w when m is small.

The other case we examine is when m is relatively small. Figure 5 shows the simulation results of the optimal d and w when $m = 0.1$ and $v_0 = 0.5$. In this setting we find that current shareholders may actually prefer lower information quality than that for firm value maximization (i.e., $d_v^* \geq d_s^*$), which is in contrast to our main setting. Contrary to the case when m is large, two pure strategy equilibria are now possible: a high-price-bidding equilibrium ($E1$), or a separating-price-bidding equilibrium ($E3$). This suggests that when the private benefit of the manager is small, the equilibrium shifts to the equilibrium with a higher price bidding. The reason is that the manager's effort is now primarily motivated by the wage contract and less affected by the takeover market's threat. As a result, the shareholders can rely on wage contracts to both motivate the manager and encourage the raider to bid a high price.

When the raider's private benefit (b) is small, the separating equilibrium ($E3$) is optimal. In this case, the raider bids less aggressively due to a small private benefit. Therefore both the current shareholders and firm value maximization need a high level of information quality to increase the informativeness of signals and encourage the raider to bid a high price. When b gets large, the high-price-bidding equilibrium ($E1$) becomes optimal. This is because when the raider's private benefit is large, the raider bids aggressively as the wage contract alone can signal the manager's high effort to the raider. To maximize the expected payoff, the current shareholders prefer the minimum level of information quality, $d_s^* = 1/2$, to enjoy the overbidding premium. For the firm value maximization, the information quality is irrelevant as long as the equilibrium constraint is satisfied.

5 Conclusion

This paper develops a theoretical model to examine the interaction between information quality and the takeover market as the corporate governance mechanism to discipline managers. In corporate takeovers, financial accounting information of a target firm is useful for the acquirer to assess the target firm's value when there is information asymmetry about the true value. We show that when the target firm can choose the information quality level to maximize either the expected payoff of the current shareholders or the expected firm value, some imprecise information is optimal in the presence of the takeover market. In addition, we find that the information quality that maximizes the current shareholders' payoff is different from that which maximizes the expected firm value due to the overbidding premium. To be more precise, the current shareholders actually prefer a higher level of information quality in order to receive the overbidding premium through more aggressive bidding for a low-value firm. We also analyze the effect of antitakeover laws on the optimal information quality. We find that the optimal information quality is higher after the passage of antitakeover laws, and the antitakeover laws always improve the firm value but not necessarily the current shareholders' payoff. These results have implications for the target firms' disclosure policies in the context of the takeover market.

Although we examine an extension of our main setting to incorporate the compensation contract as another disciplinary mechanism, our focus is not on the interaction between the compensation contract and takeover market. Managers' compensation is an internal governance mechanism, while the corporate takeover market is an external governance mechanism, which is applied when internal governance mechanisms are weak or ineffective. In our model, the compensation is based on the realized firm value, and the information quality does not play a direct role in the compensation contract. It would be interesting for future research to examine the role of financial information considering both internal and external governance mechanisms.

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Appendix

Proof of Lemma 1

Proof of Proposition 1

Proof. The following conditions are equivalent given the raider's belief in (6):

$$\begin{aligned} h(G, \hat{e}) &\leq \frac{1}{1+b} \;\Leftrightarrow\; \hat{e} \leq \frac{1-d}{1-d+db}, \\ h(B, \hat{e}) &\leq \frac{1}{1+b} \;\Leftrightarrow\; \hat{e} \leq \frac{d}{b+d-db}, \\ \textit{where}\; &\frac{1-d}{1-d+db} < \frac{d}{b+d-db}. \end{aligned}$$

- When the raider's belief satisfies $\hat{e} > \dfrac{d}{b+d-db}$ such that she always offers a high price, $\alpha = \beta = 1$, the manager will receive no private benefit regardless of his effort as the takeover always succeeds. Her best response is to make no effort, $e^* = 0$. Hence this cannot be an equilibrium.

- When the raider's belief satisfies

$$\frac{1-d}{1-d+db} < \hat{e} < \frac{d}{b+d-db} \tag{12}$$

  such that she offers a separating bidding strategy, i.e., $\alpha = 1$ and $\beta = 0$, the manager's expected payoff is:

$$\Pi_m(e) = e(1-d)m - \frac{e^2}{2}$$

  Thus the manager chooses the optimal effort of $e^* = (1-d)m$, which cannot satisfy the raider's belief constraint in (12), given that $0 < m < 1$.

- When the raider's belief is $\hat{e} = \dfrac{d}{b+d-db}$, the raider offers a high price when observing the good signal, $\alpha = 1$. When observing the bad signal, the raider is indifferent between two prices and she follows a mixed-bidding-strategy:

$$p(B) = \begin{cases} v_0 & \textit{with prob}\ 1-\beta \\ 1+v_0 & \textit{with prob}\ \beta \end{cases}$$

Then the manager's expected payoff is:

$$\Pi_m(e) = e(1-d)(1-\beta)m - \frac{e^2}{2}$$

The manager's optimal effort in this case is $e^* = (1-d)(1-\beta)m$. If $\hat{e} = e^*$, we get $\beta^* = 1 - \dfrac{d}{m(1-d)(b+d-db)}$. It can be shown that $\beta^* < 0$ given our assumptions about b, d, and m. Thus the mixed-bidding-strategy under the belief $\hat{e} = \dfrac{d}{b+d-db}$ cannot be an equilibrium strategy.

- When the raider's belief satisfies $\widehat{e} < \frac{1-d}{1-d+db}$ such that she always offers a low price, i.e., $\alpha = \beta = 0$, the manager's expected payoff is:

$$\Pi_m(e) = e \cdot m - \frac{1}{2}e^2.$$

  By taking the first order condition of $\Pi_m(e)$ with respect to e, we obtain the manager's optimal effort of $e^* = m$. To satisfy the raider's belief constraint, $e^* = m = \widehat{e} < \frac{1-d}{1-d+db}$ must hold, i.e., $d < \frac{1-m}{1-(1-b)m}$. Given our assumption about d, $\frac{1}{2} \leq d \leq 1$, we have $d < \frac{1-m}{1-(1-b)m}$ holds if and only if $C1$ holds, where $C1$ is $m < \frac{1}{1+b}$and $\frac{1}{2} \leq d < \frac{1-m}{1-(1-b)m}$.

- When the raider's belief is $\widehat{e} = \frac{1-d}{1-d+db}$, the raider offers a low price when observing the bad signal, $\beta = 0$. When observing the good signal, the raider is indifferent between two prices and she follows a mixed-bidding-strategy:

$$p(G) = \begin{cases} v_0 & \text{with probability } 1-\alpha \\ 1+v_0 & \text{with probability } \alpha \end{cases}$$

  Then the manager's expected payoff is:

$$\Pi_m(e) = [1-d+d(1-\alpha)] \cdot e \cdot m - \frac{1}{2}e^2.$$

  By taking the first order condition of $\Pi_m(e)$ with respect to e, we obtain the manager's optimal effort of $e^* = m(1-d\alpha)$. To satisfy the raider's belief $e^* = \widehat{e}$, $m(1-d\alpha) =$

$\frac{1-d}{1-d+db}$ must hold, i.e., $\alpha^* = \frac{1}{d}\frac{bdm-(1-d)(1-m)}{(1-d)m+bdm}$. It can be shown that $0 < \alpha^* < 1$ if and only if condition $C2$ holds, where $C2$ is $m > \frac{1}{1+b}$, or $m < \frac{1}{1+b}$ and $\frac{1-m}{1-(1-b)m} \leq d < 1$.

■

Proof of Corollary 1

Proof. In the mixed-price-bidding equilibrium, the manager's optimal effort $e^* = \frac{1-d}{1-d+db}$. The raider always offers a low price v_0 upon a bad signal, and offers a high price $1 + v_0$ with probability α^* and a low price v_0 with probability $1 - \alpha^*$ upon a good signal, where $\alpha^* = \frac{1}{d}\frac{bdm-(1-d)(1-m)}{(1-d)m+bdm}$.

Given our assumption about b, d, and m, we have

$$\frac{\partial e^*}{\partial d} = -\frac{b}{(1-d+db)^2} < 0,$$

and $$\frac{\partial \alpha^*}{\partial d} = \frac{1-m-(1-b)d\{2-d-m[2-(1-b)d]\}}{m(d-d^2+bd^2)^2} > 0. \quad ■$$

Proof of Proposition 2

Proof. Given Equations (8) and (9), according to Proposition 1, the expected payoff for the current shareholder is

$$\Pi_s = \begin{cases} e^* + (1-e^*)v_0, & \text{given } C1, \\ e^* + [1-e^*+e^*d\alpha^*]v_0 + [(1-e^*)(1-d)\alpha^*], & \text{given } C2. \end{cases}$$

The expected firm value is

$$\Pi_v = \begin{cases} e^* + (1-e^*)v_0, & \text{given } C1, \\ e^* + [1-e^*+e^*d\alpha^*]v_0 & \text{given } C2, \end{cases} \text{. where}$$

C1: $m \leq \frac{1}{1+b}$ and $d < \frac{1-m}{1-(1-b)m}$

C2: $m > \frac{1}{1+b}$, or $m \leq \frac{1}{1+b}$ *and* $d \geq \frac{1-m}{1-(1-b)m}$.

In the low-price-bidding equilibrium ($C1$ holds), $e^* = m$. In the mixed-price-bidding equilibrium ($C2$ holds), $e^* = \frac{1-d}{1-d+db}$and $\alpha^* = \frac{1}{d}\frac{bdm-(1-d)(1-m)}{(1-d)m+bdm}$.

Substituting e^* and α^* into Π_s and Π_v, we have

$$\Pi_s = \begin{cases} m + (1-m)v_0 & \text{given } C1 \\ \frac{b^2dm[1-d(1-v_0)]+(1-d)^2[m-(1-m)v_0]+b(1-d)(d+m+2dmv_0-1)}{[1-(1-b)d]^2m} & \text{given } C2 \end{cases}, \tag{13}$$

and

$$\Pi_v = \begin{cases} m + (1-m)v_0 & \text{given } C1 \\ \frac{-(1-d)^2 v_0 + [1-(1-b)d]m\{1+v_0-d[1+(1-b)v_0]\}}{[1-(1-b)d]^2 m} & \text{given } C2 \end{cases}. \tag{14}$$

It's easy to prove that Π_s and Π_v are continuous under our assumptions about b, d, m, and v_0. We will prove the following two cases separately: (1) when $m \le \frac{1}{1+b}$, and (2) when $m > \frac{1}{1+b}$.

(1). When $m \le \frac{1}{1+b}$, both low-price-bidding equilibrium and mixed-price bidding-equilibrium are possible depending on the information quality d.

- When $\frac{1}{2} < d \le \frac{1-m}{1-(1-b)m}$, the equilibrium is the low-price-bidding equilibrium. Choosing any information quality within this range yields the same payoff for both the current shareholders and the expected firm value, $\Pi_s = \Pi_v = m + (1-m)v_0$.
- When $\frac{1-m}{1-(1-b)m} \le d \le 1$, the equilibrium is the mixed-price-bidding equilibrium.

  Taking the partial derivative of Π_s with respect to d, we have $\frac{\partial \Pi_s}{\partial d} = \frac{-b[b^2dm - b(2-2d-m)+(1-d)(m-2v_0)]}{(1-d+bd)^3 m}$.

  Solving the first order condition $\frac{\partial \Pi_s}{\partial d} = 0$, we have $d_s = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$. The second order condition holds, i.e., $\frac{\partial^2 \Pi_s}{\partial d^2}|_{d_s} = \frac{-[m-(2+bm)b-2v_0]^4}{8b^2m(b+v_0)^3} < 0$

  Similarly, taking the partial derivative of Π_v with respect to d, we have $\frac{\partial \Pi_v}{\partial d} = \frac{-b[bm(1-d+bd)-2(1-d)v_0]}{(1-d+bd)^3 m}$.

  Solving the first order condition $\frac{\partial \Pi_v}{\partial d} = 0$, we have $d_v = \frac{2v_0-m}{2v_0+bm-m}$. In addition, the second order condition holds, i.e., $\frac{\partial^2 \Pi_v}{\partial d^2}|_{d_v} = \frac{-[(b-1)m+2v_0]^4}{8b^2mv_0^3} < 0$.

  Next, we need to check whether the maximum points d_s and d_v are within the feasible range of d, $d \in [\frac{1-m}{1-(1-b)m}, 1]$.

  - If $\frac{1-m}{1-(1-b)m} < d_s < 1$, i.e., $\frac{1-b}{2} < v_0 < 1$, the optimal information quality that maximizes the current shareholders' expected payoff is $d_s^* = d_s = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$.
  - If $d_s \notin (\frac{1-m}{1-(1-b)m}, 1)$, i.e., $0 < v_0 < \frac{1-b}{2}$, we need to compare Π_s at $\frac{1-m}{1-(1-b)m}$ and 1. Since $\Pi_{s,v}|_{d=\frac{1-m}{1-(1-b)m}} = m + (1-m)v_0 > \Pi_{s,v}|_{d=1} = v_0$, the optimal information quality is $\frac{1}{2} \le d_s^* < \frac{1-m}{1-(1-b)m}$, with $\Pi_s|_{d_s^*} = m + (1-m)v_0$.

In sum, the optimal information quality that maximizes the current shareholders' expected payoff when $m \leq \frac{1}{1+b}$ is

$$d_s^* = \begin{cases} [\frac{1}{2}, \frac{1-m}{1-(1-b)m}] & \text{if } 0 < v_0 \leq \frac{1-b}{2} \\ \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m} & \text{if } \frac{1-b}{2} < v_0 < 1 \end{cases}. \tag{15}$$

Similarly, we can get the optimal information quality that maximizes the expected firm value when $m \leq \frac{1}{1+b}$ as below:

$$d_v^* = \begin{cases} [\frac{1}{2}, \frac{1-m}{1-(1-b)m}] & \text{if } 0 < v_0 \leq \frac{1}{2} \\ \frac{2v_0-m}{2v_0+bm-m} & \text{if } \frac{1}{2} < v_0 < 1 \end{cases}. \tag{16}$$

(2). When $m > \frac{1}{1+b}$, only the mixed-price-bidding equilibrium is possible.

In this case we need to check whether the maximum points d_s and d_v are within the feasible range of d, $[\frac{1}{2}, 1]$.

- If $d_s = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m} \in (\frac{1}{2}, 1)$, i.e., $\frac{m(1+b)^2}{2} - b < v_0 < 1$, $d_s^* = d_s$. If $\frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m} \notin (\frac{1}{2}, 1)$, i.e., $0 < v_0 < \frac{m(1+b)^2}{2} - b$, then $d_s^* = \frac{1}{2}$ because $\Pi_s|_{d=\frac{1}{2}} > \Pi_s|_{d=1}$.
- If $d_v = \frac{2v_0-m}{2v_0+bm-m} \in (\frac{1}{2}, 1)$, i.e., $\frac{m(1+b)}{2} < v_0 < 1$, $d_v^* = d_v$. If $\frac{2v_0-m}{2v_0+bm-m} \notin (\frac{1}{2}, 1)$, i.e., $v_0 < \frac{m(1+b)}{2}$, then $d_v^* = \frac{1}{2}$ because $\Pi_v|_{d=\frac{1}{2}} > \Pi_v|_{d=1}$.

Thus when $m > \frac{1}{1+b}$, we have the following optimal information quality that maximizes the current shareholders' expected payoff and the expected firm value, respectively,

$$d_s^* = \begin{cases} \frac{1}{2} & \text{if } 0 < v_0 \leq \frac{m(1+b)^2}{2} - b \\ \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m} & \text{if } \frac{m(1+b)^2}{2} - b < v_0 < 1 \end{cases}, \tag{17}$$

and

$$d_v^* = \begin{cases} \frac{1}{2} & \text{if } 0 < v_0 \leq \frac{m(1+b)}{2} \\ \frac{2v_0-m}{2v_0+bm-m} & \text{if } \frac{m(1+b)}{2} < v_0 < 1 \end{cases}. \tag{18}$$

Combining (15)-(18), we get Proposition 2. ■

Proof of Corollary 2 Proof.

When $0 < m < \frac{1}{1+b}$:

for $0 < v_0 \le \frac{1-b}{2}$, d_s^* and d_v^* can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b)m}]$;

for $\frac{1-b}{2} < v_0 \le \frac{1}{2}$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$, and d_v^* can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b)m}]$. Since it can be proved $\frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m} > \frac{1-m}{1-(1-b)m}$, we have $d_s^* > d_v^*$;

for $\frac{1}{2} < v_0 \le 1$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$, and $d_v^* = \frac{2v_0-m}{2v_0+bm-m}$, and $d_s^* > d_v^*$ holds.

When $\frac{1}{1+b} \le m < 1$:

for $0 < v_0 \le \frac{m(1+b)^2}{2} - b$, $d_s^* = d_v^* = \frac{1}{2}$;

for $\frac{m(1+b)^2}{2} - b < v_0 \le \frac{m(1+b)}{2}$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m} > d_v^* = \frac{1}{2}$;

for $\frac{m(1+b)}{2} < v_0 \le 1$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$and $d_v^* = \frac{2v_0-m}{2v_0+bm-m}$, $d_s^* > d_v^*$ holds.

Combining all cases, we conclude that $d_s^* \ge d_v^*$. ■

Proof of Proposition 3

Proof.

We only show the proof for the change of the optimal information quality, d_s^*, that maximizes the current shareholders' payoff. Similar proof follows for the optimal information quality, d_v^*, that maximizes the expected firm value.

Suppose the raider's private benefit b decreases to b' after antitakeover laws, where $0 < b' < b < 1$. The optimal information quality levels for the current shareholders are d_s^* and d_s^{**} before and after the antitakeover laws, respectively.

(1). When $0 < m < \frac{1}{1+b}$:

- For $0 < v_0 \le \frac{1-b}{2}$, according to Proposition 2, d_s^* can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b)m}]$; d_s^{**} can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b')m}]$. Since $b' < b$, we can show that $\frac{1-m}{1-(1-b)m} < \frac{1-m}{1-(1-b')m}$. d_s^{**} varies in a larger range than d_s^*.
- For $\frac{1-b}{2} < v_0 \le \frac{1-b'}{2}$, according to Proposition 2, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$; d_s^{**} can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b')m}]$. It can be shown that $\frac{1-m}{1-(1-b')m} > \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$. Therefore d_s^{**} could be higher than d_s^*.
- For $\frac{1-b'}{2} < v_0 \le 1$, according to Proposition 2, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$and $d_s^{**} = \frac{b'(2-m)-m+2v_0}{b'(2+b'm)+2v_0-m}$. It can be shown that $d_s^{**} > d_s^*$.

Notice that as $b \to 0$, for $0 < v_0 \le \frac{1}{2}$, $d_s^*$and d_s^{**} can be any value in the range $[\frac{1}{2}, 1]$; for $v_0 > \frac{1}{2}$, $d_s^* \to 1$ and $d_s^{**} \to 1$.

(2). When $\frac{1}{1+b} \le m < \frac{1}{1+b'}$:

we need to consider two cases: (i) $b > \frac{1+\sqrt{1-(1+b')m}}{m} - 1$, and (ii) $b \le \frac{1+\sqrt{1-(1+b')m}}{m} - 1$.

- If $b > \frac{1+\sqrt{1-(1+b')m}}{m} - 1$, we have $\frac{1-b'}{2} < \frac{m(1+b)^2}{2} - b$.
  - For $0 < v_0 \le \frac{1-b'}{2}$, according to Proposition 2, $d_s^* = \frac{1}{2}$and d_s^{**} can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b')m}]$. Therefore $d_s^{**} \ge d_s^*$).
  - For $\frac{1-b'}{2} < v_0 \le \frac{m(1+b)^2}{2} - b$, according to Proposition 2, $d_s^* = \frac{1}{2}$ and $d_s^{**} = \frac{b'(2-m)-m+2v_0}{b'(2+bm)+2v_0-m}$. Therefore $d_s^{**} > d_s^*$.
  - For $\frac{m(1+b)^2}{2} - b < v_0 \le 1$, according to Proposition 2, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$and $d_s^{**} = \frac{b'(2-m)-m+2v_0}{b'(2+bm)+2v_0-m}$. It can be shown that $d_s^{**} > d_s^*$.
- If $b \le \frac{1+\sqrt{1-(1+b')m}}{m} - 1$, we have $\frac{1-b'}{2} \ge \frac{m(1+b)^2}{2} - b$.
  - For $0 < v_0 \le \frac{m(1+b)^2}{2} - b$, according to Proposition 2, $d_s^* = \frac{1}{2}$; d_s^{**} can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b')m}]$. Therefore $d_s^{**} \ge d_s^*$.
  - For $\frac{m(1+b)^2}{2} - b < v_0 \le \frac{1-b'}{2}$, according to Proposition 2, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$; d_s^{**} can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b')m}]$. It can be shown that $\frac{1-m}{1-(1-b')m} > \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$, thus d_s^{**} could be higher than d_s^*.
  - For $\frac{1-b'}{2} < v_0 \le 1$, according to Proposition2, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$ and $d_s^{**} = \frac{b'(2-m)-m+2v_0}{b'(2+bm)+2v_0-m}$. It can be shown that $d_s^{**} > d_s^*$.

(3). When $\frac{1}{1+b'} \le m < 1$:

- For $0 < v_0 \le \frac{m(1+b')^2}{2} - b'$, according to Proposition 2, $d_s^* = d_s^{**} = \frac{1}{2}$.
- For $\frac{m(1+b')^2}{2} - b' < v_0 \le \frac{m(1+b)^2}{2} - b$, according to Proposition 2, $d_s^* = \frac{1}{2}$and $d_s^{**} = \frac{b'(2-m)-m+2v_0}{b'(2+bm)+2v_0-m}$. It can be shown $d_s^{**} > d_s^*$.
- For $\frac{m(1+b)^2}{2} - b < v_0 \le 1$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$, and $d_s^{**} = \frac{b'(2-m)-m+2v_0}{b'(2+bm)+2v_0-m}$. It can be shown $d_s^{**} > d_s^*$.

Combining all above cases, we get $d_s^{**} \ge d_s^*$ for any $b' < b$. ■

Proof of Proposition 4

Proof. The shareholder's expected payoff Π_s and the expected firm's value Π_v in equilibrium are given by (13) and (14), respectively. Given the optimal information quality d_s^* derived in Propostion 2, we have the following analysis.

(1). When $0 < m < \frac{1}{1+b}$:

- For $0 < v_0 \leq \frac{1-b}{2}$, d_s^* can be any value in the range $[\frac{1}{2}, \frac{1-m}{1-(1-b)m}]$. $\Pi_v|_{d=d_s^*} = \Pi_s|_{d=d_s^*} = m + v_0 - mv_0$. Decreasing b does not affect both Π_v and Π_s.
- For $\frac{1-b}{2} < v_0 \leq 1$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$. We have $\Pi_v|_{d=d_s^*} = \frac{b^2[m(2-v_0)+4v_0]+(2b+v_0)(m+4v_0^2)}{4(b+v_0)^2}$, and $\Pi_s|_{d=d_s^*} = v_0 + \frac{(1+b)^2 m}{4(b+v_0)}$.

  Taking the partial derivative of $\Pi_v|_{d=d_s^*}$ and $\Pi_s|_{d=d_s^*}$ with respect to b, we have $\frac{\partial \Pi_v|_{d=d_s^*}}{\partial b} = \frac{-bm(1-v_0)^2}{2(b+v_0)^3} < 0$, and $\frac{\partial \Pi_s|_{d=d_s^*}}{\partial b} = \frac{(1+b)m(b+2v_0-1)}{4(b+v_0)^2} > 0$. Therefore, as b decreases, $\Pi_v|_{d=d_s^*}$ increases and $\Pi_s|_{d=d_s^*}$ decreases.

(2). When $\frac{1}{1+b} \leq m < 1$:

- For $0 < v_0 \leq \frac{1-b}{2}$, $d_s^* = \frac{1}{2}$. We have $\Pi_v|_{d=d_s^*} = \frac{(1+b)m(1+v_0+bv_0)-v_0}{m(1+b)^2}$ and $\Pi_s|_{d=d_s^*} = \frac{m+b(-1+(2+b)m)-v_0+(1+b)^2 mv_0}{m(1+b)^2}$.

  Taking the partial derivative of $\Pi_v|_{d=d_s^*}$ and $\Pi_s|_{d=d_s^*}$ with respect to b, we have $\frac{\partial \Pi_v|_{d=d_s^*}}{\partial b} = \frac{2v_0-(1+b)m}{m(1+b)^3} < 0$; $\frac{\partial \Pi_s|_{d=d_s^*}}{\partial b} = \frac{2v_0-1+b}{m(1+b)^3} < 0$. Therefore, as b decreases, $\Pi_v|_{d=d_s^*}$ increases, and $\Pi_s|_{d=d_s^*}$ increases.
- For $\frac{1-b}{2} < v_0 \leq \frac{m(1+b)^2}{2} - b$, $d_s^* = \frac{1}{2}$. We have $\Pi_v|_{d=d_s^*} = \frac{(1+b)m(1+v_0+bv_0)-v_0}{m(1+b)^2}$ and $\Pi_s|_{d=d_s^*} = \frac{m+b(-1+(2+b)m)-v_0+(1+b)^2 mv_0}{m(1+b)^2}$.

  Taking the partial derivative of $\Pi_v|_{d=d_s^*}$ and $\Pi_s|_{d=d_s^*}$ with respect to b, we have $\frac{\partial \Pi_v|_{d=d_s^*}}{\partial b} = \frac{2v_0-(1+b)m}{m(1+b)^3} < 0$; $\frac{\partial \Pi_s|_{d=d_s^*}}{\partial b} = \frac{2v_0-1+b}{m(1+b)^3} > 0$. Therefore, as b decreases, $\Pi_v|_{d=d_s^*}$ increases, and $\Pi_s|_{d=d_s^*}$ decreases.
- For $\frac{m(1+b)^2}{2} - b < v_0 \leq 1$, $d_s^* = \frac{b(2-m)-m+2v_0}{b(2+bm)+2v_0-m}$. We have $\Pi_v|_{d=d_s^*} = \frac{b^2[m(2-v_0)+4v_0]+(2b+v_0)(m+4v_0^2)}{4(b+v_0)^2}$, and $\Pi_s|_{d=d_s^*} = v_0 + \frac{(1+b)^2 m}{4(b+v_0)}$.

  Taking the partial derivative of $\Pi_v|_{d=d_s^*}$ and $\Pi_s|_{d=d_s^*}$ with respect to b, we have $\frac{\partial \Pi_v|_{d=d_s^*}}{\partial b} = \frac{-bm(1-v_0)^2}{2(b+v_0)^3} < 0$, and $\frac{\partial \Pi_s|_{d=d_s^*}}{\partial b} = \frac{(1+b)m(b+2v_0-1)}{4(b+v_0)^2} > 0$. Therefore, as b decreases, $\Pi_v|_{d=d_s^*}$ increases and $\Pi_s|_{d=d_s^*}$ decreases.

Combining all the cases, we get Proposition 4. ■

Proof of Proposition 5

Proof. The raider follows the bidding strategy, (α', β'), in $S1' - S5'$. Given the raider's bidding strategy, the manager maximizes his expected payoff in (11). The first order condition gives the manager's optimal effort for any bidding strategy, (α', β'),

$$e^* = w + m[1 - d\alpha' - (1-d)\beta']. \tag{19}$$

Given any pre-specified information quality d and compensation contract w, we have the following five cases:

(1). If the raider's belief satisfies $\widehat{e} > \frac{d(1-w)}{d(1-w)+b-db}$, the raider's strategy is $\alpha' = \beta' = 1$ ($S1'$). Substituting (α', β') into (19), we get the manager's optimal effort $e^* = w$. The raider's belief needs to be consistent with the manager's optimal effort, $e^* = \hat{e}$, i.e., $w \geq \frac{d(1-w)}{d(1-w)+b-db} \Rightarrow w \geq \frac{b+2d-bd-\sqrt{b(1-d)[b+(4-b)d]}}{2d}$.

Therefore if the compensation contract satisfies $1 > w \geq w_1 \equiv \frac{b+2d-bd-\sqrt{b(1-d)[b+(4-b)d]}}{2d}$, we get the equilibrium $E1$, where $\alpha'^* = \beta'^* = 1$ and $e^* = w$.

(2). If the raider's belief satisfies $\widehat{e} = \frac{d(1-w)}{d(1-w)+b-db}$, the raider's strategy is $\alpha' = 1$, $0 < \beta' < 1$ ($S2'$). Substituting (α', β') into (19), we get the manager's optimal effort $e^* = m(1-d)(1-\beta') + w$. The raider's belief needs to be consistent with the manager's optimal effort, $e^* = \hat{e}$, i.e., $m(1-d)(1-\beta')+w = \frac{d(1-w)}{d(1-w)+b-db} \Rightarrow \beta' = 1+\frac{1}{m}(\frac{b}{b+d-bd-dw} - \frac{1-w}{1-d})$. β' needs to satisfy $0 < \beta' < 1$. It follows that $\frac{b+md^2+d(2-b-m)-\sqrt{(1-d)\{(b^2+d^2m^2)(1-d)+2bd[2+m(1-d)]\}}}{2d} < w < w_1$.

Therefore if the compensation contract satisfies $w_2 < w < w_1$, where $w_1 = \frac{b+2d-bd-\sqrt{b(1-d)[b+(4-b)d]}}{2d}$ and $w_2 = \frac{b+md^2+d(2-b-m)-\sqrt{(1-d)\{(b^2+d^2m^2)(1-d)+2bd[2+m(1-d)]\}}}{2d}$, we get the equilibrium $E2$, where $\alpha'^* = 1$, $\beta'^* = 1 + \frac{1}{m}(\frac{b}{b+d-bd-dw} - \frac{1-w}{1-d})$ and $e^* = m(1-d)(1-\beta'^*) + w$.

(3). If the raider's belief satisfies $\frac{(1-d)(1-w)}{(1-d)(1-w)+db} < \widehat{e} < \frac{d(1-w)}{d(1-w)+b-db}$, the raider's strategy is $\alpha' = 1$ and $\beta' = 0$ ($S3'$). Substituting (α', β') into (19), we get the manager's optimal effort $e^* = m(1-d) + w$. The raider's belief needs to be consistent with the manager's optimal effort, $e^* = \hat{e}$, we get $\frac{1}{2}[2+\frac{bd}{1-d}-m(1-d)-\sqrt{\frac{bd[4-(4-b)d]}{(1-d)^2}+2bdm+(1-d)^2m^2}] \equiv w_3 \leq w \leq w_2$.

Therefore if the compensation contract satisfies $w_3 < w \leq w_2$, we get the equilibrium $E3$, where $\alpha'^* = 1$, $\beta'^* = 0$ and $e^* = m(1-d) + w$.

(4). If the raider's belief satisfies $\widehat{e} = \frac{(1-d)(1-w)}{(1-d)(1-w)+db}$, the raider's strategy is $0 < \alpha' < 1$, $\beta' = 0$ ($S4'$). Substituting (α', β') into (19), we get the manager's optimal effort $e^* = m(1-d\alpha') + w$. The raider's belief needs to be consistent with the manager's optimal effort, $e^* = \hat{e}$, i.e., $m(1-d\alpha') + w = \frac{(1-d)(1-w)}{(1-d)(1-w)+db} \Rightarrow \alpha' = \frac{1}{m}(\frac{b}{1-w-d(1-b-w)} - \frac{1-m-w}{d})$. α' needs to satisfy $0 < \alpha' < 1$. It follows that if $C2$ in Proposition 1 holds, $w < w_3$; otherwise $C1$ in Proposition 1 holds and $w_4 < w < w_3$, where $w_4 = \frac{2-m-d(2-b-m)-\sqrt{b^2d^2+(1-d)^2m^2+2bd(1-d)(2+m)}}{2(1-d)}$.

Therefore if $C2$ in proposition 1 holds and the compensation contract satisfies $w > w_3$; or if $C1$ in Proposition 1 holds and $w_4 < w < w_3$, we get the equilibrium $E4$, where $\alpha'^* = \frac{1}{m}(\frac{b}{1-w-d(1-b-w)} - \frac{1-m-w}{d}$, $\beta'^* = 0$ and $e^* = m(1-d\alpha'^*) + w$.

(5). If the raider's belief satisfies $\widehat{e} < \frac{(1-d)(1-w)}{(1-d)(1-w)+db}$, the raider's strategy is $\alpha' = 0$ and $\beta' = 0$ ($S5'$). Substituting (α', β') into (19), we get the manager's optimal effort $e^* = w + m$. The raider's belief needs to be consistent with the manager's optimal effort, $e^* = \hat{e}$. It follows that $w \leq w_4$ and $C1$ in Proposition 1 holds.

Therefore $C1$ in Proposition 1 holds and the compensation contract satisfies $w \leq w_4$, we get the equilibrium $E5$, where $\alpha'^* = 0$, $\beta'^* = 0$ and $e^* = m + w$.

■