Performance Pay, CEO Dismissal and the Dual Role of Takeovers*

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Abstract

We propose that an active takeover market also provides incentives by offering acquisition opportunities to successful managers. This allows firms to reduce perfomance-based compensation and can rationalize loss-making acquisitions. At the same time, takeovers remain a substitute to board dismissal for the replacement of poorly performing managers. The joint impact of the two mechanisms on managerial turnover is, however, multi-faceted: In firms with strong boards, turnover and performance-based pay are non-monotonic in the intensity of the takeover threat. In firms with weak boards, turnover (performance-based pay) increases (decreases) with the intensity of the takeover threat. When choosing the quality of its board, each firm does not take into account the effect on other firms' acquisition opportunities. As a result, there is excessive board interference in equilibrium and too few takeovers occur.

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1 Introduction

An active takeover market is commonly considered to create value by redeploying corporate assets. A plethora of empirical studies documents that target shareholders as well as target and acquiring shareholders taken together benefit from takeovers (Andrade et al., 2001). Moreover, an active market for corporate control also affects managerial behavior. In particular, the threat of a takeover is seen to discipline incumbent managers, thereby reducing agency costs (Jensen, 1986, and Scharfstein, 1988).[1]

This paper takes a new look at the incentive implications of takeovers. While extant work emphasizes the risk of being a target, we want to draw attention to the flip side, namely the prospect of acquiring another firm. We therefore posit that the market for corporate control shapes managerial incentives through two channels, the takeover threat and the acquisition opportunity. Taking both these sides into account, we derive the optimal quality of internal governance in a single-firm setting. We also analyze how firms' governance choices and takeover activity interact in equilibrium.

More specifically, we consider a simple two-period moral hazard model in which a firm hires a manager whose ability is unknown to all parties. First-period performance is a function of both managerial effort and ability. Second-period performance only depends on ability, and dismissing an incompetent manager increases expected second-period profits. A manager who is deemed competent retains his job for the second period and may in addition have the possibility to acquire another firm. Managers are induced to exert effort explicitly through performance-based compensation and implicitly through future private benefits. As managers enjoy more private benefits from running larger firms, acquisition opportunities provide (additional) incentives. This in turn mitigates moral hazard and the need to offer performance-based compensation. Thus, the market for corporate control can benefit shareholders even in the absence of disciplinary takeovers, i.e., even if incompetent managers are never retained.

This insight has implications for firms' acquisition policies. When shareholders, or the board of directors on their behalf, decide on the acquisition budget, they face a trade-off: on the one hand, more funds enable the manager to undertake also a (more) unprofitable takeover. On the other hand, a larger budget increases the chance of making an acquisition and therefore provides more incentives. Due to the latter effect, the optimal acquisition budget never permits only profitable acquisitions but always allows for some unprofitable takeovers as well.[2] Our model predicts an inverse relationship between (managerial discretion over) the acquisition budget and (performance-based) CEO pay,

[1] Though the literature also points out potential inefficiencies of the takeover threat. For instance, Stein (1988) and Shleifer and Summers (1988) argue that takeover pressure can lead to distorted investment decisions.

[2] Contrary to the literature on empire building, acquisitions are here a remedy rather than a source of incentive problems. However, our model assumes that shareholders have the control over the acquisition budget. This precludes takeovers against the shareholders' best interest in equilibrium.

and worse acquisition performances for firms with larger budgets.[3]

For the sake of clarity, we derive the acquisition opportunity effect in a simplified setting in which disciplinary takeovers play no role as incompetent managers are always dismissed by the board. To explore the interaction between board quality and the takeover market, we extend the framework in two ways: First, we let the firm choose the quality of its internal governance, modeled as the probability that an incompetent manager is dismissed by the board. Second, a firm can be a potential acquirer or target, depending on its first-period performance. Board interference and (hostile) takeovers are both means to dismiss incompetent managers and jointly determine managerial turnover. Since board interference is costly to the firm, more intense takeover pressure crowds out internal governance. Better prospects of selling the firm reduce the cost of retaining an incompetent manager and hence the benefits of good internal governance.

While takeovers and boards are substitutes with respect to disciplining managers as in e.g., Hirshleifer and Thakor (1998), their combined impact on managerial turnover and performance-based compensation is more complex. In particular, more takeover pressure can exacerbate the agency problem and necessitate more performance-based pay. When board interference is not very costly, the quality of internal governance is high, and introducing a small takeover probability entails a strong crowding out effect. As a result, an incompetent manager is less likely to retain his job in the absence of disciplinary takeovers compared to being exposed to a small takeover risk.[4] When the takeover risk is sufficiently large, increases in the takeover probability always lead to higher managerial turnover. Thus, we obtain a non-monotonic relation between takeover threat and managerial turnover when internal governance is intrinsically strong. This in turn translates into a non-monotonic relation between takeover threat and performance-based compensation, as compensation is inversely related to managerial turnover. By contrast, when internal governance is costly and hence weak, more takeover pressure always increases the overall dismissal risk. Therefore, the relation between takeover threat and managerial turnover (performance-based pay) is always positive (negative) in this case.

In the last part of the paper we show how governance externalities can arise through interactions in the takeover market. To this end, we consider a large number of ex-ante identical firms whose role in the takeover market depends on their first-period cash flows. Poorly performing firms become potential targets and well performing firms are potential acquirers. In equilibrium firms choose too much board interference (quality) but too small acquisition budgets. On the one hand, each firm fails to internalize that improvements in its board reduce the acquisition opportunities for other firms. On the other hand, each

[3]Harford (1999) finds that high-cash firms make more acquisitions than other firms and that those acquisitions have lower announcement returns.

[4]In support of this prediction, Huang and Zhao (2009) document that the sensitivity of CEO turnover to performance increases in firms with strong boards following the passage of antitakeover legislation.

firm does not take into account that a larger budget would strengthen the takeover threat to other firms and discipline their managers.

Our paper is related to theoretical work on takeovers, boards of directors and governance spillovers. While takeovers are but a threat to incumbent managers in existing takeover models, we argue that they are also opportunities which offer implicit incentives. In Almazan and Suarez (2003) a weak board is optimal when incentive provision through future control rents is cheaper than through incentive pay. In our model a weak board exacerbates the agency conflict within the firm but creates an acquisition opportunity, thereby mitigating agency problems in other firms.

Hirshleifer and Thakor (1998) also analyze the joint functioning of board dismissals and takeovers. In their model, the acquirer can replace the manager and in addition dismiss the board. Due to this latter possibility, the takeover market and board interference are complements when the costs of removing the board are low. When these costs are sufficiently large, internal and external control mechanisms are substitutes as in our model where the position of the board is never under threat. Our paper further differs from theirs by exploring the dual role of the takeover market and the joint impact of board dismissal and takeovers on managerial turnover and performance-based compensation.

Finally, several recent papers study the interaction between firms' choices of corporate governance. Acharya and Volpin (2009) identify an externality that operates through the competition for scarce managerial talent. To incentivize managers, firms with weaker governance offer more generous compensation packages. To remain attractive employers, other firms also have to pay high(er) salaries, which reduces the benefits of investing in corporate governance. As a result, the overall governance in the economy is too weak. Dicks (2008) also derives a governance externality operating through executive compensation and explores its regulatory implications. Cheng (2008) explores governance spillovers in a setting where relative performance evaluation provides incentives for managers to manipulate earnings. Our model differs form these as the governance externality operates through the takeover market rather than the managerial labour market or CEO compensation.

The next section presents the basic model. Section 3 develops the acquisition opportunity effect. Section 4 analyzes the interactions between takeovers and board interference and their implications for CEO turnover and compensation. Section 5 studies the link between the firms' governance arrangements and the takeover market outcome. Concluding remarks are in Section 6. All mathematical proofs are in the Appendix.

2 Model

We consider a moral hazard problem with two periods of production. A firm hires a manager who is either competent or incompetent. As in Holmström (1982) or Gibbons

and Murphy (1992), the manager's type $\theta \in (\underline{\theta}, \bar{\theta})$ is initially unknown even to him. All parties hold the common prior $p \in (0,1)$ that the manager is competent ($\theta = \bar{\theta}$). Everyone is risk-neutral and there is no discounting.

Once hired, the manager chooses a non-observable effort $e \in \{e_l, e_h\}$. He enjoys private benefits Z_1 if he exerts low effort ($e = e_l$). At the end of the first period, the cash flow $X_1 \in \{0, X_1^H\}$ realizes which is contractible and depends on both managerial ability and effort. Let $q_i(\theta) = \Pr[X_1 = X_1^H \mid e_i, \theta]$ denote the probability of a high cash flow given managerial ability θ and effort e_i.

Assumption 1 $q_l(\underline{\theta}) = q_h(\underline{\theta}) = q_l(\bar{\theta}) = 0$ *and* $q_h(\bar{\theta}) = 1$.

A competent manager generates a high cash flow only if he works. A richer technology where a competent manager sometimes fails despite high effort or an incompetent one sometimes succeeds would not qualitatively change our results. Shareholders receive the cash flow X_1 net of any wage paid to the manager.

If the manager is retained after the first period, he receives private benefits $Z_2 > 0$ and produces a second-period cash flow $X_2 \in \{0, X_2^H\}$ which only depends on his ability: a competent manager produces $X_2 = X_2^H$, whereas an incompetent manager produces 0. A retained manager finds a potential takeover target with probability ρ^a which he can acquire if he has sufficient funds. The acquisition budget is part of the contract that the manager accepts at the outset (see below). Following a successful bid the manager enjoys additional private benefits $\Delta Z_2 > 0$ from running a larger firm in the second period. Let $X_2^a \in \{0, X_2^H\}$ be the gross return to acquiring shareholders from a successful takeover which is determined by the ability of their manager: if θ equals $\bar{\theta}$, the gross return is X_2^H. If θ equals $\underline{\theta}$, it is zero. Hence, the firm simply doubles its scale with an acquisition. For simplicity, we abstract from incentive or coordination problems in the acquisition process and simply assume a (for now exogenous) purchase price $P^a \leq X_2^H$. Besides the price, a successful transaction imposes a takeover (or retooling) cost c. The cost c is random and drawn from a commonly known uniform distribution function $F(c)$ on $[0, \overline{c}]$; its realization is publicly observed prior to the takeover bid. Overall, the net return to shareholders from an acquisition is $X_2^a - c - P^a$.

If the manager is dismissed at the end of the first period, a new manager of unknown ability is hired and expected second-period cash flow is pX_2^H. For simplicity, a newly hired manager cannot undertake an acquisition. This assumption could be relaxed without qualitatively affecting our results. Furthermore, we restrict the takeover cost:

Assumption 2 $X_2^H - \frac{1}{2}\overline{c} \geq pX_2^H$.

Acquisition opportunities will be used as an incentive device only if the potential losses from an acquisition are not too large. As will become clear below, this is ensured

by the above assumption. It states that the expected profit that a competent manager creates in an acquired firm is at least equal to the value created by a new manager.

Throughout the paper we assume that the board takes the decisions on behalf of the shareholders and does so in their best interest. At the hiring stage, the board offers the manager a contract, comprising a compensation scheme and an acquisition rule. The compensation scheme stipulates payments to the manager contingent on the firm's cash flow. Since the manager takes no actions in the second period, there is no role for second-period wage payments. Let (w_H, w_L) denote the payments in case of first-period success and failure respectively neither of which can be negative.

The acquisition rule amounts to an acquisition budget over which the manager has complete discretion when undertaking a takeover. The budget is contingent on first-period performance. Let (L_H, L_L) be the non-negative budgets in case of first-period success and failure, respectively. The manager can only carry out a takeover if the budget covers the total acquisition cost $c + P^a$.[5]

To sum up, the timing of the game is as follows: (i) The parties sign a contract (w_H, w_L, L_H, L_L) and the manager chooses an unobservable effort level $e \in \{e_l, e_h\}$. (ii) First-period cash flow $X_1 \in \{0, X_1^H\}$ realizes and is publicly observed. (iii) The board decides to retain or dismiss the manager. (iv) If retained, the manager finds a potential takeover target with probability ρ^a, in which case (c, P^a) is publicly observed. (v) A takeover may or may not occur and second-period cash flow realizes.

Finally, we want to ensure that shareholders always find it optimal to induce high effort.

Assumption 3 $p\left[X_1^H + (1-p)X_2^H\right] \geq Z_1$.

High effort is surely in the shareholders' interest if the disutility of effort is smaller than its expected benefits. A high effort is not only a prerequisite for a high cash flow in the first period but may also allow to infer the manager's ability (whereas nothing is learned if the manager exerts low effort). Hence, high effort increases the expected payoff in the second-period by $(1-p)X_2^H$. The assumption is stricter than necessary as it abstracts from the manager's future private benefits and the potential gains from an acquisition.

The above framework captures in a simple manner the notion of corporate governance as a mechanism that "selects the most able managers and makes them accountable to investors" (Tirole, 2001). Following first-period performance, shareholders update their beliefs about the manager's ability. If they suspect him to be unsuitable a new manager can be hired. Indeed, Cornelli et al. (2010) find that boards fire CEOs once they have

[5] From the condition $L > c + P^a$ it is clear that contracting on an acquisition budget is equivalent to contracting on a cut-off rule for the cost c. More generally, we can allow the parties to contract on all variables save of the effort choice.

come to view them as incompetent. In our setting, the level of competence refers to general managerial skills. If a manager proved his competence in one firm, he can also successfully manage a rival following a takeover. This feature is consistent with Kaplan et al. (2008) who study hiring decisions in LBO and venture capital firms and find that these decisions are driven by general or transferable managerial skills.

We do not explicitly model the labor market in which firms can compete for a competent manager at the interim date. However, the private benefit Z_2 can be interpreted as the outcome of a bargaining game between a competent manager and shareholders whereby the former obtains part of the surplus that he generates compared to a random outside replacement.

3 Acquisitions and CEO Incentives

This section analyzes the optimal compensation scheme and acquisition policy taking the probability of finding a potential target and the purchase price as given. To start with, suppose that the incentive compatibility constraint of the manager is satisfied. Given that the manager exerts high effort, the first-period cash flow perfectly reveals his ability. Hence, the posterior belief that the manager is competent $p(X_1)$ equals zero following poor performance and one following a high performance.

The firing decision after the first period influences firm value in two ways. It determines the ability of the manager in the second period and thus X_2 (ex-post effect). In addition, it affects the manager's incentive to exert effort because he receives private benefits if retained (ex-ante effect). It is straightforward to see that the optimal firing policy is to dismiss the manager unless $X_1 = X_1^H$. An incompetent manager never produces positive profits in the second period ($X_2^a = X_2 = 0$), whereas hiring a new manager generates expected cash flow of pX_2^H. Furthermore, it is also optimal to punish poor performance from an ex-ante perspective. Given that poor performance triggers dismissal, the choice of the corresponding budget L_L is immaterial and is subsequently ignored. The only caveat against retaining a successful manager is the risk that he subsequently incurs excessive losses in an acquisition. Indeed, a manager always favours an acquisition because of the additional private benefits ΔZ_2. However, (very) poor acquisitions can be avoided through a tight(er) acquisition budget.

A retained manager is competent and finds with probability ρ^a a target. Provided that the acquisition budget exceeds the total cost, i.e., that $L_H \geq c + P^a$, he purchases the target and gets additional private benefits ΔZ_2. The expected second-period profit

from retaining a successful manager with an acquisition budget L_H is

$$\pi_2(L_H) \equiv X_2^H + \rho^a \left[\int_0^{L_H - P^a} (X_2^H - P^a - c) f(c) dc \right]$$

where the integral corresponds to the expected net profit from a takeover.

Having established the outcome for competent and incompetent managers, we can derive the contract offered at the outset of the game. By Assumption 3 shareholders find it optimal to induce high effort. As it is never beneficial to reward poor performance, the wage in case of a low first-period cash flow w_L is set to zero. Given the acquisition budget following poor performance is immaterial, the shareholders' expected payoff simplifies to

$$p\left[X_1^H - w_H + \pi_2(L_H)\right] + (1-p)pX_2^H$$

With probability p the manager turns out to be competent and produces a first-period profit of X_1^H net of his wage plus $\pi_2(L_H)$ in the second-period. With probability $(1-p)$ the manager is incompetent, and the expected second-period cash flow under the newly hired manager is pX_2^H. The manager's incentive compatibility constraint is:

$$p\left[w_H + Z_2 + \rho^a F(L_H - P^a) \triangle Z_2\right] \geq Z_1$$

If the manager works and turns out to be competent he receives expected private benefits $Z_2 + \rho^a F(L_H - P^a)\triangle Z_2$ in addition to his (non-negative) wage w_H. Recall that the manager does not know his own type when choosing his effort. Rearranging the IC constraint we find

$$w_H \geq \frac{Z_1}{p} - \left[1 + \rho^a F(L_H - P^a)\triangle\right] Z_2.$$

Future private benefits serve as an implicit incentive to exert effort. In particular, the takeover market relaxes the IC constraint by offering additional private benefits with probability $\rho^a F(L_H - P^a)$. The positive effect on incentives arises because first-period success is a prerequisite for making an acquisition. Since the objective function is decreasing in w_H, the incentive compatibility constraint determines the optimal wage unless the constraint $w_H \geq 0$ binds. If the implicit incentives as measured by $\left[1 + \rho^a F(L_H^* - P^a)\triangle\right] Z_2$ are sufficiently large, the optimal wage is zero. In the following, we focus on the case where the IC constraint binds.

Assumption 4 $Z_1 > p(1 + \triangle)Z_2$.

Given that monetary incentives are necessary to ensure effort provision, the following result holds:

Lemma 1 *The optimal wage is*

$$\widetilde{w}_H = \frac{Z_1}{p} - \left[1 + \rho^a F(L_H^* - P^a)\triangle\right] Z_2 \qquad \textit{and} \qquad \widetilde{w}_L = 0,$$

and the optimal acquisition budget for a successful manager is

$$\widetilde{L}_H = X_2^H + \triangle Z_2.$$

The wage is increasing in the private benefits from shirking and decreasing in the private benefits from running the firm in the second period. The optimal acquisition budget equals the sum of shareholders' gross return and the manager's private benefits from an acquisition. The above argument and the subsequent analysis assume that the manager is risk-neutral and his reservation utility is to equal zero. Together with the assumption of a positive wage this allows us to ignore the participation constraint of the manager. A more general setting would allow for risk aversion and an outside option, which may lead to a binding participation constraint. In this case, the optimal compensation scheme would include a fixed payment in addition to the performance-based reward. While we continue to assume that the participation constraint is slack, we henceforth interpret the wage w_H as the performance-based component of the compensation scheme rather than the overall level.

Proposition 1 *The market for corporate control provides managerial incentives even in the absence of disciplinary takeovers.*

The common view of takeovers emphasizes the benefits from the "contestability" of the managerial position. For instance, Jensen (1988) argues that (the prospects of) disciplinary takeovers reduce agency conflicts and improve performance. In the above setting there is no scope for an external disciplinary mechanism since an incompetent or failed manager is always dismissed by the board. Still, the market for corporate control benefits shareholders by reducing agency costs through acquisition opportunities. Compensation is decreasing in the acquisition probability $\rho^a F(\widetilde{L}_H - P^a)$ and in the private benefits from running a larger firm $\triangle Z_2$. Note that the acquisition opportunity effect also arises in more general settings with risk-aversion and outside options as it relaxes both the incentive compatibility constraint *and* the participation constraint. When assessing the empirical magnitude of this effect, one needs to take into account that the acquisition opportunity effect, just like the well-established threat effect, also arises for non-transacting firms.

Proposition 2 *The optimal acquisition budget also allows for some loss-making acquisitions.*

From the shareholders' perspective, the ex-post optimal budget equals X_2^H and only allows for profitable acquisitions. Due to the acquisition opportunity effect, it is, however, in the shareholders' interest that the manager can undertake also some loss-making acquisitions ($\widetilde{L}_H > X_2^H$). That is, the optimal budget policy trades off the cost of a loss-making acquisition with the benefit of lower incentive pay. Since both effects are proportional to the acquisition probability ρ^a, $\widetilde{L}_H$ does not depend on the acquisition probability. By taking future control benefits into account, the model provides a novel rationale for loss-making acquisitions.[6] Rather than being a symptom of weak corporate governance, acquisition losses are an integral part of the optimal incentive scheme.

Once effort has been exerted, shareholders would never voluntarily provide funds in excess of X_2^H for an acquisition. Hence, the optimal acquisition budget has to be fixed in the initial contract. While the board or the shareholders must be able to commit to $\widetilde{L}_H$, the above solution is renegotiation-proof in the sense that the manager cannot be bribed into accepting a lower acquisition budget ex-post. The joint surplus of the manager and (acquiring) shareholders is maximized by $\widetilde{L}_H$ since a takeover occurs if and only if $X_2^H + \triangle Z_2 \geq P^a - c$. Hence, there is no scope to renegotiate.

The optimal budget policy can be implemented in many different ways. If the intermediate income is low ($X_1^H < \widetilde{L}_H$), implementation requires additional funds beyond those generated internally. For example, at the hiring stage the firm can obtain a non-revokable credit line, amounting to $\widetilde{L}_H - X_1^H$, in combination with a commitment to leave the intermediate income in the firm. Instead of using a credit line, the board can ex-ante endow the manager with cash reserves or other liquid assets of the same amount. Conversely, if the intermediate income is larger than the optimal budget ($\widetilde{L}_H < X_1^H$), funds need to be pumped out of the firm to prevent the manager from incurring excessive acquisition losses. For instance, short-term debt of $X_1^H - \widetilde{L}_H$ can reduce the resources under the manager's control.

Lemma 1 has several further implications. Shareholders' expected acquisition losses are

$$l = p\rho^a \int_{X_2^H - P^a}^{\widetilde{L}_H - P^a} c f(c) dc$$

increasing in $\widetilde{L}_H$. Hence, the model predicts that firms with more financial slack experience higher acquisition losses in expectation. At the same time, the performance-based component of compensation, $\widetilde{w}_H$, should be lower if a manager has more financial resources under his control. Hence, performance-based compensation and expected future acquisition losses move in opposite directions: an increase in $\triangle Z_2$ raises l while lower-

[6] Alternative explanations include empire building (Marris, 1963), managerial overconfidence (Roll, 1986) or envy (Goel and Thakor, 2009).

ing $\widetilde{w}_H$. Interpreting w_H as a measure of pay-for-performance sensitivity, this result is consistent with Yang et al. (2008). They find that banks whose CEOs have higher pay-for-performance sensitivity are less likely to undertake value-reducing acquisitions. To the extent that more performance-based compensation is also associated with a higher level of compensation, our model is consistent with Falato (2007) who documents a negative relationship between the level of compensation and acquisition losses.

The career concern literature argues that future private benefits are positively correlated with the manager's career horizon (Gibbons and Murphy, 1992). They are likely to be lower for a manager who is close to retirement.[7] According to this interpretation, our model suggests that a younger manager, for whom Z_2 and $\triangle Z_2$ are large, should be endowed with a larger budget. Since the acquisition probability is increasing in $\widetilde{L}_H$, he should thus be more likely to undertake acquisitions. Yim (2010) documents that a firm's acquisition propensity is indeed decreasing in the age of the CEO. (Though she does not find that younger managers enjoy greater financial slack.) The sensitivity of compensation to the acquisition budget ($\delta\widetilde{w}_H/\delta\widetilde{L}_H$) should be larger for younger managers.

The literature has identified two means by which an active takeover market can enhance efficiency, the reallocation of corporate resources (ex-post) and the disciplinary role of the takeover threat (ex-ante). We uncover a third channel that may arise independently from these two. The takeover market reduces agency conflicts by providing growth opportunities for successful managers. Discretion over the acquisition decision is part of the optimal incentive scheme and shareholders allow some loss-making acquisitions.[8]

4 Board Interference, Takeovers and CEO Turnover

In this section we extend the model in two ways to allow for the possibility of both internal governance failure and disciplinary takeovers. First, we let the firm choose the quality of its board. Second, the firm can now be an acquirer or a target in the takeover market, depending on its first-period performance. Hence, a poorly performing manager can be dismissed either by the board or through a disciplinary takeover.[9]

We model internal governance as choosing the probability that the board is able or not to dismiss the manager. Let $s \in \{g, b\}$ denote the state or quality of internal governance and $\tau \in [0, 1]$ the probability that the firm is well governed ($s = g$) in which case the board can replace the manager at the interim date. With probability $(1 - \tau)$ internal governance breaks down ($s = b$) in which case board dismissal never occurs. The state s

[7] Lemma 1 suggests that explicit incentives should, ceteris paribus, be lower for managers early on in their career which is consistent with Gibbons and Murphy (1992).

[8] The idea that managerial autonomy comes not only with costs but also with benefits has been previously pointed out (Almazan and Suarez, 2003; Burkart et al., 1997).

[9] Jensen (1993, p. 863) notes that "the available evidence does suggest that CEOs are removed after poor performance, but the effect [...] seems too late and too small to meet the obligations of the board".

realizes and becomes observable at the end of the first period. Before hiring the manager, shareholders choose the probability τ at a cost $K(\tau) = \frac{1}{2}k\tau^2$ with $k > 0$. To ensure an interior solution for the probability that the firm is well governed we impose a lower bound on the interference cost parameter:

Assumption 5 $k \geq pZ_2 + (1-p)pX_2^H$.

The cost $K(\tau)$ can be interpreted literally as the resources spent on evaluating managerial performance (for instance by installing a transparent accounting system). Alternatively, $K(\tau)$ can be understood as a measure of the conflict of interest between the board and shareholders. The failure to dismiss a poorly performing manager may be due to board members' lack of independence, excessive workload, or simply the desire to avoid conflicts. A positive interference cost captures in a reduced form the notion that compensation and other incentive schemes cannot fully resolve the conflict of interest.

A firm with a failed manager can now be taken over. Following poor first-period performance, an acquirer shows up with probability ρ^t and offers to purchase the firm for a price P^t.[10] For now we assume that this price is exogenous and larger than the (expected) value of the target under a newly hired manager. Since $P^t \geq pX_2^H$ target shareholders always accept the offer. If the target manager has not already been replaced by the board he loses his position in the takeover.[11] A firm can be a target also when the board has previously dismissed the manager. By contrast, we rule out that a firm with a high first-period cash flow can be acquired.[12]

The outcome of the game remains the same following high first-period cash flow. The manager is retained and with probability $\rho^a F(L_H - P^a)$ he makes an acquisition at the exogenous price P^a. Following poor first-period performance, the firm is taken over with probability ρ^t at a price P^t. In the absence of a takeover, the manager retains his job if internal governance fails.

When a poorly performing manager escapes dismissal, he should be prevented from making an acquisition. Hence, L_L is no longer indeterminate but has to be set equal to zero.

As it remains optimal to never reward failure ($w_L = 0$), the maximization problem of the extended game is:

$$\max_{w_H, L_H, \tau} p\left[X_1^H - w_H + \pi_2(L_H)\right] + (1-p)[\rho^t P^t + (1-\rho^t)\tau p X_2^H] - \frac{1}{2}k\tau^2$$

[10] The previous model is the special case with flawless internal governance ($k = 0$ and $\tau = 1$) and no takeover threat ($\rho^t = 0$).

[11] Increased managerial turnover in target firms after the takeover has been documented by several studies (e.g., Kini et al., 2004; Martin and McConnell, 1991; Morck et al., 1989).

[12] We exclude this possibility as we want to focus on the incentive effects of takeovers. Arguably, mergers among successful firms are likely to be (more) incentive-neutral. Such mergers would indeed not affect incentives in our model if each manager is equally likely to become CEO of the combined firm, implying a gain of ΔZ_2, as to be demoted to divisional manager, implying a loss of $-\Delta Z_2$ private benefits.

subject to the incentive compatibility constraint

$$p\left[w_H + Z_2 + \rho^a F(L_H - P^a)\triangle Z_2\right] + (1-p)(1-\tau)(1-\rho^t)Z_2 \geq Z_1 + (1-\tau)(1-\rho^t)Z_2$$

and the constraints

$$w_H \geq 0 \qquad \text{and} \qquad \tau \in [0,1]$$

The manager may now receive the private benefit Z_2 despite poor performance when both internal and external control mechanisms fail (which happens with probability $(1-\tau)(1-\rho^t)$). Rearranging the incentive compatibility constraint yields:

$$w_H \geq \frac{Z_1}{p} - [\tau + (1-\tau)\rho^t + \rho^a F(L_H - P^a)\triangle]Z_2$$

The firm has three means at its disposal to incentivize the manager. It can offer a monetary reward for good performance and provide funds for future acquisitions. In addition, it chooses the quality of internal governance which translates into a dismissal threat following poor performance.[13]

Lemma 2 *The optimal wage is*

$$w_H^* = \frac{Z_1}{p} - \left[\tau^* + \rho^t(1-\tau^*) + \rho^a F(L_H - P^a)\triangle\right] Z_2 \qquad \textit{and} \qquad w_L^* = 0, \tag{1}$$

the optimal acquisition budget is

$$L_H^* = X_2^H + \triangle Z_2 \textit{ and } L_L^* = 0 \tag{2}$$

and the optimal board quality is

$$\tau^* = \frac{1}{k}\left\{p(1-\rho^t)Z_2 + (1-p)(1-\rho^t)pX_2^H\right\}. \tag{3}$$

As before, the performance-based compensation is decreasing with the implicit incentives embedded in the acquisition opportunities and the dismissal risk. The overall dismissal risk comprises the probability of being dismissed by the board[14] τ^* and the takeover threat in case of internal governance failure $\rho^t(1-\tau^*)$. Thus, the takeover market plays now a dual role, rewarding performing managers with acquisition opportunities and disciplining the others. Though, unless the takeover market operates as a

[13] In our framework, board activity corresponds to interference which prevents entrenchment thereby relaxing the incentive compatibility constraint. By contrast, when board activity amounts to learning about managerial quality, it can aggravate agency conflicts (Crémer 1995).

[14] Fahlenbrach (2009) finds that CEO performance-based pay in the US is lower in firms with higher board quality.

flawless disciplinary device ($\rho^t = 1$), an incompetent manager no longer loses his job with certainty. Consequently, the performance-based compensation has to be larger than in Lemma 1. As the modifications to the model pertain to the contingency of poor first-period performance, the optimal acquisition budget for a competent manager remains unchanged.

Better board quality adds value by replacing incompetent managers in the absence of a takeover and by relaxing the incentive compatibility constraint. The former benefit is reflected in the second term of equation (3): with probability $(1-p)(1-\rho^t)$ no bidder appears upon poor performance in which case board interference raises expected second-period cash flow by pX_2^H. The latter benefit is the expected pay reduction $p(1-\rho^t)Z_2$ due to the board dismissal threat. Since board intervention is costly, flawless internal governance ($\tau = 1$) is typically not optimal. Optimal board quality increases with the manager's future private benefits Z_2, as the dismissal threat becomes a more effective means for lowering managerial pay. Higher future cash flow makes board interference more valuable. A stronger board also goes together with a lower cost k.[15]

We now turn to the effects of disciplinary takeovers on board interference, turnover

takeover pressure discourages board interference, thereby indirectly lowering the dismissal threat.

When the takeover market is an efficient disciplining device (high ρ^t values), the direct effect of an increase in ρ^t always dominates, and the overall dismissal threat increases. This does not necessarily hold for low ρ^t values but depends on the optimal board quality. To distinguish between strong and weak boards we define the threshold level $\overline{k} = 2[pZ_2 + (1-p)pX_2^H]$.

Proposition 3 *In firms with strong boards ($k \leq \overline{k}$), managerial turnover following poor performance is first decreasing and then increasing in the intensity of the takeover threat.*

For low interference cost the optimal board quality is high in the absence of a takeover threat. As the board operates in this case at high marginal interference cost, the introduction of a small takeover risk leads the firm to substantially cut board quality. That is, the indirect effect of an increase in ρ^t dominates and a greater takeover threat makes the manager's position not less but more secure. Once the takeover probability is large the reverse holds. An increase in ρ^t always goes together with a higher turnover risk. This also applies to the case of weak boards ($k < \overline{k}$). In support of Proposition 3, Huang and Zhao (2009) document that the sensitivity of CEO turnover to performance increases following the adoption of antitakeover legislation in firms with strong boards.

From the optimal wage in (1) it is clear that performance-based compensation and overall turnover risk move in opposite directions. Hence, if turnover is non-monotonic in takeover pressure, so is compensation:

Corollary 2 *In firms with strong boards ($k \leq \overline{k}$), CEOs' performance-based compensation is non-monotonic in the intensity of the takeover threat.*

Agrawal and Knoeber (1998) study the effect of the takeover threat on CEO compensation empirically. They find that a greater takeover risk leads to higher compensation and attribute this finding to risk aversion.[16] Our model suggests an alternative explanation for their finding. A higher takeover threat can in fact lower overall turnover risk for managers thereby necessitating a higher salary. Hence, it would be of interest to explore to what extent this relationship differs for firms with strong and weak boards.

5 Market Outcome and Externality

This section goes beyond the single-firm partial equilibrium analysis and explores how firms' governance choices affect the outcome in the takeover market. To this end we

[16] More specifically, they distinguish between opposing effects of an increase in the takeover threat: on the one hand, more contestability reduces the manager's ability to extract high salaries. On the other hand, a risk averse CEO needs to be compensated for a greater dismissal risk through higher compensation and this latter effect dominates.

consider a continuum of ex-ante identical firms with unit mass which all play the game of the previous section. That is, firms simultaneously choose the quality of their board (τ) and then agree with a manager on a performance-based pay and an acquisition budget. Managerial ability is initially unknown, and the probability of hiring a competent manager is p and independent across firms. After the managers' effort choices, first-period cash flows realize, board (non-)interference takes place, and the takeover market opens. Given managers exert effort in equilibrium, first-period performance fully reveals their type. Firms with a competent manager can by assumption not be targets, whereas incompetent managers will in equilibrium lack the funds to make an acquisition. Therefore, the proportion of potential acquirers and targets in equilibrium is p and $1-p$ respectively.

Depending on p being larger or smaller than $1/2$, each target would in the absence of frictions be approached by an acquirer, or each acquirer would find a target. We instead assume that the takeover market is plagued by search frictions such that both ρ^a and ρ^t are always smaller than one. Besides being plausible, this allows us to work with formal expressions that are invariant to which side of the market is the short one.[17] To this end, we impose the following matching technology. Firms are uniformly distributed along a circle, and each firm is a potential target or acquirer depending on its first-period performance. Following a high first-period performance, a firm can only bid for the neighboring firm to the right if that firm is indeed a target. Provided the budget L_H is sufficient to cover takeover price and takeover cost, the bid succeeds with probability $\gamma \in [0,1]$ where γ captures the extent to which the institutional and regulatory environment is conducive to takeovers.

The transaction price comprises the outside option of the target $\Psi \in \{0; pX_2^H\}$ and a takeover premium which is equal to a fraction $\lambda \in [0,1]$ of the gross takeover surplus $X_2^H - \Psi$. If the target is poorly governed, the price is $P_b = \lambda X_2^H$, whereas the price increases to $P_g = \lambda(X_2^H - pX_2^H) + pX_2^H$ if the target is well governed.

Let ρ_b^t and ρ_g^t denote the probabilities that a firm is taken over following poor performance for a price P_b or P_g respectively. Let $\widehat{L}_H$ and $\widehat{\tau}$ be the acquisition budget (following success) and the interference intensity of the representative firm in the economy. Then a firm with budget L_H faces the following takeover probabilities from an ex-ante perspective in the above setting:

$$\rho_g^t = \gamma p F(\widehat{L}_H - P_g) \qquad \text{and} \qquad \rho_b^t = \gamma p F(\widehat{L}_H - P_b) \tag{5}$$

$$\rho^a(\widehat{\tau}) = \gamma(1-p)[\widehat{\tau}F(L_H - P_g) + (1-\widehat{\tau})F(L_H - P_b)] \tag{6}$$

For example, the probability of being taken over following a governance failure ρ_b^t

[17] Our qualitative results, notably the market externality, do not rely on frictions, provided that each target (acquirer) does not keep being matched with acquirers (targets) until a favourable takeover cost realizes.

simply equals the probability that the neighboring manager to the left turns out to be competent and has sufficient funds, $pF(\widehat{L}_H - P_b)$, times the institutional friction γ. A firm is more likely to be taken over if it is poorly governed ($\rho_b^t > \rho_g^t$) because it demands a lower price. Furthermore, a firm's probability of being taken over is increasing in the acquisition budget of the representative firm $\widehat{L}_H$. Takeover pressure is greater if rival managers are well funded. While the risk of being taken over depends on other firms' behavior through the budget $\widehat{L}_H$, the chance of taking somebody else over, $\rho^a(\widehat{\tau})$, depends on rival firms through $\widehat{\tau}$. The probability that a successful manager can acquire another firm, given in (6), is decreasing in $\widehat{\tau}$. If the economy-wide level of internal governance increases, a successful manager is more likely to face a well-governed target. Better internal governance, in turn, raises the potential target's reservation price and thus reduces the probability that a transaction takes place ($F(L_H - P_g) < F(L_H - P_b)$). In a nutshell, board interference reduces the scope for takeovers.

We first derive the equilibrium where all firms act simultaneously and non-cooperatively. The takeover market gives rise to strategic interactions between firms that operate through the takeover probabilities. In the Appendix we prove the following result:

Lemma 3 *In equilibrium, the ex-ante identical firms all choose wage*

$$w_H^{**} = \frac{Z_1}{p} - \left[\tau^{**} + \rho_b^t(1-\tau^{**}) + \rho^a(\tau^{**})\triangle\right] Z_2 \quad \textit{and} \quad w_L^{**} = 0, \tag{7}$$

and the acquisition budget

$$L_H^{**} = X_2^H + \triangle Z_2 \textit{ and } L_L^{**} = 0, \tag{8}$$

and the equilibrium interference intensity

$$\tau^{**} = \frac{1}{k}\left\{p(1-\rho_b^t)Z_2 + (1-p)\left[pX_2^H + \rho_g^t(P_g - pX_2^H) - \rho_b^t P_b\right]\right\}, \tag{9}$$

where ρ_b^t, ρ_g^t and $\rho^a(\tau^{**})$ are given by equations (5) and (6).

The crucial change compared to Lemma 2 is the endogeneity of the takeover probabilities. As discussed in Section 3, the tradeoff which determines the optimal budget is independent of these probabilities. Hence, the equilibrium acquisition budget in (8) coincides with that in (2). In particular, a firm's budget is independent of the level of board interference in rival companies.

The equilibrium budget determines the respective probabilities of being taken over in (5) which in turn fix the equilibrium intensity of board interference in (9). The expected returns of a target in the takeover market now depend on the strength of its board: the second summand in squared brackets on the RHS in (9), $\rho_g^t(P_g - pX_2^H)$, is the expected takeover premium for a well-governed seller and the last term, $\rho_b^t P_b$, is the expected

premium if internal control breaks down. Note that one firm's choice of τ depends on the budget policies in other firms through ρ_b^t and ρ_g^t.

The equilibrium level of interference determines the acquisition probability in (6). In equilibrium, the performance based component of compensation in (7) depends on both the budget policy and board control in other firms. Both variables affect compensation directly through the takeover probabilities. Moreover, the budget policies of peers have an indirect effect as they also alter the optimal level of board interference.

The comparative statics analysis in Section 4 generalizes to the market setting in a straightforward manner. Fewer frictions in the takeover market reduce the equilibrium level of internal governance, i.e., τ^{**} is decreasing in γ. Thus, Corollary 1 remains valid in a slightly modified form. Also, Proposition 3 continues to hold. In equilibrium, overall turnover risk $\Gamma^{**} = \tau^{**} + \rho_b^t(1 - \tau^{**})$ is non-monotonic in the intensity of the takeover threat as measured by γ. Furthermore, we obtain the following result:

Proposition 4 *More board interference may strengthen or weaken the need to provide managerial incentives.*

Stronger board control can result from a decrease in the interference cost. For example, better legal shareholder protection may reduce k. The ensuing increase in the economy-wide level τ^{**} has two opposing effects on incentives. The dismissal threat Γ^{**} increases which strengthens incentives. At the same time, improved board control diminishes acquisition opportunities which forces shareholders to increase performance-based compensation. Overall, the effect on the IC constraint is ambiguous. In contrast, if an exogenous shock increases board control in rival firms only, a manager's wage should increase.

More frictions in the takeover market (decrease in γ) strengthen the board's incentive to intervene. The effect on compensation is ambiguous, though, due to the aforementioned argument.[18]

What is the socially optimal budget policy and governance arrangement that maximizes joint profits for all firms? In the Appendix we derive the socially optimal governance arrangement and the socially optimal budget policy and find the following result:

Proposition 5 *In equilibrium, there is excessive board interference ($\tau^o < \tau^{**}$) and acquisition budgets are too small ($L_H^{**} < L_H^o$).*

In equilibrium, shareholders fail to internalize the negative impact of their governance effort on the acquisition opportunities of rival firms which hardens the incentive compatibility constraints for all other managers in the economy. Hence, $\tau^o < \tau^{**}$. Thus, profits

[18] A change in the friction parameter not only affects incentives through its indirect effect on the board but also through its direct effect on the takeover probabilities.

of the corporate sector would increase if each firm deviated from the privately optimal governance arrangement and installed a weaker board. Weak boards create a more liquid takeover market by increasing the supply of potential target firms. However, the liquidity of the takeover market is a public good and the supply of targets is too low in equilibrium.

The privately optimal level of funding is lower than the socially optimal one. In equilibrium, each firm ignores that a higher budget imposes greater takeover pressure on rival managers. Higher budgets relax funding constraints of acquirers and thus create a more liquid takeover market. The takeover threat is inefficiently low in equilibrium.

Both the equilibrium interference intensity and the budget policy deviate from the

reduced. Moreover, while we find overprovision of governance in equilibrium, there is underprovision in their model.

6 Conclusion

Previous research on the incentive implications of takeovers has focused on the threat of being taken over and its effect on management behavior. We argue that the takeover market mitigates agency conflicts by providing acquisition opportunities for successful managers. As a consequence, takeovers may benefit shareholders even if they neither play any disciplinary role vis-a-vis target firms nor create any value directly (e.g. through the installation of a new management team). At the same time, takeover pressure stifles the board's incentive to discipline management, possibly to the extent that it aggravates agency conflicts in target firms. In firms with strong boards, a higher risk of being taken over may secure management's position in the firm. Finally, a liquid takeover market with a sufficient supply of potential targets and acquirers constitutes a public good that provides implicit incentives to all managers in the economy. In equilibrium, an externality in governance choices across firms arises. Board interference, which reduces the scope for value-enhancing acquisitions, is excessive and acquisition budgets are too small. As a consequence takeover activity is inefficiently low.

Appendix

Proof of Lemma 1. Assumption 4 implies that the incentive compatibility constraint binds. Substituting the IC constraint for the wage in the objective function yields the following simplified program:

$$\max_{L_H} p\left[X_1^H - (\frac{Z_1}{p} - [1+\rho^a F(L_H - P^a)\triangle]Z_2) + X_2^H + \pi_2(L_H)\right] + (1-p)pX_2^H$$

The first-order condition is

$$p\rho^a f\triangle Z_2 + p\rho^a(X_2^H - L_H)f = 0 \Leftrightarrow \widetilde{L}_H = X_2^H + \triangle Z_2.$$

■

Proof of Lemma 2. Assumption 4 implies that the incentive compatibility constraint binds. Substituting the IC constraint for the wage in the objective function yields the

following program:

$$\max_{L_H,\tau} p[X_1^H - (\frac{Z_1}{p} - [\tau + (1-\tau)\rho^t + \rho^a F(L_H - P^a)\triangle]Z_2)]$$
$$+p\left[X_2^H + \pi_2(L_H)\right] + (1-p)[\rho^t P^t + (1-\rho^t)\tau p X_2^H] - \frac{1}{2}k\tau^2$$

The first order conditions with respect to L_H and τ give the results in (2) and (3). ■

Proof of Proposition 4. Overall turnover risk equals $\Gamma^* = \tau^* + (1-\tau^*)\rho^t$ with

$$\tau^* = \frac{1}{k}\{p(1-\rho^t)Z_2 + (1-p)(1-\rho^t)pX_2^H\}.$$

Then

$$\frac{\partial \Gamma^*}{\partial \rho^t} = 1 - \tau^* + (1-\rho^t)\frac{\partial \tau^*}{\partial \rho^t}$$

with

$$\frac{\partial \tau^*}{\partial \rho^t} = \frac{1}{k}\left\{-pZ_2 - (1-p)pX_2^H\right\} < 0.$$

Furthermore

$$\frac{\partial^2 \Gamma^*}{\partial (\rho^t)^2} = -2\frac{\partial \tau^*}{\partial \rho^t} > 0.$$

Hence, Γ^* is a strictly convex function of ρ^t. As $\rho^t \to 1$, $\Gamma^* \to 1$, and as $\rho^t \to 0$, $\Gamma \to \tau^*_{NT}$ where

$$\tau^*_{NT} = \frac{1}{k}[pZ_2 + (1-p)pX_2^H].$$

As $\rho^t \to 1$, $\partial\Gamma^*/\partial\rho^t \to 1$. As $\rho^t \to 0$, $\partial\Gamma^*/\partial\rho^t \to 1 - \tau^*_{NT} + \partial\tau^*/\partial\rho^t$ where

$$\begin{aligned} 1 - \tau^*_{NT} + \partial\tau^*/\partial\rho^t &= 1 - \frac{1}{k}[pZ_2 + (1-p)pX_2^H] + \frac{1}{k}\left\{-pZ_2 - (1-p)pX_2^H\right\} \\ &= 1 - 2\tau^*_{NT} \end{aligned}$$

Hence, turnover decreases in takeover pressure around for small ρ^t if $\tau^*_{NT} > \frac{1}{2}$.

More generally, the sensitivity of turnover with respect to the takeover threat is:

$$\frac{\partial \Gamma^*}{\partial \rho^t} = 1 - \tau^* + (1-\rho^t)\frac{\partial \tau^*}{\partial \rho^t} = 1 - (1-\rho^t)2\tau^*_{NT}$$

Obviously, turnover is always increasing in the takeover threat as ρ^t becomes large. However, if ρ^t is sufficiently small and τ^*_{NT} sufficiently high, the above expression can be negative and overall turnover is decreasing in the takeover threat. More precisely, if $k > \overline{k} = 2[pZ_2 + (1-p)pX_2^H]$, then $\frac{\partial\Gamma^*}{\partial\rho^t} > 0$ for all ρ^t. If $k \leq \overline{k}$, then $\frac{\partial\Gamma^*}{\partial\rho^t} \geq 0$ as long as $\rho^t \geq \overline{\rho}^t(k) = 1 - \frac{k}{2[pZ_2+(1-p)pX_2^H]}$ and $\frac{\partial\Gamma^*}{\partial\rho^t} < 0$ as long as $\rho^t < \overline{\rho}^t(k)$. ■

Proof of Proposition 5. By the chain rule $\partial w_H^*/\partial\rho^t = -(\partial w_H^*/\partial\Gamma^*)(\partial\Gamma^*/\partial\rho^t)$. From $\partial w_H^*/\partial\Gamma^* < 0$ it follows that the performance-based component of compensation

and turnover move in opposite directions. Hence, using the results from the proof of Proposition 4 one finds that in firms with strong boards ($k \leq \overline{k}$), performance-based compensation is non-monotonic in the intensity of the takeover threat: If $\rho^t < \overline{\rho}^t(k)$, then $\partial w_H^*/\partial \rho^t > 0$. If $\rho^t \geq \overline{\rho}^t(k)$, then $\partial w_H^*/\partial \rho^t \leq 0$. ■

Proof of Lemma 3. Taking the budget and interference intensity of the representative firm, $\widehat{L}_H$ and $\widehat{\tau}$, as given, shareholders in each firm solve:

$$\max_{w_H,\tau,L_H} p\left[X_1^H - w_H + X_2^H + (1-p)\widehat{\tau}[\int_0^{L_H-P_g}(X_2^H - P_g - c)f(c)dc)]\right] +$$
$$p\left[(1-p)(1-\widehat{\tau})[\int_0^{L_H-P_b}(X_2^H - P_b - c)f(c)dc)]\right] +$$
$$(1-p)[\tau(\rho_g^t P_g + (1-\rho_g^t)pX_2^H) + (1-\tau)\rho_b^t P_b^t] - \frac{1}{2}k\tau^2$$

subject to

$$w_H \geq \frac{Z_1}{p} - \left[\tau + (1-\tau)\rho_b^t + \Delta\rho^a(\widehat{\tau})\right] Z_2$$

and $w_H \geq 0$ and $\tau \in [0,1]$.

The binding incentive compatibility constraint yields w_H^{**} in (7). The FOC with respect to τ yields (9). The first-order condition with respect to L_H is

$$\begin{aligned} p[(-\frac{\partial w_H^{**}}{\partial L_H}) + (1-p)(X_2^H - L_H)f] &= 0 \Leftrightarrow \Delta Z_2 \frac{\partial \rho^a(\widehat{\tau})}{\partial L_H} + (1-p)(X_2^H - L_H)f = 0 \\ &\Leftrightarrow L_H^{**} = X_2^H + \Delta Z_2 \end{aligned}$$

■

Proof that $\partial\tau^{**}/\partial\gamma < 0$.

$$\frac{\partial \tau^{**}}{\partial \gamma} = \frac{1}{k}\left\{p(-\frac{\partial \rho_b^t}{\partial \gamma})Z_2 + (1-p)\left[\frac{\partial \rho_g^t}{\partial \gamma}(P_g - pX_2^H) - \frac{\partial \rho_b^t}{\partial \gamma}P_b\right]\right\}$$

To prove that the above expression is negative is suffices to show that the term in squared brackets on the RHS is negative. Substituting the takeover probabilities and prices into $\left[\frac{\partial \rho_g^t}{\partial \gamma}(P_g - pX_2^H) - \frac{\partial \rho_b^t}{\partial \gamma}P_b\right]$ yields

$$\lambda X_2^H(1-p)pF(L_H^{**} - P_g) - \lambda X_2^H pF(L_H^{**} - P_b)$$

which is equivalent to

$$\frac{\lambda X_2^H p}{\overline{c}}[(1-p)(L_H^{**}-P_g)-(L_H^{**}-P_b)] = \frac{\lambda X_2^H p}{\overline{c}}[-pL_H^{**}-(1-p)(\lambda X_2^H(1-p)+pX_2^H)+\lambda X_2^H].$$

Further simplification gives

$$\frac{\lambda X_2^H p}{\overline{c}}[-pL_H^{**}+(2-p)p\lambda X_2^H-(1-p)pX_2^H].$$

Setting $\lambda = 1$, yields $\frac{\lambda X_2^H p}{\overline{c}}[-pL_H^{**}+pX_2^H] < 0$. ■

Proof that $\partial\Gamma^{**}/\partial\gamma < 0$. Overall turnover risk in equilibrium equals $\Gamma^{**} = \tau^{**} + (1-\tau^{**})\rho_b^t$ where τ^{**} is given by (9) and ρ_b^t is given by (5). Then

$$\frac{\partial\Gamma^{**}}{\partial\gamma} = \frac{\partial\tau^{**}}{\partial\gamma} + (1-\tau^{**})\frac{\partial\rho_b^t}{\partial\gamma} - \rho_b^t\frac{\partial\tau^{**}}{\partial\gamma} = (1-\tau^{**})\frac{\partial\rho_b^t}{\partial\gamma} + (1-\rho_b^t)\frac{\partial\tau^{**}}{\partial\gamma}$$

with

$$\frac{\partial\tau^{**}}{\partial\gamma} = \frac{1}{k}\left\{-pZ_2\frac{\partial\rho_b^t}{\partial\gamma} + (1-p)\left[\frac{\partial\rho_g^t}{\partial\gamma}(P_g - pX_2^H) - \frac{\partial\rho_b^t}{\partial\gamma}P_b\right]\right\} < 0.$$

If the interference cost is very large ($k \to \infty$), $\partial\tau^{**}/\partial\gamma$ and τ^{**} go to zero. Hence, $\partial\Gamma^{**}/\partial\gamma$ is positive. Conversely, as the interference cost approaches its minimum level given by Assumption 5 in Section 4, i.e. $k \to pZ_2 + (1-p)pX_2^H$, and as $\gamma \to 0$, one finds that $\partial\Gamma^{**}/\partial\gamma \to \frac{\partial\tau^{**}}{\partial\gamma} < 0$. ■

Proof of Proposition 6. The social planner solves the following program:

$$\max_{w(X_1^H),\widehat{\tau},\widehat{L}_H} p\left[X_1^H - w(X_1^H) + X_2^H + (1-p)\widehat{\tau}[\int_0^{\widehat{L}_H-P_g}(X_2^H - P_g - c)f(c)dc)]\right] +$$
$$p\left[(1-p)(1-\widehat{\tau})[\int_0^{\widehat{L}_H-P_b}(X_2^H - P_b - c)f(c)dc)]\right] +$$
$$(1-p)[\widehat{\tau}(\rho_g^t P_g^t + (1-\rho_g^t)pX_2^H) + (1-\widehat{\tau})\rho_b^t P_b^t] - \frac{1}{2}k\widehat{\tau}^2$$

subject to

$$w(X_1^H) \geq \frac{Z_1}{p} - \left[\widehat{\tau} + (1-\widehat{\tau})\rho_b^t + \Delta\rho^a(\widehat{\tau})\right]Z_2$$

and $w(X_1^H) \geq 0$ and $\widehat{\tau} \in [0,1]$.

Let ε denote the price difference: $\varepsilon = P_g - P_b$. The first order condition with respect

to τ yields:

$$\begin{aligned}\tau^o &= \frac{1}{k}\{p(1-\rho_b^t)Z_2 + (1-p)[pX_2^H + \rho_g^t(P_g - pX_2^H) - \rho_b^t P_b] \\ &\quad -p(1-p)[\int_0^{\widehat{L}_H - P_b - \varepsilon} \varepsilon f(c)dc + \int_{\widehat{L}_H - P_b - \varepsilon}^{\widehat{L}_H - P_b} (X_2^H - P_b - c)f(c)dc]\}\end{aligned}$$

The first order condition with respect to $\widehat{L}_H$ yields:

$$L^o = X_2^H + \Delta Z_2 + \frac{p}{1-p}(1-\tau^o) + [\tau^o(P_g - pX_2^H) + (1-\tau^o)P_b]$$

From the first order conditions it is immediately apparent that $\widehat{L}^o > \widehat{L}^*$ and $\tau^* > \tau^o$. ■

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