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Stock options and employees' firm-specific human capital under the threat of divestitures and acquisitions

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Abstract

This paper considers whether the first-best level of firm-specific human capital investment is attained by the use of stock option plans for workers and stock offers in acquisitions even though workers are threatened with the possibility of a divestiture and acquisition. We show that the first-best level of investment is achieved by a stock option plan with a positive exercise price for workers conditional on the event of a divestiture. We also suggest that, under certain conditions, a stock offer in acquisition can resolve a collusion problem between the target firm (TF) and its workers.

JEL classification: D82; G34
Keywords: Stock option plans; Stock offers; Firm-specific human capital

1. Introduction

Although potential distortion in firm-specific human capital investment in divestiture and acquisition decisions has been the subject of extensive academic work, the role of stock option plans for workers and stock offers in such decisions has largely been ignored. The purpose of this paper is to explore whether the first-best level of firm-specific human capital investment is attained by the use of stock option plans for workers and stock offers in acquisitions even though divestiture and acquisition decisions affect the ability of firms to contract efficiently with workers.

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We first consider a situation in which one firm, denoted by the acquiring firm (AF), seeks to purchase a division of another firm, denoted by the target firm (TF), with cash offers; and the TF needs to enhance the productivity by motivating its workers to acquire firm-specific skills. However, since it is costly for workers to invest their effort in firm-specific skills, workers have an incentive to underinvest if they are compensated in advance and are free to quit at their discretion and if their investment level is observable only after their productivity is revealed. This is because workers can take the money and run and can receive a wage attainable elsewhere if their underinvestment is observed after they are compensated.

To resolve the opportunism by workers, the TF can rely on deferred compensation that is paid to workers after their productivity is revealed. The contract involving such deferred compensation removes the incentive for workers to shirk even though their investment level is not observable by the TF. The reason is that the deferred compensation acts as a bond tying workers to their investment. Thus, if the TF does not renege on its promise by reason of reputation considerations or so on, the contract involving the deferred compensation deters the opportunism on the part of workers.

Nevertheless, if the TF sells a division to the AF, the workers of the division may be discharged or, if retained, not be paid deferred compensation due because the control of the division has changed hands.[1] In this paper, we focus on the case in which the TF commits itself to upholding an initial contract, whereas the AF does not.[2] We will then find a mechanism that can implement the first-best level of investment even under the possibility of a divestiture and acquisition.

Now, if workers rationally expect that their initial contract will be breached after their division is divested, they may have an incentive to shirk on their investment. Thus, the TF additionally needs to compensate workers for the potential cost arising from the possibility of a divestiture. The need for additional compensation is likely to induce the TF to choose a contract that leads to the lower level of investment. Then, the possibility of a divestiture

[1] In the empirical literature of takeovers, Shleifer and Summers (1988), Bhagat et al. (1990), Pontiff et al. (1990), Ippolito and James (1992), and Franks and Mayer (1996) find evidence for the theory of the breach of implicit contract, whereas Kaplan (1989), Rosett (1990), and Healy et al. (1992) do not. Lichtenberg and Siegel (1990) obtain a mixed result. Knoeber (1986) gives evidence that golden parachutes are beneficial and designed to provide an assurance to managers against tender related opportunism. Agrawal and Knoeber (1998) also support the hypothesis that a threat of takeovers increases compensation by making managers' implicitly deferred compensation less secure.

[2] The particular asymmetry that we focus on here is often assumed in the literature of the breach of implicit contract in the transfer of control (see Knoeber, 1986; Shleifer and Summers, 1988; Bagwell and Zechner, 1993; Jaggia and Thakor, 1994; Schnitzer, 1995). These authors defend the assumption in several ways. The main reason for this is that the breach of promise or job security would force the TF to lose its reputation and to find it difficult to retain or replace its incumbent workers, whereas the breach of promise need not cause the AF to lose any reputation because the AF never made any promise with the incumbent workers of the TF. As a result, although the AF would not renege on an implicit contract with its own workers, it would breach an implicit contract with the incumbent workers of the TF. In contrast, Holmström (1988) proposes an alternative theory that coordination problems make it difficult for shareholders of the TF to act in unison and capture rents enjoyed by stakeholders, while the AF enjoys an advantage over managers in enacting changes because the AF typically comes in with a reputation for toughness. In fact, irrespective of which theory is more plausible, our main results still hold.

causes an inefficient level of investment through a threat of the transfer of the control of the divested division.

To overcome the inefficiency, the TF may use a stock option with a positive exercise price that is awarded workers conditionally on a divestiture. Then, we can show that the conditional stock option can achieve the first-best level of investment even though the initial contract is breached after a divestiture. The intuition behind the result is that the AF can adjust its acquisition tender price so as to compensate the TF for the liability to award the conditional stock option. This implies that, if workers make efficient investment, the burden of additional compensation due to the breach of the initial contract by the AF can be transferred from the TF to the AF through an acquisition tender price that reflects the conditional stock option award. The potential divergence in incentive between the TF and AF is then eliminated. The TF thus has an incentive to compensate workers for the potential cost arising from the breach of the original contract by the AF.

The use of conditional stock options has several advantages. For example, the TF may be forced to sell off some divisions to repay its debt or to finance a new project when its cash flow realizations are not high. Even then, the TF can utilize conditional stock option awards to attain the first-best level of investment.

We also indicate that any initial contract with stock option plans which are awarded workers nonconditionally is dominated by an initial contract with conditional stock option plans. The intuition behind this result is that the TF must also pay workers stock option benefits even though the division is not divested. This causes nonconditional stock option plans to be costlier to the TF than conditional stock option plans.

Until now, we have assumed that the TF does not collude with workers. However, if the initial contract is implicit or if it can be renegotiated after the AF makes no acquisition offer, then the TF may collude with workers and attempt to raise an acquisition tender price up to the level that is consistent with the first-best level of investment even though workers actually choose an inefficient level of investment. Thus, if the AF expects this collusion possibility, it may not make an acquisition offer. Furthermore, the first-best level of investment is not attained.

Nevertheless, if the AF is allowed to consider offering its own stock instead of cash, we show that under certain conditions, the AF can overcome this problem. The intuitive reason is that a key difference between the stock and cash offers is due to the feature that the stock value depends on the ex post profitability of the acquisition, while the value of cash does not. Thus, if structured properly, the stock offer can motivate the TF not to collude with workers. In contrast, the value of the cash offer is not contingent on the future cash flows of the divested division. This implies that the TF makes its collusive decision independently of any information on these future cash flows. The cash offer thus cannot deter the TF from colluding with workers.

We can now summarize the main results of this paper as follows.

(i) The first-best level of firm-specific human capital investment is attained by a stock option plan with a positive exercise price for workers conditional on the event of a divestiture and acquisition even though the possibility of a divestiture and acquisition induces an inefficient level of investment in the absence of such a mechanism.

(ii) Under certain conditions, a stock offer in acquisition can resolve a collusion problem in which the TF may collude with workers and attempt to deceive the AF.

Our results yield several implications. First, conditional stock options and stock offers in acquisitions serve to foster the formation of firm-specific skills even under expanding M&A opportunities. Furthermore, although an initial contract is breached, this does not imply that workers are not compensated for their investment. Second, the arguments of the breach of implicit contract by Shleifer and Summers (1988) are appropriate to traditional Japanese large firms. However, the recent depression and financial crisis together with the financial deregulation in Japan has been undermining the foundation of the intercorporate shareholding and main bank systems. Since these systems entrench managers to uphold implicit contracts based on trust, there is a wide interest in the subject of whether M&A activities will likely result in the loss of firm-specific human capital. This interest is further strengthened if the efficiency of the Japanese labor system depends upon the acquisition of firm-specific skills by workers and if the increasing global competition will intensify M&A activities in Japanese firms.[3] In fact, our model suggests that the adoption of the American style of management—such as stock option plans and stock offers in acquisitions—can resolve the underinvestment problem.

This is certainly not the first model to discuss whether the reactions of managers to the transfer of control to other agents have undesirable effects. Shleifer and Summers (1988) informally argue that hostile takeovers undermine implicit contracts with workers and other stakeholders. Schnitzer (1995) formally analyzes how the simultaneous use of poison bills and golden parachutes can solve the underinvestment problem without foregoing profitable takeovers.[4] What distinguishes her model from ours is that our model predicts that the first-best allocation can be attained by the use of stock option plans and stock offers in acquisitions. There are also several studies which investigate that the method of payment plays an important role in explaining the stock returns of bidding firms.[5] The difference between their results and ours is that in our paper, the benefits of stock offers come out of the possibility that stock offers prevent the TF from colluding with its employees.

The paper is organized as follows. Section 2 presents the basic model. Section 3 considers an optimal contract for the basic model and indicates that the possibility of a divestiture and acquisition causes an inefficient level of investment of workers. Section 4 shows that the first-best level of investment can be achieved by a stock option plan with a positive exercise price conditional on the event of a divestiture. Section 5 discusses that a collusion possibility between the TF and its workers can be resolved by a stock offer in acquisition. Section 6 concludes.

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[3] See Aoki (1989) and Osano (1997).

[4] Knoeber (1986) also informally suggests that golden parachutes or shark repellent amendments can deter opportunism toward managers because those attempts make hostile tender offers more costly and less likely to succeed.

[5] See Hansen (1987), Fishman (1989), Brown and Ryngaert (1991), and Ghosh and Ruland (1998).

2. Basic model

There are three kinds of agents in the economy: workers, the target firm (TF), and the acquiring firm (AF). The preference of workers is given by $u = w - e$, where w is the wage bill and e is the cost to workers of firm-specific human capital investment. The TF and AF are also assumed to be all-equity firms controlled by risk neutral shareholders. Since the equilibrium risk-free interest rate is zero, all cash flows are discounted at this rate.

Now, consider the four-period game illustrated in Fig. 1 that will be explained below. The story behind the game is that the TF proposes an initial contract to

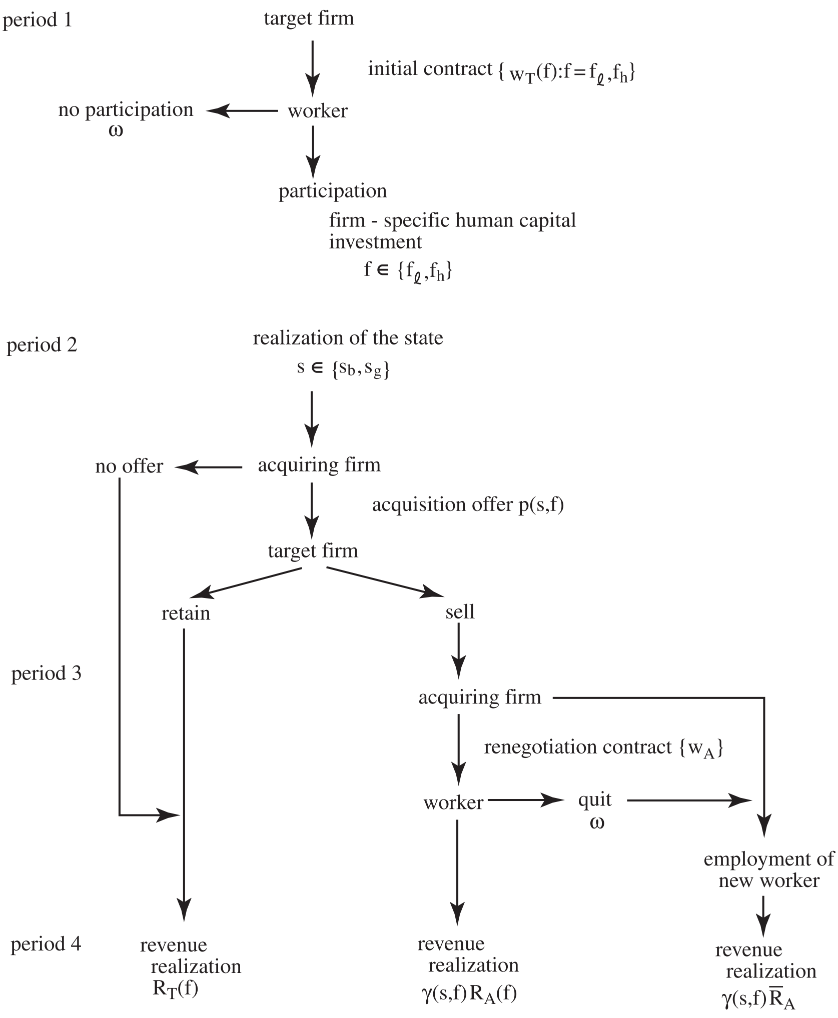

Fig. 1. Timing of events.

workers who invest in firm-specific skills, and that the AF decides whether to buy a division of the TF. The key points are (i) that the AF need not be committed to the initial contract between the TF and workers, although the TF is committed to the initial contract,[6] and (ii) that the TF can pay workers their compensation after the output of their division is realized in the final period. For simplicity, we assume that the TF has one division.

Since firm-specific human capital investment takes time, the TF and the representative worker must sign a contract at the beginning of period 1 before the AF makes an acquisition offer. More specifically, the TF offers the worker an initial contract $\{w_T(f)\,|\,f=f_l, f_h\}$, where f is the level of investment chosen by the worker and $w_T(f)$ is the wage level for f. The investment level f is set to be f_l or f_h ($f_l<f_h$). We also assume that the initial contract offered by the TF is publicly observable.

The environment in this model is common knowledge, except that the worker privately observes his investment level and cost although the other agents know the two values only from his output level realized in the final period. This implies that the worker need not be committed to the prespecified level of f if his wage is paid before his productivity is realized. To resolve such opportunism, the TF can rely on deferred compensation in which the worker's wage is paid after his productivity is realized. This enables the TF to deter the worker from shirking.[7] Furthermore, we assume that the TF can be committed to the initial contract with the worker as long as the TF retains the division. This assumption will be relaxed in Section 5.

Given the contract, the worker decides whether to contract with the TF. If the worker does not contract, he receives a wage ω attainable elsewhere in the economy. If the worker obtains a job elsewhere in the economy, the game ends. If the worker contracts with the TF in period 1, he invests in firm-specific human capital. The cost of the investment imposed on the worker is cf for each level of $f\in\{f_l, f_h\}$. Since f is unknown to the other agents before the output realization, the investment cost is also unknown to the other agents before the output realization.

At the beginning of period 2, the state of nature that affects the productivity of the division for the AF is realized. We assume that there are just two possible states of nature, s_b and s_g, where $\sigma(s_i)$ is the probability of state i (i = b or g).

[6] As argued in Section 1, there are several reasons to justify this assumption. Furthermore, in some countries such as Japan, workers need to experience wide-ranging operating tasks under a long-term association with the firm because the efficiency of the system depends upon the information processing and communicative capacities of workers at the operating level. In this labor system, incomplete, long-term labor contracts are the essential ingredients of production efficiency. For simplicity, instead of modeling this kind of mechanism explicitly, we assume that the TF can be committed to the initial contract. There is also empirical evidence that some part of the gains from mergers and acquisitions arises from the redistribution of existing wealth from incumbent workers to stockholders. See the empirical literature mentioned in footnote 1. Thus, we assume that the AF need not be committed to the initial contract between the TF and workers.

[7] The primary reason for deferring compensation here is to prevent the worker from behaving opportunistically. Another possible reason for deferred compensation is to allow a more precise determination of the worker performance. For example, see Knoeber (1986), which discusses deferred compensation for managerial executives.

The AF has exclusive access to a technology for finding valuable improvements in the productivity of the division of the TF through monitoring and independent research. More specifically, the AF investigates the TF costlessly and finds the following: (i) if the AF buys the division of the TF and retains the incumbent worker, then the productivity per worker is given by $\gamma(s, f)R_A(f)$ for each $f \in \{f_l, f_h\}$; and (ii) if the AF buys the division of the TF, but discharges the incumbent worker and employs a new worker, then the productivity per worker is given by $\gamma(s, f)\bar{R}_A$. Here, $\gamma(s, f)$ represents a general condition that affects the productivity per worker irrespective of whether the AF retains the incumbent worker. This formulation captures the following: (i) if the firm-specific skills of the incumbent worker have an effect on the extent of the completion of the project or the maintenance of physical capital equipment or the brand quality of the product or so on, some portion of this effect still remains even after he quits in the midst of the project; and (ii) if the incumbent worker trains the new worker before quitting, some part of the incumbent worker's specific skills is transferred to the new worker even though the training period is short. For these reasons, we assume that $\gamma(s, f)$ depends on both the index of the general environment s and the investment level of the incumbent worker f even after he quits. The remaining part $R_A(f)$ (or $\bar{R}_A$) reflects the direct contribution of the incumbent worker (new worker) to the productivity per worker.

For the realized state of nature and the anticipated investment level of the incumbent worker, the AF decides to make a take-it-or-leave-it acquisition offer $p(s, f)$ to the TF at the end of period 2. The way in which the AF infers the anticipated investment level is given as follows: if the TF offers an equilibrium contract that supports f_h, the AF expects that the worker chooses f_h; otherwise, the AF expects that the worker chooses f_l. For the moment, we assume that the medium of exchange in the acquisition is in the form of cash. This assumption will be relaxed in Section 5.2.

If the AF does not make an acquisition offer or if the AF does so but the TF rejects it, the TF retains the division. Then, the TF receives the gross revenues $R_T(f)$ in the final period. If the AF makes an acquisition offer and the TF accepts it, the AF buys the division from the TF. Then, the AF contracts with the incumbent worker. However, the AF need not be committed to executing the original contract: the AF may breach the original contract so as to expropriate gains coming at the expense of wage losses of the incumbent worker. In fact, the AF may not choose to take full advantage of this prerogative because the incumbent worker can leave the AF and obtain ω from another job. In this case, the AF must hire a new worker. If the AF decides to replace the incumbent worker with a new worker, then it receives the gross revenues $\gamma(s, f)\bar{R}_A + Q_A$ in the final period, where Q_A denotes the net profits of the AF that does not buy the division of the TF. If the AF retains the incumbent worker and makes a take-it-or-leave-it renegotiation offer $\{w_A\}$ so as to prevent his turnover, then it receives the gross revenues $\gamma(s, f)R_A(f) + Q_A$ in the final period. Note that w_A need not depend on f because the investment has already been made in period 1.

In the final period, the gross revenues are realized. If the worker is employed by the TF (or AF), then he is paid in accordance with the initial (or new) contract. If the worker leaves the AF, then he receives ω from alternative employment.

3. Optimal contract for the basic model

3.1. Parametric assumptions

To simplify the analysis, we put the following assumptions:

Assumption 1. $R_T(f) - \omega - cf \geqq 0$ for each $f \in \{f_l, f_h\}$.

Assumption 2. Both $\gamma(s_b, f)$ for each $f \in \{f_l, f_h\}$ and $\gamma(s_g, f_l)$ are small enough to guarantee that the AF never makes an acquisition offer for $s = s_b$ or $(s, f)=(s_g, f_l)$.

Assumption 3. $R_A(f_h) \geqq \overline{R}_A$.

Assumption 4. $\gamma(s_g, f_h)R_A(f_h) \geqq R_T(f_h)$.

Assumption 5. $R_T(f_h) - cf_h > R_T(f_l) - cf_l$ and $\gamma(s_g, f_h)R_A(f_h) - cf_h > \gamma(s_g, f_l)R_A(f_l) - cf_l$.

Assumption 1 ensures that the TF could make nonnegative profits by retaining the division if the TF paid the worker $\omega + cf$. Assumption 2 indicates that the AF can make an acquisition offer only for (s_g, f_h). This assumption can be justified if the synergy effect is strong enough to compensate the AF for the M&A cost only if $(s, f)=(s_g, f_h)$. Assumption 3 shows that for (s_g, f_h), the AF does not receive less gross revenues from the acquired division by retaining the incumbent worker than by hiring a new worker, that is, $\gamma(s_g, f_h)R_A(f_h) \geqq \gamma(s_g, f_h)\overline{R}_A$. Assumption 4 implies that for (s_g, f_h), the AF does not receive less gross revenues from the acquired division by retaining the incumbent worker than the TF receives from the retained division. Finally, Assumption 5 means that the higher investment generates the more surplus than the lower one irrespective of whether the TF retains or divests the division.

Under Assumptions 1–5, the first-best allocation implies that the worker makes the higher investment f_h, that the AF buys the division of the TF if and only if $(s, f)=(s_g, f_h)$, and that the AF retains the incumbent worker after the acquisition.

3.2. Optimal renegotiation decision of the AF in period 3

Under Assumption 2, the AF makes an acquisition offer only if $(s, f)=(s_g, f_h)$. If the AF makes a take-it-or-leave-it renegotiation offer and the incumbent worker accepts it, then the optimal renegotiation contract $\{w_A\}$ is determined by

$$\max_{w_A} \gamma(s_g, f_h)R_A(f_h) - w_A + Q_A - p(s_g, f_h), \tag{1a}$$

$$\text{s.t. } w_A \geqq \omega. \tag{1b}$$

where $p(s_g, f_h)$ is the acquisition payment. The constraint Eq. (1b) is the ex post no-quit condition for the incumbent worker. Solving Eqs. (1a) and (1b) immediately yields $w_A = \omega$. Substituting this into Eq. (1a), we see that the net payoff of the AF is $\gamma(s_g, f_h)R_A(f_h) - \omega + Q_A - p(s_g, f_h)$. On the other hand, if the AF does not make a renegotiation offer that satisfies Eq. (1b), the AF must hire a new worker. Then, the net payoff of the AF is $\gamma(s_g, f_h)\bar{R}_A - \omega + Q_A - p(s_g, f_h)$. Comparing these two values, the AF makes a renegotiation offer and retains the incumbent worker if and only if $\gamma(s_g, f_h)R_A(f_h) \geqq \gamma(s_g, f_h)\bar{R}_A$. Under Assumption 3, this inequality is always satisfied.

Thus, if the AF buys the division of the TF, then the optimal renegotiation offer in period 3 is $w_A = \omega$ so that the AF retains the incumbent worker.

3.3. Optimal acquisition decision of the AF in period 2

Under Assumption 2, we can again focus on the case of $(s, f)=(s_g, f_h)$. We begin by examining the bidding decision of the AF. If the AF proposes $p(s_g, f_h)$, the net payoff of the AF is represented by $\gamma(s_g, f_h)R_A(f_h) - \omega + Q_A - p(s_g, f_h)$. Since Q_A can be received independently of the acquisition decision, the AF makes an acquisition offer if and only if

$$\gamma(s_g, f_h)R_A(f_h) - \omega - p(s_g, f_h) \geqq 0. \tag{2}$$

We next discuss how $p(s_g, f_h)$ is determined. The TF does not divest the division if the acquisition tender price is smaller than the net revenues of the division that the TF receives by retaining the division. Since we simplify the bidding process by assuming that the AF can make a take-it-or-leave-it offer, the AF can capture all the surplus generated by the improvements due to the acquisition.[8] This assumption implies that the AF can always buy the division of the TF at a price that is exactly equal to what the TF receives by retaining the division:

$$p(s_g, f_h) = R_T(f_h) - w_T(f_h). \tag{3}$$

Substituting Eq. (3) into Eq. (2), we see that the AF makes an acquisition offer if and only if

$$w_T(f_h) \geqq R_T(f_h) + \omega - \gamma(s_g, f_h)R_A(f_h). \tag{4}$$

If this condition is not satisfied, the AF does not purchase the division of the TF.

3.4. Optimal initial contracting decision of the TF in period 1

We first discuss the initial contracting subproblem for $f=f_h$. We divide our analysis into two cases according to whether or not the AF really makes an acquisition offer at $s=s_g$. Under Assumption 2, the AF makes no acquisition offer at $s=s_b$.

If the AF proposes an acquisition offer at $s=s_g$, then the acquisition tender price is given by Eq. (3). Thus, the expected net payoff of the TF, $\Pi_T(f_h, w_T(f_h))$, is represented by $\Pi_T(f_h, w_T(f_h)) = \sigma(s_b)[R_T(f_h) - w_T(f_h)] + [1 - \sigma(s_b)]p(s_g, f_h) = R_T(f_h) - w_T(f_h)$. The initial contracting subproblem in this case is now described by

$$\max_{w_T(f_h)} R_T(f_h) - w_T(f_h), \tag{5a}$$

[8] An alternative formulation is possible in which the bargaining position of the AF would be weaker. In this case, the AF would share the surplus with the TF. Nevertheless, the qualitative results in this paper are robust to this modification.

$$\text{s.t. } \sigma(s_b)[w_T(f_h) - cf_h] + [1 - \sigma(s_b)](\omega - cf_h) \geqq \omega, \tag{5b}$$

$$w_T(f_h) \geqq R_T(f_h) + \omega - \gamma(s_g, f_h)R_A(f_h), \tag{5c}$$

$$w_T(f_h) - cf_h \geqq \omega - cf_l. \tag{5d}$$

Here, Eq. (5b) is the ex ante participation condition for the worker. Note that the worker is paid $w_A = \omega$ if the AF buys the division of the TF. The constraint Eq. (5c) is the tendering condition for the AF, which is derived from Eq. (4). The constraint Eq. (5d) is the incentive compatibility condition for the worker investing f_h. Since the worker's compensation is paid after his productivity is realized, the TF only has to pay the worker ω if his productivity corresponds to f_l. Hence, the left-hand (right-hand) side of Eq. (5d) is the worker's compensation if he invests f_h (f_l).

Solving the subproblem (5) leads to

$$\begin{aligned} w_T^*(f_h) &= \max\left[\omega + \frac{cf_h}{\sigma(s_b)},\ R_T(f_h) + \omega - \gamma(s_g, f_h)R_A(f_h),\ \omega + cf_h - cf_l\right] \\ &= \omega + \frac{cf_h}{\sigma(s_b)}, \end{aligned} \tag{6}$$

where the second equality follows from Assumption 4. Substituting Eq. (6) into Eq. (5a), we obtain the optimal value to the subproblem (5), $\Pi_T(f_h, w_T^*(f_h))$:

$$\Pi_T(f_h, w_T^*(f_h)) = R_T(f_h) - \omega - \frac{cf_h}{\sigma(s_b)}. \tag{7}$$

On the other hand, if the AF does not make an acquisition offer at $s = s_g$, then the initial contracting subproblem is

$$\max_{w_T(f_h)} R_T(f_h) - w_T(f_h), \tag{8a}$$

$$\text{s.t. } w_T(f_h) - cf_h \geqq \omega, \tag{8b}$$

$$w_T(f_h) < R_T(f_h) + \omega - \gamma(s_g, f_h)R_A(f_h). \tag{8c}$$

Here, Eq. (8b) is the ex ante participation condition for the worker and Eq. (8c) ensures that the AF makes no acquisition offer at $s = s_g$. Note that the incentive compatibility constraint for the worker investing f_h always holds if Eq. (8b) is satisfied.

The feasible solution to subproblem (8) must satisfy $\omega + cf_h \leqq w_T(f_h) < R_T(f_h) + \omega - \gamma(s_g, f_h)R_A(f_h)$. However, under Assumption 4, these inequalities do not hold. Thus, if $f = f_h$, the AF is always induced to make an acquisition offer at $s = s_g$.

We next examine the initial contracting subproblem for $f=f_{\mathrm{l}}$. In this case, under Assumption 2, the AF never makes an acquisition offer at any $s \in \{s_{\mathrm{b}}, s_{\mathrm{g}}\}$. Thus, the initial contracting subproblem is

$$\max_{w_{\mathrm{T}}(f_{\mathrm{l}})} R_{\mathrm{T}}(f_{\mathrm{l}}) - w_{\mathrm{T}}(f_{\mathrm{l}}), \tag{9a}$$

$$\text{s.t. } w_{\mathrm{T}}(f_{\mathrm{l}}) - cf_{\mathrm{l}} \geqq \omega, \tag{9b}$$

where Eq. (9b) is the ex ante participation condition for the worker. The incentive compatibility constraint for the worker investing f_{l} always holds under Eq. (9b).

Solving this problem immediately leads to $w_{\mathrm{T}}^{*}(f_{\mathrm{l}}) = \omega + cf_{\mathrm{l}}$. Substituting this into Eq. (9a), we have the optimal value to the subproblem (9), $\Pi_{\mathrm{T}}(f_{\mathrm{l}}, w_{\mathrm{T}}^{*}(f_{\mathrm{l}}))$:

$$\Pi_{\mathrm{T}}(f_{\mathrm{l}}, w_{\mathrm{T}}^{*}(f_{\mathrm{l}})) = R_{\mathrm{T}}(f_{\mathrm{l}}) - \omega - cf_{\mathrm{l}}. \tag{10}$$

Comparing $\Pi_{\mathrm{T}}(f_{\mathrm{h}}, w_{\mathrm{T}}^{*}(f_{\mathrm{h}}))$ from Eq. (7) with $\Pi_{\mathrm{T}}(f_{\mathrm{l}}, w_{\mathrm{T}}^{*}(f_{\mathrm{l}}))$ from Eq. (10), we now show that $f=f_{\mathrm{h}}$ or f_{l} according to $R_{\mathrm{T}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{l}}) \geqq (cf_{\mathrm{h}}/\sigma(s_{\mathrm{b}})) - cf_{\mathrm{l}}$ or $R_{\mathrm{T}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{l}}) < (cf_{\mathrm{h}}/\sigma(s_{\mathrm{b}})) - cf_{\mathrm{l}}$. Given Assumptions 1–5, we have the following proposition.

Proposition 1. *Suppose that Assumptions 1–5 hold. (i) If $R_T(f_h) - R_T(f_l) \geqq (cf_h/\sigma(s_b)) - cf_l$, the optimal initial contract $\{w_T^{*}(f) \mid f=f_l, f_h\}$ involves $f^{*}=f_h$ and $w_T^{*}(f_h) = \omega + (cf_h/\sigma(s_b))$. The AF buys the division of the TF at $s=s_g$. (ii) If $cf_h - cf_l < R_T(f_h) - R_T(f_l) < (cf_h/\sigma(s_b)) - cf_l$, the optimal initial contract $\{w_T^{*}(f) \mid f=f_l, f_h\}$ involves $f^{*}=f_l$ and $w_T^{*}(f_l) = \omega + cf_l$. The AF never buys the division of the TF at any s.*

Proposition 1 suggests that the first-best allocation is not attained if $cf_{\mathrm{h}} - cf_{\mathrm{l}} < R_{\mathrm{T}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{l}}) < (cf_{\mathrm{h}}/\sigma(s_{\mathrm{b}})) - cf_{\mathrm{l}}$. The intuition behind this proposition is readily provided. For $s=s_{\mathrm{g}}$, the AF attempts to buy the division of the TF and to renegotiate the initial contract with the worker who invests f_{h}. Since the AF does not compensate the worker for the investment cost cf_{h}, the TF must compensate the worker for this cost beforehand by paying additional wages. However, if $cf_{\mathrm{h}} - cf_{\mathrm{l}} < R_{\mathrm{T}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{l}}) < (cf_{\mathrm{h}}/\sigma(s_{\mathrm{b}})) - cf_{\mathrm{l}}$, the TF has no incentive to do so because it is not profitable. Since the worker rationally anticipates this, he chooses to invest f_{l}. Then, the AF infers this and decides not to buy the division of the TF under Assumption 2.

Although every agent is risk neutral, opportunistic behavior exists in our model. The reason is that the worker's investment is not marketable, and that the investment cost is irrecoverable if the AF buys the division of the TF. If it is costly for the TF to compensate the worker for the investment cost that is not paid by the AF, the worker cannot recover the investment cost at a divestiture. Thus, even though the worker is risk neutral, he is averse to making higher investment.

4. Conditional stock option plans

4.1. Environment

In the preceding section, we have verified that the possibility of the breach of the original contract by the AF causes inefficient investment and acquisition decisions. In this section, we will show that these inefficiencies can be eliminated under a stock option plan to the worker conditional on the event of a divestiture.

In fact, the two inefficiencies can also be eliminated under a severance payment conditional on the event of a divestiture. However, for several reasons, the conditional severance payment may be infeasible. First, the TF may sell off the division so as to repay its debt or finance investment funds for the other profitable projects when its cash flow realizations are low. Then, the TF may not be able to make the conditional severance payment or may be induced to default on it. Second, the TF may not be able to make enough conditional severance payment because of various restrictions of wage contract agreements. On the other hand, the stock option plan is immune from the financial constraint factor because it is bestowed on the worker prior to the event of a divestiture.

In addition to Assumptions 1–5, we will impose the following assumption.

Assumption 6. $[1-\sigma(s_{\mathrm{b}})][\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}})-R_{\mathrm{T}}(f_{\mathrm{h}})]<cf_{\mathrm{l}}$.

Assumption 6 implies that the expected potential gains due to the divestiture, $[1-\sigma(s_{\mathrm{b}})][\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}})-R_{\mathrm{T}}(f_{\mathrm{h}})]$, are smaller than the cost of the lower investment level cf_{l}. This is a technical assumption for ensuring that $w_{\mathrm{T}}(f_{\mathrm{h}})$ satisfies the incentive compatibility condition under optimal conditional stock options. If the shirking worker cannot receive ω from alternative employment, this can be more relaxed.

For simplicity, we assume from now on that the worker either sells all the acquired stocks to the AF for the acquisition tender price before the AF completes the acquisition procedure or sells them to the market before the realization of returns if the TF is still listed in the stock exchange market after the acquisition.[9,10] We also assume that the worker always exercises his awarded stock option if the conditional event occurs (otherwise, our problem is trivial because it is reduced to the one in Section 3). Since the AF can always set the exercise price to be small enough so as to motivate the worker to exercise his awarded stock option, this assumption is not restrictive.

4.2. Implementation of the first-best allocation

Suppose that the TF offers the worker a conditional stock option which is the right to buy a fraction of the shares of the TF, $0<\alpha<1$, with an exercise price $p_{\mathrm{e}}\geqq 0$ if the TF divests the division. In this setup, note that the worker can receive the stock holding ratio α as long as he pays the exercise price p_{e} if the TF divests the division.

We now investigate whether the first-best allocation is implemented by an initial contract with the conditional stock option $\{w_{\mathrm{T}}(f), \alpha, p_{\mathrm{e}}\,|\,f=f_{\mathrm{l}}, f_{\mathrm{h}}\}$. We should notice that the renegotiation contracting problem in period 3 is the same as that in the basic model. Thus, we can set $w_{\mathrm{A}}=\omega$. Then, the AF still makes an acquisition offer if and only if Eq. (2) is satisfied.

[9] We assume that if the TF offers an equilibrium contract that supports f_{h}, investors expect the worker to choose f_{h}; otherwise, they expect the worker to choose f_{l}.

[10] Even if the worker cannot sell the acquired stocks before the realization of returns, our main conclusions still hold although more tedious calculations are needed.

We next discuss the optimal acquisition offer of the AF in period 2. We can focus on the case of $(s, f)=(s_g, f_h)$ under Assumption 2. Under the conditional stock option plan, the net profits of the initial owners of the TF are represented by $R_T(f_h) - w_T(f_h)$ if the division is not divested, and $(1-\alpha)[p(s_g, f_h)+p_e]$ if the division is divested. We assume that the AF can look at the TF's announced initial contract policy and determine the acquisition tender price. Thus, $p(s_g, f_h)$ is given by

$$p(s_g, f_h) = \frac{R_T(f_h) - w_T(f_h)}{1-\alpha} - p_e \qquad \text{for } \alpha < 1. \tag{11}$$

Combining Eqs. (2) and (11), we see that the AF makes an acquisition offer if and only if

$$w_T(f_h) \geqq R_T(f_h) - (1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e] \qquad \text{for } \alpha < 1. \tag{12}$$

Given Eqs. (11) and (12), we examine the optimal initial contract of the TF in period 1. Let us start by discussing the initial contracting subproblem for $f=f_h$. Appendix A shows that for $\alpha<1$, the net expected payoff of the initial owners of the TF, $\Pi_T^{CSO}(f_h, w_T(f_h))=R_T(f_h)-w_T(f_h)$; and the net expected payoff of the worker investing f_h, $U_T^{CSO}(f_h, w_T(f_h), \alpha, p_e)=\sigma(s_b)[w_T(f_h)-cf_h]+[1-\sigma(s_b)]\{\omega-cf_h+([\alpha/(1-\alpha)])[R_T(f_h)-w_T(f_h)]-p_e\}$. The initial contracting subproblem for $f=f_h$ is then

$$\max_{w_T(f_h),\alpha,p_e} R_T(f_h) - w_T(f_h), \tag{13a}$$

$$\text{s.t. } \sigma(s_b)[w_T(f_h) - cf_h] + [1-\sigma(s_b)] \times \left\{\omega - cf_h + \frac{\alpha}{1-\alpha}[R_T(f_h) - w_T(f_h)] - p_e\right\} \geqq \omega, \tag{13b}$$

$$w_T(f_h) \geqq R_T(f_h) - (1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e], \tag{13c}$$

$$w_T(f_h) - cf_h \geqq \omega - cf_l, \tag{13d}$$

$$1 > \alpha \geqq 0 \text{ and } p_e \geqq 0. \tag{13e}$$

Here, Eq. (13b) is the ex ante participation condition for the worker. The constraint Eq. (13c) is the tendering condition for the AF, which is derived from Eq. (12). The constraint Eq. (13d) is the incentive compatibility condition for the worker investing $f=f_h$. The constraints Eq. (13e) are the feasibility conditions of (α, p_e).

If the AF does not make an acquisition offer at $s=s_g$, then the initial contracting subproblem for $f=f_h$ is described by

$$\max_{w_T(f_h),\alpha,p_e} R_T(f_h) - w_T(f_h), \tag{14a}$$

$$\text{s.t. } w_T(f_h) - cf_h \geqq \omega, \tag{14b}$$

$$w_{\mathrm{T}}(f_{\mathrm{h}}) < R_{\mathrm{T}}(f_{\mathrm{h}}) - (1 - \alpha)[\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}}) - \omega - p_{\mathrm{e}}], \tag{14c}$$

$$w_{\mathrm{T}}(f_{\mathrm{h}}) - cf_{\mathrm{h}} \geqq \omega - cf_{\mathrm{l}}, \tag{14d}$$

$$1 > \alpha \geqq 0 \text{ and } p_{\mathrm{e}} \geqq 0, \tag{14e}$$

where Eq. (14c) is the condition that deters the AF from making an acquisition offer.

In fact, Appendix A proves that the AF is always induced to make an acquisition offer for $(s, f)=(s_{\mathrm{g}}, f_{\mathrm{h}})$ under the optimal initial contract. Thus, if $f=f_{\mathrm{h}}$, we only have to consider the subproblem (13).

Let us next turn to the initial contracting subproblem for $f=f_{\mathrm{l}}$. The subproblem is still given by (9) because the AF never makes an acquisition offer if $f=f_{\mathrm{l}}$. Hence, the optimal value in this case is given by Eq. (10).

Now, we solve the subproblem (13) and obtain the associated optimal solution, $\{\hat{w}_{\mathrm{T}}(f), \hat{\alpha}, \hat{p}_{\mathrm{e}} \,|\, f=f_{\mathrm{l}}, f_{\mathrm{h}}\}$, and the associated optimal value, $\Pi_{\mathrm{T}}^{\mathrm{CSO}}(f_{\mathrm{h}}, \hat{w}_{\mathrm{T}}(f_{\mathrm{h}}))$. The optimal solution can be represented by $\hat{w}_{\mathrm{T}}(f_{\mathrm{l}}) = \omega + cf_{\mathrm{l}}$ and

$$\hat{w}_{\mathrm{T}}(f_{\mathrm{h}}) = \omega + cf_{\mathrm{h}} - [1 - \sigma(s_{\mathrm{b}})][\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{h}})], \tag{15}$$

$$\hat{\alpha} = \frac{\sigma(s_{\mathrm{b}})[\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{h}})] + cf_{\mathrm{h}} + \hat{p}_{\mathrm{e}}}{\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}}) - \omega + \hat{p}_{\mathrm{e}}} < 1, \tag{16}$$

where the final inequality of Eq. (16) holds for any $\hat{p}_{\mathrm{e}} \geqq 0$ under Assumptions 1 and 4. Comparing $\Pi_{\mathrm{T}}^{\mathrm{CSO}}(f_{\mathrm{h}}, \hat{w}_{\mathrm{T}}(f_{\mathrm{h}}))$ with $\Pi_{\mathrm{T}}(f_{\mathrm{l}}, w_{\mathrm{T}}^{*}(f_{\mathrm{l}}))$ from Eq. (10), we can determine the optimal choice of f and specify the associated optimal initial contract. As a result, we have the following proposition. The proof is relegated to Appendix A.

Proposition 2. *Suppose that Assumptions 1–6 hold. If the initial contract includes a stock option plan α conditional on the event of a divestiture, then the optimal initial contract $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ is given by $\hat{w}_T(f_l) = \omega + cf_l$, $\hat{w}_T(f_h)$ from Eq. (15) and $\hat{\alpha}$ from Eq. (16) for any $\hat{p}_e \geqq 0$ that is small enough to motivate the worker to exercise his stock option. Furthermore, the optimal initial contract can achieve the first-best allocation: the worker invests f_h and the AF always buys the division of the TF at $s=s_g$.*

Proposition 2 suggests that the initial contract with the conditional stock option can achieve the first-best allocation even though the absence of such a stock option prevents this for $cf_{\mathrm{h}} - cf_{\mathrm{l}} < R_{\mathrm{T}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{l}}) < (cf_{\mathrm{h}}/\sigma(s_{\mathrm{b}})) - cf_{\mathrm{l}}$. To understand the intuition, note that the acquisition tender price can be adjusted so as to compensate for the stock option liability borne by the TF (see Eq. (11)). Thus, even if the worker invests f_{h}, the TF can design a conditional stock option so that the burden of the stock option liability due to the breach of the initial contract by the AF can be transferred from the TF to the AF. This implies that, through the conditional stock option, the TF can compensate the worker for the potential cost of nonmarketable investment arising from the breach of the original contract by the AF.

The initial contract $\{\hat{w}_{\mathrm{T}}(f), \hat{\alpha}, \hat{p}_{\mathrm{e}} \,|\, f=f_{\mathrm{l}}, f_{\mathrm{h}}\}$ given by Eqs. (15) and (16) for $\hat{p}_{\mathrm{e}} = 0$ might be interpreted as employee stock ownership schemes. However, the difficulty of this interpretation is that employee stock ownership schemes are not the ex ante arrangements made at the time workers are hired, to be triggered automatically by a takeover bid. Rather, employee stock ownership schemes can often be viewed as the ex post arrangements made by the TF management to defend itself against hostile takeovers.[11]

4.3. Implementation failure of nonconditional stock option plans

The TF might also award the worker a stock option that is not conditional on the event of a divestiture. However, we can show that any initial contract with the nonconditional stock option is dominated by an initial contract with the conditional stock option.

To verify this, suppose that the worker is offered a stock option which is the right to buy a fraction of the shares of the TF, $0<\alpha<1$, with an exercise price $p_e \geqq 0$ irrespective of whether or not the TF divests the division. For simplicity, we assume that the worker sells all the acquired stocks to the market before the realization of returns if no acquisition occurs. Then, we can still indicate that the renegotiation wage is $w_A=\omega$. On the other hand, under this stock option, the net profits of the initial owners of the TF are represented by $(1-\alpha)[R_T(f_h)-w_T(f_h)+p_e]$ if the division is not divested, and $(1-\alpha)[p(s_g,f_h)+p_e]$ if the division is divested. Thus, the acquisition tender price and the tendering condition are given by Eqs. (3) and (4). Appendix A then shows that the net expected payoff of the initial owners of the TF, $\Pi_T^{NSO}(f_h,\ w_T(f_h),\ \alpha,\ p_e)=(1-\alpha)[R_T(f_h)-w_T(f_h)+p_e]$; and the net expected payoff of the worker investing f_h, $U_T^{NSO}(f_h, w_T(f_h), \alpha, p_e)=\sigma(s_b)w_T(f_h)+[1-\sigma(s_b)]$ $\omega-cf_h-p_e+\alpha[R_T(f_h)-w_T(f_h)+p_e]$.

Now, let us find a condition for a pair of $\{w_T(f_h), \alpha, p_e\}$ under which $\Pi_T^{NSO}(f_h, w_T(f_h), \alpha,$ $p_e)=\Pi_T^{CSO}(f_h,\ \hat{w}_T(f_h))$. Under Eq. (15), the condition for $\Pi_T^{NSO}(f_h,\ w_T(f_h),\ \alpha,\ p_e)=\Pi_T^{CSO}$ $(f_h,\ \hat{w}_T(f_h))$ yields

$$\frac{\omega + cf_h - [1-\sigma(s_b)][\gamma(s_g,\ f_h)R_A(f_h) - R_T(f_h)] - \alpha R_T(f_h)}{1-\alpha} + p_e = w_T(f_h). \tag{17}$$

Given Eq. (17), the participation condition for the worker requires

$$\begin{aligned} U_T^{NSO}(f_h, w_T(f_h), \alpha, p_e) = {} & \frac{\sigma(s_b)-\alpha}{1-\alpha}\{\omega + cf_h - [1-\sigma(s_b)][\gamma(s_g,\ f_h)R_A(f_h) \\ & - R_T(f_h)] - \alpha R_T(f_h)\} + [1-\sigma(s_b)]\omega - cf_h + \alpha R_T(f_h) \\ & - [1-\sigma(s_b)]p_e \geqq \omega. \end{aligned}$$

Rearranging the above inequality, we see

$$\alpha \geqq \frac{\sigma(s_b)[\gamma(s_g,\ f_h)R_A(f_h) - R_T(f_h)] + cf_h + p_e}{\gamma(s_g,\ f_h)R_A(f_h) - \omega + p_e}. \tag{18}$$

[11] A block of shares owned by an employee stock ownership plan makes hostile bidding more difficult. For the wealth effects of announcements of employee stock ownership plans, see Chang and Mayers (1992).

Combining Eqs. (17) and (18) yields[12]

$$\frac{\Gamma}{\sigma(s_b)R_T(f_h) + [1 - \sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) - \omega - cf_h} \geqq w_T(f_h), \tag{19}$$

where $\Gamma = \omega[\gamma(s_g, f_h)R_A(f_h) - \omega - cf_h] - [\gamma(s_g, f_h)R_A(f_h) - R_T(f_h)]\{\sigma(s_b)R_T(f_h) + [1 - \sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) - [1 - \sigma(s_b)]\omega - cf_h\}$. However, the left-hand side of Eq. (19) is smaller than ω.[13] Since the worker sells all the acquired stocks to the market before the realization of returns, the incentive compatibility condition for the worker requires $w_T(f_h) - cf_h \geqq \omega - cf_l$. Hence, this is a contradiction.

Therefore, we obtain the following proposition.

Proposition 3. *Suppose that Assumptions 1–6 hold. Then, any initial contract with the nonconditional stock option plan is dominated by an initial contract with the conditional stock option plan.*

The intuition can be explained as follows. In this case, the worker can receive stock option benefits from the TF even under no divestiture. To prevent the worker from shirking, the TF must pay the worker $w_T(f_h)$ that is at least equal to $\omega + cf_h - cf_l$. Since the TF must pay the worker not only stock option benefits but also $w_T(f_h)$ ($\geqq \omega + cf_h - cf_l$) under no divestiture, this causes the nonconditional stock option to be costlier to the TF than the conditional stock option.

5. Collusion problem and the method of payment for acquisition

Until now, we have assumed that the TF can be committed to the initial contract. However, if the initial contract is implicit or can be discarded after the AF's decision on an acquisition offer, the TF may collude with the worker and attempt to raise the acquisition tender price up to the level that is consistent with f_h although the worker invests f_l. In this section, we will first indicate that the TF has an incentive to collude with the worker. We will then show that the AF prefers to pay stock for the acquisition to overcome this collusion. For simplicity, we modify Assumption 6 as follows:

Assumption 6′. $[1 - \sigma(s_b)][\gamma(s_g, f_h)R_A(f_h) - R_T(f_h)] < \min[cf_l, cf_h + ((cf_l - cf_h)/\sigma(s_b))]$.

5.1. Collusion problem

Suppose that the TF colludes with the worker. Then, in period 1, the TF pretends to settle with the worker the contract $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f = f_l, f_h\}$ given in Proposition 2. However, the worker invests only $f = f_l$. In period 2, if the AF does not buy the division of the TF, then $\hat{w}_T(f)$ is canceled; instead, the TF offers a wage w_T^c. In contrast, if the AF

[12] From Assumptions 1 and 4, note that $\partial(\text{left-hand side of Eq. (17)})/\partial\alpha < 0$.

[13] From Assumptions 1 and 4, we see $\sigma(s_b)R_T(f_h) + [1 - \sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) - [1 - \sigma(s_b)]\omega - cf_h > \sigma(s_b)\omega$.

buys the division of the TF, then ($\hat{\alpha}$, $\hat{p}_e$) is executed because it is difficult to change the initial conditional stock option plan at this stage.[14]

For the moment, let us suppose that the AF believes $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ to be a true contract. Even then, the renegotiation problem is the same as that presented in Section 4.2. Thus, $w_A = \omega$. Since the TF pretends to make the initial contract $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ with the worker, the acquisition offer is represented by Eq. (11). Substituting Eqs. (15) and (16) into Eq. (11) yields $p(s_g, f_h) = \gamma(s_g, f_h)R_A(f_h) - \omega$. This implies that the TF's expected payoff under the collusion is $\sigma(s_b)[R_T(f_l) - w_T^c] + [1 - \sigma(s_b)](1 - \hat{\alpha})[\gamma(s_g, f_h)R_A(f_h) - \omega + \hat{p}_e]$. The worker's expected payoff under the collusion is $\sigma(s_b)[w_T^c - cf_l] + [1 - \sigma(s_b)]\{\omega - cf_l + \hat{\alpha}[\gamma(s_g, f_h)R_A(f_h) - \omega + \hat{p}_e] - \hat{p}_e\}$, while substituting Eqs. (15) and (16) into $U_T^{CSO}(f_h, w_T(f_h), \alpha, p_e)$ implies that the worker's expected payoff under the initial contract is ω.

Now, using Eq. (16), the collusion problem is

$$\max_{w_T^c} \ \sigma(s_b)[R_T(f_l) - w_T^c] + [1 - \sigma(s_b)]\{[1 - \sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) + \sigma(s_b)R_T(f_h) - \omega - cf_h\}, \tag{20a}$$

$$\text{s.t. } \sigma(s_b)(w_T^c - cf_l) + [1 - \sigma(s_b)]\{\omega - cf_l + \sigma(s_b)[\gamma(s_g, f_h)R_A(f_h) - R_T(f_h)] + cf_h\} \geqq \omega, \tag{20b}$$

$$w_T^c \geqq \omega. \tag{20c}$$

Here, Eq. (20b) is the condition that induces the worker to participate in the collusion contract instead of the initial one, whereas Eq. (20c) is the ex post no-quit condition for the worker. Note that the tendering condition for the AF holds because the AF believes $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ to be a true contract. We can also neglect the incentive compatibility condition for the worker investing $f=f_l$ because w_T^c satisfies Eq. (20c). We further assume that all the collusion gains are received by the TF.

Solving problem (20), we have the following result. The proof is given in Appendix A.

Proposition 4. *Suppose that the TF can pretend to settle with the worker the initial contract $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ given in Proposition 2 although the worker invests only f_l. Also suppose that the AF believes $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ to be a true contract. Under Assumptions 5 and 6′, if $cf_h - cf_l < R_T(f_h) - R_T(f_l) < ((cf_h - cf_l)/\sigma(s_b))$, the TF has an incentive to make such collusion with the worker.*

Proposition 4 shows that, if $R_T(f_h) - R_T(f_l) < ((cf_h - cf_l)/\sigma(s_b))$, the TF has an incentive to collude with the worker and to pretend that $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f=f_l, f_h\}$ is a true contract. Thus, if $R_T(f_h) - R_T(f_l) < ((cf_h - cf_l)/\sigma(s_b))$, the AF always expects the TF to collude with the worker. As a result, the AF anticipates that the actual investment level of the worker is

[14] Even if the initial conditional stock option plan can be altered after the divestiture decision, the main qualitative conclusion in this section still holds.

f_l if $R_T(f_h) - R_T(f_l) < ((cf_h - cf_l)/\sigma(s_b))$.[15] Under Assumption 2, this implies that the AF never attempts to buy the division of the TF.

Corollary to Proposition 4. *Under the assumptions of Proposition 4 and Assumption 2, if $cf_h - cf_l < R_T(f_h) - R_T(f_l) < ((cf_h - cf_l)/\sigma(s_b))$, the AF never buys the division of the TF even under the initial contract with the conditional stock option.*

5.2. Method of payment for acquisitions

In the previous sections, the method of payment for acquisitions is assumed to be in the form of cash. Now, we relax this assumption and allow the payment to be in the form of equity. A key difference between cash and stock offers is that the value of equity depends on the profitability of the acquisition, while the value of cash does not. We can show that under certain conditions, this feature eliminates the inefficiency caused by the possibility of collusive action between the TF and the worker.

Suppose that in period 2, the AF makes to the initial owners of the TF a take-it-or-leave-it offer in which the division of the TF is to be transferred in exchange for a fraction of the shares of the AF, $0 < \beta < 1$.

We now discuss whether the first-best allocation is implemented by an initial contract $\{w_T(f), \alpha, p_e \,|\, f{=}f_l, f_h\}$ and a stock offer β even under the possibility of collusion between the TF and the worker. In this setting, the AF again faces a renegotiation problem similar to that in Section 4.2, except that the holding ratio of the shares of the initial owners of the AF is β. Thus, we can set $w_A = \omega$.

We next examine the optimal acquisition offer of the AF in period 2. We can still focus on $(s, f) = (s_g, f_h)$ under Assumption 2. Under the stock offer β, the net profits of the initial owners of the TF are represented by $R_T(f_h) - w_T(f_h)$ if the division is not divested, and $\beta\{(1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e] + Q_A\}$ if the division is divested. Thus, the stock offer β must satisfy

$$\beta = \frac{R_T(f_h) - w_T(f_h)}{(1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e] + Q_A}. \tag{21}$$

On the other hand, the AF makes the stock offer β if and only if

$$(1-\beta)(1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e] \geqq \beta Q_A, \tag{22}$$

where the left-hand side of Eq. (22) indicates the incremental gains received by the initial owners of the AF in the acquisition, and the right-hand side expresses the losses incurred by the initial owners of the AF in the acquisition. Substituting Eq. (21) into Eq. (22) and rearranging it, we see that the AF makes the stock offer β if and only if

$$w_T(f_h) \geqq R_T(f_h) - (1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e]. \tag{23}$$

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[15] This is consistent with our assumption on the belief formation of the AF because $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f{=}f_l, f_h\}$ is not an equilibrium contract under collusion.

We now proceed to find an optimal initial contract and a stock offer that implement the first-best allocation even under the possibility of collusion. It follows from Eq. (21) that, if the worker really invests f_h, the net expected payoffs of the initial owners of the TF and the worker ($\Pi_T^{EO}(f_h, w_T(f_h))$, $U_T^{EO}(f_h, w_T(f_h), \alpha, p_e)$) are $\Pi_T^{EO}(f_h, w_T(f_h)) = \sigma(s_b)[R_T(f_h) - w_T(f_h)] + [1-\sigma(s_b)]\beta\{(1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e] + Q_A\} = R_T(f_h) - w_T(f_h)$; and $U_T^{EO}(f_h, w_T(f_h), \alpha, p_e) = \sigma(s_b)[w_T(f_h) - cf_h] + [1-\sigma(s_b)]\{\omega - cf_h + \alpha[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e] - p_e\}$. For simplicity, we assume that the worker sells all the obtained stocks to the market before the realization of returns.[16]

Suppose that

$$\tilde{w}_T(f_h) = \hat{w}_T(f_h), \quad \tilde{\alpha} = \hat{\alpha}, \quad \text{and } \tilde{p}_e = \hat{p}_e, \tag{24}$$

where $\hat{w}_T(f_h)$, $\hat{\alpha}$, and $\hat{p}_e$ are given by Eqs. (15) and (16). Substituting Eq. (24) into Eq. (21), we see

$$\tilde{\beta} = \frac{[1-\sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) + \sigma(s_b)R_T(f_h) - \omega - cf_h}{[1-\sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) + \sigma(s_b)R_T(f_h) - \omega - cf_h + Q_A}. \tag{25}$$

Note that $0 < \tilde{\beta} < 1$. Substituting Eq. (24) into $\Pi_T^{EO}(f_h, w_T(f_h))$ and $U_T^{EO}(f_h, w_T(f_h), \alpha, p_e)$, we have $\Pi_T^{EO}(f_h, \tilde{w}_T(f_h)) = \Pi_T^{CSO}(f_h, \hat{w}_T(f), \hat{\alpha}, \hat{p}_e)$ and $U_T^{EO}(f_h, \tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e) = U_T^{CSO}(f_h, \hat{w}_T(f), \hat{\alpha}, \hat{p}_e)$. Thus, if $\{\tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}\}$ involves Eqs. (24) and (25), and if the worker invests f_h, both the initial owners of the TF and the worker can receive the same net expected payoff levels as those attained by the optimal initial contract with the conditional stock option in the absence of the collusion possibility. Furthermore, Eqs. (24) and (25) imply that $\{\tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}\}$ satisfies the tendering condition Eq. (23) and the participation and incentive compatibility conditions for the worker with f_h.

The remaining problem is to check whether $\{\tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}\}$ meets the collusion-proofness condition. To this end, we first compute the optimal net expected payoff of the initial owners of the TF, $\Pi_T^C(f_l, w_T^c, \tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta})$, under collusion. Let us solve the following collusion problem of the TF:

$$\max_{w_T^c} \sigma(s_b)[R_T(f_l) - w_T^c] + [1-\sigma(s_b)]\tilde{\beta}\{(1-\tilde{\alpha})[\gamma(s_g, f_l)R_A(f_l) - \omega + \tilde{p}_e] + Q_A\}, \tag{26a}$$

$$\text{s.t. } \sigma(s_b)(w_T^c - cf_l) + [1-\sigma(s_b)]\{\omega - cf_l + \tilde{\alpha}[\gamma(s_g, f_l)R_A(f_l) - \omega + \tilde{p}_e] - \tilde{p}_e\} \geqq \omega, \tag{26b}$$

$$w_T^c \geqq \omega. \tag{26c}$$

Here, Eq. (26b) is the condition that induces the worker to participate in the collusion contract, while Eq. (26c) is the ex post no-quit condition for the worker.

[16] We assume that the TF is still listed in the stock exchange market after the acquisition, as is often observed in Japan or in the case that the TF is a conglomerate firm.

Solving problem (26), we have the following lemma. The proof is given in Appendix A.

Lemma 1. *$\Pi_T^C(f_l,\ w_T^c,\ \tilde{w}_T(f_h),\ \tilde{\alpha},\ \tilde{p}_e,\ \tilde{\beta}) = \sigma(s_b)\{R_T(f_l) - \omega - cf_h - ((cf_l - cf_h)/\sigma(s_b)) + [1-\sigma(s_b)][\gamma(s_g,\ f_h)R_A(f_h) - R_T(f_h)]\} + [1-\sigma(s_b)]\tilde{\beta}\{(1-\tilde{\alpha})[\gamma(s_g,\ f_l)R_A(f_l) - \omega + \tilde{p}_e] + Q_A\}$.*

The collusion-proofness constraint for the TF is now described as follows: $\Pi_T^{EO}(f_h, w_T(f_h)) \geqq \Pi_T^C(f_l, w_T^c, \tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta})$. It follows from the definition of $\Pi_T^{EO}(f_h, w_T(f_h))$, Eqs. (24), (25), and Lemma 1 that

$$\begin{aligned}
&\Pi_T^{EO}(f_h, \tilde{w}_T(f_h)) - \Pi_T^C(f_l, w_T^c, \tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}) \\
&\quad = \sigma(s_b)[R_T(f_h) - R_T(f_l) + cf_l - cf_h] + [1-\sigma(s_b)] \\
&\qquad \times \frac{\{[1-\sigma(s_b)]\gamma(s_g,\ f_h)R_A(f_h) + \sigma(s_b)R_T(f_h) - \omega - cf_h\}^2}{[1-\sigma(s_b)]\gamma(s_g,\ f_h)R_A(f_h) + \sigma(s_b)R_T(f_h) - \omega - cf_h + Q_A} \\
&\qquad \times \frac{[\gamma(s_g,\ f_h)R_A(f_h) - \gamma(s_g,\ f_l)R_A(f_l)]}{\gamma(s_g,\ f_h)R_A(f_h) - \omega + \hat{p}_e} + [1-\sigma(s_b)](cf_l - cf_h).
\end{aligned} \tag{27}$$

Given Assumptions 1, 4, and 5, all of the terms except the final term are positive.

We now see that, if the right-hand side of Eq. (27) is nonnegative, $\{\tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}\}$ not only satisfies all the constraints of the initial contracting problem with the conditional stock option in the *presence* of collusion, but also achieves the optimal value to such an initial contracting problem in the *absence* of collusion. Since $\{\tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}\}$ attains the optimal value to the latter initial contracting problem even though the collusion-proofness constraint is added, it gives a solution to the former initial contracting problem if the right-hand side of Eq. (27) is nonnegative.

Proposition 5. *Suppose that the TF can pretend to settle with the worker the initial contract $\{\hat{w}_T(f), \hat{\alpha}, \hat{p}_e \,|\, f = f_l, f_h\}$ given in Proposition 2 although the worker invests only f_l. Also suppose that the AF makes a take-it-or-leave-it offer in which the initial owners of the TF receive a fraction of the shares of the AF, $0 < \beta < 1$, in exchange for the divested division. Under Assumptions 1–5 and 6′, if the right-hand side of Eq. (27) is nonnegative, then the optimal initial contract $\{\tilde{w}_T(f), \tilde{\alpha}, \tilde{p}_e \,|\, f = f_l, f_h\}$ still involves $\tilde{w}_T(f) = \hat{w}_T(f)$, $\tilde{\alpha} = \hat{\alpha}$, and $\tilde{p}_e = \hat{p}_e$; and the optimal acquisition offer $\tilde{\beta}$ is given by Eq. (25). The worker invests f_h, and the AF always buys the division of the TF.*

Several remarks on Proposition 5 are in order. First, the intuition is that the TF has a stronger incentive to motivate the worker to invest f_h under the stock offer than under the cash offer because the value of the equity offer depends on the profitability of the AF after the acquisition, while the value of the cash offer does not.

Second, rearranging the right-hand side of Eq. (27) with Eqs. (16) and (25), we see

$$\begin{aligned}
&\Pi_T^{EO}(f_h, \tilde{w}_T(f_h)) - \Pi_T^C(f_l, w_T^c, \tilde{w}_T(f_h), \tilde{\alpha}, \tilde{p}_e, \tilde{\beta}) \\
&\quad = \sigma(s_b)[R_T(f_h) - R_T(f_l)] + [1-\sigma(s_b)]\tilde{\beta}(1-\tilde{\alpha})[\gamma(s_g,\ f_h)R_A(f_h) \\
&\qquad - \gamma(s_g,\ f_l)R_A(f_l)] - [cf_h - cf_l].
\end{aligned} \tag{28}$$

The first term in the right-hand side of Eq. (28) is the incremental gross gain of the TF due to an increase in f under no divestiture, $R_{\mathrm{T}}(f_{\mathrm{h}}) - R_{\mathrm{T}}(f_{\mathrm{l}})$, multiplied by the probability, $\sigma(s_{\mathrm{b}})$. The second term in the right-hand side of Eq. (28) is the incremental gross gain of the TF due to an increase in f under the divestiture, $\tilde{\beta}(1-\tilde{\alpha})[\gamma(s_{\mathrm{g}}, f_{\mathrm{h}})R_{\mathrm{A}}(f_{\mathrm{h}}) - \gamma(s_{\mathrm{g}}, f_{\mathrm{l}})R_{\mathrm{A}}(f_{\mathrm{l}})]$, multiplied by the probability, $1-\sigma(s_{\mathrm{b}})$. The third term in the right-hand side of Eq. (28) is the incremental cost due to an increase in f. Thus, the right-hand side of Eq. (28) represents the expected incremental net gain of the TF in response to an increase in f. If the right-hand side of Eq. (28) is nonnegative, the expected incremental net gain of the TF due to an increase in f is nonnegative. Then, the stock offer causes the higher investment to be implementable. Note that this condition depends only on the expected incremental net gain of the TF due to an increase in f, but not on the sum of those gains of the TF and AF.

Inspecting the right-hand of Eq. (27) further leads to the following corollary.

Corollary to Proposition 5. *Suppose that the assumptions of Proposition 5 hold. Other things being equal, the higher investment in firm-specific human capital is more likely to be attained as the incremental gross gain of the AF due to an increase in the investment,* $\gamma(s_g, f_h)R_A(f_h) - \gamma(s_g, f_l)R_A(f_l)$*, is large enough, while the other net revenues of the AF,* Q_A*, and the differences in the investment cost,* $c(f_h - f_l)$*, are small enough.*

The intuition behind this corollary is that if the conditions of the corollary are satisfied, the revenues of the TF strongly depend on the revenues of the divested division under the stock offer.

6. Conclusion

We discuss how the efficient level of firm-specific human capital investment is attained even though divestiture and acquisition decisions affect the ability of firms to contract efficiently with workers. We show that the efficient level of investment is achieved by a stock option plan with a positive exercise price for workers conditional on the event of a divestiture. We also suggest that under certain conditions, a stock offer in acquisition can resolve a collusion problem between the target firm and its workers.

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Appendix A

Representation of $\Pi_{\mathrm{T}}^{\mathrm{CSO}}(f_{\mathrm{h}}, w_{\mathrm{T}}(f_{\mathrm{h}}))$ and $U_{\mathrm{T}}^{\mathrm{CSO}}(f_{\mathrm{h}}, w_{\mathrm{T}}(f_{\mathrm{h}}), \alpha, p_{\mathrm{e}})$: If the worker invests f_{h} and if the AF makes an acquisition offer at $s = s_{\mathrm{g}}$, then it follows from Eq. (11) that

$\Pi_T^{CSO}(f_h, w_T(f_h)) = \sigma(s_b)[R_T(f_h) - w_T(f_h)] + [1-\sigma(s_b)](1-\alpha)[p(s_g, f_h) + p_e] = R_T(f_h) - w_T(f_h)$ for $\alpha < 1$; and $U_T^{CSO}(f_h, w_T(f_h), \alpha, p_e) = \sigma(s_b)[w_T(f_h) - cf_h] + [1-\sigma(s_b)]\{\omega - cf_h + \alpha[p(s_g, f_h) + p_e] - p_e\} = \sigma(s_b)[w_T(f_h) - cf_h] + [1-\sigma(s_b)]\{\omega - cf_h + (\alpha/(1-\alpha))[R_T(f_h) - w_T(f_h)] - p_e\}$ for $\alpha < 1$.

Proof of Proposition 2. Solving the subproblem (13), we obtain the following first-order conditions:

$$-1 + \frac{\sigma(s_b) - \alpha}{1-\alpha}\lambda_1 + \lambda_2 + \lambda_3 = 0, \tag{A1}$$

$$\frac{1-\sigma(s_b)}{(1-\alpha)^2}[R_T(f_h) - w_T(f_h)]\lambda_1 - [\gamma(s_g, f_h)R_A(f_h) - \omega + p_e]\lambda_2 + \lambda_4 = 0, \tag{A2}$$

$$-[1-\sigma(s_b)]\lambda_1 + (1-\alpha)\lambda_2 + \lambda_5 = 0, \tag{A3}$$

where λ_1, λ_2, and λ_3 are the nonnegative multipliers associated with Eqs. (13b)–(13d), and λ_4 and λ_5 are the nonnegative multipliers associated with $\alpha \geqq 0$ and $p_e \geqq 0$. To inspect Eqs. (A1–3), we divide our analysis into the two cases: $\lambda_2 > 0$ or $\lambda_2 = 0$.

[1] $\lambda_2 > 0$: In this case, it is immediate from Eq. (13c) that

$$w_T(f_h) = R_T(f_h) - (1-\alpha)[\gamma(s_g, f_h)R_A(f_h) - \omega + p_e]. \tag{A4}$$

Now, suppose that $\lambda_1 > 0$. Then,

$$\sigma(s_b)[w_T(f_h) - cf_h] + [1-\sigma(s_b)] \times \left\{\omega - cf_h + \frac{\alpha}{1-\alpha}[R_T(f_h) - w_T(f_h)] - p_e\right\} = \omega. \tag{A5}$$

Substituting Eq. (A4) into Eq. (A5) and rearranging it lead to

$$0 < \hat{\alpha} = \frac{\sigma(s_b)[\gamma(s_g, f_h)R_A(f_h) - R_T(f_h)] + cf_h + \hat{p}_e}{\gamma(s_g, f_h)R_A(f_h) - \omega + \hat{p}_e} < 1. \tag{A6}$$

Here, the first inequality is immediate from Assumptions 1 and 4, and the final inequality also follows from Assumptions 1 and 4 for any $\hat{p}_e \geqq 0$. Substituting Eq. (A6) into Eq. (A4), we have

$$\hat{w}_T(f_h) = \omega + cf_h - [1-\sigma(s_b)][\gamma(s_g, f_h)R_A(f_h) - R_T(f_h)] > \omega + cf_h - cf_l, \tag{A7}$$

where the inequality is immediate from Assumption 6. Thus, $\{\hat{w}_T(f_h), \hat{\alpha}, \hat{p}_e\}$ satisfies all of the constraints of problem (13). The expected net payoff of the TF is then

$$\Pi_T^{CSO}(f_h, \hat{w}_T(f_h)) = \sigma(s_b)R_T(f_h) + [1-\sigma(s_b)]\gamma(s_g, f_h)R_A(f_h) - \omega - cf_h. \tag{A8}$$

Next, suppose that $\lambda_1=0$. Then, it is found from Eq. (A2) with $\lambda_2>0$ that $\lambda_4>0$. This implies $\alpha=0$. Substituting $\alpha=0$ into Eq. (A4), we see $w_T(f_h)=R_T(f_h)+\omega-p_e-\gamma(s_g, f_h)R_A(f_h)$. This contradicts Eq. (13b) because it follows from Assumption 4 that $\sigma(s_b)[w_T(f_h)-cf_h]+[1-\sigma(s_b)](\omega-cf_h-p_e)=\sigma(s_b)[R_T(f_h)-\gamma(s_g,f_h)R_A(f_h)]+\omega-cf_h-p_e<\omega$.

[2] $\lambda_2=0$: If $R_T(f_h)\leqq w_T(f_h)$, then $\Pi_T^{CSO}(f_h, w_T(f_h))\leqq 0$, which is smaller than $\Pi_T^{CSO}(f_h, \hat{w}_T(f_h))$ given by Eq. (A8) under Assumption 1. Thus, we must have $R_T(f_h)>w_T(f_h)$. Using Eqs. (A1) and (A2) with $\lambda_1\geqq 0$ and $\lambda_4\geqq 0$, this implies $\lambda_1=\lambda_4=0$ and $\lambda_3=1$. Thus, $w_T(f_h)=\omega+cf_h-cf_l$. Given Eqs. (13b) and (13c), we see $(\sigma(s_b)cf_l+[1-\sigma(s_b)]cf_h)/(1-\sigma(s_b))+p_e\leqq(\alpha/(1-\alpha))[R_T(f_h)-w_T(f_h)]\leqq[(1/(1-\alpha))-1][R_T(f_h)-w_T(f_h)]\leqq\gamma(s_g,f_h)R_A(f_h)-R_T(f_h)+cf_h-cf_l+p_e$. However, these inequalities are infeasible because of Assumption 6.

As a result, the optimal solution to problem (13) is given by Eqs. (A6) and (A7) for any $\hat{p}_e\geqq 0$, and the expected net payoff of the TF is represented by Eq. (A8).

We next proceed to verify that it is always optimal for the AF to make an acquisition offer for $(s, f)=(s_g, f_h)$. Inspecting (14), we see that the optimal value to (14) is at most $R_T(f_h)-\omega-cf_h$, which is smaller than $\Pi_T^{CSO}(f_h, \hat{w}_T(f_h))$ from Eq. (A8).

Now, comparing $\Pi_T^{CSO}(f_h, \hat{w}_T(f_h))$ from Eq. (A8) and $\Pi_T(f_l, w_T^*(f_l))$ from Eq. (10), we show that $\Pi_T^{CSO}(f_h, \hat{w}_T(f_h))-\Pi_T(f_l, w_T^*(f_l))=\sigma(s_b)R_T(f_h)+[1-\sigma(s_b)]\gamma(s_g, f_h)R_A(f_h)-R_T(f_l)+cf_l-cf_h>0$, where the final inequality follows from Assumptions 4 and 5. The optimal initial contract with the conditional stock option therefore involves $f=f_h$ and $\{\hat{w}_T(f_h), \hat{\alpha}, \hat{p}_e\}$ given by Eqs. (A6) and (A7) for any $\hat{p}_e\geqq 0$ that is small enough to motivate the worker to exercise his stock option. □

Representation of $\Pi_T^{NSO}(f_h, w_T(f_h), \alpha, p_e)$ and $U_T^{NSO}(f_h, w_T(f_h), \alpha, p_e)$: Using Eq. (3), $\Pi_T^{NSO}(f_h, w_T(f_h), \alpha, p_e)=\sigma(s_b)(1-\alpha)[R_T(f_h)-w_T(f_h)+p_e]+[1-\sigma(s_b)](1-\alpha)[p(s_g, f_h)+p_e]=(1-\alpha)[R_T(f_h)-w_T(f_h)+p_e]$; and $U_T^{NSO}(f_h, w_T(f_h), \alpha, p_e)=\sigma(s_b)\{w_T(f_h)-cf_h+\alpha[R_T(f_h)-w_T(f_h)+p_e]-p_e\}+[1-\sigma(s_b)]\{\omega-cf_h+\alpha[p(s_g, f_h)+p_e]-p_e\}=\sigma(s_b)w_T(f_h)+[1-\sigma(s_b)]\omega-cf_h-p_e+\alpha[R_T(f_h)-w_T(f_h)+p_e]$.

Proof of Proposition 4. Inspecting (20) with Assumption 6′, we see

$$w_T^c=\omega+cf_h+\frac{cf_l-cf_h}{\sigma(s_b)}-[1-\sigma(s_b)][\gamma(s_g, f_h)R_A(f_h)-R_T(f_h)]>\omega. \quad \text{(A9)}$$

Substituting Eq. (A9) into Eq. (20a), we obtain

$$\Pi_T^C(f_l, w_T^c)=\sigma(s_b)R_T(f_l)+[1-\sigma(s_b)]\gamma(s_g, f_h)R_A(f_h)-\omega-cf_l. \quad \text{(A10)}$$

Comparing $\Pi_T^{CSO}(f_h, \hat{w}_T(f_h))$ from Eq. (A8) and $\Pi_T^C(f_l, w_T^c)$ from Eq. (A10), we show that if $R_T(f_h)-R_T(f_l)<((cf_h-cf_l)/\sigma(s_b))$, then $\Pi_T^{CSO}(f_h, \hat{w}_T(f_h))-\Pi_T^C(f_l, w_T^c)=\sigma(s_b)[R_T(f_h)-R_T(f_l)]+cf_l-cf_h<0$, which implies that the TF has an incentive to collude with the worker. □

Proof of Lemma 1. Substituting Eq. (24) (or Eq. (16)) into Eq. (26b), we see that the constraints of (26) are the same as those of (20). Repeating arguments similar to those in Proposition 4, we can prove Lemma 1. □

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