Active Board and CEO Efforts

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Abstract

We investigate the value of having an active board to a firm. Specifically, we investigate how an active board advises and monitors the CEO in evaluating and implementing a risky project. We demonstrate two effects of active boards that have not been documented in the literature. We find that useful board advice on investment decisions not only improves decision accuracy, but also motivates the CEO to acquire information and evaluate the project beforehand. We also find that active monitoring of CEO actions can break the efficient synergy between the tasks, decreasing firm value.

1 Introduction

In the wake of corporate financial fraud in the early 2000s and the recent credit crisis, boards of directors have become more active in monitoring firm performance and advising top management. The public and regulations also urge boards to become more involved in various firm operations. For example, the Securities and Exchange Commission (SEC) disclosure rules (2010) require firms to describe in their proxy statements the role of the board of directors in managing risky investments. It seems that with more pairs of fresh eyes involved, higher monitoring and advisory activities should lead to improvements in firm performance. However, empirical studies showed mixed results. Brick and Chidambaran (2010) presented evidence that is consistent with active boards add value to the firm; while Vafeas (1999) found that active boards are associated with lower firm performance. Both studies use board meeting times as a proxy for active/passive boards, but this proxy may not fully capture the effects of boards' actual activities.

Using an analytic model, we look directly into a firm's project investment setting to further investigate the effects of active boards. Periodically, a firm considers adopting a risky project, for example, acquiring a supplier, entering a new geographic market, developing a new product, forming strategic alliances with a rival, etc.. We demonstrate two effects of active boards that have not been documented in the literature. We find that useful board advice on investment decisions not only improves decision accuracy, but also motivates the CEO to acquire information and evaluate the project beforehand. We also find that active monitoring of CEO actions can break the efficient synergy between the tasks, decreasing firm value.

To ensure a satisfactory result, a CEO normally engages in two tasks: first acquiring information to evaluate the profitability of a potential project (evaluation task, such as investigating feasible production technology and capacity), then expending effort to complete the project (implementation task, such as recruiting and training employees for the new project). When there is no board intervention (under a passive board), the incentives for the CEO to pursue evaluation task need to be set stronger than implementation task. That is, the CEO's compensation will be set riskier with respect to the final project outcome. The reason is that, the project's final success is more indicative of implementation effort than evaluation effort, because without diligent implementation the project would fail surely. Implementation effort is easier to infer from the project outcome. Therefore, if the board can provide incentives for the CEO to evaluate the project, these incentives should be strong enough to motivate the second task (implementation task).

However, one of the board monitoring activities is to assess the risks posed by the compensation programs, to see whether the level of risk in current incentive plans provides optimal motivation.[1] An active board is probably more intended to engage in such an activity than a passive board. The board will mitigate the compensation risk after project evaluation is completed. The focus now shifts to the implementation task, which does not require that high level of risk. This monitoring activity is beneficial for the firm from an *ex post* point of view, but impedes the CEO's decision to evaluate the project *ex ante*, as the CEO expects the final compensation will contain less risks.

The CEO's incentives to evaluate the project can be restored by board offering advice. The active board provides advice after the CEO's evaluation that determines whether invest in the project or not. An important feature of board advice is whether the board advice is useful depends critically on the CEO's initial evaluation of the project. A board rarely begins to investigate a project without knowing anything about it. Directors are generally not as familiar to the firm's operations as the CEO, due to lack of firm-specific expertise or limited time spend in the firm. Only when the CEO's initial evaluation of the project resolves some level of uncertainty and points to the right direction for the board is the board able to provide useful advice.

When the active board also advises, the CEO will be motivated to evaluate the project because only after s/he evaluated the project, chances are higher that his/her report is consistent with the board's assessment. Consistent report with board advice becomes an indicator of the CEO's evaluation effort.

We use a passive board to serve as a benchmark to address the ultimate question, what is the value of having an active board? A passive board adopts a more hands-off approach. The board

[1]Please see an example from the management consulting firm Hay Group, "A guide to compensation risk assessments: a process to understand and mitigate risk in compensation programs".

designs the CEO compensation at the outset but is not involved in the project till its completion. Whether an active board adds value to the firm depends on the quality of the advice provided by the active board. We also find having inside directors sitting on an active board helps truthful communication from the board to the CEO.

Our result of board advising differs significantly from Aghion and Tirole [1997] and Burkart, Gromb and Panunzi [1997] who show that the board and the CEO's information acquiring activities are substitutes. Board acquiring information directly reduces the impact of the CEO's effort on the outcome, thus reducing the CEO's incentives. We show that these two activities can be complements: board information acquisition provides incentives for the CEO to acquire information.

Unlike the literature of compensation contract renegotiation (e.g., Demski and Frimor 1999, Indjejikian and Nanda 1999, Christensen, Demski and Frimor 2002) where the result of renegotiation is usually information suppression, we demonstrate anther result of contract renegotiation: breaking the synergy between the tasks so that each task has to be individually motivated.

We present a problem from active monitoring, which differs significantly from the well-known time-consistency problem in managerial investment decisions: a hold-up problem. A hold-up problem arises when the principal directly extract the manager's rent *ex post* which reduces the *ex ante* efficiency of a manager's action (e.g., Grossman and Hart 1986, Rajan 1992, Adam and Ferreira 2007). The board depicted in our study is more benigh: the board does not extract the CEO's rent, instead, the board adjusts down the CEO compensation risk which is mutually beneficial. But still, this activity reduces the *ex ante* efficiency of the CEO's action.

2 Model Setup

There are three players: shareholders, a board of directors, and a CEO. The CEO is risk-averse and has CARA utility. Both the shareholders and board of directors are risk-neutral syndicates. There are two types of boards: active boards and passive boards. An active board provides advice to the CEO and also closely monitors the CEO. An passive board, on the other hand, only designs the compensation contract for the CEO at the outset. The shareholders decide which type of boards to hire and what proportion of insiders should be on the board.

The CEO needs be motivated to pursue two tasks: (1) evaluating a potential project (evaluation task) and, (2) if the project is adopted, implementing the project (implementation task). To simplify the analysis, we assume that both the CEO's evaluation effort η and implementation effort t are binary: $\eta \in \{0, 1\}$ and $t \in \{0, 1\}$. The cost of $\eta = 0$ and $t = 0$ are normalized to zero, the cost of $\eta = 1$ is $k > 0$ and the cost of $t = 1$ is $c > 0$. If the project is adopted, the firm's gross profit x depends on the project quality $\theta \in \{0, 1\}$, the CEO's implementation effort t and the size of the project X. Specifically,

$$x = \theta \cdot t \cdot X.$$

That is, the project is a success only if the project is of good quality $\theta = 1$ and the CEO has exerted effort to implement it. If the project is rejected, the CEO receives a rejection wage and the game ends. The project, if accepted, has an up-front cost d. We focus on the parameter regions in which the firm's optimal investment policy is to invest when the posterior probability of state being good ($\theta = 1$) is higher than $1/2$.

The project quality θ is either bad ($\theta = 0$) or good ($\theta = 1$), with ex-ante probability being $1/2$. The CEO can expend effort η to acquire information to evaluate the project quality. If the CEO exerts evaluation effort, the CEO receives signal $s \in \{G, B\}$ about the project quality with precision i. Otherwise, the CEO's signal s is pure noise. That is, the CEO can costlessly observe some information inside the firm. But without carefully searching for and analyzing information, the CEO will not learn much about the project. Specifically,

$$Pr[s = G|\theta = 1] = Pr[s = B|\theta = 0] = 0.5 + i \cdot \eta.$$

We carry the analysis assuming that the CEO's signal is observable. Relaxing this assumption will not affect our results qualitatively.

The CEO has a CARA utility with multiplicative cost. If the CEO fulfils both tasks, his/her utility is

$$U_{CEO} = -e^{-r(w-c-k)} = e^{r(c+k)}(-e^{-r\cdot w}),$$

where w is the CEO's wage and r is the CEO's risk aversion. The CEO has a reservation utility $-e^0 = -1$.

We represent the board's utility function as a weighted average of the firm's expected net output and the CEO's utility.[2] If the project is accepted, the board's utility is

$$U_B = (1-\alpha)E[(x-d) - w] + \alpha CE^{CEO},$$

where CE^{CEO} represents the CEO's certainty equivalent. If the project is rejected, the board's utility is $(1-\alpha)E[-w] + \alpha CE^{CEO}$. Intuitively, α represents the proportion of insiders on the board of directors. If the board is fully independent, $\alpha = 0$, then the board's preference is the same as shareholders.

3 Passive Board

As a useful benchmark, we first study how a passive board interacts with the CEO. A passive board is not actively involved in the firm's operations beyond designing the CEO compensation.

[2]The same utility function is used for modelling boards' preference in Drymiotes (2007).

The sequence of events is as follows:

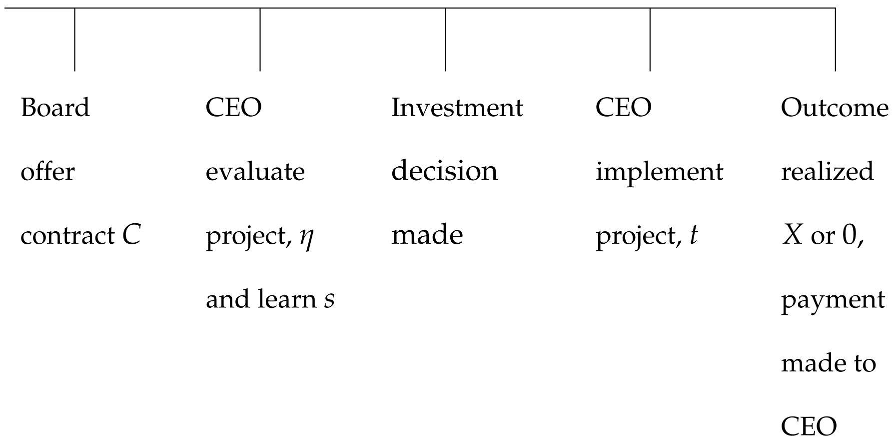


Figure 1. Timeline for a Passive Board

The board designs the compensation to motivate the CEO to evaluate the project and implement the project. The project is invested if and only if the CEO's signal is G. The board offers the CEO a contract C based on the CEO's signal s, the investment decision, and the final gross profit x. The compensation contract can be written as a triplet $(\overline{W}, \underline{W}, W_o)$, $\overline{W}$ represents the CEO's wage for project success ($x = X$), $\underline{W}$ is the wage for project failure ($x = 0$), and W_o is the wage for no investment. The corresponding utility terms are $(\overline{U}, \underline{U}, U_o)$. In the following analysis, we work on the utility space. The wage function $w = \Phi(U) = -\frac{1}{r}ln(-U)$, which is the inverse of the CEO's CARA utility function.

Denote EU_p as the CEO's expected utility when s/he exerts both evaluation and implementation efforts.

$$EU_p = e^{rk}\{0.5e^{rc}[(0.5+i)\overline{U} + (0.5-i)\underline{U}] + 0.5U_0\}.$$

The investment is undertaken with probability 0.5, because $\Pr[G] = 0.5(0.5+i) + 0.5(0.5-i) = 0.5$, similarly, $\Pr[B] = 0.5$. Conditional on investment being undertaken and the CEO exerting implementation effort, the project succeeds with $\Pr[\theta = 1|G] = 0.5 + i$, in which case the CEO receives $\overline{W}$ (the corresponding utility is $\overline{U}$). If the project fails, which is with probability $1 - \Pr[\theta = 1|G] = 0.5 - i$, the CEO receives wage $\underline{W}$ with a corresponding utility $\underline{U}$. With probability 0.5, no investment is made and the CEO receives W_o.

The board aims to minimize the compensation cost, subject to the CEO's incentive-compatible constraints and participation constraint. Therefore, the board's optimization program is as follows:

$$\min_{\overline{U},\underline{U},U_0} \; 0.5[(0.5+i)\Phi(\overline{U}) + (0.5-i)\Phi(\underline{U})] + 0.5\Phi(U_0)\ , \qquad (P-p)$$

subject to the participation constraint

$$EU_p \geq -e^{-r\cdot 0} = -1\ , \qquad (IR)$$

the evaluation effort selection constraints

$$EU_p \;\geq\; 0.5e^{rc}(0.5\overline{U} + 0.5\underline{U}) + 0.5U_0 \qquad (IC\eta_1)$$

$$EU_p \;\geq\; 0.5\underline{U} + 0.5U_0 \qquad (IC\eta_2)$$

and the implementation effort selection constraint

$$e^{rc}[(0.5+i)\overline{U} + (0.5-i)\underline{U}] \geq \underline{U}\ . \qquad (ICt)$$

Constraint $(IC\eta_1)$ ensures that the CEO does not just implement and drop the project according to a random signal without evaluating the project first. Constraint $(IC\eta_2)$ ensures that the CEO does not make a random investment decision and then not providing implementation effort.

Notice that the CEO's evaluation effort does not increase the probability of receiving good news, s/he is only discovering the nature of the project. Hence based on the CEO's signal alone cannot motive the CEO's evaluation effort. That is, the board has to rely on the project final outcome to provide incentives for the CEO to evaluate the project. Given that evaluation effort does not increase the final outcome in the sense of first-order stochastic dominance, and evaluation effort is not as necessary for the project's success as implementation effort, the final outcome is less indicative of the CEO's evaluation effort than his/her implementation effort. Therefore, in order for the CEO to expend effort evaluating the project, compensation should provide stronge incentives. That is, the CEO receives large reward when the project is a success ($\overline{U} \gg \underline{U}$). These strong incentives turn out to be sufficient for the ensuing implementation effort.[3]

Lemma 1. The implementation effort selection constraint is always slack for a passive board.

Proof by contradiction. If the implementation effort selection constraint were binding, constraint ($IC\eta_2$) would be violated.

The next result shows that which of the incentive compatible constraints for the CEO's evaluation effort is binding depends on the relative costs between evaluation effort and implementation effort.

Proposition 1. When $e^{rc} \leq 1 + G(k)$, constraint ($IC\eta_1$) binding and constraint ($IC\eta_2$) slack; when $e^{rc} > 1 + G(k)$, constraint ($IC\eta_2$) binding and constraint ($IC\eta_1$) slack; where

$$G(k) = \frac{(2/i)(e^{rk}-1)}{1+\sqrt{1+[(2/i^2)(e^{rk}-1)+8e^{rk}](e^{rk}-1)}}, \text{and } \frac{\partial G(k)}{\partial k} > 0.$$

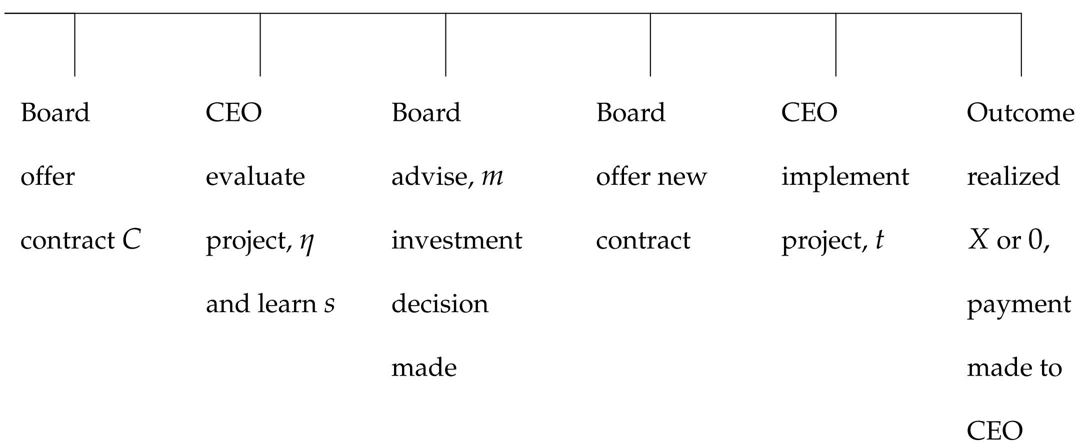
When the cost of evaluation effort (k) is large, the moral hazard problem is severe so the incentives need to be set very steep ($\overline{U} \gg \underline{U}$). At the same time, if the cost of implementation effort (c)

[3] If the CEO is allowed to misreport his/her findings to the board, the result is qualitatively the same. Particularly, the (ICt) constraint is still slack.

is relatively small, such steep incentives are sufficient to motivate the CEO to take implementation effort even if the CEO did not exert effort to evaluate the project: $e^{rc}(0.5\overline{U} + 0.5\underline{U}) \geq \underline{U}$. That is, the $(IC\eta_2)$ constraint is binding. Similarly, if the initial evaluation effort problem is not severe, the resulted incentives are weaker. Coupled with a large implementation cost (c), the CEO would not exert effort to implement the project if s/he did not evaluate the project initially.

4 Active Board

An active board monitors the CEO regularly to ensure the CEO's incentives are best aligned with the shareholders' preference. At the same time, the board also provides advice to the CEO to improve the investment decision. The sequence of events in this setting is described in the timeline shown in Figure 2:



An important feature of board advising is that it depends critically on the CEO's initial assessment of the project. The board is not as familiar to the firm's daily operations as the CEO, hence viable advice must rely on the CEO's initial assessment of the project. Directors provide advice and counsel to the CEO and senior management through formal board and committee meetings or through informal consultation.[4] We focus on the more formal channel of communication. We model the board's advice as a report issued by the board $\hat{m} \in \{H, L\}$, which is based on an additional signal $m \in \{H, L\}$ learned by the board about the project quality. Specifically, the informativeness of the board's signal depends on the CEO's signal/report s and the board's expertise i_B:

$$Pr[H|\theta = 1, s] = Pr[L|\theta = 0, s] = 0.5 + i_B \cdot I_{Pr[\theta|s]-Pr[\theta]}$$

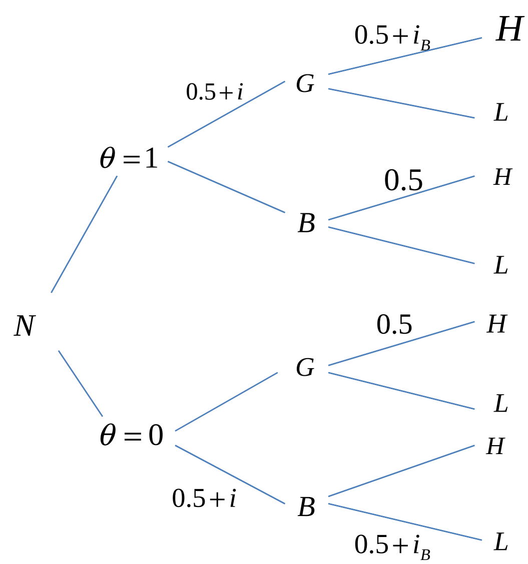
Where $I_{Pr[\theta|s]-Pr[\theta]}$ is an indicator function such that

$$I_{Pr[\theta|s]-Pr[\theta]} = \begin{cases} 1, & \text{if } \Pr[\theta|s] - \Pr[\theta] > 0 \\ 0, & \text{otherwise} \end{cases}$$

The indicator function $I_{Pr[\theta|s]-Pr[\theta]}$ describes that when the CEO's initial assessment points to the right direction for the board to further seek information, the board's signal is informative. The CEO's evaluation effort has to be able to resolve some level of the uncertainty about the project $\Pr[\theta|s] - \Pr[\theta] > 0$, so the CEO's report can serve as a starting point for the board to search for information. In addition, directors holding more relevant expertise (or experience) provide more useful advice. How informative the signal depends on the board's expertise i_B. Otherwise, the board's signal about the project quality is pure noise.

If the CEO has not evaluated the project, $\eta = 0$, s/he has not resolved any uncertainty so $\Pr[\theta|s] - \Pr[\theta] = 0$. Board advice is not informative about the project quality: $Pr[H|\theta = 1, s] = Pr[L|\theta = 0, s] = 0.5$. If the CEO has evaluated the project, $\eta = 1$, the game has the following information structure:

[4] See The Business Roundtable (2005).



4.1 How Board Monitoring affects CEO Incentives

The CEO compensation offered by an active board depends on: the CEO's signal s, the board's advice m, the investment decision (which is fully determined by the board's advice given our assumption that the board's expertise is high enough), and the final gross profit x. Hence the contract is $(\overline{W}_{GH}, \underline{W}_{GH}, W_{GL}, \overline{W}_{BH}, \underline{W}_{BH}, W_{BL})$, where the subscripts (sm) represent the CEO and board's signals. The corresponding utility terms are represented by $(\overline{U}_{GH}, \underline{U}_{GH}, U_{GL}, \overline{U}_{BH}, \underline{U}_{BH}, U_{BL})$.

After providing advice, the investment decision is made accordingly. The board's objective then shifts to ensure that the invested project is implemented efficiently. At this moment, the board can offer a revised contract to the CEO which keeps the CEO no worse off but reduces the compensation cost. As we have established in the section "Passive Board", motivating evaluation effort demands imposing higher risks on the CEO than necessary for the implementation effort alone. Now that evaluation effort is sunk, the board can reduce the risks to the level just enough to motivate implementation effort. By monitoring the CEO's incentives regularly, the board adjusts the compensation risks faced by the CEO to the current environment. That efficiently controls the unnecessary risk premium paid to the CEO, lowering the shareholders' cost.[5] Note that renegotiation happens only when the investment is undertaken. If the project is dropped, the CEO doesn't face any compensation risk so that there is no gain for renegotiation.

The board solves the problem backwards. After investment is undertaken, the board adjusts the risks in the CEO's compensation contract but not lowering the CEO's expected utility so that the CEO will not reject the revised contract. Instead of describing the actual renegotiation, we can restrict attention to the contracts that are renegotiation proof (Fudenberg and Tirole 1990). A contract is renegotiation proof if the principal will not choose to alter it at the renegotiation stage. That is, the contract is *ex-post* optimal from the board's perspective, for all information events at the renegotiation stage.

A contract $C = (\overline{U}_{sH}, \underline{U}_{sH})$ is renegotiation-proof if it minimize the board's expected compensation cost subject to the implementation effort constraint (ICt_{sH}) and the IR constraint (IR_{sH}).

$$e^{rc}(\Pr[\theta = 1|s, H]\overline{U}_{sH} + (1 - \Pr[\theta = 1|s, H])\underline{U}_{sH}) \geq \underline{U}_{sH} \qquad (\text{ICt}_{sH})$$

$$e^{rc}(\Pr[\theta = 1|s, H]\overline{U}_{sH} + (1 - \Pr[\theta = 1|s, H])\underline{U}_{sH}) \geq EU^{I}(s, H) \qquad (\text{IR}_{sH})$$

where $EU^{I}(s, H)$ is the CEO's expected utility before accepting the revised contract.

Lemma 2. The implementation effort constraint is always binding for an active board.

Both constraints are binding for the standard moral hazard problem (Holmstrom 1979), which implies

$$\overline{U}_{sH} = (\frac{e^{-rc} - 1}{\Pr[\theta = 1|s, H]} + 1)\underline{U}_{sH}. \qquad (1)$$

[5]The board has incentives to revise the CEO's contract even if there are inside directors. There is always a strict gain because the compensation cost is reduced but the CEO's expected utility is kept constant. Thus, the presence of insiders does not reduce the monitoring intensity, unlike Adam and Ferreira (2007).

Note that the utility levels are negative, hence $\overline{U}_{sH} > \underline{U}_{sH}$. The pay differential is set just enough to motivate the CEO to take the implementation effort.

A well-known negative effect of renegotiation is that it might harm the agent's *ex-ante* incentives. The same logic holds here and displays in an extreme form: the CEO will not have any incentives to evaluate the project. To elaborate, note that now the pay differential is just enough to motivate the CEO's implementation effort. That is, the CEO's expected utility when G is realized equals $\underline{U}_{sH}$, the level of utility if shirking. As we mentioned earlier, the CEO's evaluation effort does not increase the probability of receiving good news G: still 0.5. Thus, the utility for the CEO after exerting evaluation effort is the same as what s/he will receive if s/he does not evaluate the project. Since the effort is costly, the CEO will not be motivated to expend that effort.

4.2 How Board Advising Affects CEO Incentives

We now study whether board advising can restore the CEO's *ex-ante* evaluation effort incentive, which is thwarted by board monitoring. Notice that the unconditional probability of the board receiving favorable signal is also 0.5, no matter it is informed or not. Hence depending on the board's advising alone, it is impossible to motivate CEO evaluation effort. However, the combination/comparison of board advising and CEO's signal together is informative about whether the CEO's evaluation effort is taken.

To see this, note that, by the information structure we imposed, if the CEO exerts evaluation effort ($\eta = 1$), the conditional probabilities of board advice m based on initial CEO input s are:

$$\begin{aligned}
\Pr[H|G, \eta = 1] = \Pr[L|B, \eta = 1] &= 0.5 + i_B(0.5 + i) \\
\Pr[H|B, \eta = 1] = \Pr[L|G, \eta = 1] &= 0.5 - i_B(0.5 + i).
\end{aligned}$$

In contrast, if the CEO does not exert evaluation effort ($\eta = 0$), then both the CEO's assessment and the board's advice are pure noise, hence the conditional probabilities are $\Pr[m|s, \eta = 0] = 0.5$ for any $m \in \{H, L\}$ and $s \in \{G, B\}$.

As we discussed in the previous section, renegotiation-proofness implies that the implementation effort constraint (ICt_{sH}) is binding, hence the CEO receives an expected utility $\underline{U}_{GH}$ for the event (G, H) and $\underline{U}_{BH}$ for the event (B, H), if s/he evaluates the project $\eta = 1$. Thus, the CEO's *ex ante* expected utility if s/he takes both efforts is

$$EU_a = e^{rk}\{\underbrace{0.5(0.5 + i_B(0.5 + i))}_{Pr(G,H)=Pr(B,L)}(\underline{U}_{GH} + U_{BL}) + \underbrace{0.5(0.5 - i_B(0.5 + i))}_{Pr(B,H)=Pr(G,L)}(\underline{U}_{BH} + U_{GL})\}.$$

After incorporating the binding implementation effort constraint (ICt_{sH}) implied by renegotiation-proofness, the active board's optimization problem P_a can be written as[6]

$$\min_{\underline{U}_{G,H}, \underline{U}_{BH}, U_{GL}, U_{BL}} \; Pr(G, H)[\Phi(\underline{U}_{GH}) + \Phi(U_{BL})] + Pr(B, H)[\phi(\underline{U}_{BH}) + \phi(U_{GL})] \,, \qquad (P - a)$$

subject to the following constraints:

$$EU_a \geq 0.5[0.5(\underline{U}_{GH} + U_{BL}) + 0.5(\underline{U}_{BH} + U_{GL})] \qquad (IC\eta)$$

$$EU_a \geq -e^{-r \cdot 0} = -1 \qquad (IR)$$

To understand the right hand side of the evaluation effort constraint (IC_η), note that the CEO is made indifferent for the implementation effort after s/he takes the evaluation effort. If the CEO does not take the evaluation effort $\eta = 0$, then s/he will not take the implementation effort either.

[6]Due to the multiplicative cost structure, $\Phi(\overline{U}_{sH}) = \Phi(\underline{U}_{sH}) - \frac{1}{r} Ln(\frac{e^{-rc}-1}{\Pr[\theta=1|s,H]} + 1)$. Hence $\overline{U}_{sH}$ doesn't show up in the board's objective function. We also ignore the second term in the board's objective function since it is not a choice variable.

The reason is that, if evaluation effort is taken, both $\Pr[\theta = 1|G, H]$ and $\Pr[\theta = 1|B, H]$ are greater than 0.5, the conditional probability of $\theta = 1$ if no evaluation effort is taken.

Both evaluation effort constraint (IC_η) and the IR constraint (IR) have to be binding for a moral hazard problem. Therefore the solution to Program $P - a$ is as follows:

Proposition 2. Constrasting with board advice can provide incentives for the CEO to undertake evaluation effort:

$$\underline{U}_{GH} = U_{BL} = -1 + \frac{1 - e^{-rk}}{i_B(1 + 2i)} \tag{2}$$

$$\underline{U}_{BH} = U_{GL} = -1 - \frac{1 - e^{-rk}}{i_B(1 + 2i)} \tag{3}$$

The board provides incentives for the CEO to exert evaluation effort, by rewarding the consistent report with the board advice. The CEO's information and the board's information are correlated only if the CEO took evaluation effort. Reflecting the same underlying status θ, the CEO's report should be correlated with the board advice if the CEO has diligently searched for information.

Interestingly, the same results hold when the CEO are allowed to misreport his acquired information. The evaluation effort incentives provided by board advising are so strong that render all the CEO's reporting constraints slack.

5 Benefit and Cost of Active Board

A well-known benefit of board advice is to improve on investment efficiency. Without board advice, the optimal investment policy is to invest when the CEO discovers G. Board advice may revise the investment decision in the following two cases: (1) When the signal combination is (G, L), board advice will change the investment decision from "invest" to "no invest", with a gain $I - Pr[\theta = 1|G, L]X$;[7] (2) When the signal combination is (B, H), board advice will change the investment decision from "no invest" to "invest", with a gain $Pr[\theta = 1|B, H]X - I$. The total investment efficiency improvement will be $Pr(G, L)(Pr[\theta = 1|B, H] - Pr[\theta = 1|G, L])X = 0.5[(0.5 + i)i_B - i]X$.

Besides the investment efficiency gain, we establish another benefit for board advising. Board advice does not quench the CEO's incentives to diligently evaluate the project. Instead, board advice serves as a disciplining device: only after the CEO acquires information, board advice can be informative about the project. The heavy reliance of the CEO's input turns out to be beneficial for the shareholders. That motivates the CEO to take the first step.

Being an active board does bear some cost. The cost is that the active board adjusts the CEO's compensation to the current environment. Reducing risk premium paid to the CEO is beneficial for shareholders *ex post*, but it is costly from an *ex ante* point of view. Recall the case with a passive board. When there is no board intervention, a natural synergy exists between motivating the CEO's tasks. The incentives provided for him/her to exert evaluation effort are sufficient for motivating implementation effort. In other words, it is "free" to ask the CEO to implement the project. Whereas an active board shifts the focus to monitor project implementation after the CEO completes evaluation, that breaks the synergy between the two tasks. The board chooses to explicitly motivate the CEO's implementation effort, adding another constraint. Now the two tasks are motivated individually: board advice disciplines the CEO's behavior in project evaluation and project outcome disciplines the CEO's behavior in project implementation. This incentive separation due to board active monitoring is a cost to the shareholders from an *ex ante* point of

[7] Here we ignore the associated compensation cost for implementation effort.

view.

Proposition 3. If $i_B \leq \frac{1-e^{-rk}}{1+2i}$, an active board is not feasible to motivate evaluation effort. A passive board is beneficial.

Recall that the CEO's incentives to evaluate the project entirely depends on the comparison of board advice and CEO assessment. The motivation efficiency decreases with the board expertise i_B. When the board advising expertise is low, the information contained in board advice is low, so is the correlation between the CEO's discovery and board advice. Knowing that board advice is not necessarily indicative about the expended effort, the CEO will lose motivation to exert effort. So the investment decision has to be made without information.

6 Board Advising Incentives

In this section we relax the assumption that the board always offers truthful advice. Now the board can freely advise the CEO based on their observed information.

Proposition 4. For a board full of outsiders, the following condition has to be satisfied in order for the board to offer truthful advice: $X \geq -\frac{1}{r}\ln(\frac{e^{-rc}-1}{\Pr[\theta=1|s,H]}+1)$. Adding insiders to the board relaxes the condition.

The project's size X has to be large enough to offset the board's incentives to mislead the CEO. The board cares about the project outcome but also cares about minimizing the compensation paid to the CEO. The CEO's compensation is designed to reward consistent reports, to ensure right effort incentives. Because of that, the board may have incentives to provide false advice to save on wage payment. But providing false advice will reduce the firm's investment efficiency. If the project's size X is large, there is much at stake, the board will choose to advice truthfully.

The condition can become hard to satisfy, for example, when a project's size (X) is not large enough, the cost of implementation effort (c) is very large or the information about implementation effort ($\Pr[\theta = 1|s, H]$) is not good enough. The nature of the latter two quantities determines how large is the pay difference $\overline{U}_{sH} > \underline{U}_{sH}$. The larger the pay difference, the more the board tempts to provide false advice.

When insiders are added to the board, the board preference is changed. The board now cares about the shareholders' benefit and also the CEO's welfare. The board's utility function is a weighted average of the shareholders' benefit and the CEO's certainty equivalent:

$$(1-\alpha)(\text{investment proceeds - compensation})+\alpha CE^{CEO}$$

Adding insiders to the board relaxes the advising incentives. As truthful advice can both improve the investment proceeds and the CEO's welfare, the board has one more reason to advise truthfully.

Appendix: Proofs

The proofs and details omitted below are available upon request from the authors.

Proof of Proposition 1:

Firstly we know that the (IR) constraint has to be binding, otherwise, the expected compensation cost can be reduced by multiplying $\delta > 0$ to $\overline{U}$, $\underline{U}$ and U_0, respectively. This change will lower the equilibrium expected utility (i.e., tightening the IR constraint) but not altering the two (IC) constraints ($IC\eta_1$ or $IC\eta_2$). Secondly we know that at least one of the (IC) constraints has to be binding ($IC\eta_1$ or $IC\eta_2$), otherwise, a flat-rate payment will result and that cannot provide any effort incentives.

Now consider the ($IC\eta_1$) constraint is binding. Together with the binding (IR) constraint, we have

$$e^{rc}(0.5\overline{U} + 0.5\underline{U}) + U_0 = -2 \tag{4}$$

$$e^{rc}[(0.5+i)\overline{U} + (0.5-i)\underline{U}] + U_0 = -2e^{-rk} \tag{5}$$

That implies $\overline{U} - \underline{U} = \frac{2(1-e^{-rk})}{ie^{rc}}$, and $U_0 = -2 - e^{rc}(0.5\overline{U} + 0.5\underline{U})$. Let

$$\begin{aligned} \overline{U} &= (y + \frac{1-e^{-rk}}{i})e^{-rc} \\ \underline{U} &= (y - \frac{1-e^{-rk}}{i})e^{-rc} \\ \text{then,} \qquad U_0 &= -2 - y. \end{aligned}$$

Now the problem becomes an unconstrained optimization problem:

$$\underset{y}{Max}\ (0.5+i)\ln(-\overline{U}) + (0.5-i)\ln(-\underline{U}) + \ln(-U_0).$$

The FOC is

$$\frac{0.5+i}{y + \frac{1-e^{-rk}}{i}} + \frac{0.5-i}{y - \frac{1-e^{-rk}}{i}} + \frac{1}{2+y}.$$

Let $D = \frac{1-e^{-rk}}{i}$. Setting the FOC to zero, we obtain

$$2y^2 + 2(1-Di)y - (D^2 + 4Di) = 0.$$

Solving for the equation, we have

$$y = \frac{-2(1-Di) \pm \sqrt{4(1-Di)^2 + 8(D^2 + 4Di)}}{4}.$$

To ensure $\overline{U} < 0$, y has to be negative. Substituting D to the expression, we have

$$y = \frac{-1 - \sqrt{1 + [(2/i^2)(e^{rk} - 1) + 8e^{rk}](e^{rk} - 1)}}{2e^{rk}}$$

Notice that the SOC is strictly negative, so there exists a unique solution to the problem.

Substitute the solution to the $(IC\eta_2)$ constraint to show the constraint is slack. We have $e^{rc}(0.5\overline{U} + 0.5\underline{U}) = y$ and $\underline{U} = (y - \frac{1-e^{-rk}}{i})e^{-rc}$. With the condition $e^{rc} \leq 1 + G(k)$, we have shown $e^{rc}(0.5\overline{U} + 0.5\underline{U}) \geq \underline{U}$. That is, the $(IC\eta_2)$ constraint is slack.

Now we know when $e^{rc} > 1 + G(k)$, the $(IC\eta_1)$ constraint cannot be binding. Because if the $(IC\eta_1)$ constraint is binding, with condition $e^{rc} > 1 + G(k)$, $e^{rc}(0.5\overline{U} + 0.5\underline{U}) < \underline{U}$ then the $(IC\eta_1)$ constraint cannot be binding. A contradiction. But we have established that at least one (IC) constraint has to be binding. Thus, the $(IC\eta_2)$ constraint has to be binding in this case.

Now we show $\frac{\partial G(k)}{\partial k} > 0$. Let $g(k) = \sqrt{1 + [(2/i^2)(e^{rk} - 1) + 8e^{rk}](e^{rk} - 1)}$, clearly, $g(k) > 0$.

$$\frac{\partial g(k)}{\partial k} = \frac{e^{rk} r[(2/i^2 + 8)e^{rk} - (2/i^2 + 4)]}{g(k)}$$

Substitute $\frac{\partial g(k)}{\partial k}$ into $\frac{\partial G(k)}{\partial k}$:

$$\frac{\partial G(k)}{\partial k} = \frac{(2/i)e^{rk} r[1 + g(k)] - (2/i)(e^{rk} - 1)\frac{\partial g(k)}{\partial k}}{[1 + \sqrt{1 + [(2/i^2)(e^{rk} - 1) + 8e^{rk}](e^{rk} - 1)}]^2}.$$

Since the denominator is positive, we need to show the numerator is positive:

$$(2/i)e^{rk} r[1 + g(k)] - (2/i)(e^{rk} - 1)\frac{e^{rk} r[(2/i^2 + 8)e^{rk} - (2/i^2 + 4)]}{g(k)},$$

with common denominator:

$$\begin{aligned} & (2/i)e^{rk} r \frac{[g(k) + 1 + [(2/i^2)(e^{rk} - 1) + 8e^{rk}](e^{rk} - 1) - (e^{rk} - 1)[(2/i^2 + 8)e^{rk} - (2/i^2 + 4)]}{g(k)} \\ = \; & (2/i)e^{rk} r \frac{g(k) + 1 + 4(e^{rk} - 1)}{g(k)} > 0. \square \end{aligned}$$

Proof of Proposition 3:

When $i_B \leq \frac{1-e^{-rk}}{1+2i}$, $\underline{U}_{GH} = U_{BL} = -1 + \frac{1-e^{-rk}}{i_B(1+2i)} \geq 0$, which contradicts the negative exponential utility function form.□

Proof of Proposition 4:

For a board full of outsiders.

The two advising constraints ensure truthful communication:

$$\Pr[\theta = 1|s, H]X - \{\Pr[\theta = 1|s, H]\Phi(\overline{U}_{sH}) + (1 - \Pr[\theta = 1|s, H])\Phi(\underline{U}_{sH})\} \geq -\Phi(U_{sL}) \quad (6)$$

$$-\Phi(U_{sL}) \geq \Pr[\theta = 1|s, L]X - \{\Pr[\theta = 1|s, L]\Phi(\overline{U}_{sH}) + (1 - \Pr[\theta = 1|s, L])\Phi(\underline{U}_{sH})\} \quad (7)$$

Notice that the two constraints have a common quantity $-\Phi(U_{sL})$ at the either side of inequalities. Substitute the inverse utility function $\Phi(U) = -\frac{1}{r}\ln(-U)$ and binding constraint (ICe_{sH}), we have

$$\begin{aligned} \Pr[\theta &= 1|s, H]X + \frac{1}{r}\Pr[\theta = 1|s, H]\ln(\frac{e^{-rc} - 1}{\Pr[\theta = 1|s, H]} + 1) + \frac{1}{r}\ln(-\underline{U}_{sH}) \\ &\geq \Pr[\theta = 1|s, L]X + \frac{1}{r}\Pr[\theta = 1|s, L]\ln(\frac{e^{-rc} - 1}{\Pr[\theta = 1|s, H]} + 1) + \frac{1}{r}\ln(-\underline{U}_{sH}). \end{aligned}$$

That implies $X \geq -\frac{1}{r}\ln(\frac{e^{-rc}-1}{\Pr[\theta=1|s,H]} + 1)$. Notice $\ln(\frac{e^{-rc}-1}{\Pr[\theta=1|s,H]} + 1)$ is negative.

For a board composed of insiders.

The two advising constraints ensure truthful communication:

$$\begin{aligned} &(1-\alpha)\{\Pr[\theta = 1|s, H]X - [\Pr[\theta = 1|s, H]\Phi(\overline{U}_{sH}) + (1 - \Pr[\theta = 1|s, H])\Phi(\underline{U}_{sH})]\} \\ &+\alpha\Phi(e^{rc}(\Pr[\theta = 1|s, H]\overline{U}_{sH} + (1 - \Pr[\theta = 1|s, H])\underline{U}_{sH})) \geq -\Phi(U_{sL}) \quad (8) \end{aligned}$$

$$\begin{aligned} -\Phi(U_{sL}) \geq &(1-\alpha)\{\Pr[\theta = 1|s, L]X - [\Pr[\theta = 1|s, L]\Phi(\overline{U}_{sH}) + (1 - \Pr[\theta = 1|s, L])\Phi(\underline{U}_{sH})]\} \\ &+\alpha\Phi(V_{sL}) \quad (9) \end{aligned}$$

Where $V_{sL} = e^{rc}(\Pr[\theta = 1|s, L]\overline{U}_{sH} + (1 - \Pr[\theta = 1|s, L])\underline{U}_{sH})$. Notice $V_{sL} < e^{rc}(\Pr[\theta = 1|s, H]\overline{U}_{sH} + (1 - \Pr[\theta = 1|s, H])\underline{U}_{sH})$ since $\Pr[\theta = 1|s, H] > \Pr[\theta = 1|s, L]$. With the binding constraint (ICe_{sH}), $V_{sL} < \underline{U}_{sH}$.

Similarly, substitute the inverse utility function $\Phi(U) = -\frac{1}{r}\ln(-U)$ and binding constraint (ICe_{sH}), we have the following condition:

$$(1-\alpha)(\Pr[\theta = 1|s, H] - \Pr[\theta = 1|s, L])(X + \frac{1}{r}\ln(\frac{e^{-rc} - 1}{\Pr[\theta = 1|s, H]} + 1)) \\ +\alpha[\Phi(\underline{U}_{sH}) - \Phi(V_{sL})] \geq 0 \quad .$$

Since $V_{sL} < \underline{U}_{sH}$, $\Phi(\underline{U}_{sH}) - \Phi(V_{sL}) > 0$. If the first part with $1 - \alpha$ is negative, adding the second part can still make the condition hold.□

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