11-2013

Innovation, Information Quality, and Career Concerns

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Recommended Citation
Zhao, Ran, "Innovation, Information Quality, and Career Concerns" (2013). Accounting Faculty Articles and Research. 14.
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Abstract

Career concerns provide managers with implicit incentives, which benefit shareholders. However, these concerns are also costly to shareholders because managers need to be compensated for career risk. Career risk is especially significant if a manager’s perceived ability is largely exposed to the labor market, as it is the case when the manager is asked to implement innovative strategies. Although lowering the quality of the information disclosed by the firm can mitigate a manager’s career risk, it also hinders the manager’s effort. This study theoretically examines shareholders decisions on innovative investments and information quality in the presence of managerial career concerns. I show that there is a tension between mitigating the career risk resulting from innovation and motivating managerial effort. I find that when the innovation urgency is intense, shareholders invest more in innovation and lower the information quality to protect the manager from career risk. In contrast, when the level of innovation urgency is low, shareholders invest less to mitigate the manager’s career risk, while increasing the explicit incentive to motivate higher effort. My results provide possible explanations for mixed empirical findings on the relationship between career concerns and investment. Moreover, my results suggest that when we examine the impact of career concerns on investments in innovation, disclosure policy and managerial explicit incentives, we need to consider the innovation urgency. Since innovation urgency is also an industry-specific characteristic, my results also shed light on the aforementioned career concerns effects across industries. In addition, my results predict that experienced CEOs may not be favored by extremely innovative or least innovative firms as much as by middle-of-the-road innovation firms.

*I would like to express my deepest gratitude to my dissertation committee—Carlos Corona (chair), Jing Li, Pierre Jinghong Liang, Lin Nan—for their invaluable support and guidance. I also thank Andrew Bird, Jonathan Glover, Thomas Rucht, Jack Stecher, and seminar participants at Carnegie Mellon for their comments. All errors and ambiguities are my responsibility. Ran Zhao is a Ph.D. candidate in accounting at Carnegie Mellon University. E-mail: ranzhao@andrew.cmu.edu.
1 Introduction

Over the past 60 years, innovation-related expenditures have been increasing dramatically, and become a crucial strategic decision for many firms. During 1995-2007, U.S. firms’ annual innovation investments comprised 12.8% of the U.S. GDP, which is more than double the number during the high-growth period after World War II (1948-1972) (Corrado and Hulten, 2010). March (1991) identifies two forms of innovation: exploitation and exploration. Exploitation aims at improving the efficiency of the current business model, while exploration seeks to develop new business opportunities. The innovation I examine in this paper, better characterized as exploration, includes any radical innovation that transforms the firm, such as a broad organizational change, a strategic acquisition, entering into new markets, creating and/or adopting new technologies, etc. Boards of directors often initiate such explorative innovations when the competitive situation renders an intense urgency for transformation.  

As pointed out by Kotter (1995), the first step in transforming a firm is cultivating a sense of urgency, followed by hiring a powerful leader to steer the change (see also Helmich and Brown, 1972). For example, after years of J.C. Penney’s alarming performance, Bill Ackman, a board member and the largest shareholder, strongly suggested that the board hire Ron Johnson as CEO because of his remarkable success in Apple’s retail operations. Indeed, a manager’s ability is a key factor in undertaking a firm transformation (Banker et al., 2013). However, in such endeavors, the manager puts his own future career prospects at great risk. If the innovation fails, the manager may be considered ineffective, lose his job, and damage his reputation. In the J. C. Penney example, the changes that Johnson implemented caused a dramatic drop in the firm’s revenues. He was shortly ousted and, since then, he has not been reported to have taken an executive job. In contrast, CEOs of firms with a clear deficiency in innovation, such as GE and CISCO, are still at the helm even though their firms have been losing profits for years (Hartung, 2012). In this sense, managers that are asked to implement innovations bear a higher career risk than those simply adopting an inconspicuous stewardship role. Moreover, managers’ career risk needs to be appropriately compensated. Therefore, shareholders must take into account managerial career risk when they make decisions to innovate.

The empirical evidence regarding the relation between CEO career concerns and firm investment decisions is mixed. Some studies find that firms’ investment decreases with the

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1 The innovation urgency is different among firms, depending on the prevailing and potential crises and opportunities. For example, firms with recessive performances are desperate to make radical transformations to survive (Greve, 1998); firms facing rapid market shifts should also change business practices to adapt to the market environment; high-tech firms need to make constant innovations to maintain their reputation and maintain a competitive advantage.

2 In previous studies, it is a common perception that the degree of career concern is negatively related
degree of managers’ career concerns. For example, Pan et al. (2013) empirically find that firms with CEOs in their early tenure tend to disinvest and, later on, increase investments as the CEOs tenures extend. In contrast, Serfling (2012) finds that firms with younger CEOs invest more than those with older CEOs, but this evidence is only significant for high-growth industries. This seemingly contradicting evidence suggests that deeper insight into the interaction between managerial career concerns and innovation is needed. Moreover, although it may appear unrelated, career concerns also have an important influence on financial statement practices. Indeed, in a survey conducted by Graham et. al., (2005) more than three quarters of the managers admitted to have a strong incentive to meet earnings benchmarks due to reputation concerns rather than short-term compensation. In this sense, financial statement practices affect manager exposure to career concerns and, therefore, must also affect innovative investment decisions. The aforementioned evidence indicates that there seems to be a relation between managerial career concerns and shareholders decisions on both innovation investment and financial information quality that deserves further examination.

In this study, I develop an analytical model to examine how shareholders jointly make decisions on innovation and information quality in the presence of managerial career concerns. I assume that shareholders are risk-neutral and endowed with a level of innovation urgency, such as developing opportunities to gain a competitive advantage, resolving a current or potential crisis, etc. Depending on the innovation urgency, shareholders decide the extent to which changes are undertaken in the firm’s business. The more the shareholders want to change, the more they invest. Moreover, shareholders need to hire a manager to implement such innovation. The innovative investment outcome depends on the manager’s ability—more so when the change is large. In addition, the manager is risk-averse and can improve the outcome with a costly effort that is not publicly observable. This effort can be thought of as an operating effort in maintaining routine business. Shareholders offer a contract to the manager to motivate his operating effort and compensate him for career risk. In addition, shareholders can also choose the quality of accounting information. The lower the level of information quality, the less weight the labor market puts on the public signal when assessing the manager’s ability and, therefore, the lower the manager’s career risk. However, this also induces a noisier performance measure, thereby making motivation of the manager’s effort more difficult. Together, the model determines the shareholders jointly optimal decisions on innovation, information quality, and compensation contract taking into consideration the manager’s career risk.

I show that shareholders prefer imperfect information in order to protect the manager from career risk, especially when the innovative investment is large. I find that innovation

with CEO age and tenure.
urgency plays a critical role in determining the way shareholders cope with career concerns. When innovation urgency is intense, shareholders invest heavily and choose a low level of information quality to reduce the manager's exposure to career risk. At high levels of innovation and low levels of information quality, the outcome is very volatile and, therefore, motivating effort is very costly. However, innovation investment is inexpensive because the manager is hardly exposed to the labor market. This yields an unexpected result: the more concerned the manager is about his career prospects (e.g., the less is known about the manager’s ability), the more shareholders invest in innovation. In contrast, when the level of innovation urgency is low, shareholders invest less to mitigate the manager's career risk, and focus on motivating the manager's effort with high levels of information quality and strong compensation incentives. At high levels of information quality, innovation investment is costly because it exposes the manager’s ability conspicuously, whereas motivating the operating effort with explicit incentives is more efficient. This produces another unexpected result: an increase in the manager career-risk concerns induces shareholders to increase the power of explicit compensation incentives. Indeed, higher managerial career-risk concerns shift shareholders focus towards the operating effort even further. As a result, shareholders reduce innovative investment, increase information quality, and increase explicit incentives. In addition, I find that shareholders preferences over managerial degree of career concerns are not monotonic in the urgency of innovation. In fact, in firms with intermediate levels of innovation urgency, managerial career concerns are most detrimental to shareholders. Indeed, in these firms, stronger career concerns result in both lower innovative investment and managerial effort. Therefore, these firms value an experienced manager most because his ability is well known and, as a result, the manager is less concerned about being exposed to the labor market. Through a numerical example in a matching model, I show that managers with fewer career concerns, such as experienced managers, are most favored by middle-of-the-road innovation firms. In summary, I show that innovation urgency is critical in the relation between managerial career concerns and shareholders decisions on innovation, disclosure policy, managerial compensation, as well as manager selection. Moreover, the impact of innovation urgency on these relations is non-monotonic. Because innovation urgency is also an industry-specific characteristic, my results shed light on cross-industry studies on the impact of career concerns on firms investment and managerial compensation decisions.

My study sheds light on the mixed evidence in the literature with respect to the relationship between CEO career concerns and firm investment decisions. The finding of a non-monotonic relationship between career concerns and innovative investment is supported by the empirical evidence by Serfling (2012). Existing studies theoretically examining the link between a firm’s investment decision and career concerns are scattered. Holmstrom and
Ricart i Costa (1986) show that career concerns induce a manager to underinvest in projects with returns contingent on his ability, and the distortion in investment decisions cannot be completely addressed with a compensation contract. Zwiebel (1995) and Prendergast and Stole (1996) consider a setting in which the manager has private information about his ability. Zwiebel (1995) shows that if the labor market assesses managers abilities based on their relative performance, managers may have an incentive to undertake innovative paths in order to avoid such comparison, therefore making their evaluation less accurate and less risky. Prendergast and Stole (1996) demonstrate that in order to signal high ability, managers may overweigh their private information in making investment decisions at the early stage but may ultimately become too conservative. In contrast to these papers, I focus on the tradeoff shareholders face in taking decisions on innovation investment, information quality as devices to motivate effort and mitigate the manager’s career risk in a setting with no information asymmetry about the manager’s ability.

My study also contributes to the broad literature on the effect of career concerns on managers’ compensation. Holmstrom (1999) shows that career concerns may benefit shareholders by providing implicit incentives that motivate managerial effort by linking managerial performance to future wages. Gibbons and Murphy (1992) argue that career concerns can actually substitute for explicit incentives in motivating managerial effort (henceforth, the substitution effect). However, Chen and Jiang (2006) suggest that the substitution effect may be weakened or even reversed by considering the case in which a manager can control the informativeness of the report about his ability. Autrey et al. (2003, 2006) examine the role of career concerns on incentive provision considering the availability of two signals, a public signal and a private signal. My study suggests that in addition to the direct substitution effect between career concerns and the explicit incentive, career concerns also interact with the compensation contract indirectly through a firm’s innovation. Specifically, I find that when the level of innovation urgency is low, shareholders decrease innovation as career concerns increase; therefore, the business becomes relatively stable and motivating managerial effort is more efficient. As a result, my result predicts that managers’ pay-performance-sensitivity increases with career concerns if the level of innovation urgency is low.

My study is also related to the literature on the relationship between career concerns and information quality. There is a line of literature that focuses on the role of career concerns in motivating managerial effort in different information environments. Dewatripont et al. (1999a) compare the different roles of career concerns incentives within various information structures. Arya and Mittendorf (2011), building upon Dewatripont et al. (1999a), study a multi-agent model and compare the aggregated and disaggregated performance measures with the existence of career concerns. There is another line of literature that implies that
a less transparent information environment may be good for shareholders in the sense of reducing manager career risk, which must be compensated ex-ante by the shareholders (as seen in Hermalin and Weisbach, 2007). Arya, Glover, and Sunder (1998) show that allowing earnings manipulation will reduce the frequency of management turnover. Therefore, shareholders save ex-ante compensation for managers’ dismissal risk. In my study, I examine the tension that shareholders face between reducing information quality to protect the manager from exposure to the labor market and improving information transparency to better motivate managerial effort.

The rest of the paper proceeds as follows: Section 2 describes the model setup and analyzes the labor market assessment of the manager’s ability as well as the manager’s effort input strategy. Section 3 characterizes the shareholders’ optimal variable choices and examines the impact of career concerns on shareholders decisions and Section 4 concludes the paper.

2 The model

2.1 The model setup

Risk-neutral shareholders are endowed with a certain level of innovation urgency $m$ ($m > 0$), and commit to making an investment in innovation $i$ ($i > 0$) at a cost $\frac{c}{2} \cdot i^2$ ($c > 0$). The shareholders’ innovation urgency, $m$, and decisions on innovation, $i$, are public information. The assumption that shareholders make innovative investment decisions is descriptive of firms’ transformation practices. Although managers may usually be given complete authority for decision makings in routine operations, investments in transformations are either initiated or at least approved by the board. The shareholders hire a risk-averse manager to lead the innovation. The manager is endowed with random ability, $a$, which is unknown to all. It is common knowledge that $a$ follows a normal distribution $N(0, 1/h_a)$. $1/h_a$ represents the ex-ante uncertainty of the manager’s ability. The revenue, $r$, is shown as:

$$r = i \cdot m + i \cdot a + e. \quad (1)$$

The revenue consists of three components. The first component $i \cdot m$ captures the complementary effects of the innovation urgency and innovative investment on the output. When the competition is intense or the market shifts radically, the shareholders have an intense urgency to change the business practice ($m$ is higher). In other words, innovation is profitable and the marginal benefit of innovative investment is large. Shareholders therefore increase the magnitude of innovation. However, due to the convexity of the investment cost, the
investment should be finite. The second term \( i \cdot a \) is contribution of the manager’s ability to the revenue. In previous studies, the sensitivity of revenue to the manager’s ability is assumed to be fixed, usually normalized to 1. However this may not be descriptive on the case in which managers are asked to undertake different business. The manager’s ability is more crucial in transformations compared with routine business.\(^3\) Therefore, I assume the manager’s ability’s effect on the revenue is magnified by the innovative investment \( i \), representing the fact that the manager’s ability is more influential on the revenue when he is asked to implement innovations.\(^4\) In other words, undertaking changes will largely expose the manager’s ability. Besides the manager’s ability, the manager’s effort, \( e \), contributes to the firm’s revenue as well. \( e \) could be thought of as the operating effort in maintaining the status quo. As is standard in literature, the manager’s choice of effort, \( e \), is assumed to be unobservable to the shareholders and the labor market and incurs cost \( \frac{1}{2} \cdot e^2 \) to the manager.

The revenue, \( r \), is unobservable. However, a noisy signal \( y \) about \( r \) is contractible and reported by the financial reporting system:

\[
y = r + \epsilon,
\]

where \( \epsilon \sim N[0, \frac{1}{h}] \), and \( h > 0 \).

The shareholders determine the quality of the financial reporting system, \( h \), and offer a contract linear in \( y \), \( w_1(y) \), to hire the manager. The manager will exert effort, \( e \), if he accepts the contract. The timeline is summarized in Figure 1.

The model is a two-period model with Dates 0, 1, and 2. On Date 0, the shareholders determine the financial reporting system’s quality \( h (> 0) \), commit to invest \( i \) in innovation, and offer a linear contract \( w_1(y) \) to the manager. Following Gibbons and Murphy (1992), I assume the contract is short term and linear in the accounting signal, \( y \): \( w_1(y) = k_1 y + c_1 \).

The shareholders decisions are all publicly observable.

On Date 1, the manager accepts the contract if his expected utility is no less than his reservation utility (i.e. his ex-ante expected ability), which is normalized to 0. The manager

\(^3\)Banker et. al. (2013) indicate that managers in R&D intensive firms are taking relatively complex jobs, including responding to competitor’s actions and environmental changes promptly, making investment decisions, managing the R&D work force, etc. As a result, the manager’s ability is more important for R&D intensive firms compared to non-R&D intensive firms.

\(^4\)The mean of the manager’s ability is normalized to zero, and as a result, ex-ante the shareholders cannot benefit from the manager’s ability through innovative investment. \( m \) is the only source of benefit for the shareholders by investing in innovation.

I assume that in the revenue the only source of riskiness is manager ability uncertainty so that the revenue randomness induces significant career risk. I can introduce a systematic risk, \( \eta(\eta \sim N[0, \sigma^2]) \), and rewrite the revenue as \( r = i \cdot (m + \eta) + i \cdot a + e \). The main results will quantitatively hold. However, the career risk will be dampened because the labor market believes that the revenue is partially attributable to random shock rather than the manager’s ability.
inputs an operating effort \( e > 0 \) at a cost \( \frac{1}{2} \cdot e^2 \). Then the signal \( y \) is reported and the shareholders pay the manager \( w_1(y) \).

On Date 2, the manager can either stay with the firm or leave and look for another job. His new wage \( w_2 \) is determined by the labor market as the perception of the manager’s ability based on the public signal \( y \), namely \( w_2 = E[a|y] \).\(^5\) The manager’s career concerns are introduced here. If the signal is low, the manager would be regarded as having low ability. Therefore, in the future, the manager can only earn a low wage due to his bad reputation. For a risk-averse manager, the volatility of future wages, \( w_2 \), causes a dis-utility.

I assume the manager has an additively separable mean-variance utility function, as shown in Eq (2). \( \rho \) is the manager’s degree of risk aversion:

\[
U(w_1, w_2, e) = E[w_1] - \frac{\rho}{2} Var[w_1] - \frac{1}{2} e^2 + E[w_2] - \frac{\rho}{2} Var[w_2].
\]  \( (2) \)

I assume that the manager does not have access to the credit market. This utility function follows a study by Chen and Jiang (2006), who cite empirical evidence that managers cannot completely hedge future career risks, particularly early in their careers (Jin, 2002; Garvey and Mibourn, 2003).\(^6\) Many other studies assume that the principal is limited to offering a fixed contract (Arya and Mittendorf, 2011; Dewatripont et al., 1990b; Hermelin and Weisbach, 2007) such that the shareholders cannot provide the manager insurance for his future career risk through an incentive contract.

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\(^5\)To be more precise, \( E[a|y] \) is the manager’s reservation utility on Date 2. I do not model the case in which the manager is asked to implement innovations or exert effort on Date 2. As a result, the manager’s future wage should exactly equal his reservation utility. If there is an effort input or risk-taking on Date 2, then the manager’s future wage should compensate for the cost of effort and risk. However, the manager’s certainty equivalent of his future wage should still equal his reservation utility \( E[a|y] \).

\(^6\)The restriction here is simply to ensure that the manager cannot insure his career risks through savings or lendings, which raises the manager’s career concerns. This assumption is stronger than necessary. Actually, the manager’s career concerns exist as long as it is not possible to completely insure the manager’s future career risk. However, it is by assuming that insurance is totally infeasible that career concerns are most succinctly captured.
2.2 The labor market’s updated belief about the manager’s ability and the manager’s optimal effort

I solve for the equilibrium by backward induction, starting with the labor market’s perception about the manager’s ability on Date 2. Because the final revenue depends on both the manager’s effort and ability, to update the belief of the manager’s ability, the labor market makes a conjecture of $e$ denoted by $\hat{e}$. Given $\hat{e}$, the updated belief of the manager’s ability upon signal, $y$, follows a normal distribution:

$$a[y] \sim N\left[\frac{i}{h_a} \cdot (y - i \cdot m - \hat{e}), \frac{1}{h_a} \cdot \frac{1}{\text{var}_y}\right],$$

where $\text{var}_y$ is the variance of the signal $y$:

$$\text{var}_y \equiv \text{Var}[y] = \frac{i^2}{h_a} + \frac{1}{h}.$$  

The first term of signal $y$’s variance, $\frac{i^2}{h_a}$, is due to the uncertainty of the manager’s ability, and the innovation investment has a multiplicative effect here. That is, innovations induce riskiness in the business, especially when the manager’s ability is highly uncertain. The second term of $\text{var}_y$, $\frac{1}{h}$, is the noise of the accounting signal. In previous studies, the randomness of the signal is taken as given. However, in this model, the signal’s volatility is contingent on shareholders’ endogenous choices of innovative investment, $i$, and information quality, $h$. The future wages can be expressed as:

$$w_2(y, i, \hat{e}) = E[a|y] = k_2 \cdot (y - i \cdot m - \hat{e}),$$

where $k_2 = \frac{\text{cov}(a, y)}{\text{var}_y} = \frac{i}{h_a} \cdot \frac{1}{\text{var}_y}$.

As suggested by previous studies, career concerns work as an implicit contract to the manager: the manager has an incentive to exert effort to improve the signal thereby obtaining a better evaluation in the labor market.\footnote{In the equilibrium, the labor market’s conjecture of the manager’s effort is consistent with the manager’s equilibrium effort, and the labor market will accordingly undo the effect of the manager’s effort on the revenue. As a result, the manager’s effort will not bias the labor market’s belief about his ability. However, the manager still has the incentive to exert effort. According to Holmstrom (1999), “the manager is trapped in supplying the equilibrium level that is expected of him, because, as in a rat race, a lower supply of labor will bias the evaluation procedure against him.”} The slope of $w_2$, $k_2$ is referred as the career concerns incentive. Lemma 1 captures that the career concerns incentive increases with the information quality and the uncertainty about ability, $1/h_a$.

**Lemma 1.** The career concerns incentive, $k_2$, increases with $h$ and $1/h_a$.

**Proof.** See Appendix.\hfill $\square$
According to previous studies, career concerns stem from uncertainty about a manager’s ability. The stronger the career concerns (1/\(h_a\) is larger), the higher the career concerns incentive. I show that the information quality is also critical to the career concerns incentive. The more informative the signal \(y\) about the revenue, the more weight the labor market puts on the signal to form posterior beliefs about the manager’s ability. The manager’s effort then results in a stronger upward revision of the labor market perception. Therefore, the manager is more motivated to exert effort (\(k_2\) is higher). Lemma 1 shows that the career concerns incentive increases with the information quality, as well as with the career concerns.

After considering the labor market perception about the manager’s ability, I now return to Date 1. The manager chooses the optimal effort to maximize his expected utility, taking the shareholders’ explicit contract, \(w_1\), and his future wages determined by the labor market, \(w_2\), as given. Formally, the manager solves \(\max_e U(w_1, w_2, e)\).

From the first-order condition of the manager’s utility function, one can derive the manager’s optimal effort, \(e^* = k_1 + k_2\). This is a standard result in literature, suggesting that the managerial effort is motivated by both the compensation incentive and the career concerns incentive. Moreover, in the perfect Bayesian equilibrium, the labor market conjecture about the manager’s operating effort \(\hat{e}\) should coincide with the manager’s optimal operating effort: \(\hat{e} = e^* = k_1 + k_2\).

### 2.3 Managerial career risk

It can be seen from Eq (3) that the manager’s future wages, \(w_2\), is contingent on the signal \(y\). Therefore, the volatility of \(w_2\) incurs a disutility to the manager, \(\frac{1}{2} \text{Var}[w_2]\), which is referred to as career risk and denoted by \(C_R\), thus,

\[
C_R \equiv \frac{\rho}{2} \text{Var}[w_2] = \frac{\rho \left(\frac{\epsilon^2}{h_a} / \text{var}_y\right)}{2h_a \text{var}_y}
\]

(4)

It can be easily proved that \(C_R\) increases with \(\rho\) and \(\frac{1}{h_a}\), both of which relate to the manager’s personal characteristics: the risk-averse degree as well as the ex-ante uncertainty of his ability. Therefore, for the sake of illustration, I refer to \(\rho / h_a\) as the degree of career concern throughout: when the manager is more risk-averse (\(\rho\) is larger) or more uncertain about his ability (\(h_a\) is smaller), the career risk is larger. \(C_R\) can then be rewritten as a product of two terms, \(\frac{\rho}{2h_a}\) and \(\frac{\epsilon^2 / h_a}{\text{var}_y}\), which is shown in Eq (4). The first term, \(\frac{\rho}{2h_a}\), is the manager’s degree of career concerns as discussed above. The second term, \(\frac{\epsilon^2 / h_a}{\text{var}_y}\), is the proportion of the total volatility of the performance measure \(y\) that is attributable to the manager’s unknown ability. This could be considered as the extent to which the manager’s ability is exposed to the labor market through the accounting signal. As the manager’s ability
is increasingly exposed in the labor market, the manager bears a higher career risk. It can be verified that \( \frac{i^2}{h} \) increases with the shareholders’ two choice variables: the information quality \( h \) and the innovative investment \( i \).

**Lemma 2.** The manager’s career risk, \( C_R \), increases with the information quality and the innovative investment; i.e., \( \frac{\partial C_R}{\partial h} > 0 \), and \( \frac{\partial C_R}{\partial i} > 0 \).

**Proof.** See Appendix.

Hermalin and Weisbach (2007) indicate that in a more transparent information environment, the labor market puts more weight on the random signal when forming perceptions about the manager’s ability. Thus, the manager suffers from higher career risk. Besides the information quality, a higher level of innovation makes the manager’s ability has a stronger influence on the firm’s revenue, which leads to increased exposure of the manager’s ability in the labor market, thus creating a higher career risk as well.

### 3 Main Results

In the previous section, I characterized the labor market determination of the manager’s future wages, the manager’s optimal effort, and then captured the manager’s career risk. In this section, I return to Date 0 to examine the shareholders’ optimal strategies about the compensation contract, \( w_1 \), the information quality, \( h \), and the innovative investment, \( i \). I next characterize the impact of career concerns on the shareholders decisions on the innovative investment and the compensation incentive. I then examine the manager’s career concerns’ impact on the shareholders’ equilibrium payoff and provide a numerical example comprised of heterogeneous shareholders and managers to illustrate the endogenous matching patterns between shareholders and managers. I finally characterize the impact of imposing a highly-stringent disclosure policy on firms’ innovation decisions.

#### 3.1 The shareholders’ optimal decisions

On Date 0, the shareholders choose the optimal decisions on the compensation contract, \( w_1 \), the information quality, \( h \), and the innovative investment, \( i \), to maximize their expected payoff, \( \pi_s \). The compensation contract should satisfy the manager’s participation constraint (IR) and incentive compatible constraint (IC). The shareholders’ problem is:
$$\begin{align*}
\text{Max}_{\{k_1, c_1, h, i\}} & \quad \pi_s(k_1, c_1, h, i) = E[r|e = e^*] - E[w_1(y)|e = e^*] - \frac{c}{2}i^2, \\
\text{s.t.} & \quad U(w_1, w_2, e^*) \geq 0, \text{(IR)}, \\
& \quad e^* = \arg\max_{e} U(w_1, w_2, e) \text{ (IC)}. 
\end{align*} \tag{5}$$

In the following, I restrict attention to the cases with interior solutions by assuming that parameters $\rho, h_a, m, k$ satisfy condition C1.

**Condition C1:** $\frac{2+\sqrt{2}}{2} < \frac{\rho}{h_a} < (1 + \sqrt{2})m$ and $c > \frac{(\sqrt{2}-1)\rho h}{h_a}$.

I am able to show the shareholders’ optimal choices of $k_1, c_1, h, i$ in the following proposition.

**Proposition 1.** In the equilibrium, the shareholders optimally choose

- the innovative investment $i^* = \frac{k_2^*}{h_a} - \frac{\rho h}{h_a}$,
- the information quality $h^* = \frac{1}{\text{var}_y^{-1/2}}$, where $\text{var}_y = \frac{i^*[\sqrt{2}h_a + (2+\sqrt{2})\rho]}{h_a^2 + 2i^*\rho h_a}$,

and the contract $w_1^*(y) = k_1^*y + c_1^*$, with $k_1^* = 1 - \frac{3\sqrt{2}}{2} - \frac{4i^*}{2h_a}$ and $c_1^* = \frac{k_2^* - k_1^2 + (k_2^* + k_1^2)\text{var}_y}{2}$.

$k_1^* \cdot i^* \cdot m$, where $k_2^* = \frac{\sqrt{2}}{2} - \frac{(2-\sqrt{2})i^*}{h_a}$ is the equilibrium career concerns incentive.

**Proof.** See Appendix.

In the equilibrium, the IR constraint of Eq (5) is binding. As a result, according to Eq (2), the expected payment to the manager by the shareholders, $E[w_1^*]$, can be calculated as:

$$E[w_1^*] = \frac{\rho}{2h_a} \text{Var}[w_1^*] + \frac{1}{2}a^* + C^*_{R}, \tag{6}$$

where $C^*_{R} = \frac{\rho}{2h_a} \frac{i^*}{\text{var}_y}$ is the equilibrium career risk.\(^8\)

The expression of Eq (6) is similar to the equilibrium compensation payment in a standard principal-agent model without career concerns, which covers the manager’s cost of effort and the risk from the explicit contract, with the addition of the manager’s career risk. In other words, the manager’s disutility of his career risk must be compensated by the explicit contract. Balkin et al. (2000) find empirical evidence that for high-tech firms, CEOs’ short-term compensation is positively related to innovation. My model may provide a possible explanation for this evidence. According to Lemma 2, with other things held equal, the manager’s career risk increases with innovative investment. In other words, managers in firms with high levels of innovative investment bear higher career risks, which must be compensated with a higher payments from the shareholders.

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\(^8\)Note that $E[w_2]$ is the ex-ante expected value of the manager’s ability, which is normalized to 0.
It can be seen from Proposition 1 that the shareholders' equilibrium decisions depend on both the innovation urgency, $m$, and the manager's characteristics, $\rho$ and $h_a$. With the manager’s characteristics held equal, it can be verified that as $m$ increases, the shareholders' equilibrium innovative investment, $i^*$ increases while the optimal information quality $h^*$ decreases. It is intuitive that the shareholders increase the magnitude of innovative investment as innovation becomes more profitable. Larger innovation magnitude induces more exposure of the manager’s ability in the labor market and thus increases the manager’s career risk for which the shareholders must compensate. To mitigate the manager’s career risk, the shareholders choose to reduce the information quality. Therefore, the shareholders’ equilibrium information quality, $h^*$, decreases with $m$. The above results are presented in the following corollary.

**Corollary 1.** The innovative investment that maximizes the shareholders’ expected payoff, $i^*$, increases with the innovation urgency; i.e., $\frac{\partial i^*}{\partial m} > 0$. The information quality that maximizes the shareholders’ expected payoff, $h^*$, decreases with the innovation urgency; i.e., $\frac{\partial h^*}{\partial m} < 0$.

**Proof.** See Appendix.

Corollary 1 implies that firms with a higher level of innovative investment may choose a lower level of information quality. Empirical evidence shows that the value relevance of financial statement has been deteriorating during the recent decades (Lev and Zarowin, 1999; Chang, 1998; and Srivastava, 2013). Lev and Zarowin (1999) find that the deterioration in the usefulness of financial information to investors is due to changes in business scale. Firms undergoing considerable business changes, which are measured by changes in book or market values, have a significant decline in the informativeness of financial statements. They interpret this evidence as the result of business changes generally driven by R&D investments. R&D investments are usually believed to lower the informativeness of financial statements in two ways: first, the financial statements cannot reflect the economic consequences of innovations (Healy and Palepu, 2001); second, the outcomes of R&D investments are highly uncertain, resulting in high volatility in both incomes and cash flows (Srivastava, 2013). My results may provide an alternative explanation from the career concerns point of view. That is, when firms initiate changes in business practices by investing in innovations, their managers are bearing future career risk. In a survey conducted by Graham et. al., (2005) most managers agree that they have a strong incentive to meet the earnings target due to reputation concerns rather than short-term compensation, suggesting that managers’ career concerns have an important influence on financial reporting practices. My result suggests that shareholders may choose less stringent policies for preparing financial statements, which works to mitigate the manager’s career risk. This finding provides implications for future
empirical research on the interaction between innovative investment and disclosure policy regarding managers’ career concerns.

Shareholders decisions depend not only on the urgency of innovation, but also on the manager’s characteristics. For firms with a homogenous level of innovation urgency, shareholders’ decisions may be different if their managers are heterogeneous regarding to career concerns. As shown in Lemma 2, shareholders can mitigate the manager’s career risk in two ways: reducing the information quality of the accounting signal, or reducing the magnitude of innovation. However, both methods are costly to shareholders. A lower level of information quality hinders contracting with the manager, resulting in a lower level of operation effort. Reducing the innovation magnitude directly reduces the profit of innovation, especially when there is an intense innovation urgency. The shareholders optimally determine the level of information quality and innovative investment to maximize their expected payoff, given the manager’s degree of career concerns. In the following sections, I will examine the manager’s career concerns’ impact on the shareholders’ choices of innovative investment and information quality.

3.2 The manager’s career concerns’ effect on the shareholders’ optimal innovative investment

I now analyze the effect of the manager’s degree of career concern on the firm’s optimal innovative investment. In the case in which the manager’s ability is perfectly observable \( h_a = \infty \), namely, when there are no career concerns, it is easy to see that the career risk is 0. In other words, the shareholders do not need to compensate the manager extra for his career risk. The shareholders will optimally choose perfect information to most efficiently motivate the manager’s operating effort and choose innovative investment to maximize the innovation profit \( i(m + a) - \frac{1}{2}i^2 \). That is, the shareholders’ optimal decisions on information quality and innovative investment are independent. For example, consider the case in which the manager’s ability, \( a \), is known as 0 for certain, which is the ex-ante expected ability in the model, then optimal innovative investment for the shareholders is \( i_0 = m/c \). Corollary 2 shows that in the presence of career concerns, the shareholders invest less in innovation compared with the case in which there is no career concerns, namely \( i^* < i_0 \).

**Corollary 2.** The shareholders underinvest in innovation in the presence of career concerns, compared with the case in which the manager’s ability is perfectly observable as 0; i.e., \( i^* = \frac{k_2 m - (\sqrt{2} - 1)ph_a}{h_2 c - (3 - 2\sqrt{2})p} < i_0 = m/c \).

Proof. See Appendix.
In the event that the manager is uncertain about his ability (i.e., \( h_a < \infty \)), the manager’s degree of career concern affects the shareholders’ innovation decisions. The innovation increases the variability of the revenue due to the manager’s ability uncertainty and consequently induces higher volatility in the signal. According to the standard principal-agent model, the manager’s equilibrium effort decreases as the risk unrelated to the effort increases. Thus, the benefit of motivating the manager’s effort decreases with \( i \). Furthermore, as mentioned earlier in Lemma 2, the manager’s career risk increases with innovative investment. Both effects of the innovation are costly to the shareholders. As a result, due to the manager’s career concerns, there is a downward distortion in the shareholders decisions on the innovative investment.

I next analyze the relationship between the degree of career concern and the shareholders’ optimal innovative investment, represented in Proposition 2.

**Proposition 2.** The shareholders’ optimal innovative investment increases (decreases) as the manager’s degree of career concern becomes weaker when the level of innovation urgency is low (high); i.e.,

\[
\frac{d i^*}{d \rho / h_a} < 0 \quad \text{if} \quad m < \left( \sqrt{2} - 1 \right) \frac{(\rho / h_a)^2 + (\sqrt{2} + 1)c}{2p/h_a}, \quad \text{and} \\
\frac{d i^*}{d \rho / h_a} > 0 \quad \text{if} \quad m > \left( \sqrt{2} - 1 \right) \frac{(\rho / h_a)^2 + (\sqrt{2} + 1)c}{2p/h_a}.
\]

*Proof.* See Appendix.

It is helpful to illustrate the above results through Figure 2, which shows a numerical example \((c = 2)\) of the relationship between the shareholders’ equilibrium choice variables \((i^*, h^*/h_a, \text{and } k^*_1)\) and the degree of career concern, \( \rho / h_a \). Figure 2 depicts three cases contingent on different expected returns of innovation \((m = 1, 1.5, 2)\). In each cases, the X-axis is the manager’s degree of career concerns, and the Y-axis is the shareholders’ optimal choice variables, which are \(i^*, h^*/h_a\), and \(k^*_1\) respectively. Figure 2 shows that the relationship between the shareholders’ optimal choice variables and the manager’s degree of career concerns is nonmonotonic, depending on the level of innovation urgency. A detailed analysis is provided as follows.

As the manager’s degree of career concern increases, the shareholders must compensate the manager more for higher career risk. As discussed in Lemma 2, the shareholders have two methods of mitigating the manager’s career risk: lowering the innovative investment and lowering the information quality. To examine how the shareholders use these two methods, the equilibrium career risk can be rewritten as follows:

\[
C^*_R = \frac{\rho}{2h_a} \frac{i^{*2}/h_a}{\text{var}_y} = \frac{\rho}{2h_a} i^* \cdot k^*_2.
\]
Figure 2: The shareholders’ equilibrium choice variables with respect to the manager’s degree of career concern.
From Eq (7), I derive the impact of the innovative investment on the manager’s career risk, \( \frac{\partial C^*_R}{\partial i^*} = \frac{1}{2} \frac{\partial}{\partial \rho_{ha}} k^*_2 \). Because the manager’s career risk is costly to the shareholders, the shareholders have an incentive to decrease the innovative investment when the impact of the innovative investment on career risk increases. As the manager’s degree of career concern \( \frac{\rho}{h_a} \) increases, I have

\[
\frac{d}{d \frac{\rho}{h_a}} \frac{\partial C^*_R}{\partial i^*} = \frac{\partial}{\partial \rho_{ha}} \frac{\partial C^*_R}{\partial i^*} + \frac{\partial}{\partial k^*_2} \frac{\partial k^*_2}{\partial \rho_{ha}} = \frac{1}{2} k^*_2 + \left( \frac{2 - \sqrt{2}}{2} \frac{i^*}{\rho_{ha}} \right)
\]

(8)

From the first term of Eq (8) \((\frac{d}{d \frac{\rho}{h_a}} \frac{\partial C^*_R}{\partial i^*} > 0)\), we can see that an increase in the degree of career concern provides a direct incentive for the shareholders to reduce \( i \), because the innovation investment results in higher career risk. However, there is an indirect incentive \((\frac{d}{d \frac{\rho}{h_a}} \frac{\partial k^*_2}{\partial \rho_{ha}} < 0)\) to increase \( i \), which is implied by the second term of Eq (8). The reason is that the increase of \( \frac{\rho}{h_a} \) also provides an incentive for the shareholders to reduce the information quality, resulting in lower \( k^*_2 \). The decline in \( k^*_2 \) dampens \( i \)'s impact on \( C_R \), and provides the shareholders an incentive to increase the innovative investment. The indirect incentive is strong enough to dominate the direct incentive if the information quality dramatically declines, such that the shareholders increase the innovative investment as a response to a higher degree of career concern.

The indirect incentive dominates when the level of innovation urgency, \( m \), is large, as shown in the case \( m = 2 \) in Figure 2. In this case, innovation profit relatively outweighs the managerial effort in the shareholders’ expected payoff. The shareholders invest a lot in innovation. As career concerns become stronger, driven by either a higher risk-averse degree or larger ability uncertainty, the benefit of motivating the manager’s operating effort declines. Because the innovative investment magnifies the revenue volatility that is attributable to the manager’s ability uncertainty, the decline is exacerbated by the investment. In other words, the increase of career concerns dampens the tradeoff of reducing the information quality, especially when the innovative investment is high. Therefore, when the level of innovation urgency is high, as career concerns become stronger, the shareholders largely lower the information quality to mitigate the manager’s career risk, and increase the innovative investment to most efficiently earn innovation profits.

Serfling (2012) finds that firms with younger CEOs invest more than firms with older CEOs, and the evidence only prevails with respect to high-growth industries. Conventional wisdom interprets this as that older CEOs may be more conservative, or have the horizon problem that they cannot benefit from the long-term return of the investment. However, Serfling (2012) documents that older CEO compensation contains fewer stock options than
younger CEO, which implies that shareholders do not tend to encourage older CEOs to invest. My results explain this finding from the career concerns point of view. High growth is associated with high levels of innovative investment, which induce relatively volatile revenue. There is large ability uncertainty among young managers, which magnifies the revenue volatility. The volatility impedes motivating the manager’s effort and shifts shareholders’ focus towards innovation. As a result, the shareholders will increase innovative investment and choose a lower level of information quality to protect managers from career risk. In contrast, an older manager’s ability is well known and less uncertain, therefore, the revenue is not as volatile. Thus, the shareholders have comparably intense incentives of motivating the manager’s operating effort and obtaining innovation profit. In other words, the shareholders will not overemphasize either the innovation or the effort. Therefore, the shareholders choose a lower level of innovative investment and a higher level of information quality. The above analysis suggests the underinvestment of older CEOs in a high growth firm may actually work in the shareholders’ favor.

In contrast to the case with a large $m$, when the level of innovation urgency is not extremely large, the direct incentive dominates and the shareholders reduce the innovative investment to mitigate the manager’s career risk. Many empirical findings suggest firms with managers that have large career concerns invest less. For example, Pan et al. (2013) empirically find that firms with CEOs in early tenure tend to disinvest, and increase investment subsequently. Likewise, Barker and Mueller (2002) find that firms with more experienced CEOs in output functions (functions emphasize growth through discovering new products and markets, such as marketing/sales and engineering/R&D) spend more on R&D. My result suggests that this evidence may present only in firms that are not engaged in intensive innovations.

3.3 The manager’s career concerns’ effect on the shareholders’ optimal explicit incentive

I next examine how the degree of career concern affects the explicit incentive $k_1^*$. The relationship between the CEO pay-performance-sensitivities (PPS) and CEO characteristics related to career concerns has been extensively studied. Previous studies suggest that as the manager’s tenure increases, his ability uncertainty decreases, and his career concerns incentive decreases. Consequently, shareholders increase the explicit incentive to motivate the manager’s effort (namely the substitution effect). In other words, for managers with a shorter tenure or who have less experience, the career concerns incentive is relatively strong, which lead to a lower level of explicit incentive. However, I find the substitution effect does
not always exist when the innovative investment decision is considered. To see this, consider
the equilibrium explicit incentive, $k_1^*$, and career concerns incentive, $k_2^*$, characterized in
Proposition 1:

$$k_2^* = \frac{\sqrt{2}}{2} - (2 - \sqrt{2})i^* \frac{\rho}{h_a},$$

(9)

$$k_1^* = 1 - \frac{\sqrt{2}}{2} - (3\sqrt{2}/2 - 2)i^* \frac{\rho}{h_a}.$$  

(10)

In previous studies such as Gibbons and Murphy (1992), the career concerns incentive, $k_2$, depends only on the manager’s characteristics represented by $\rho$ and $h_a$. However, in my
model, the shareholders are able to set the information quality and innovative investment in
response to the manager’s career concerns, both of which affect the career concerns incentive.
In other words, the shareholders are able to determine the career concerns incentive through
the information quality and set the explicit incentive through the contract. Because both
incentives are contingent on the same performance measure, $y$, they should respond to
the manager’s career concerns in the same direction to optimize the shareholders’ expected
payoff, which is in contrast to the different movement directions of the explicit incentive and
career concerns incentive with respect to career concerns as suggested in previous studies.

As a result, the substitution effect may not always hold, especially when the innovation
urgency is small. In this case, the shareholders invest little in innovation and focus on
motivating the manager’s effort by choosing a high level of information quality. Due to
the low innovative investment, the firm’s business is relatively safe and the revenue is less
volatile. Motivating the manager’s effort is then efficient, hence the benefit of motivating
the manager’s effort is large. On the other hand, due to the high level of information quality,
the labor market pays particular attention to the accounting signal when evaluating the
manager’s ability. As a result, reducing the innovative investment, thereby reducing the
volatility of the accounting signal, is an efficient way to mitigate the career risk. Therefore,
as the degree of career concerns increases, the shareholders’ focus shifts further toward
motivating the operating effort. The shareholders will increase the compensation incentive
and mitigate the manager’s career risk by dramatically reducing the innovative investment
(as shown in the case of $m = 1$ in Figure 2). The above results are summarized in Proposition
4.

**Proposition 3.** *In the equilibrium, the shareholders’ optimal explicit incentive increases
(decreases) as the manager’s degree of career concern becomes weaker when the level of in-
novation urgency is low (high); i.e.,*
\[
\frac{d k_1^*}{d \rho/h_a} < 0 \text{ if } m > \frac{(6-4\sqrt{2})c \rho/h_a}{(5\sqrt{2}-7)(\rho/h_a)^2+(\sqrt{2}-1)c}, \text{ and }
\frac{d k_1^*}{d \rho/h_a} > 0 \text{ if } m < \frac{(6-4\sqrt{2})c \rho/h_a}{(5\sqrt{2}-7)(\rho/h_a)^2+(\sqrt{2}-1)c}.
\]

**Proof.** See Appendix. \(\square\)

Proposition 3 identifies the link between CEO PPS with career concerns through innovative investment. It suggests that career concerns impact PPS non-monotonically depending on the expected level of innovation urgency \(m\). For firms with low levels of innovation urgency such as monopoly firms, the above results predict a positive relationship between managers’ career concerns and PPS. The prediction stems from the fact that as the manager’s degree of career concern diminishes, the shareholders invest more in innovation, resulting in volatile revenues. Therefore, the shareholders choose to reduce PPS because it is less efficient in motivating the manager’s effort. However, for firms with larger R&D spending such as, high-tech firms, the above results predict a negative relationship between the manager’s career concerns and PPS. The reason is that as the manager’s career concerns get weaker, the efficiency of motivating the manager’s effort largely improves and the shareholders consequently increase the PPS. Because the level of innovation urgency varies among industries, Proposition 3 suggests that we should examine the link between managers’ career concerns and PPS in cross-industry studies.

### 3.4 The effect of career concerns on the shareholders payoff

So far, I have analyzed the shareholders’ optimal choice variables and the manager’s optimal effort inputting strategy. In the equilibrium, the shareholders’ expected payoff is calculated as:

\[
\pi_s^*(m, \frac{\rho}{h_a}) = \frac{c + m[m - 2(\sqrt{2} - 1)\rho/h_a]}{2[c - (3 - 2\sqrt{2})(\rho/h_a)^2]}.
\]  \(\text{(11)}\)

With all other things held equal, a higher degree of career concern leads to higher career risk for the manager, which should be compensated by the shareholders. Furthermore, a higher degree of career concern reduces the manager’s incentive to exert effort, which also negatively affects the shareholders. Thus, the shareholders’ expected payoff decreases with the degree of the manager’s career concerns. Throughout this study, I assume that there is only one firm and managers are identical in their degree of career concerns. However, in reality, managers are heterogeneous in their career concerns while the innovation urgency varies among firms. For instance, more experienced managers, whose ability is well known and have less uncertainty than rookie managers could be considered to have a lower degree of career concern. Because the shareholders are better off with managers having a lower degree
of career concern, the shareholders may compete to hire experienced managers. Competition increases experienced managers’ compensation. Finally, experienced managers will be hired by the shareholders who most value them most.

One way to observe this is by considering a matching model for a market with \( N \) firms and \( N \) managers. The number of the players are not crucial. For example, I assume \( N = 11 \). Firm \( j \) is endowed with a level of innovation urgency, \( m_j \) while manager \( k \) is endowed with a degree of career concerns, \( d_k \equiv \rho_k/h^k \), \( j, k = 1, 2, \ldots, 11 \). \( m_j \) and \( d_k \) are public information. I still assume managers have the same expected ability, which is normalized to 0. However, uncertainty about their ability, \( h^k \), or risk aversion degree, \( \rho_k \), may be different, which captures the fact that managers are different in tenure or experience. Moreover, I assume \( \{m_j\} \) is an arithmetic sequence between 1 and 2 with a common difference of 0.1, while \( d_k \) is an arithmetic sequence between 2 and 2.4 with a common difference of 0.04. Each firm is matched with one manager. A matching pair of firm \( j \) and manager \( k \), \((m_j, d_k)\), generates a net profit \( \Pi_{j,k} = \pi^*_s(m_j, d_k) \), which is the firm’s revenue subtract the shareholder’s cost of innovation and the manager’s cost of effort and risk. In the main setting with the assumption of one firm and identical managers, the shareholders grab all the net profit and the manager’s participation constraint is binding. In the current case, there are heterogeneous managers and firms, and shareholders are competing in hiring experienced managers. As a result, managers may earn a premium due to the competition and shareholders can only get part of the net profit \( \Pi_{j,k} \). Denote \( x_{j,k} \in \{0, 1\} \) as the result of matching: \( x_{j,k} = 1 \) if firm \( j \) hires manager \( k \), and \( x_{j,k} = 0 \) otherwise. By the assignment game in Shapley and Shubik (1972), I can derive the equilibrium matchings \( \{x^*_{j,k}\} \) by solving the following linear programming problem:

\[
\begin{align*}
\text{Max}_{\{x_{j,k}\}} & \quad \sum_{k=1}^{11} \sum_{j=1}^{11} \Pi_{j,k} \cdot x_{j,k}, \\
\text{s.t.} & \quad \sum_{j=1}^{11} x_{j,k} \leq 1; \\
& \quad \sum_{j=1}^{11} x_{j,k} \leq 1; \\
& \quad x_{j,k} \geq 0.
\end{align*}
\]

It is a standard result (as shown in Roth and Sotomayor, 1990) that there exists a solution \( \{x^*_{j,k}\} \) to the above linear programming problem with \( x^*_{j,k} = 0 \) or 1. The equilibrium matching pattern is depicted in the following figure, where the X-axis is the shareholders’
innovation urgency, $m_j$, and the Y-axis is the manager’s degree of career concerns, $d_k$. The dot with coordinate $(m_j, d_k)$ means the shareholders with $m_j$ hires the manager $d_k$ in the equilibrium matching pattern, namely $x^*_{j,k} = 1$. It can be seen from Figure 3 that in the equilibrium matching pattern, the managers with the least career concerns are hired by firms with intermediate levels of innovation urgency. The intuition is that the equilibrium matching pattern maximizes the sum of profits from all pairs of firms and managers. Because managers with lower degrees of career concern generate higher profits, they are hired by shareholders who value them most. For the shareholders, the value of a less career concerned manager is measured by the marginal benefit of reducing the degree of career concern, $-\frac{d\pi^*_s(m, \frac{\rho}{h_a})}{d\rho/h_a}$, which depends on the innovation urgency, $m$. It can be verified that $-\frac{d\pi^*_s(m, \frac{\rho}{h_a})}{d\rho/h_a}$ has an inverse U-shape relationship with respect to the level of innovation urgency $m$, which is shown in Proposition 4. Figure 4 shows a numerical example of the relationship between $-\frac{d\pi^*_s}{d\rho/h_a}$ and the level of innovation urgency, when $c = 2$ and $\rho/h_a = 2$. One way to understand Figure 4 is to consider the extreme cases in which the level of innovation urgency is excessively low or high. For firms with a level of innovation urgency, the innovative investment is low, which barely exposes the manager’s ability through the accounting signal. As previously shown in the case $m = 1$ in Figure 2, as the degree of career concern increases, the shareholders choose a higher level of information quality to motivate higher effort and at the same time decreases the innovative investment. The
shareholders are worse off by innovation decline, yet can be compensated somehow through
the manager’s higher effort. As a result, the shareholders’ expected payoff does not decrease
that much as the manager’s degree of career concerns increases. In the opposite case, wherein
the level of innovation urgency is extremely high, as shown in the case \( m = 2 \) in Figure 2,
in which the degree of career concern increases, the shareholders focus more on innovation,
choosing a lower level of information quality to mitigate the manager’s career risk. The
incremental innovation profit offsets the shareholders’ innovation profit decline. As a result,
the shareholders’ expected payoff is not very sensitive to the manager’s degree of career
concern.

Unlike the extreme cases, for intermediate values of \( m \), there is a strong tension between
motivating the manager’s effort and obtaining innovation profit. As shown in the case of
\( m = 1.5 \) in Figure 2, when the manager’s degree of career concern increases, the shareholders
are not able to rely on either method to mitigate the career risk, but have to decrease both the
information quality and the innovative investment. As a result, the shareholders incur losses
from both the lower effort and innovation profit. In this case, hiring a manager with less
career concerns largely improves the shareholders’ expected payoff. Proposition 4 presents
the above results.

\textbf{Proposition 4.} The shareholders’ marginal benefit of reducing the degree of career concern
\(- \frac{d\pi^s}{dp/h_a}\) has an inverse U-shaped relationship with the expected level of innovation urgency:
\(- \frac{d\pi^s}{dp/h_a}\) increases with \( m \) if \( m < \frac{(\sqrt{2} - 1)(\rho/h_a)^2 + (\sqrt{2} + 1)c}{2p/h_a} \), and decreases with \( m \) if \( m > \frac{(\sqrt{2} - 1)(\rho/h_a)^2 + (\sqrt{2} + 1)c}{2p/h_a} \).

\textit{Proof.} See Appendix. \qed

Proposition 4 together with Figure 3 provide various implications for empirical studies
about the relationship between managers’ characteristics regarding career concerns and
firms’ innovation decisions. It shows that compared with their peers with intermediate levels
of innovation urgency, shareholders with extreme values of innovation urgency have payoffs
less sensitive to managers’ career concerns. The reason is that shareholders will protect the
manager from career risk by either implementing relatively safe business practices (for share-
holders with low levels of innovation urgency), or disclosing less information (for shareholders
with high levels of innovation urgency). However, for firms with intermediate levels of in-
novation urgency, stronger career concerns result in both lower innovation investment and
managerial productive effort. As a result, managers’ career concerns are most detrimental to
shareholders. In other words, these shareholders are the ones that most favor an experienced
manager that has ability with less uncertainty and is less concerned about exposure in the

Figure 4: The marginal benefit of reducing the manager’s degree of career concern as a function of $m$.

Throughout the paper, I assume that the shareholders are able to choose both the information quality and the innovative investment. However, it would be interesting to examine the case in which a regulator determines the information quality, and to study how shareholders choose the innovative investment as a response. Due to the complexity of the model, the shareholders’ optimal level of innovative investment for a given level of information quality $i^*(h)$ cannot be solved in the closed-form. However, I find that the shareholders will reduce the innovative investment when a regulator enforces a level of information quality above the shareholders’ optimal level, which is summarized in Proposition 5.

**Proposition 5.** An improvement in the information quality from the optimal level for the shareholders would induce the shareholders to decrease innovative investment; i.e., $\frac{\partial \pi_s(k^*_i, c^*_i, h, i)}{\partial h} < 0$ for $i = i^*$ and $h = h^*$. 
Proposition 5 echoes concerns by regulators and academics that the implementation of SOX may induce a decline in firms’ R&D investments. SOX mandates internal control disclosures and improves transparency by increasing disclosure requirements. There is plenty of empirical evidence showing that firms’ R&D investments declined dramatically since SOX was enacted (Bargeron et al., 2009; Cohen et al., 2013). This phenomenon is interpreted as that SOX incurs an extra reporting cost to the firm for R&D practices, resulting in less R&D investment. For example, the Biotechnology Industry Organization sent a letter to the SEC, commenting on SOX’s Section 404 rules: “Many emerging biotech companies are directing precious resources away from core research and development of new therapies for patients due to overly complex controls or unnecessary evaluation of controls” (Lehn, 2008). My results provide a possible explanation for this evidence regarding the manager’s career concerns. I expect that after the implementation of SOX, firms disclosure is more informative, which helps the labor market form a more accurate perception about managerial ability. My results imply that the mandated high information quality leads to a higher career risk for the manager. To mitigate the manager’s career risk, the shareholders consequently decrease the innovative investment.

4 Conclusions

This study examines shareholders joint decisions on the information quality and innovative investment in the presence of managers’ career concerns. Innovation initiatives are instructed by shareholders with the objective to transform the firm and increase its competitiveness. However, this kind of investments expose the manager’s ability conspicuously to the labor market. This exposure increases the manager’s career risk, which must be compensated through an explicit contract. In other words, innovation generates managerial career risk, which is a cost to shareholders.

I identify two methods by which shareholders can mitigate managerial career risk: lowering reporting information quality and reducing innovative investment. Nevertheless, lowering information quality makes motivating managerial operating effort more difficult. Therefore, shareholders, face a tradeoff between mitigating the manager career-risk and motivating the managerial effort. The relative value of innovation and the managerial effort for shareholders is mainly contingent on the level of innovation urgency. I find that the impact of the manager’s degree of career concerns on shareholders decisions on innovative investment, information quality and explicit incentives is non-monotonically contingent on the level of innovation urgency.

When the level of innovation urgency is high, shareholders focus more on innovation and
reduce information quality to mitigate the manager’s career risk. As a result, the information quality declines dramatically when the manager degree of career concerns increases. A lower information quality protects the manager in the labor market, and induces shareholders to increase innovative investment. Therefore, the shareholders increase innovative investment as the degree of career concern increases.

When the level of innovation urgency is low, as the manager’s degree of career concern increases, shareholders rely on reducing innovative investment to mitigate the manager’s career risk. As the innovative investment declines, the firm outcome becomes less volatile, and that allows shareholders to choose a higher explicit incentive to motivate the manager’s operating effort.

For intermediate levels of innovation urgency, shareholders have to reduce both information quality and innovative investment in response to an increase in the manager’s career concerns, which leads to both lower innovation profit and lower productive effort. Therefore, firms with intermediate levels of innovation urgency favor experienced managers (i.e. managers with lower career concerns) most.

This study contributes to the extant literature that examines the interaction between managers’ career concerns and shareholders’ investment decisions regarding innovation. My results indicate that the relationship between managers’ career concerns and firms’ investment and compensation decisions depend non-monotonically on the level of innovation urgency. When we examine the impact of career concerns on firms’ decisions on investment, managerial incentives and manager selection, we need to consider the firms’ innovation urgency. Because the level of innovation urgency may also varies among industries, my results shed light on cross-industry studies on the impact of career concerns on firms’ aforementioned decisions.

5 Appendix

Proof of Lemma 1:

Proof. The deduction of \( w_2(y) \) follows standard procedures. We have:

\[
y = i \cdot (m + a) + e + \epsilon, \quad \text{where} \quad a \sim N[0, 1/h_a], \quad \text{and} \quad \epsilon \sim N[0, 1/h].
\]

Therefore, after observing \( y \), the labor market’s updated belief about \( a \), \( w_2(y) \), is:

\[
w_2(y) = E[a|y] = \frac{Cov(a, y)}{Var[y]} \cdot (y - E[y]).
\]

Since \( Cov(a, y) = i/h_a \) and \( E[y] = i \cdot m + \hat{\epsilon} \), the above equation yields \( w_2(y) = k_2(y - i \cdot m - b \cdot \hat{\epsilon}) \), where \( k_2 = \frac{i/h_a}{\text{var}_y} \) and \( \text{var}_y \equiv Var[y] = i^2/h_a + 1/h. \)
It can be proved that $\frac{\partial k_2}{\partial h} > 0$, and $\frac{\partial k_2}{\partial h_a} < 0$. \hfill \Box

Proof of Lemma 2:

Proof. From Eq (6), $C_R = \frac{\rho \cdot i^2}{2h_a \cdot \text{var}_y}$. Substituting $\text{var}_y = i^2/h_a + 1/h$ into $C_R$, it can be derived that:

$$\frac{\partial C_R}{\partial h} = \frac{i^2 \rho}{2(h_a + h \cdot i^2)^2} > 0;$$
$$\frac{\partial C_R}{\partial i} = \frac{h \cdot i \cdot \rho}{(h_a + h \cdot i^2)^2} > 0.$$

\hfill \Box

Proof of Proposition 1:

Proof. In the model, the shareholders make decisions on the $i$, $h$, and $w_1$ simultaneously. However, for the sake of illustration, I first calculate the shareholders’ optimal linear contract taking information $i$ and $h$ as given. Then, I solve for the shareholders’ optimal information quality given $i$ and the shareholders’ optimal linear contract. Finally, I solve for the shareholders’ optimal investment decision. According to the envelope theorem, the result I derive from solving the three choice variables sequentially will be the same as solving them simultaneously.

First, I solve for the shareholders’ optimal linear contract taking $h$ and $i$ as given: $w_1^*(i, h)$. Substituting the manager’s optimal effort $e^* = k_1 + k_2$ into the manager’s expected utility function Eq (2) yields:

$$U(w_1, w_2, e) = k_1(i \cdot m + k_1 + k_2) + c_1 - \frac{\rho}{2} k_2^2 \text{var}_y - \frac{1}{2} (k_1 + k_2)^2 - \frac{\rho}{2} k_2^2 \text{var}_y.$$

In the equilibrium, the manager’s IR constraint should be binding, namely $U(w_1, w_2, e) = 0$. It can be easily verified that $\text{var}_y = i/h_a$. As a result, $c_1$ can be derived as:

$$c_1^*(k_1, i, h) = \frac{k_2^2 - k_1^2}{2} \cdot \frac{(k_2^2 + k_1^2)}{\text{var}_y} - k_1 \cdot i \cdot m.$$

Substituting $c_1 = c_1^*(k_1, i, h)$ into shareholder’s objective function as shown in Eq (5), and from the first order condition w.r.t $k_1$, it can be derived:

$$k_1^*(i, h) = \frac{1-k_2}{1+\rho \text{var}_y}.$$

Consequently, $c_1^*(i, h)$ can be calculated as:

$$c_1^*(i, h) = c_1^*(k_1^*(i, h), i, h) = \frac{k_2^2 - k_1^2 + (k_2^2 + k_1^2) \rho \cdot \text{var}_y}{2} - k_1^* \cdot i \cdot m.$$

The shareholders’ optimal linear contract taking $i$ and $h$ as given is:

$$w_1^*(i, h) = k_1^*(i, h) \cdot y + c_1^*(i, h).$$

Next, I solve for the shareholders’ optimal information quality given $w_1^*(i, h)$ and $i$: $h^*(i)$. After substituting $e = k_1 + k_2$, $k_2 = \frac{i^2}{\text{var}_y}$ and $w_1^*(i, h)$ derived above into Eq (5), the shareholders’ objective function can be expressed as:
\[ \pi_s(h, i) = i \cdot m + \frac{1 + \rho \cdot i/h_a \cdot (2 - i/\text{var}_y)}{2(1 + \rho \cdot \text{var}_y)} - \frac{\rho \cdot i^2/h_a}{2h_a \text{var}_y} - \frac{c}{2}. \]  

(12)

In order to derive the optimal \( h \) for a given level of \( i \), \( h^*(i) \), it is instructive to solve for the optimal volatility of the signal, \( \text{var}_y \), for the shareholders first. Because \( \text{var}_y = i^2/h_a + 1/h \) and \( h > 0 \), \( \text{var}_y \) should be no less than \( i^2/h_a \). I focus on the interior solution which is sustainable under Condition 1. From the first order condition of \( \pi_s(h, i) \) w.r.t \( \text{var}_y \), with Condition 1, it can be derived:

\[ \text{var}_y^*(i) = \frac{i\sqrt{2}h_a + (2\sqrt{2})\rho}{h_a^2 + 2\rho h_a - i^2 \rho^2}. \]

The optimal information quality \( h^*(i) \) can be calculated as:

\[ h^*(i) = \frac{1}{\text{var}_y^*(i) - i^2/h_a}. \]

Now, I calculate the shareholders optimal \( i \) in the equilibrium. Substituting \( h = h^*(i) \) and \( w_1 = w_1^*(i, h) \) into Eq (5), the shareholder’s objective function can be expressed as

\[ \pi_s(i) = i \cdot m + \frac{h_a^2 - 2(\sqrt{2} - 1)h_a i \rho + (3 - 2\sqrt{2})i^2 \rho^2}{2h_a^2} - \frac{c}{2}. \]

The first order condition w.r.t. \( i \) yields:

\[ i^* = \frac{h_a^2 m - (\sqrt{2} - 1)\rho h_a}{h_a^2 c - (3 - 2\sqrt{2})\rho}. \]

Substituting \( i^* = \frac{h_a^2 m - (\sqrt{2} - 1)\rho h_a}{h_a^2 c - (3 - 2\sqrt{2})\rho} \) into \( h^*(i) \), and \( w_1^*(i, h) \), Proposition 1 will be derived. \( \square \)

**Proof of Corollary 1:**

*Proof.\* It can be verified that under Condition 1,

\[ \frac{\partial \pi_s^*}{\partial m} = \frac{1}{c - (3 - 2\sqrt{2})(\rho/h_a)^2} > 0 \] and \( \frac{\partial \pi_s^*}{\partial i} < 0. \)

Therefore, I can derive that \( \frac{\partial \pi_s^*}{\partial m} = \frac{\partial h^*(i)}{\partial i} \cdot \frac{\partial \pi_s^*}{\partial m} < 0. \) \( \square \)

**Proof of Corollary 2:**

*Proof.\* It can be easily verified that \( i^* = \frac{h_a^2 m - (\sqrt{2} - 1)\rho h_a}{h_a^2 c - (3 - 2\sqrt{2})\rho} < i_0 = m/c \) for any \( \rho/h_a > 0. \) \( \square \)

**Proof of Proposition 2:**

*Proof.\* \( \frac{d i^*}{d h_a} = (5\sqrt{2} - 7) \cdot \frac{-(\rho/h_a)^2 + 2(1 + \sqrt{2})m \cdot \rho/h_a - (3 + 2\sqrt{2})c}{c - (3 - 2\sqrt{2})(\rho/h_a)^2} \cdot \frac{1}{c - (3 - 2\sqrt{2})(\rho/h_a)^2} \)

Therefore, it can be derived that:

\( \frac{d i^*}{d h_a} < 0 \) if \( m < \frac{(\sqrt{2} - 1)(\rho/h_a)^2 + (\sqrt{2} + 1)c}{2\rho/h_a} \) and \( \frac{d i^*}{d h_a} > 0 \) if \( m > \frac{(\sqrt{2} - 1)(\rho/h_a)^2 + (\sqrt{2} + 1)c}{2\rho/h_a} \). \( \square \)

**Proof of Proposition 3:**
Proof. Substituting $i^* = \frac{h^2 m-(\sqrt{2} - 1)\rho h_a}{h^2 c-(3-2\sqrt{2})p}$ into $k_1^*$ as shown in Eq (10), we can rewrite $k_1^*$ as:
\[
k_1^* = \frac{(2-\sqrt{2})c-(3\sqrt{2}-4)m\rho/h_a}{2c-(3-2\sqrt{2})(\rho/h_a)^2}.
\]
As a result, we have
\[
\frac{dk_1^*}{d\pi_a} = \frac{2(10-7\sqrt{2})c\rho/h_a-m(17\sqrt{2}-24)(\rho/h_a)^2+(3\sqrt{2}-4)c}{2c-(3-2\sqrt{2})(\rho/h_a)^2}.
\]
Therefore, we can derive:
\[
\frac{dk_1^*}{d\pi_a} < 0 \quad \text{if} \quad m > \frac{(6-4\sqrt{2})c\rho/h_a}{(5\sqrt{2}-7)(\rho/h_a)^2+(\sqrt{2}-1)c}, \quad \text{and} \quad \frac{dk_1^*}{d\pi_a} > 0 \quad \text{if} \quad m < \frac{(6-4\sqrt{2})c\rho/h_a}{(5\sqrt{2}-7)(\rho/h_a)^2+(\sqrt{2}-1)c}.
\]

Proof of Proposition 4:

Proof. Substituting $i^* = \frac{h^2 m-(\sqrt{2} - 1)\rho h_a}{h^2 c-(3-2\sqrt{2})p}$, $h^*$ and $w_1^*(h, i)$ derived in Proposition 1 into the shareholders’ payoff function as shown in Eq (5), the shareholders’ equilibrium expected payoff can be calculated as:
\[
\pi_s^*(m, \frac{\rho}{h_a}) = \frac{c+m[m-2(\sqrt{2}-1)\rho/h_a]}{2c-(3-2\sqrt{2})(\rho/h_a)^2}.
\]
As a result, we have:
\[
\frac{d^2 \pi_s^*(m, \frac{\rho}{h_a})}{dm d\pi_a} = \frac{-2(10-7\sqrt{2})c\rho/h_a}{2c-(3-2\sqrt{2})(\rho/h_a)^2}.
\]
Therefore, we can derive:
\[
-\frac{d^2 \pi_s^*(m, \frac{\rho}{h_a})}{dm d\pi_a} > 0 \quad \text{if} \quad m < \frac{(\sqrt{2}-1)(\rho/h_a)^2+(\sqrt{2}+1)c}{2\rho/h_a}, \quad \text{and} \quad -\frac{d^2 \pi_s^*(m, \frac{\rho}{h_a})}{dm d\pi_a} < 0 \quad \text{if} \quad m > \frac{(\sqrt{2}-1)(\rho/h_a)^2+(\sqrt{2}+1)c}{2\rho/h_a}.
\]

Proof of Proposition 5:

Proof. Taking the linear contract $w_1$ as the optimal contract given $i$ and $h$, $w_1^*(h, i)$, we have the shareholders’ expected payoff function as $\pi_s(k_1^*, c_1^*, h, i)$.

For a given level of $h$, the optimal investment for the shareholder, $i^*(h)$ should satisfy the first order condition that:
\[
\frac{\partial \pi_s(k_1^*, c_1^*, h, i)}{\partial i} = 0 \quad \text{for} \quad i = i^*(h).
\]

The impact of $h$ on the above first order condition is:
\[
\frac{\partial \pi_s(k_1^*, c_1^*, h, i)}{\partial h} = \frac{\partial^2 \pi_s(k_1^*, c_1^*, h, i)}{\partial i \partial h}.
\]
In the equilibrium, we have $i = i^*$ and $h = h^* = h^*(i^*)$. $h^*(i)$ is shown in Proposition 1.

As shown in the proof of Proposition 1, we have $\frac{\partial \pi_s(k_1^*, c_1^*, h, i)}{\partial h} = 0$ if $h = h^*(i)$ for any $i$. It can be verified that
\[
\frac{\partial h^*(i)}{\partial i} = -\frac{\partial^2 \pi_s(k_1^*, c_1^*, h, i)}{\partial i \partial h} \frac{\partial^2 \pi_s(k_1^*, c_1^*, h, i)}{\partial h^2}, \quad \text{where} \quad h = h^*(i).
\]
The denominator of the above equation, $\frac{\partial^2 \pi_s(k_1^*, c_1^*, h, i)}{\partial h^2}$ is negative for $h = h^*(i)$. Therefore, if $h = h^*(i)$, we have $\frac{\partial^2 \pi_s(k_1^*, c_1^*, h, i)}{\partial i \partial h} \propto \frac{\partial h^*(i)}{\partial i} > 0.
\]
As derived in the proof of Corollary 1, $\frac{\partial h^*(i)}{\partial i} < 0$. As a result, $\frac{\partial^2 \pi_s(k_1^*, c_1^*, h, i)}{\partial i \partial h} < 0$ for $i = i^*$ and $h = h^*$. \[\Box\]
References


