Don't Say a Word: Auditor and Management Disclosures*

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Abstract

In this paper, we analyze the effects of auditor risk disclosure on manager voluntary disclosures, audit effort, and investment efficiency. We demonstrate that auditor disclosure and manager voluntary disclosure may be substitutes or complements depending on the level of business risk. These two disclosures jointly influence audit effort and investment efficiency. We find that auditor disclosure does not impact investment efficiency when a company's business risk is low. Conversely, when the business risk is high, auditor disclosure enhances investment efficiency by conveying the risk information about the audit. When the business risk falls within the intermediate range, auditor disclosure might impair investment efficiency through its impact on manager voluntary disclosure and audit effort. Our research contributes to the understanding of the dynamics between auditor and manager disclosures and sheds light on their collective impact on audit effort and investment efficiency.

Keywords: significant risk, auditor disclosure, voluntary disclosure, investment efficiency

JEL Codes: M42, M48

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1 Introduction

The recurrence of accounting scandals around the world has shattered investors' confidence in capital markets and in the effectiveness of audits. Financial statement users are increasingly demanding more information from auditors. In response to this demand, regulators and standard setters have implemented more-intensive inspections and stringent rules. One notable example is the requirement for auditors to disclose more information in audit reports. Many jurisdictions have implemented an expanded report format to enhance the information content and usefulness of audit opinions. These expanded audit reports include disclosures about significant matters in a company's financial reporting audit, known as key audit matters (KAM) in the UK and Canada, and critical audit matters (CAM) in the US. Such disclosures may alter investors' perceptions of a company's riskiness and their investment decisions, which may in turn influence managers' voluntary disclosure strategies. By anticipating both managers' disclosures and investors' decisions, auditors choose their audit effort accordingly. Consequently, the following question arises: How does auditor disclosure affect managers' voluntary disclosure, audit effort and investment efficiency? This paper presents a theoretical framework to explore the interaction between auditor disclosure and manager voluntary disclosure, as well as their impacts on audit effort and investment efficiency.

In our model, a manager seeks to raise capital from investors to fund a project. An auditor is hired to issue an audit report about the company's financial state to facilitate the investors' decisions. During the audit engagement, the auditor assesses whether there are "significant risks" involved. "Significant risks" refer to identified and assessed risks of material misstatements that require special audit consideration, which is an important part of the CAM disclosure (PCAOB AS 3101). The accuracy of the audit report varies based on the presence or absence of significant risks. To examine the impact of auditor disclosure, we analyze two regimes: the auditor disclosure regime, and the no-auditor-disclosure regime. Under the auditor disclosure regime, auditors provide investors with two types of information: (1) an audit report about the company's financial state and (2) a risk disclosure regarding the presence of significant risks in the audit. In contrast, under the no-auditor-disclosure regime, auditors only issue an opinion on (1) without disclosing (2).

Moreover, to attract investment, the manager may exert unobservable efforts to acquire private information about the potential cash flow and strategically disclose it if informed. For example, the manager could expand the disclosure in financial statement footnotes or provide information about new products and related sales predictions. The potential cash flow will be realized only if the company's financial state is good. Lastly, investors base their investment decisions on the audit report, the auditor's disclosure (only in the auditor disclosure regime), and the manager's voluntary disclosure (if any).

We find that the manager's disclosure strategy is influenced by the auditor disclosure regime, and together, they determine audit effort and investment efficiency. Specifically, we demonstrate that the relationship between the manager and auditor disclosure is non-monotonic and is affected by the company's business risk (i.e., the likelihood of the project failure). When the business risk is low, investors are willing to invest if the auditor issues a favorable opinion regardless of the auditor's disclosure. The manager's disclosure is irrelevant and auditor disclosure has no effect on the manager's disclosure. When the business risk is intermediate, auditor disclosure induces more manager disclosure. Under the disclosure regime, the manager is pressured to disclose favorable information to secure project funding if the presence of a significant risk is revealed. In contrast, under the no-auditor-disclosure regime, due to the possibility of no significant risk, investors are willing to fund the project upon a good audit report, relieving the manager from disclosure pressure and making manager disclosure and auditor disclosure complementary. Conversely, when the business risk is high, manager and auditor disclosure are substitutes. Under the no-disclosure regime, the manager is compelled to disclose since investors fund the project only if favorable information is disclosed by the manager due to the high business risk. Under the disclosure regime, the manager faces little pressure to disclose if no significant risk is revealed, implying less uncertainty in the audit report. Thus, manager's disclosure is more important under the no-disclosure regime, and manager disclosure and auditor disclosure become substitutes.

Since the auditor disclosure regime affects manager's disclosure strategy, it also affects audit effort decision. We find that auditor disclosure can reduce audit effort through the endogenous manager's disclosure when the business risk is not low. The reason is that when a significant risk

is revealed under the disclosure regime, investors are more cautious in their investment decision. Investors fund the project only if the manager provides favorable disclosure. As a result, the likelihood of investment decreases due to such cautious funding decision when a significant risk is revealed. Anticipating a lower expected liability due to the reduced likelihood of investment, the auditor have less incentive to exert effort, leading to less audit effort under the disclosure regime. Conversely, under the no-auditor-disclosure regime, investors are more willing to fund the project upon receiving a good audit report due to the chance that the company has no significant risk. Investors even fund the project without the manager's favorable disclosure. As a result, by anticipating a higher likelihood of investment, the auditor has more incentive to exert effort to improve the accuracy of audit opinion, resulting in higher audit effort under the no-auditor-disclosure regime.

We then analyze the overall information impact of auditor disclosure via investment efficiency. We find that its effect is linked to both the business risk and auditor's effort incentive. When the business risk is low, investors fund the project when the audit report is good, regardless of the auditor's risk disclosure. Hence, the two regimes have no impact on investment efficiency. However, when the business risk is high, investors are more concerned about the risk of project failure. Under the disclosure regime, companies with no significant risks can be revealed, and investors can avoid missing the opportunity to fund profitable projects, which consequently improves investment efficiency. These results confirm conventional wisdom that the auditor's disclosure reveals useful information about significant risk and improves investment efficiency.

When the business risk is intermediate, auditor's effort incentive plays an important role in efficiency. Under the no-auditor-disclosure regime, investors are still willing to fund the project without favorable manager disclosure, which prevents under-investment but may lead to over-investment. Under the disclosure regime, investors require favorable manager disclosure if the presence of significant risks is revealed. Given that the manager may not always be able to obtain and disclose favorable information, under-investment can occur. When the auditor's incentive to work hard is high, the over-investment is greatly mitigated by high audit effort under the no-auditor-disclosure regime, resulting in higher investment efficiency under the no-auditor-disclosure regime

compared to the disclosure regime. Our analysis highlights that the impact of auditor disclosure is twofold: on the one hand, it directly affects investment efficiency by conveying information on significant risks. On the other hand, auditor disclosure also impacts manager disclosure decision, which, in turn, affects audit effort and investment efficiency.

Our study connects management voluntary disclosure with the auditing literature. We advance the understanding of the interaction between auditor disclosure and manager voluntary disclosure (Ye 2023). Many voluntary disclosure studies focus on the efficiency implications and analyze how voluntary disclosure incentives affect investment decisions (Shavell 1994; Kumar et al. 2012; Wen 2013; Bertomeu et al. 2021; Guttman and Meng 2021). Laux and Laux (2023) allows managers to gather additional information about firms' performance in a debt-contracting setting and finds that conservative financial reporting can become optimal if the project is ex ante more likely to be of high quality than of low quality. Our paper chooses a unique perspective and analyzes how manager's voluntary disclosure is influenced by auditor disclosure. We find that auditor and manager's disclosure could be substitutes or complements depending on the business risk level, and the manager's disclosure strategy would, in turn, affect audit effort and investment efficiency.

Our paper also contributes to the emerging literature on the expanded audit report. Most extant papers in this literature are empirical or experimental studies. For example, Burke et al. (2023) documents significant changes to financial statement footnotes referenced by CAMs, which suggests an indirect consequence where management disclosure changes in areas that are expected to be scrutinized following auditor-provided disclosure. Bentley et al. (2021), an experimental study, shows that a CAM disclosure decreases managers' risk-decreasing activities (due to increased disclosure costs) more than managers' risk-increasing activities. Our paper shows the expanded audit report may encourage or discourage management disclosure and explains how the audit disclosure could reduce audit effort and investment efficiency through its impact on management disclosure. Our analysis provides a theoretical framework to connect audit disclosure, management disclosure and their real effects on investment decisions.

Moreover, the existing theoretical studies on audit report reform are limited. Chan and Liu (2023) models auditor effort and investor scrutiny as strategic substitutes and demonstrates that

CAM disclosures result in larger investor scrutiny and smaller audit effort in expectation if and only if the auditor's legal liability is low or the CAM signal is precise. Chen et al. (2019) shows that audit quality disclosure of audit effort increases auditors' effort incentives only if the underlying financial reporting quality is relatively weak. Deng et al. (2023b) adopts a two-period model wherein an auditor acquires private information about a company's audit risk and finds that the auditor disclosure about audit risk eliminates the incumbent auditor's information advantage, which impairs audit quality and could reduce investment efficiency. In contrast, we focus on the interaction between auditor disclosure and manager's voluntary disclosure, and study their joint impact on audit effort and investment efficiency. In particular, we find that auditor disclosure has no impact on efficiency when the business risk is low, could impair efficiency when the business risk is intermediate and enhances the efficiency when the business risk is high. Our study contributes to the sparse theoretical literature on audit reform and sheds light on how the efficiency implications of auditor disclosure are related to the business risk level.

In addition, by endogenizing managers' disclosure and investors' funding decisions, some of our findings may challenge conventional wisdom and enhance the understanding of the real effects of auditor disclosure. In contrast to conventional wisdom that audit effort always increases with business risk, we show that audit effort may decrease in the business risk level under certain conditions. This counter-intuitive result is driven by the endogenous manager disclosure threshold. We show that the disclosure threshold could increase in business risk due to the higher likelihood of project failure. With a higher disclosure threshold, the manager is less likely to obtain sufficiently favorable information to attract investment. A lower likelihood of investment reduces auditor's expected liability and consequently, discourages the audit effort.

The rest of the paper proceeds as follows. Section 2 describes the model setup. Section 3 solves the equilibria under the auditor disclosure regime and no-auditor-disclosure regime. Section 4 analyzes the impact of auditor disclosure regime on the manager's disclosure strategy, audit effort and investment efficiency. Section 5 concludes the study. We provide all the proofs in Appendix A.

2 The model

Consider an economy containing a company manager, an auditor, and investors. The company is endowed with a project that requires investment cost, which is normalized to 1. The project's outcome is determined by the company's financial state $S \in \{G, B\}$. The prior probability of bad state $S = B$ is p and the prior probability of good state $S = G$ is $1 - p$, where $p \in (0, 1)$. Following prior literature(Lu and Sapra 2009; Chan and Liu 2023), we refer p as the company's business risk, which indicates its financial prospects. If the company's financial state is bad (B), the project will fail and generate zero cash flow. If the company's financial state is good (G), the project will succeed and generate a cash flow $\tilde{X}$, which is a random variable over $[X_l, X_h]$ with a mean of $E(\tilde{X}) = \bar{X}$, where $\bar{X} > 1$. This implies that the project yields a positive expected net return when the financial state is good. The cumulative distribution function (CDF) and probability density function (PDF) of $\tilde{X}$ are $F(\tilde{X})$ and $f(\tilde{X})$, respectively.

At the beginning, an auditor is hired with a non-contingent audit fee W to provide an audit report on the company's financial state. The manager is required to provide unaudited financial report about the company's financial state to the auditor. Following the prior analytical auditing literature (Lu and Sapra 2009; Ye and Simunic 2013; Simunic et al. 2017), we assume that the manager always claims the state to be good. The auditor will attest to this assertion and prepare an audit report.

During the audit engagement, the auditor forms a risk assessment of the company and privately observes whether there are significant risks in the audit, denoted by $\theta \in \{Y, N\}$. With probability λ, there exist significant risks in the company ($\theta = Y$) and with probability $1 - \lambda$, there are no significant risks in the company ($\theta = N$). A significant risk is an identified and assessed risk of material misstatement that, in the auditor's judgment, requires special audit consideration (AS 2110, ISA 315, CAS 315).[1] For example, the risk associated with the degree of uncertainty

[1]Specifically, a significant risk is an identified risk of material misstatement for which the assessment of inherent risk is close to the upper end of the spectrum of inherent risk due to the degree to which the inherent risk factors affect the combination of the likelihood of a misstatement occurring and the magnitude of the potential misstatement should that misstatement occur. Areas of significant management judgment and significant unusual transactions may often be identified as significant risks. Significant risks are therefore often areas that require significant auditor attention.

associated with the future occurrence and conditions underlying the significant assumptions or the complexity of the process for developing the accounting estimates or in the measurements involving a wide range of uncertainty. Significant risks differ from business risks, since business risks are risks resulting from significant conditions that could adversely affect an entity's ability to achieve its objectives and execute its strategies. For example, expansion of business into new products and services may not be successful. PCAOB AS 3101 states that in determining critical audit matters and whether a matter involves especially challenging, subjective, or complex auditor judgment, the auditor should consider factors relating to the auditor's assessment of the risks of material misstatement, including significant risks, among others. Thus, significant risks are an important part of the CAM disclosure in practice.

To streamline the analysis, we assume that if there are no significant risks, the auditor is able to obtain conclusive evidence and can always receive an accurate signal, g or b, about the true financial state, i.e., $\Pr(g|G) = 1$ and $\Pr(b|B) = 1$, by exerting effort required by auditing standards (i.e., standard effort). To simplify mathematical notation, we normalize the standard effort to zero. However, if there are significant risks, besides the standard effort, the auditor has to exert additional effort $a \in (0, 1)$ to collect additional audit evidence. The auditor will obtain an inaccurate signal about the company's financial state at a quadratic cost of effort, $\frac{1}{2}ka^2$. The signal is always correct when the financial state is good, but only correctly reveals the financial state with probability a if the financial state is bad:

$$\Pr(g|G) = 1 \text{ and } \Pr(b|B) = a.$$

The auditor makes no mistakes in confirming a good-state project (i.e., there are no Type I errors), but may make Type II errors with probability $1 - a$ when the company's financial state is bad.[2] Auditors collecting additional evidence includes interviewing managers who can provide detailed justifications and asking managers to provide supporting documentation, in addition to performing

[2]That is, disclosure of significant risks primarily reveals possible Type II errors in good audit reports. The reason is that Type II errors (overstatements) are the primary concern of the PCAOB to protect investors from potential losses. In practice, when an auditor issues a clean opinion alongside CAM disclosures that reveal the presence of significant risks, investors learn that there are risks in the clean opinion.

other auditing procedures, such as seeking advice from specialists, examining a sample of transaction in detail to verify their accuracy and completeness, etc. Since significant risks involve future uncertainty and complexity of accounting estimates, the additional effort can not eliminate the presence of significant risks. However, these efforts can reduce the impact of significant risks on the accuracy of audit opinion, and thus, increase the accuracy of audit opinion about the financial state.

An audit failure occurs when investors fund the project ($I = 1$), the auditor issues a good report ($r = g$) and the project fails ($S = B$). In the event of audit failure, the auditor will bear a liability of L.[3] If there are significant risks ($\theta = Y$), the auditor's expected audit liability will be $p(1-a)L$ when investors fund the project and zero when investors forgo the project. In litigation practices, investors can sue auditors if they suffer a loss, and thus, the auditors' expected liability is associated with investment loss. This practice has been adopted in the analytical literature (e.g., Chen et al. 2019). Moreover, Palmrose (1991) provides an overview of the auditors' litigation process, showing that investors' loss generation is a key part of the litigation process. Recent papers also provide evidence linking auditor liability to investment loss, such as Pickerd and Piercey (2021), Maksymov and Reffett (2020), and De Meyst et al. (2021).

Upon observing significant risks in the audit, the auditor chooses her additional audit effort a to maximize

$$U_A = W - p(1-a)L \cdot 1_{I>0} - \frac{1}{2}ka^2, \tag{1}$$

where $1_{I>0}$ is an indicator function for $I > 0$. The auditor reports her signal $r \in \{g, b\}$ truthfully to the public. If the auditor reports b when her signal is g, she may lose the client since the client will not accept this report without proper supporting audit evidence. If the auditor reports g when her

[3]Negligence rule is mostly considered in papers that analyze auditing/legal standards (Ye 2023). Since our focus is on auditor disclosure, we follow prior literature (Chen et al. 2019; Chan and Liu 2023; Deng et al. 2023a) and consider a strict liability regime. This liability cost could also be regarded as any cost incurred in dealing with lawsuits under a negligent liability regime. It may include time and effort incurred by the auditor in preparing a legal defense (Laux and Newman 2010) and settlement costs (Zhang and Thoman 1999). Lastly, incorporating negligence liability regime by assuming that the likelihood that the auditor is found negligent is $\alpha \in (0, 1)$ like in Chen et al. (2019) generates the same inferences.

signal is b, her expected liability will increase. We abstract away from auditor independence issues (Lu and Sapra 2009; Deng et al. 2014; Kronenberger et al. 2024) in this paper, since our focus is on the impact of auditor's disclosure. Figure 1 illustrates the information structure of audit report.

Insert Figure 1 here

To study the effect of risk disclosure by auditors, we consider two regimes: (1) auditor disclosure regime, in which the auditor issues her audit report r and also truthfully discloses her information about the risk θ, and (2) no-auditor-disclosure regime, in which the auditor only issues her audit report r and does not disclose any information about the existence of significant risks.

After receiving the audit report and auditor disclosure, if any, the manager may strategically disclose additional information to investors.[4] Specifically, the manager can exert an unobservable effort $e \in (0, 1)$ at a cost of $\frac{1}{2}ce^2$ to acquire private information about the potential project cash flow X. We assume that the cost parameter c is high enough so that the manager's choice of e is less than 1 and there is a unique equilibrium. After exerting effort, the manager perfectly observes X with probability e and obtains no information about X with probability $1 - e$. If the manager successfully acquires information, he can choose to disclose it truthfully to investors or not to disclose it. The potential cash flow X is realized only if the financial state is good.[5] For example, managers may voluntarily disclose information about new product sale predictions, and the actual sales performance would depend on the product quality and market perceptions.

When the project is funded, the manager will enjoy a private benefit β, which represents benefits due to empire building or career incentives. The private benefit β can be understood as a benefit that increases with the investment or a compensation, e.g., empire benefits from overseeing the project (Baldenius 2003) or a bonus contract (Ewert and Wagenhofer 2019). The private benefit can also encompass job perks, the acquisition of human capital, and the potential to signal ability

[4]The manager will not exert costly effort to obtain information before the auditor's attestation since it is more efficient to wait for the auditor's signal. For example, if the auditor issues a qualified opinion (without Type I error), investors will never provide funding regardless of what the manager discloses, which renders manager's disclosure useless.

[5]Similarly, in Langberg and Sivaramakrishnan (2010), the manager privately observes his firm's value potential as hard information with some probability and can credibly disclose it. The value potential is realized only if the manager takes the appropriate action.

(Aghion and Tirole 1997). Thus, the manager chooses his information acquisition decision e and disclosure decision to maximize

$$U_M = \beta \cdot 1_{I>0} - \frac{1}{2}ce^2. \tag{2}$$

After observing the audit report, auditor's disclosure and the manager's disclosure, if any, investors make investment decision $I \in \{0, 1\}$. We assume that the investors' payoff equals the expected investment net return. The investor will choose to fund the project ($I = 1$) if the expected investment net return is positive and forgo the project ($I = 0$) otherwise. Investors will never fund the project when the auditor's report is bad ($r = b$), because there are no Type I errors in the auditor's report regardless of the presence or absence of significant risks. When the auditor's report is good ($r = g$), investors make the funding decision based on the auditor disclosure and the manager's disclosure (if any).

To make the manager's disclosure relevant to investment decision, we assume that the upper bound of the distribution X_h is high enough such that given a good audit report ($r = g$), the project yields positive NPV when the manager discloses a sufficiently high X regardless of the auditor's disclosure about θ, i.e., $\Pr(G|g, \theta) \cdot X_h > 1$ for any $\theta \in \{Y, N\}$. Otherwise, the manager will not have incentives to exert costly effort to acquire the cash flow information due to lack of benefits, and management disclosure is a moot issue. We relax this assumption and analyze a setting with expanded parameter space in Appendix B.

The sequence of events (timeline) is summarized in Figure 2.

Insert Figure 2 here

3 Equilibrium analysis

In this section, we analyze the equilibrium under both auditor disclosure regime and no-auditor-disclosure regime. The equilibrium consists of the additional audit effort a, the manager's information acquisition e and disclosure strategy, and investors' investment decisions I.

3.1 Auditor disclosure regime

Under the auditor disclosure regime, the auditor is required to disclose whether there exist significant risks or not to the public. If the auditor discloses that no significant risk exists ($\theta = N$), the audit report perfectly represents the company's financial state, and the investor will always choose to fund (forgo) the project based on a good (bad) audit report. The manager has no incentive to acquire and disclose information about project cash flow X because it does not influence the investment decision. Therefore, in this subsection, we only focus on the case when the auditor discloses that significant risks exist ($\theta = Y$), and analyze the investors', auditor's and manager's equilibrium strategy.

3.1.1 Investment decision

Following backward induction, we first solve investors' investment decision. When the auditor's report is bad ($r = b$), investors will never fund the project since there are no Type I errors in the audit report and a bad report indicates certainty of a bad state. When the auditor issues a good audit report ($r = g$) and discloses that there exist significant risks ($\theta = Y$), investors will fund the project if

$$\Pr(G|g, Y) \cdot \bar{X} > 1,$$

where $\Pr(G|g, Y) = \frac{1-p}{1-p+p(1-\hat{a})}$ is the posterior belief of project success given $r = g$ and $\theta = Y$, and $\hat{a}$ stands for investors' conjecture of the additional audit effort under the auditor disclosure regime.

However, if $\Pr(G|g, Y) \cdot \bar{X} < 1$, the expected project cash flow is not high enough to cover the investment cost and the investors will not fund the project without further disclosure. To attract investment, the manager will exert costly effort to acquire private information about X and disclose this information strategically. Investors will fund the project only if the disclosed cash flow X is sufficiently high such that $\Pr(G|g, Y)X \geq 1$, and otherwise, they will not invest.

3.1.2 Auditor's objective and effort

The auditor is able to assess the existence of significant risks during the audit engagement. If the auditor finds that there is no significant risk, she is able to obtain accurate signals about the true financial state. If the auditor finds that significant risks exist in the company, she is subject to two costs. First, the auditor's additional effort in detecting a bad project is costly. Second, she will suffer a liability L in the event of audit failure when investors funded the project ($I = 1$), the auditor's report is good ($r = g$) and the project fails ($S = B$). That is, the auditor's expected liability is affected by both the investor's decision and the accuracy of the audit report.

As we discussed above, investors' decision is contingent on both the auditor's report and the manager's disclosure. Based on investors' decision, we show that there are two cases.

- Case one: $\Pr(G|g,Y)\bar{X} > 1$ (i.e., $p \leq t_D$, where $t_D \equiv \frac{\bar{X}-\sqrt{\bar{X}^2-4L(\bar{X}-1)/k}}{2L/k}$ and the subscript D stands for the auditor disclosure regime)

When the company's business risk p is low, investors always fund the project if the auditor's report is good, and the manager has no incentive to acquire and disclose any private information. The auditor's expected liability is $p\,(1-a)\,L$ and her expected payoff in (1) is

$$\max_a E[U_A] = W - p\,(1-a)\,L - \frac{1}{2}ka^2.$$

Since the audit fee W is determined at the beginning of the audit engagement, the auditor chooses her additional audit effort a by minimizing her expected total cost. Therefore,

$$a_1 = pL/k,$$

where a_1 stands for the optimal additional audit effort in Case one.

- Case two: $\Pr(G|g,Y)\bar{X} < 1$ (i.e., $p > t_D$)

When the company's business risk p is high, the investors fund the project only if the auditor's

report is good and the manager discloses potential cash flow $X \geq X^*$. Given the conjecture on manager's information acquisition decision $\hat{e}$ and the probability of potential cash flow greater than or equal to X^*, the auditor's expected audit liability is $\hat{e}\Pr(X \geq X^*)p(1-a)L$. The auditor's expected liability is lower in Case two since investors may not fund the project even after receiving a good audit report. The auditor's expected payoff in (1) is

$$\max_a E[U_A] = W - \hat{e}\Pr(X \geq X^*)p(1-a)L - \frac{1}{2}ka^2.$$

Hence, the additional audit effort decision is

$$a_2 = \hat{e}\Pr(X \geq X^*)pL/k,$$

where a_2 stands for the optimal additional audit effort in Case two. Given the same p, we have $a_1 > a_2$, and thus, $\Pr(G|g,Y,a_1) > \Pr(G|g,Y,a_2)$. That is, if $\Pr(G|g,Y,a_1)\bar{X} > 1 > \Pr(G|g,Y,a_2)\bar{X}$, there may exist two equilibria. In our analysis, we apply Pareto dominance criterion for equilibria refinement. We provide a detailed analysis of the equilibrium in the proof of Proposition 1. The same equilibria refinement is applied to our anlaysis under the no-auditor-disclosure regime.

3.1.3 Manager's disclosure and information acquisition decision

As discussed in the above, in Case two ($p > t_D$), investors will fund the project only if the audit report is good and the manager discloses high potential cash flow. Since the manager benefits from the investment, he will disclose only if $\Pr(G|g,Y)X \geq 1$. Hence, the manager's disclosure threshold X^* solves $\Pr(G|g,Y)X^* = 1$ such that the expected investment return is zero.

Given the manager's information acquisition e, the probability that the manager discloses $X \geq X^*$ and receives investment is $e\Pr(X \geq X^*)$. Thus, the manager chooses information acquisition effort e to maximize his expected payoff in (2)

$$E[U_M] = \beta \cdot e\Pr(X \geq X^*) - \frac{1}{2}ce^2.$$

Therefore, the manager's information acquisition effort is

$$e = \Pr(X \geq X^*)\beta/c.$$

Note that the manager exerts information acquisition only when the auditor reveals the existence of significant risks ($\theta = Y$) and the business risk is high ($p > t_D$). By anticipating the manager's information acquisition decision ($e = \Pr(X \geq X^*)\beta/c$), the auditor's effort in Case two a_2 is

$$a_2 = \frac{pL\beta}{kc}[\Pr(X \geq X^*)]^2.$$

Lastly, we substitute a_2 to $\Pr(G|g, Y)X^* = 1$ and solve for X^*.

3.1.4 Equilibrium

We summarize the equilibrium under the auditor disclosure regime in the following proposition:

Proposition 1. *Under the auditor disclosure regime,*

- *if the auditor discloses that no significant risk exists $\theta = N$, investors fund the project if $r = g$, and forgo the project, otherwise. The auditor exerts the standard effort. The manager does not acquire any information and has no information to disclose;*
- *if the auditor discloses that significant risks exist $\theta = Y$,*
  - *when the business risk is low ($p \leq t_D$), investors fund the project if $r = g$, and forgo the project, otherwise. In addition to the standard effort, the auditor exerts additional effort $a_1 = pL/k$. The manager does not acquire any information and has no information to disclose;*
  - *when the business risk is high ($p > t_D$), investors fund the project if $r = g$ and the manager discloses $X \geq X^*$, and forgo the project, otherwise. The additional audit effort is $a_2 = \frac{pL\beta}{kc}[\Pr(X \geq X^*)]^2$. The manager's information acquisition decision is $e = \Pr(X \geq X^*)\beta/c$ and the manager discloses if he observes $X \geq X^*$.*

Both the manager's information acquisition e and the auditor's effort a_2 are heavily dependent upon the disclosure threshold X^* since the threshold determines the likelihood of disclosure and the likelihood of investment. Recall that the manager's disclosure threshold X^* solves $\Pr(G|g,Y)X^* = 1$ such that the expected investment return is zero. The following corollary shows how the disclosure threshold is affected by the business risk.

Corollary 1. *When the business risk is high ($p > t_D$), the disclosure threshold X^* increases in p and $\Pr(X \geq X^*)$ decreases in p if c is high.*

The effect of the business risk p on the disclosure threshold X^* is determined by its effect on the posterior belief $\Pr(G|g,Y)$. On the one hand, the posterior belief decreases in the business risk since the project is less likely to succeed. On the other hand, as the business risk p increases, the auditor may exert higher effort a_2 to avoid audit failure, which improves the posterior belief. We find that when the manager's marginal cost of information acquisition c is high, the business risk has less effect on the likelihood of manager's disclosure, and thus, has less effect on the investment decision and the auditor effort decision. As a result, the posterior belief decreases in the business risk, and the disclosure threshold X^* increases in the business risk.

Next, we compare the auditor's decision between Case one and Case two. Recall that in Case one the business risk is low and the auditor's effort decision is $a_1 = pL/k$. Hence, a_1 is higher than a_2 given the same level of p since $\Pr(X \geq X^*)\hat{e} < 1$. The auditor's effort decision is lower in Case two due to the possibility of information acquisition failure and lower realization of X. However, a_1 occurs when $p < t_D$ and a_2 occurs when $p > t_D$. To compare a_1 with a_2, we rewrite a_1 as $a_1 = p_1 L/k$ and a_2 as $a_2 = \Pr(X \geq X^*)\hat{e}p_2 L/k$, where $p_1 < t_D < p_2$. We summarize the comparison results in the following corollary.

Corollary 2. *(i) If $\Pr(X \geq X^*)\hat{e} < \frac{p_1}{p_2}$ (where $p_1 < t_D < p_2$), we have $a_1 > a_2$ and otherwise, $a_1 < a_2$;*

(ii) The auditor's effort a_2 increases in the conjecture of manager's information acquisition decision $\hat{e}$;

(iii) The auditor's effort a_2 decreases in p when c is high and p is high.

In contrast to the conventional wisdom that audit effort always increases with business risk due to a higher likelihood of audit failure, we show that audit effort is not strictly monotonic in business risk. Audit effort can be higher (lower) when the company's business risk is lower (higher) if the manager's disclosure and investors' funding decisions are endogenized. The reason is that when the business risk is high, investors may not fund the project without favorable disclosure from the manager. The auditor's expected liability decreases due to a lower potential investment loss. As a result, the auditor has less incentive to exert effort. Moreover, the auditor will increase her additional effort in response to a higher conjectured manager's information acquisition effort, which indicates that these two efforts are complementary in our setting. Higher information acquisition results in a higher likelihood of manager's disclosure, and thus, a higher likelihood of investment, which increases the auditor's expected liability and audit effort incentive.

In addition, we find that the auditor's additional effort in Case two a_2 may monotonically decrease in p in certain regions. This counter-intuitive result is driven by the endogenous disclosure threshold X^*. Corollary 1 indicates that the disclosure threshold X^* could increase with p due to a higher likelihood of project failure. With a higher disclosure threshold, the manager is less likely to obtain sufficiently favorable information to attract investment, which discourages both the manager's information acquisition and the auditor's effort. When p is high, the threshold X^* is also high, making the chance of favorable disclosure very slim, and thus, the auditor's effort a_2 is minimal. That is, a_2 decreases with p when both c and p are high.

Figure 3 illustrates how the audit effort (a_1 and a_2) changes with the business risk p. When the business risk is low ($p \leq t_D$), the audit effort a_1 monotonically increases in the business risk as suggested by the conventional wisdom. The audit effort in Case two (a_2 when $p > t_D$) could be lower than that in Case one (a_1 when $p \leq t_D$) as suggested by part (i) of Corollary 2. Moreover, the audit effort in Case two (a_2) could decrease in p as suggested by part (iii) of Corollary 2.

Insert Figure 3 here

3.1.5 Investment efficiency

The investment efficiency (denoted by Π) is defined as the ex ante expected investment return net of the cost of investment. When the business risk is low (Case one: $p \leq t_D$), investors fund the project if the audit report is good $r = g$ regardless of the auditor's disclosure regarding the existence of significant risks θ, and the expected net project return is

$$\Pi^D (p \leq t_D) = (1-p)\left(\bar{X} - 1\right) - \lambda p(1-a_1), \tag{3}$$

where the superscript D stands for the auditor disclosure regime. When significant risks exist (with probability λ), over-investment occurs with probability $p(1-a_1)$ due to the Type II error in the good audit report, and with probability $1-p$, investors make efficient investment decision.

When the business risk is high (Case two: $p > t_D$) and the auditor discloses no significant risk ($\theta = N$), investors still fund the project if the audit report is good $r = g$. However, when the existence of significant risks is disclosed ($\theta = Y$), investors fund the project only if both the audit report is good $r = g$ and the manager discloses $X \geq X^*$. In this case, the expected net project return is

$$\Pi^D (p > t_D) = \lambda e \Pr(X \geq X^*)[(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)] + (1-\lambda)(1-p)\left(\bar{X} - 1\right). \tag{4}$$

When significant risks exist (with probability λ), both over-investment and under-investment may occur. If the manager discloses $X \geq X^*$ (with probability $e \Pr(X \geq X^*)$), over-investment occurs with probability $p(1-a_2)$ due to the Type II error in the good audit report. If the manager does not disclose, under-investment may occur because good-state projects with high potential cash flow might be forgone due to information acquisition failure.

3.2 No-auditor-disclosure regime

Under the no-auditor-disclosure regime, the auditor only issues an audit report $r \in \{g, b\}$. Investors do not receive any information about whether significant risks exist or not in the audit.

In other words, if the auditor's report is good ($r = g$), investors cannot identify whether the audit report is accurate (from a company without significant risks) or inaccurate (from a company with significant risks). However, the auditor still observes the presence or absence of significant risks θ during her audit engagement and uses her knowledge about significant risks in her audit effort decision.

3.2.1 Investment decision

If the auditor's report is bad ($r = b$), investors will never fund the project. When the auditor's report is good ($r = g$), investors will fund the project if

$$\Pr(G|g, \phi) \cdot \bar{X} > 1,$$

where ϕ stands for no auditor disclosure about significant risks, $\Pr(G|g, \phi) = \frac{1-p}{1-p+\lambda p(1-\hat{a})}$ is the posterior belief of project success given $r = g$ and no auditor disclosure, and $\hat{a}$ stands for the conjecture of the auditor's effort.

Compared with the posterior belief given that significant risks are disclosed under the disclosure regime, i.e., $\Pr(G|g, Y) = \frac{1-p}{1-p+p(1-\hat{a})}$, the posterior belief under the no auditor disclosure regime $\Pr(G|g, \phi)$ is higher since investors believe that Type II errors occur with a lower probability $\lambda p(1-\hat{a})$. Intuitively, investors believe that the project is more likely to be good when they receive a positive audit report without any disclosure about significant risks than when significant risks are disclosed. This higher posterior belief is due to the possibility that there might not be any significant risks in the audit.

When $\Pr(G|g, \phi) \cdot \bar{X} < 1$, the expected cash flow is not high enough to cover the investment cost. To attract investment, the manager is motivated to acquire private information about X. Investors will fund the project only if the manager discloses the cash flow is sufficiently high such that $\Pr(G|g, \phi)X \geq 1$, and otherwise, they will forgo the project.

3.2.2 Auditor's objective and effort

In the no-auditor-disclosure regime, the auditor still observes θ before her audit effort decision. As a result, the auditor's effort decision is still contingent on her knowledge of significant risks, even though she does not disclose this information in the audit report. When the auditor observes significant risks ($\theta = Y$), her expected liability is affected by both the investor's decision and the accuracy of the audit report. Similar to the disclosure regime, we also have two cases under the no-auditor-disclosure regime.

- Case one: $\Pr(G|g,\phi)\bar{X} > 1$ (i.e., $p \leq t_N$, where $t_N \equiv \frac{\bar{X}+\lambda-1-\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}}{2\lambda L/k}$ and the subscript N stands for the no-auditor-disclosure regime)

When the company's business risk p is low, the investors will always fund the project if the auditor's report is good, and the manager has no incentive to acquire and disclose any private information. When the auditor observes significant risks ($\theta = Y$), her expected audit liability is $p\,(1-a)\,L$ and her optimal effort level is $a_1 = pL/k$.

- Case two: $\Pr(G|g,\phi)\bar{X} < 1$ (i.e., $p > t_N$)

When the company's business risk p is high, the investors will fund the project only if the auditor's report is good and the manager discloses sufficiently high project cash flow $X \geq X^*_\phi$. When the auditor observes significant risks ($\theta = Y$), her expected audit liability is $\Pr(X \geq X^*_\phi)\hat{e}_\phi p\,(1-a)\,L$. Hence, the auditor's effort is $a_{\phi 2} = \Pr(X \geq X^*_\phi)\hat{e}_\phi pL/k$, where the subscript ϕ stands for the no-auditor-disclosure regime. Since the audit efforts under both regimes are determined in a similar way, our results in Corollary 2 remain the same under the no-auditor-disclosure regime. That is, audit effort does not always increase with business risk due to the endogenous manager's disclosure and investors' funding decisions. Moreover, the audit effort and the manager's information acquisition efforts are complements.

3.2.3 Manager's disclosure and information acquisition decision

In Case two ($p > t_N$), the manager is compelled to acquire and disclose information to secure investment if the auditor's report is good. In other words, even when there is no significant risk, and the auditor's report is accurate, the manager still needs to disclose sufficiently high project cash flow to attract investments. This necessity arises because investors do not have knowledge about the presence or absence of significant risks without the auditor's disclosure, and they require additional information to compensate for the high business risk. The manager will disclose only if $\Pr(G|g,\phi)X \geq 1$. Hence, there exists a threshold, denoted by X^*_ϕ where X^*_ϕ solves $\Pr(G|g,\phi)X^*_\phi = 1$, such that the investors will fund the project only if the manager discloses X is higher than the threshold X^*_ϕ.

The manager chooses information acquisition effort to maximize:

$$E[U_M] = \beta \cdot e \Pr(X \geq X^*_\phi) - \frac{1}{2}ce^2.$$

Thus, the manager's information acquisition decision is

$$e_\phi = \Pr(X \geq X^*_\phi)\beta/c,$$

where the subscript ϕ stands for the no-auditor-disclosure regime. By anticipating the manager's information acquisition decision e_ϕ, the auditor chooses her effort in Case two as

$$a_{\phi 2} = \frac{pL\beta}{kc}[\Pr(X \geq X^*_\phi)]^2.$$

Finally, we substitute $a_{\phi 2}$ to $\Pr(G|g,\phi)X^*_\phi = 1$ and solve for X^*_ϕ. Under the no-auditor-disclosure regime, the manager's information acquisition and disclosure strategy differs from that in the disclosure regime. In Case two, without the auditor's disclosure, investors need to rely on the manager's disclosure to make their investment decisions, and the manager is compelled to disclose information regardless of the presence or absence of significant risks. Even if there is no significant

risk, the manager must disclose a high potential cash flow to obtain investment. In contrast, under the auditor disclosure regime, the manager faces disclosure pressure only when the auditor reveals significant risks.

3.2.4 Equilibrium

We summarize the equilibrium under the no-auditor-disclosure regime in the following proposition:

Proposition 2. *Under the no-auditor-disclosure regime,*

- *when the business risk is low ($p \leq t_N$), investors fund the project if $r = g$, and forgo the project, otherwise. In addition to standard effort, the auditor exerts additional effort $a_1 = pL/k$ when she observes significant risks ($\theta = Y$), and the manager does not acquire any information and has no information to disclose;*

- *when the business risk is high ($p > t_N$), investors fund the project if $r = g$ and the manager discloses $X \geq X^*_\phi$, and forgo the project, otherwise. The auditor's additional effort is $a_{\phi 2} = \frac{pL\beta}{kc}[\Pr(X \geq X^*_\phi)]^2$ when she observes significant risks ($\theta = Y$). The manager's information acquisition decision is $e_\phi = \Pr(X \geq X^*_\phi)\beta/c$, and if the manager observes $X \geq X^*_\phi$, he will disclose it.*

Although under both regimes, there are two different cases, the thresholds (t_D and t_N) are different. Under the auditor disclosure regime, when significant risks are disclosed ($\theta = Y$), the audit report contains Type II errors and the project can fail even if the audit report is good. As a result, investors are more reluctant to invest, all else being equal, and thus, the threshold t_D is lower than t_N. That is, the condition of Case one ($p \leq t_D$) is more stringent due to the possibility of project failure when significant risks are disclosed. Under the no-auditor-disclosure regime, there is a chance that the company has no significant risk and the auditor's report correctly reflects the financial state. Hence, a good audit report under the no-disclosure regime is more accurate than a good audit report combined with significant risk disclosure under the disclosure regime

($\Pr(G|g,\phi) > \Pr(G|g,Y)$). The condition of Case one ($p \leq t_N$) is less stringent under the no-disclosure regime due to the possibility of no significant risk. We summarize our findings about t_D and t_N in the following corollary.

Corollary 3. *About the two thresholds t_D and t_N, we have*

(i) t_D is always lower than t_N ($t_D < t_N$);

(ii) both t_D and t_N increase with L/k;

(iii) t_N decreases in λ, t_D is independent of λ, and thus, $t_N - t_D$ decreases in λ and converges to zero as λ approaches 1;

(iv) t_N approaches 1 when λ approaches 0.

Part (ii) of Corollary 3 indicates that the thresholds increase with auditor liability L and decrease with the marginal audit cost k. A higher L/k motivates the auditor to work harder, resulting in a more accurate audit report under both regimes. As a result, investors are more willing to fund the project upon a good audit report, which indicates it is easier to achieve Case one under both regimes.

Turning to part (iii) and part (iv) of Corollary 3, as discussed above, the threshold t_N is higher than t_D due to the chance that the company has no significant risk and the auditor's report is accurate under the no-disclosure regime. When the probability of no significant risk is lower (λ is higher), it is harder to achieve Case one under the no-disclosure regime, resulting in a lower threshold t_N. That is, the threshold t_N decreases in λ. In the extreme case, when the probability of significant risk λ approaches 1, it is certain that there always exists significant risk, and the threshold t_N converges to t_D. On the other hand, when λ is very low, it is very likely that the company has no significant risk and the auditor's report is very accurate. The threshold t_N approaches 1, which indicates that Case one is always achieved under the no-disclosure regime ($p < t_N$ is always true when λ is sufficiently low).

3.2.5 Investment efficiency

Under the no-auditor-disclosure regime, investors do not observe the presence or absence of significant risks θ and so the investment decision is not contingent on θ. Instead, it is based on the auditor's report and the manager's disclosure. When the business risk is low (Case one: $p \leq t_N$), the investor funds the project if the audit report is good $r = g$, and the expected net project return is

$$\Pi^N (p \leq t_N) = (1-p)\left(\bar{X} - 1\right) - \lambda p(1-a_1), \tag{5}$$

where the superscript N stands for the no-auditor-disclosure regime. The investment efficiency in Case one under the no-auditor-disclosure regime in (5) is the same as that in Case one under the auditor disclosure regime in (3), because the investment decision is not based on auditor's disclosure about significant risks and investors fund the project once the audit report is good.

When the business risk is high (Case two: $p > t_N$), investors fund the project only if both the audit report is good $r = g$ and the manager discloses favorable information $X \geq X^*_\phi$. In this case, the expected net project return is

$$\Pi^N (p > t_N) = e_\phi \Pr(X \geq X^*_\phi)[(1-p)\left(E[X|X \geq X^*_\phi] - 1\right) - \lambda p(1-a_{\phi 2})]. \tag{6}$$

Recall that under the auditor disclosure regime, the manager only needs to acquire information when significant risks are disclosed. In contrast, under the no-disclosure regime, the manager needs to acquire information regardless of whether significant risks exist. The investment efficiency in Case two under the no-disclosure regime in (6) is quite different from that in Case two under the disclosure regime in (4). Since investors fund the project only if the manager discloses $X \geq X^*_\phi$ (with probability $e_\phi \Pr(X \geq X^*_\phi)$), a large chance of under-investment occurs if the manager fails to acquire the related information. Compared with the disclosure regime, under-investment is more severe in the no-disclosure regime because the investment decision is based upon the manager's disclosure even when there do not exist significant risks. Meanwhile, if the manager discloses

$X \geq X_\phi^*$ and the project gets funded, over-investment is still likely to occur due to the Type II error in the good audit report when there exist significant risks.

4 Impact of auditor disclosure

To study the impact of auditor disclosure, we need to compare the equilibria between the two regimes. As in Corollaries 3, the threshold under the auditor disclosure regime is lower than that under the no-auditor-disclosure regime ($t_D < t_N$). We summarize the comparison of equilibria under each regime in the following table.

Insert Table 1 here

In Scenario I ($p \leq t_D$), the business risk is low and Case one is true under both regimes. The investors fund the project if the audit report is good $r = g$ regardless of the auditor disclosure. In Scenario II ($t_D < p \leq t_N$), the business risk is intermediate. Case two is true under the auditor disclosure regime and Case one is true under the no-auditor-disclosure regime. Under the auditor disclosure regime, with the presence of significant risks $\theta = Y$, investors fund the project only if the audit report is good and the manager's disclosure is favorable. Under the no-auditor-disclosure regime, investors fund the project if the audit report is good and no manager's disclosure is required. In Scenario III ($p > t_N$), the business risk is high and investors are more cautious in their investment decisions. Case two is true under both regimes and investors fund the project if the audit report is good $r = g$ and the manager discloses high potential cash flow ($X \geq X^*$ under the auditor disclosure regime; $X \geq X_\phi^*$ under the no-auditor-disclosure regime), or if the audit report is good $r = g$ and the auditor discloses the absence of significant risks under the auditor disclosure regime.

4.1 Impact of auditor disclosure on manager disclosure

We demonstrate that the manager's disclosure strategy may be influenced by the auditor's disclosure, and its impact varies with the business risk level. In Scenario I, the business risk is low and the manager does not need to disclose in either regime because investors are willing to invest

based on a good audit report without the manager's disclosure. Hence, the auditor's disclosure has no impact on manager disclosure.

In Scenario III, when the business risk is high, manager disclosure and auditor disclosure are substitutes since investors are very cautious in providing the funding. Under the no-disclosure regime, the manager is pressured to disclose favorable information regardless of the existence of significant risks, since investors must rely on the manager's disclosure to invest due to the high risk of business failure. Under the disclosure regime, the manager only needs to disclose when the auditor discloses the presence of significant risks. Hence, manager disclosure is more important without auditor disclosure, which implies the two disclosures are substitutes.

In Scenario II, when the business risk is in the intermediate range, manager disclosure and auditor disclosure are complements. Under the disclosure regime, when the auditor reveals the existence of significant risks, the manager is compelled to disclose to secure project funding, since investors will fund the project only if the auditor's report is good and the manager discloses a high project cash flow. But under the no-auditor-disclosure regime, investors will always fund the project when the auditor's report is good, relieving the manager of disclosure pressure. That is, the manager never discloses under the no-auditor-disclosure regime, but has incentive to disclose under the auditor disclosure regime when the auditor discloses the presence of significant risks, which implies the two disclosures are complementary.

Lemma 1. *When the business risk is low, auditor disclosure has no impact on manager disclosure; when the business risk is high, the manager discloses less under the auditor disclosure regime than under the no-auditor-disclosure regime (i.e., substitutes); when the business risk is intermediate, the manager discloses more under the auditor disclosure regime than under the no-auditor-disclosure regime (i.e., complements).*

4.2 Additional audit effort comparison

Recall the auditor exerts standard effort when there is no significant risk and takes on additional effort when she observes significant risks in the audit. The additional audit effort represents

the accuracy of audit report in the presence of significant risks since it captures the probability that the auditor detects accounting misstatements. A higher audit effort implies a higher likelihood of good financial state given a good audit report, which may improve the investment efficiency. Since the auditor's disclosure regime affects manager's voluntary disclosure strategy, which influences investment and auditor's expected liability, the endogenous manager disclosure would, in turn, affect the additional audit effort.

In Scenario I, audit effort is the same under both regimes since the same Case is achieved. However, in Scenario II, when the business risk is intermediate ($t_D < p \leq t_N$), the additional audit effort is higher under the no-auditor-disclosure regime than that under the auditor disclosure regime (i.e., $a_1 > a_2$ given the same p). The reason is that under the no-auditor-disclosure regime investors always fund the project upon receiving a good audit report, even if the manager does not disclose, and thus, the auditor has more incentives to exert effort by anticipating a higher likelihood of investment and a higher expected liability payment. In contrast, under the auditor disclosure regime, investors do not fund the project without the manager's favorable disclosure if significant risks are disclosed. Anticipating a lower expected liability due to the reduced likelihood of investment, the auditor has less incentive to exert effort. When the business risk is high ($p > t_N$), both regimes fall into Case two and the manager has to disclose high potential cash flow to get funding. Under the no-disclosure regime, due to the chance of no significant risk, a good audit report is more accurate than that combined with significant risk disclosure under the disclosure regime ($\Pr(G|g, \phi) > \Pr(G|g, Y)$). As a result, the manager's disclosure threshold is lower ($X^*_\phi < X^*$) and the likelihood of investment is higher under the no-disclosure regime. That is, the auditor has more incentives to exert effort by anticipating a higher likelihood of investment and so the audit effort is also higher under the no-auditor-disclosure regime, i.e., $a_{\phi 2} > a_2$.

We summarize our findings on audit effort in the following proposition:

Proposition 3. *When the business risk is low ($p \leq t_D$), the additional audit effort is the same under the two regimes. When the business risk is not low ($p > t_D$), the additional audit effort is higher under the no-auditor-disclosure regime.*

Though the additional audit effort a is a crucial indicator of information quality, it does not capture the overall information quality. Next, we analyze the impact of auditor disclosure on investment efficiency, which incorporates all information content from the audit report, the auditor's disclosure, and the manager's disclosure, thereby may capture the overall information quality of all public available information.

4.3 Investment efficiency

In our setting, we identify two types of risks: business risk p is the risk of project failure (which has adverse effect under both regimes) and significant risk is the risk of inaccurate audit opinion (which has more adverse effect under the no-auditor-disclosure regime because under the auditor disclosure regime, the presence or absence of significant risks is always revealed). The adverse effect of significant risk could be related to business risk. We find that the impact of disclosing θ on investment efficiency depends on the level of business risk.

In Scenario I ($p \leq t_D$), the business risk is low and investors always fund the project if the audit report is good $r = g$ regardless of the auditor's disclosure. Since the investment decision is not based on the auditor's disclosure, the investment efficiency is the same under the two regimes.

In Scenario II ($t_D < p \leq t_N$), the business risk is intermediate and the investment efficiency is the same under the two regimes when no significant risk exists ($\theta = N$). Under the auditor-disclosure regime, if the auditor discloses there is no significant risk, investors will fund the project upon receiving a good audit report. Similarly, under the no-auditor-disclosure regime, investors always fund the project if the audit report is good. Thus the most efficient investment decision is achieved under both regimes when no significant risk exists.

However, when there exist significant risks ($\theta = Y$), under the auditor-disclosure regime investors fund the project only if the audit report is good and the manager's disclosure is favorable, while under the no-auditor-disclosure regime investors still always fund the project if the audit report is good and no manager's disclosure is required. The investment efficiency of the two regimes varies because the information available to investors differs.

Comparing the investment efficiency between the two regimes in (4) and (5), we have

$$\begin{aligned} & \Pi^N\left(p<t_N\right)-\Pi^D\left(p>t_D\right) \qquad (7) \\ = \; & \lambda\{\underbrace{(1-p)\left[(1-e)\Pr(X\geq X^*)\left(E[X|X\geq X^*]-1\right)+\Pr(X<X^*)\left(E[X|X<X^*]-1\right)\right]}_{\text{Reducing under-investment loss}} \\ & \underbrace{-p\left[(1-a_1)-e\Pr(X\geq X^*)(1-a_2)\right]}_{\text{Increasing over-investment loss}}\}. \end{aligned}$$

Under-investment loss occurs only under the auditor disclosure regime. Under the no-auditor-disclosure regime, investors generously fund all projects that receive good audit reports, which eliminates the occurrence of under-investment. Under the disclosure regime, when the auditor reveals the existence of significant risks, the manager's favorable disclosure is required for project funding, in addition to a good auditor report. Under-investment occurs when a good-state project with high cash flow is not disclosed by the manager due to information acquisition failure. The second line in (7) represents the gain of the no-disclosure regime from reducing under-investment loss.

Over-investment loss, however, happens under both regimes. Under the no-disclosure regime, no manager disclosure is required for project funding and over-investment arises when the auditor fails to detect a bad-state project (with probability $\lambda p\left(1-a_1\right)$). Under the disclosure regime, investors' decision hinges on both the auditor's report and the manager's disclosure. Over-investment happens when the auditor fails to detect a bad state and the manager discloses high potential cash flow (with probability $\lambda pe\Pr(X\geq X^*)\left(1-a_2\right)$). Though audit effort is higher under the no-disclosure regime (Proposition (3)), over-investment loss could be lower under the disclosure regime because there is a chance that the project is not funded due to the absence of manager disclosure. Therefore, the sign of the bottom line in (7) is not certain.

The comparison of investment efficiency in Scenario II is determined by the trade-off between over-investment and under-investment losses. One advantage of the no-disclosure regime is the absence of under-investment losses. However, one possible disadvantage is more over-investment

loss. Specifically, since over-investment loss is closely tied to audit effort, we find that when the audit effort incentive is high (L/k is high), the audit effort under the no-disclosure regime is much higher than that under the disclosure regime, leading to a significant reduction in over-investment losses. Consequently, the investment efficiency is higher under the no-disclosure regime.

In Scenario III, both regimes fall into Case two. Investors are cautious and fund the project based on manager's favorable disclosure, which results in under-investment. However, if the auditor discloses no significant risks, investors infer that the audit report is accurate, and fund the project upon receiving a good audit report, which eliminates the under-investment loss. The auditor disclosure regime outperforms the no-auditor-disclosure regime because the auditor's disclosure helps investors identify the quality of audit report and more efficient investment is induced when the auditor discloses no significant risks. Our result in this scenario is consistent with conventional wisdom that the auditor's disclosure reveals useful information about significant risk and investors are able to make more efficient decisions thanks to the informative auditor's disclosure.

We summarize our results on investment efficiency in the following proposition.

Proposition 4. *(i) When the business risk is low ($p \leq t_D$), the investment efficiency is the same under either regime.*

(ii) When the business risk is intermediate ($t_D < p \leq t_N$)), the investment efficiency is higher under the no-auditor-disclosure regime when L/k is high, and otherwise, the investment efficiency is higher under the auditor disclosure regime.

(iii) When the business risk is high ($p > t_N$), investment efficiency is higher under the auditor disclosure regime.

Our results show that the investment efficiency comparisons of the two regimes are related to both the business risk p and audit incentive L/k. When the business risk is low, investors do not worry about project failure and fund the project if the audit report is good regardless of the auditor's risk disclosure. Hence, the two regimes have no differential impact on investment efficiency. When the business risk is high, investors are more concerned about project failure and the auditor's clean opinion is not sufficient to ensure a positive return. Under the disclosure regime,

the risk of project failure is alleviated by the informative auditor disclosure. Companies without significant risks can be identified, and investors can avoid missing the opportunity to fund profitable projects. Hence, investment efficiency is always higher under the disclosure regime.

When the business risk is intermediate, the comparison of investment efficiency becomes subtle. Firstly, the business risk is not too high and investors are still willing to fund the project without manager's favorable disclosure under the no-disclosure regime, which avoids under-investment but may result in over-investment. Secondly, the business risk is not too low either and the investors still require manager's favorable disclosure if significant risks are revealed under the disclosure regime, which results in under-investment. When both under- and over-investments occur, the audit incentive (L/k) plays an important role in improving efficiency. Since the endogenous manager disclosure affects audit incentive, the audit effort is higher under the no-disclosure regime in Scenario II as shown in Proposition 3. When L/k is high, the over-investment is greatly mitigated by high audit effort, and the investment efficiency is higher under the no-disclosure regime than under the disclosure regime.

Our analysis highlights that the impact of auditor's disclosure is twofold: on the one hand, auditor's disclosure directly affects investment efficiency by conveying information on significant risks. On the other hand, auditor disclosure also has impact on endogenous management disclosure, which, in turn, affects audit effort decision and investment efficiency.

Figure 4 illustrates how the comparison of investment efficiency under the two regimes varies with the business risk p and audit incentive L/k. The left area represents Scenario I when the business risk p is low and investment efficiency is the same under the two regimes. The right area represents Scenario III when the business risk p is high and investment efficiency is higher under the auditor disclosure regime. In the middle area, when the business risk p is intermediate (Scenario II), the investment efficiency is higher under the no-auditor-disclosure regime when L/k is high (upper middle area), and the investment efficiency is higher under the auditor disclosure regime if L/k is low (lower middle area).

Insert Figure 4 here

4.4 Empirical implications

Our analytical results provide relevant empirical implications. Lemma 1 suggests that managers may disclose more or less under the auditor-disclosure regimes, depending on the company's business risk. That is, the relation between management voluntary disclosure and auditor disclosure is influenced by business risk. Proposition 3 implies that audit quality may be lower under the auditor-disclosure regime compared to the no-auditor-disclosure regime if the business risk is high. Moreover, Proposition 4 predicts that the impact of auditor disclosure on investment efficiency is nuanced and varies with business risk. We expect investment efficiency to improve with auditor disclosure if the company's business risk is high, or if the business risk is intermediate and auditors' incentive to work is low; Conversely, investment efficiency may decrease if the business risk is intermediate and auditors' incentive to work is high. If the business risk is low, investment efficiency remains the same under both regimes.

5 Conclusion

As expanded audit reports are mandated by standard setters in numerous jurisdictions, auditors are required to disclose more information about their clients' significant matters in financial reporting. Such disclosures can alter market perceptions, which may, in turn, influence management voluntary disclosure. This paper delves into the dynamics between auditor disclosure and management voluntary disclosure, as well as their collective impacts on audit effort decision and investment efficiency. We show that auditor disclosure may encourage or discourage manager's voluntary disclosure depending on the company's business risk. Given the interaction between auditor disclosure and manager's voluntary disclosure, they collectively affect audit effort decision. We find that auditor disclosure can reduce audit effort through the endogenous manager's disclosure when the business risk is not low. Furthermore, we analyze the efficiency implications of the auditor disclosure regime and find that the impact of auditor disclosure on investment efficiency is related to both business risk and auditor's effort incentive. When the business risk is low, auditor disclosure has no impact on investment efficiency. However, when the business risk is high, auditor

disclosure enhances investment efficiency since the risk of project failure is alleviated by the informative auditor disclosure, which confirms the conventional wisdom that informative disclosure enhances efficiency. When the business risk is intermediate, investment efficiency is higher under the no-auditor-disclosure regime if the auditor's incentive to work hard is high. Our research contributes to the understanding of the impact of auditor disclosure on management disclosures and sheds light on their collective real effect on investment efficiency.

Appendix A - Proofs

Proof of Proposition 1

Under the disclosure regime, Case one exists when $\Pr(G|g,Y,a_1)\bar{X} > 1$, and Case two exists when $\Pr(G|g,Y,a_2)\bar{X} < 1$. Since $a_1 > a_2$, we have that $\Pr(G|g,Y,a_1) = \frac{1-p}{1-p+p(1-a_1)} > \Pr(G|g,Y,a_2) = \frac{1-p}{1-p+p(1-a_2)}$. That is, if $\Pr(G|g,Y,a_1)\bar{X} > 1 > \Pr(G|g,Y,a_2)\bar{X}$, there may exist two equilibria. In our analysis, we focus on the Pareto-dominant equilibrium. In particular in Case one, the expected net project return is

$$\Pi^D = \lambda[(1-p)\left(\bar{X}-1\right) - p(1-a_1)] + (1-\lambda)(1-p)(\bar{X}-1),$$

and in Case two, the expected net project return is

$$\Pi^D = \lambda e \Pr(X \geq X^*)[(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)] + (1-\lambda)(1-p)[\bar{X}-1].$$

It is clear that the expected net project return is higher in Case one when c is high since $a_1 > a_2$ and $e\Pr(X \geq X^*) < 1$ is very low. Applying Pareto dominance criterion for equilibria refinement, we identify that investors will always fund the project once the auditor's report is good when

$$\Pr(G|g,Y,a_1)\bar{X} > 1.$$

Substituting $\Pr(G|g,Y,a_1) = \frac{1-p}{1-p+p(1-a_1)}$, where $a_1 = pL/k$ into the above condition of Case one, we have

$$p < t_D \equiv \frac{\bar{X} - \sqrt{\bar{X}^2 - 4L(\bar{X}-1)/k}}{2L/k}. \tag{8}$$

Additionally, if $\Pr(G|g,Y,a_1)\bar{X} < 1$(i.e., $p > t_D$), then $\Pr(G|g,Y,a_2)\bar{X} < 1$, since $\Pr(G|g,Y,a_1) > \Pr(G|g,Y,a_2)\bar{X}$. Therefore, if $p > t_D$, a favorable disclosure about X is required to get the funding. That is, when the business risk is high, investors fund the project if $r = g$ and the manager

discloses $X \geq X^*$, where X^* solves $\Pr(G|g, Y, a_2)X^* = 1$, where $\Pr(G|g, Y, a_2) = \frac{1-p}{1-p+p(1-a_2)}$ and $a_2 = \frac{pL\beta}{kc}[\Pr(X \geq X^*)]^2$. Therefore, the disclosure threshold X^* solves

$$(1-p)X^* = 1 - \frac{p^2 L\beta}{kc}[1 - F(X^*)]^2.$$

Define $Q(X) \equiv (1-p)X - 1 + \frac{p^2 L\beta}{kc}[1 - F(X)]^2$, and we have $Q(X^*) = 0$ is true in equilibrium. In particular, we have

$$\frac{\partial Q(\cdot)}{\partial X} = 1 - p - \frac{2p^2 L\beta}{kc}[1 - F(X)]f(X) > 0,$$

if $c > \frac{2p^2 L\beta}{k(1-p)}[1 - F(X)]f(X)$ for any $X \in [X_l, X_h]$. That is, when c is high enough, $Q(X)$ monotonically increases in X, and so there is only one root of X^* such that $Q(X^*) = 0$.

□

Proof of Corollary 1

By the implicit function theorem, we have

$$\frac{dX^*}{dp} = -\frac{\frac{\partial Q(\cdot)}{\partial p}}{\frac{\partial Q(\cdot)}{\partial X^*}} = \frac{X^* - \frac{2pL\beta}{kc}[1 - F(X^*)]^2}{1 - p - \frac{2p^2 L\beta}{kc}[1 - F(X^*)]f(X^*)} > 0,$$

when c is high. In particular, we have

$$\frac{\partial Q(\cdot)}{\partial X} = 1 - p - \frac{2p^2 L\beta}{kc}[1 - F(X)]f(X) > 0,$$

if $c > \frac{2p^2 L\beta}{k(1-p)}[1 - F(X)]f(X)$ for any $X \in [X_l, X_h]$. To find the sufficient condition of $X^* - \frac{2pL\beta}{kc}[1 - F(X^*)]^2 > 0$, we have

$$X^* - \frac{2pL\beta}{kc}[1 - F(X^*)]^2 = \frac{1 + pa_2 - 2a_2}{1 - p} > 0$$

which is equivalent with $(2-p)\frac{\beta}{c}[\Pr(X \geq X^*)]^2 < 1$. Since $\Pr(X \geq X^*) < 1$, the sufficient condition is $c > (2-p)\beta$. That is, X^* increases in p if $c > \max(\frac{2p^2L\beta}{kc(1-p)}[1-F(X)]f(X), (2-p)\beta)$. Since $F'(X) > 0$ and $\Pr(X \geq X^*) = 1-F(X^*)$, we have $\Pr(X \geq X^*)$ decreases in p if c is high. □

Proof of Corollary 2

Corollary 2 part (i) and (ii) are directly derived from the analysis in the text.

For part (iii), we rewrite a_2 as $a_2 = \frac{pL\beta}{kc}[\Pr(X \geq X^*)]^2 = \frac{pL\beta}{kc}[1-F(X^*)]^2$, then we have

$$\begin{aligned}\frac{da_2}{dp} &= \frac{L\beta}{kc}[1-F(X^*)]^2 - 2\frac{pL\beta}{kc}[1-F(X^*)]f(X^*)\cdot\frac{dX^*}{dp} \\ &= \frac{L\beta}{kc}[1-F(X^*)][1-F(X^*) - 2pf(X^*)\cdot\frac{dX^*}{dp}] < 0\end{aligned}$$

When p is high enough, the threshold X^* approaches X_h, and $1-F(X^*)$ becomes a small positive number and approaches zero. Since $\frac{dX^*}{dp} > 0$ when c is high, then we have $\frac{da_2}{dp} < 0$ when c is high and p is high. □

Proof of Proposition 2

Similarly, under no disclosure regime, Case one exists when $\Pr(G|g,\phi,a_1)\bar{X} > 1$, and Case two exists when $\Pr(G|g,\phi,a_{\phi 2})\bar{X} < 1$. Since $a_1 > a_{\phi 2}$, we have that $\Pr(G|g,\phi,a_1) = \frac{1-p}{1-p+\lambda p(1-a_1)} > \Pr(G|g,\phi,a_{\phi 2}) = \frac{1-p}{1-p+\lambda p(1-a_{\phi 2})}$. That is, if $\Pr(G|g,\phi,a_1)\bar{X} > 1 > \Pr(G|g,\phi,a_{\phi 2})\bar{X}$, there may exist two equilibria. In our analysis, we focus on the Pareto-dominant equilibrium. In particular in Case one, the expected net project return is

$$\Pi^N = \lambda[(1-p)\left(\bar{X}-1\right) - p(1-a_1)] + (1-\lambda)(1-p)(\bar{X}-1),$$

and in Case two, the expected net project return is

$$\Pi^N = e_\phi \Pr(X \geq X^*_\phi)[(1-p)(E[X|X \geq X^*_\phi] - 1) - \lambda p(1-a_{\phi 2})].$$

It is obvious that the expected net project return is higher in Case one. The sufficient condition of higher expected return in Case one is $\bar{X} - 1 > e_\phi \Pr(X \geq X^*_\phi)(E[X|X \geq X^*_\phi] - 1)$. This is equivalent with $\bar{X} - 1 > [\Pr(X \geq X^*_\phi)]^2(E[X|X \geq X^*_\phi] - 1)\beta/c$, which is true if c is high.

Applying Pareto dominance criterion for equilibria refinement, we identify that investors will always fund the project once the auditor's report is good when

$$\Pr(G|g, \phi, a_1)\bar{X} > 1.$$

Substituting $\Pr(G|g, \phi, a_1) = \frac{1-p}{1-p+\lambda p(1-a_1)}$ into the above condition, we have that condition of Case one is

$$p < t_N \equiv \frac{\bar{X} + \lambda - 1 - \sqrt{(\bar{X} + \lambda - 1)^2 - 4\lambda L(\bar{X} - 1)/k}}{2\lambda L/k} \tag{9}$$

where $t_N > t_D$.

If the above condition is not met ($p > t_N$), a favorable disclosure about X is required to get the funding. That is, when the business risk is high, investors fund the project if $r = g$ and the manager discloses $X \geq X^*_\phi$. Substituting $a_{\phi 2} = \frac{pL\beta}{kc}[\Pr(X \geq X^*_\phi)]^2$ to $\Pr(G|g, \phi)X^*_\phi = 1 \Leftrightarrow \frac{1-p}{1-p+\lambda p(1-a_{\phi 2})}X^*_\phi = 1$ yields X^*_ϕ.

□

Proof of Corollary 3

First we show part (ii) that both t_D and t_N increases in L/k. From (8), we take derivative of t_D with respect to L/k and have

$$\frac{\partial t_D}{\partial (L/k)} = \frac{\frac{4L(\bar{X}-1)/k}{\sqrt{\bar{X}^2 - 4L(\bar{X}-1)/k}} - 2\left[\bar{X} - \sqrt{\bar{X}^2 - 4L\left(\bar{X} - 1\right)/k}\right]}{(2L/k)^2}.$$

Then $\frac{\partial t_D}{\partial (L/k)}$ is positive when

$$\frac{2L\left(\bar{X}-1\right)/k}{\sqrt{\bar{X}^2-4L\left(\bar{X}-1\right)/k}} > \bar{X} - \sqrt{\bar{X}^2-4L\left(\bar{X}-1\right)/k},$$

which is

$$\bar{X}^2 - 2L(\bar{X}-1)/k > \bar{X}\sqrt{\bar{X}^2-4L(\bar{X}-1)/k}.$$

It's clear that the above inequality is always true. In similar way, we show t_N also increases in L/k.

We next demonstrate the existence of t_D. The expression $\bar{X}^2-4L\left(\bar{X}-1\right)/k$ is always positive when $L/k < 1$ and $\bar{X} > 1$. Since t_D increases in L/k, the minimum of t_D is achieved when L/k approaches 0. When L/k approaches 0, a_1 approaches 0 and $\Pr(G|g, Y, a_1)$ approaches $1-p$. Case one is achieve when $p < \frac{\bar{X}-1}{\bar{X}}$. In other words, t_D approaches $\frac{\bar{X}-1}{\bar{X}}$ when L/k is sufficiently low. The maximum of $\bar{X}^2 - 4L\left(\bar{X}-1\right)/k$ is achieved when $L/k = 1$. When $L/k = 1$,

$$t_D = \frac{\bar{X} - |\bar{X}-2|}{2} = \min\{\bar{X}-1, 1\}$$

Then, we have $t_D \in (\frac{\bar{X}-1}{\bar{X}}, \min\{\bar{X}-1, 1\})$.

Expressions (8) and (9) show that t_D is independent with λ, and t_N approaches t_D when λ approaches 1. To demonstrate t_N decreases in λ, we calculate

$$\begin{aligned}
\frac{\partial t_N}{\partial \lambda} &= \frac{\left(1 - \frac{2[\bar{X}+\lambda-1]-4L(\bar{X}-1)/k}{2\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}}\right)2\lambda L/k - \left[\bar{X}+\lambda-1-\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}\right]2L/k}{(2\lambda L/k)^2} \\
&= (\bar{X}-1)\frac{[\bar{X}+\lambda-1]-2\lambda L/k-\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}}{\lambda\,(2\lambda L/k)\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}}
\end{aligned}$$

To show $\frac{\partial t_N}{\partial \lambda} < 0$, we need to show

$$[\bar{X}+\lambda-1]-2\lambda L/k-\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k} < 0,$$

which is

$$[\bar{X}+\lambda-1]-2\lambda L/k<\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}.$$

Given that t_N decreases in λ and t_N approaches t_D when λ approaches 1, we have t_D is lower than t_N.

Next, about t_N, we have

$$\begin{aligned} t_N &\equiv \frac{\bar{X}+\lambda-1-\sqrt{[\bar{X}+\lambda-1]^2-4\lambda L(\bar{X}-1)/k}}{2\lambda L/k} \\ &= \frac{\frac{(\bar{X}-1)}{\lambda}+1-\sqrt{[\frac{(\bar{X}-1)}{\lambda}+1]^2-\frac{4L(\bar{X}-1)}{\lambda k}}}{2L/k} \end{aligned}$$

To show that t_N approaches 1 when λ approaches 0, we need to show

$$\frac{(\bar{X}-1)}{\lambda}+1-\sqrt{[\frac{(\bar{X}-1)}{\lambda}+1]^2-\frac{4L(\bar{X}-1)}{\lambda k}}\to 2L/k,$$

which is

$$\frac{(\bar{X}-1)}{\lambda}+1-2L/k\to\sqrt{[\frac{(\bar{X}-1)}{\lambda}+1]^2-\frac{4L(\bar{X}-1)}{\lambda k}},$$

and then, we have

$$-\frac{4L(\bar{X}-1)}{\lambda k}-4L/k+(2L/k)^2\to-\frac{4L(\bar{X}-1)}{\lambda k}.$$

One can see that the above is true when λ approaches 0. Then we have $t_N\in(t_D,1)$. □

Proof of Lemma 1

From Table 1, in Scenarios I, auditor disclosure has no impact on manager disclosure. In Scenario II, the manager never discloses under the no-auditor-disclosure regime, but would disclose

under the auditor disclosure regime when $\theta = Y$, so the manager discloses more under the auditor disclosure regime (i.e., complements). In Scenario Scenarios III, the manager has to disclose under the no-disclosure regime to attract investment. But under the auditor disclosure regime, the manager discloses only if $\theta = Y$. That is, the manager discloses less under the auditor disclosure regime than under the no-auditor-disclosure regime (i.e., substitutes). □

Proof of Proposition 3

The additional audit effort is the same in Case one (a_1) under the two regimes. That is, when the business risk is low ($p \leq t_D$), the audit effort is the same under the two regimes.

When $t_D < p \leq t_N$, Case one is achieved with audit effort a_1 under the no-disclosure regime and Case two is achieved with audit effort a_2 under the disclosure regime. Since $a_1 > a_2$, we have the audit effort is higher under the no-disclosure regime. When $p > t_N$, Case two is achieved under both regime with audit effort a_2 and $a_{\phi 2}$ respectively.

Next, we compare a_2 and $a_{\phi 2}$. From the analysis in the text, we have $\Pr(G|g,\phi) = \frac{1-p}{1-p+p\lambda(1-a_{\phi 2})}$, where $a_{\phi 2} = \frac{pL\beta}{kc}(\Pr[X \geq X^*_\phi])^2$. Substituting $a_{\phi 2}$ into $\Pr(G|g,\phi)$, we have

$$\Pr(G|g,\phi) = \frac{1-p}{1-p+p\lambda(1-\frac{pL\beta}{kc}(\Pr[X \geq X^*_\phi])^2)}.$$

Since X^*_ϕ solves $\Pr(G|g,\phi)X^*_\phi = 1$, we have

$$(1-p)X^*_\phi = 1-p+p\lambda(1-\frac{pL\beta}{kc}[1-F(X^*_\phi)]^2).$$

Define $J(X^*_\phi) \equiv (1-p)X^*_\phi - 1 + p(1-\lambda) + \frac{p^2\lambda L\beta}{kc}[1-F(X^*_\phi)]^2$, and we have $J(X^*_\phi) = 0$ is always true. By the implicit function theorem, we have

$$\frac{dX^*_\phi}{d\lambda} = -\frac{\frac{\partial J(\cdot)}{\partial \lambda}}{\frac{\partial J(\cdot)}{\partial X^*_\phi}} = \frac{p(1-\frac{pL\beta}{kc}[1-F(X^*_\phi)]^2)}{1-p-\frac{2p^2\lambda L\beta}{kc}[1-F(X^*_\phi)]f(X^*_\phi)} > 0,$$

From the proof of Corollary 1, $Q(X)$ monotonically increases in X and so $1-p-\frac{2p^2\lambda L\beta}{kc}[1-$

$F(X_\phi^*)]f(X_\phi^*) > 0$. Since X_ϕ^* increases in λ and X^* is the threshold when λ approaches 1, we have $X^* > X_\phi^*$ and $F(X^*) > F(X_\phi^*)$. Since $a_{\phi 2} = \frac{pL\beta}{kc}[1 - F(X_\phi^*)]^2$ and $a_2 = \frac{pL\beta}{kc}[1 - F(X^*)]^2$, we have $a_{\phi 2} > a_2$. That is, we have the audit effort is higher under the no-disclosure regime. □

Proof of Proposition 4

If p is low $p \leq t_D$, Case one is achieved both regimes and the investment efficiency is the same under the two regimes ($\Pi^D = \Pi^N$). If p is high $p > t_N$, Case two is achieved under both regimes. Under disclosure regime, the expected net project return of Case two is

$$\Pi^D\left(p > t_D\right) = \lambda e \Pr[X \geq X^*][(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)] + (1-\lambda)(1-p)\left(\bar{X} - 1\right).$$

Under no disclosure regime, the expected net project return of Case two is

$$\Pi^N\left(p > t_N\right) = e_\phi \Pr[X \geq X_\phi^*][(1-p)\left(E[X|X \geq X_\phi^*] - 1\right) - \lambda p(1 - a_{\phi 2})]$$

Then we have

$$\begin{aligned}
& \Pi^D\left(p > t_D\right) - \Pi^N\left(p > t_N\right) \\
= \; & (1-\lambda)(1-p)\left(\bar{X} - 1\right) + \lambda e \Pr[X \geq X^*][(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)] \\
-e_\phi \Pr[X \; \geq \; & X_\phi^*][(1-p)\left(E[X|X \geq X_\phi^*] - 1\right) - \lambda p(1 - a_{\phi 2})] \\
> \; & (1-\lambda)(1-p)\left(\bar{X} - 1\right) + \lambda e \Pr[X \geq X^*][(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)] \\
-e_\phi \Pr[X \; \geq \; & X_\phi^*][(1-p)(1-\lambda)\left(E[X|X \geq X_\phi^*] - 1\right) > 0
\end{aligned}$$

Since $\frac{1-p}{1-p+p(1-a_2)}X^* = 1$, we have $(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2) > 0$. Also $\bar{X} - 1$ is higher than $e_\phi \Pr[X \geq X_\phi^*]\left(E[X|X \geq X_\phi^*] - 1\right)$, and then we have the investment efficiency is higher under the disclosure regime ($\Pi^D > \Pi^N$).

The last situation is when p is intermediate $t_D < p \leq t_N$, where Case two is achieved under disclosure regime, but Case one is achieved under no disclosure regime. Under disclosure regime,

the expected net project return of Case two is

$$\Pi^D\left(p > t_D\right) = \lambda e \Pr[X \geq X^*][(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)] + (1-\lambda)(1-p)\left(\bar{X} - 1\right).$$

Under no disclosure regime, the expected net project return of Case one is

$$\Pi^N\left(p \leq t_N\right) = (1-p)\left(\bar{X} - 1\right) - \lambda p(1-a_1).$$

Compare the investment efficiency under two regimes, we have

$$\begin{aligned}
& \Pi^N\left(p \leq t_N\right) - \Pi^D\left(p > t_D\right) \\
= \; & \lambda\{(1-p)\left(\bar{X} - 1\right) - p(1-a_1) - e\Pr[X \geq X^*][(1-p)\left(E[X|X \geq X^*] - 1\right) - p(1-a_2)]\} \\
= \; & \lambda\{\underbrace{(1-p)\left[(1-e)\Pr[X \geq X^*]\left(E[X|X \geq X^*] - 1\right) + \Pr[X < X^*]\left(E[X|X < X^*] - 1\right)\right]}_{\text{decreasing under-investment}} \\
& \underbrace{-p\left[(1-a_1) - e\Pr[X \geq X^*](1-a_2)\right]}_{\text{increasing over-investment}}\},
\end{aligned} \tag{10}$$

where $a_1 = pL/k$, $a_2 = e\Pr[X \geq X^*]a_1$, and $e = \beta\Pr[X \geq X^*]/c$.

First, we show that $\Pi^D > \Pi^N$ is always true when L/k is sufficiently low. Under disclosure regime, the condition of Case one is

$$\Pr(G|g, Y, a_1) \cdot \bar{X} > 1.$$

When L/k is sufficiently low, a_1 approaches zero and $\Pr(G|g, Y, a_1)$ approaches $1-p$. Case one is achieve when $p < \frac{\bar{X}-1}{\bar{X}}$. In other words, $t_D \to \frac{\bar{X}-1}{\bar{X}}$ when L/k is sufficiently low. Substituting $a_1 = 0$ and $a_2 = 0$ in (10), we have

$$\begin{aligned}
& \Pi^N\left(p \leq t_N\right) - \Pi^D\left(p > t_D\right) \\
= \; & \lambda\{(1-p)\left(\bar{X} - 1\right) - p - e\Pr[X \geq X^*][(1-p)\left(E[X|X \geq X^*] - 1\right) - p]\}.
\end{aligned}$$

That is, the condition of $\Pi^N(p \leq t_N) - \Pi^D(p > t_D) > 0$ is

$$p < \frac{\bar{X} - 1 - e\Pr[X \geq X^*](E[X|X \geq X^*] - 1)}{\bar{X} - e\Pr[X \geq X^*]E[X|X \geq X^*]}.$$

Since

$$t_D \to \frac{E(X) - 1}{E(X)} > \frac{\bar{X} - 1 - e\Pr[X \geq X^*](E[X|X \geq X^*] - 1)}{\bar{X} - e\Pr[X \geq X^*]E[X|X \geq X^*]},$$

it is never true that $\Pi^N(p \leq t_N) - \Pi^D(p > t_D) > 0$ when $t_D < p \leq t_N$ and L/k is sufficiently low. Next we show that $\Pi^N > \Pi^D$ when L/k is sufficiently high. Substituting a_1 and a_2 in (10), we have

$$\begin{aligned}&\lambda\{(1-p)\left[(1-e)\Pr[X \geq X^*](E[X|X \geq X^*] - 1) + \Pr[X < X^*](E[X|X < X^*] - 1)\right]\\&-p\left[(1 - pL/k) - e\Pr[X \geq X^*](1 - e\Pr[X \geq X^*]pL/k)\right]\}.\end{aligned}$$

Since (10) increases in both a_1 and a_2, it also monotonically increases in L/k. That is, (10) is positive when L/k is high.

It's clear that $\Pi^N(p \leq t_N) - \Pi^D(p > t_D) > 0$ when

$$L/k > \frac{p(1 - e\Pr[X \geq X^*])}{-(1-p)\left[(1-e)\Pr[X \geq X^*](E[X|X \geq X^*] - 1) + \Pr[X < X^*](E[X|X < X^*] - 1)\right]}{p^2(1 - e\Pr[X \geq X^*])(1 + e\Pr[X \geq X^*])}.$$

□

Appendix B - With Expanded Parameter Space

In our main setting, we assume that the upper bound of the distribution X_h is high enough such that given a good audit report ($r = g$), the project yields positive NPV when the manager discloses a sufficiently high X. In this Appendix, we relax this assumption and assume that there are no constraints on the upper bound X_h. This means that it is possible that investors may choose not to fund the project even if the manager discloses the highest possible value of X, which is X_h. Due to the expanded parameter space, we identify three equilibrium cases under each regime, compared to two cases in the main setting.

Under the auditor disclosure regime, when the auditor discloses that significant risks exist ($\theta = Y$), there are the three cases as follows.

- Case one: $\Pr(G|g, Y)\bar{X} > 1$ (i.e., $p \leq t_D$)

When the company's business risk p is low, investors always fund the project if the auditor's report is good, and the manager has no incentive to acquire and disclose any private information.

- Case two: $\Pr(G|g, Y)\bar{X} < 1 \leq \Pr(G|g, Y)X_h$ (i.e., $t_D < p \leq t_{D2} \equiv 1 - \frac{1}{X_h}$)

When the company's business risk p is moderate, the investors fund the project only if the auditor's report is good and the manager discloses potential cash flow $X \geq X^*$.

- Case three: $\Pr(G|g, Y)X_h < 1$ (i.e., $p > t_{D2}$)

Case three is the new addition compared with the main text.When the company's business risk p is very high, the investors will never provide funding regardless of whether the manager discloses since the investors will not receive sufficient return even with the highest possible cash flow X_h. Thus, the manager has no incentive to acquire information and disclose. The auditor will not exert additional effort either since there is no investment when significant risk is revealed.

Similarly, the three cases under the no-auditor-disclosure regime are as follows.

- Case one: $\Pr(G|g,\phi)\bar{X} > 1$ (i.e., $p < t_N$)

When the company's business risk p is low, the investors will always fund the project if the auditor's report is good, and the manager has no incentive to acquire and disclose any private information.

- Case two: $\Pr(G|g,\phi)\bar{X} < 1 < \Pr(G|g,\phi)X_h$ (i.e., $t_N < p \leq t_{N2} \equiv \frac{X_h - 1}{X_h - 1 + \lambda}$)

When the company's business risk p is moderate, the investors will fund the project only if the auditor's report is good and the manager discloses sufficiently high project cash flow $X \geq X^*_\phi$.

- Case three: $\Pr(G|g,\phi)X_h < 1$ (i.e., $p > t_{N2}$)

Relaxing the parameter restrictions introduces one extreme case: Case three under the no-auditor-disclosure regime, where the business risk is so high that investors never provide funding, irrespective of the audit report or management disclosure.

With the addition of new cases, we identify more scenarios when comparing the two regimes. We summarize the comparison of equilibria under each regime in the following table.

Insert Table 2 here.

In Table 2, we present five different scenarios driven by the different thresholds of three cases under both regimes. In particular, t_N could be higher or lower than t_{D2}. If λ is not very low, we have $t_N < t_{D2}$ and in Scenario III.1 where $t_N < p \leq t_{D2}$, both regimes fall into Case two. Alternatively, in the extreme scenario when λ is very low so that $t_{D2} < t_N$, Case three occurs under the disclosure regime and Case one under the no-disclosure regime given that $t_{D2} < p \leq t_N$.

5.1 Impact of auditor disclosure on manager disclosure

With expanded paramester space our results qualitatively remain the same. We still find that the relationship between manager and auditor disclosure can be either complementary or substitutive, depending on the business risk.

In Case one or Case three, the investment decision is not related to the manager's disclosure. That is, in Scenario I, Scenario V and Scenario III.2 in Table 2, either Case one or Case three is achieved, and the auditor's disclosure does not have any impact on the manager's disclosure. Similar to the main text, in Scenario II, when the business risk is intermediate $t_D < p \leq \min(t_N, t_{D2})$, manager disclosure and auditor disclosure are more like complements. Similar to the main text, in Scenario III.1, when the business risk is relatively high $t_N < p \leq t_{D2}$, manager disclosure and auditor disclosure are substitutes. In Scenario IV, when the business risk is high $\max(t_N, t_{D2}) < p \leq t_{N2}$, manager disclosure and auditor disclosure are also substitutes. In the no-auditor-disclosure regime, the manager is compelled to disclose since investors make the investment decision based on the manager's disclosure. In the auditor-disclosure regime, the manager does not disclose since investors will not provide funding regardless of his disclosure when the presence of significant risks is revealed.

Remark 1. *When the business risk is low or very high ($p \leq t_D$ or $p > t_{N2}$) or when the business risk is intermediate ($t_{D2} < p \leq t_N$) given that the significant risk probability is very low such that $t_{D2} < t_N$, auditor disclosure has no impact on manager disclosure; when the business risk is moderate ($t_D < p \leq \min(t_N, t_{D2})$), the manager discloses more under the auditor disclosure regime than under the no-auditor-disclosure regime (i.e., complements); when the business risk is high ($t_N < p \leq t_{N2}$), the manager discloses less under the auditor disclosure regime than under the no-auditor-disclosure regime (i.e., substitutes).*

5.2 Additional audit effort comparison

Regarding additional audit effort, our results qualitatively remain the same with similar intuition. With expanded parameter space, the only difference is the Case three under the no-auditor-disclosure regime, where the business risk is very high ($p > t_{N2}$) that investors never provide funding, irrespective of the audit report or management disclosure. In this scenario, the additional audit effort is zero under both regimes since no investment will occur.

Remark 2. *When the business risk is low ($p \leq t_D$) or very high ($p > t_{N2}$), the additional audit effort is the same under the two regimes. When the business risk is not very high or very low*

($t_D < p \leq t_{N2}$), the additional audit effort is higher under the no-auditor-disclosure regime.

5.3 Investment efficiency

Our results on investment efficiency also qualitatively remain the same with similar intuition. In Table 2, with expanded parameter space, we have the addition of Scenario III.2, IV and V. We find that in all those additional scenarios, the investment efficiency is higher under the disclosure regime than that under the no-disclosure regime. In Scenario III part 2, Case three is achieved under the disclosure regime and Case one is achieve under the no-disclosure regime. Over-investment loss occurs under the no-disclosure regime due to the absence of information about significant risk. As a result, the auditor disclosure regime still outperforms the no-auditor-disclosure regime. In the same spirit, in both scenarios IV and V, Case three is achieved under the disclosure regime. The auditor's disclosure helps investors identify the risk of audit report, and investors fund the project upon receiving an accurate good audit report when no significant risk is revealed. While under the no-disclosure regime, a severe under-investment loss occurs due to investing only with manager's favorable disclosure (scenario IV) or totally no investment (scenario V). Again, we find that the auditor disclosure regime outperforms the no-auditor-disclosure regime. In other words, consistent with conventional wisdom, the auditor's disclosure reveals useful information about significant risk and investors are able to make more efficient decisions thanks to the informative auditor's disclosure.

Remark 3. *When the business risk is low ($p < t_D$), the investment efficiency is the same under either regime. When the business risk is moderate ($t_D < p < \min(t_N, t_{D2})$), the investment efficiency is higher under the no-auditor-disclosure regime when L/k is high, and otherwise, the investment efficiency is higher under the auditor disclosure regime. When the business risk is higher than moderate ($p > \min(t_N, t_{D2})$), investment efficiency is higher under the auditor disclosure regime.*

Proof:

In Scenario V $p > t_{N2}$, Case three is achieved under both regimes and the investment efficiency is always higher under the disclosure regime ($\Pi^D > \Pi^N$).

In Scenario IV, if $\max(t_N, t_{D2}) < p < t_{N2}$, Case two is achieved under no disclosure regime

and Case three is achieved under disclosure regime. Under disclosure regime, the expected net project return of Case three is

$$\Pi^D\left(p > t_{D2}\right) = (1-\lambda)(1-p)\left(\bar{X}-1\right).$$

Under no disclosure regime, the expected net project return of Case two is

$$\begin{aligned}\Pi^N\left(t_N < p \leq t_{N2}\right) &= e_\phi \Pr[X \geq X_\phi^*][(1-p)\left(E[X|X \geq X_\phi^*]-1\right) - \lambda p(1-a_{\phi 2})] \\ &= e_\phi \Pr[X \geq X_\phi^*][(1-p)(1-\lambda)\left(E[X|X \geq X_\phi^*]-1\right) \\ &\quad + \underbrace{(1-p)\lambda\left(E[X|X \geq X_\phi^*]-1\right) - \lambda p(1-a_{\phi 2})}_{<0}].\end{aligned}$$

Since $p > t_{D2}$, we have $\frac{1-p}{1-p+p(1-a_2)}X^* < 1$ is true for any $X^* \in [X_l, X_h]$, where $a_2 = \frac{pL\beta}{kc}(\Pr[X \geq X^*])^2$. That is, $(1-p)\left(E[X|X \geq X^*]-1\right) - p[1 - \frac{pL\beta}{kc}(\Pr[X \geq X^*])^2]$ is negative for any $X^* \in [X_l, X_h]$. Since $a_{\phi 2} = \frac{pL\beta}{kc}(\Pr[X \geq X_\phi^*])^2$ and $X_\phi^* \in [X_l, X_h]$, we have $(1-p)\left(E[X|X \geq X_\phi^*]-1\right) - p(1-a_{\phi 2})$ is negative. Also $\bar{X}-1$ is higher than $e_\phi \Pr[X \geq X_\phi^*]\left(E[X|X \geq X_\phi^*]-1\right)$, and then we have the investment efficiency is higher under the disclosure regime ($\Pi^D > \Pi^N$).

In Scenario III.2 $t_{D2} < p < t_N$, Case three is achieved under disclosure regime, but Case one is achieved under no disclosure regime. Under disclosure regime, the expected net project return of Case three is

$$\Pi^D\left(p > t_{D2}\right) = (1-\lambda)(1-p)\left(\bar{X}-1\right).$$

Under no disclosure regime, the expected net project return of Case one is

$$\Pi^N\left(p < t_N\right) = (1-p)\left(\bar{X}-1\right) - \lambda p(1-a_1)$$

Then we have

$$\Pi^D\left(p > t_{D2}\right) - \Pi^N\left(p < t_N\right) = \lambda[p(1-a_1) - (1-p)\left(\bar{X}-1\right)] > 0.$$

Since $p > t_{D2} > t_D$, we have $\Pr(G|g, Y) \cdot \bar{X} > 1$ which $\frac{1-p}{1-p+p(1-a_1)}\bar{X} < 1$ and so $(1-p)\left(\bar{X}-1\right) < p(1-a_1)$. Then we have the investment efficiency is higher under the disclosure regime ($\Pi^D > \Pi^N$).

The proofs of other scenarios are the same as the proofs of main text results provided in Appendix A.

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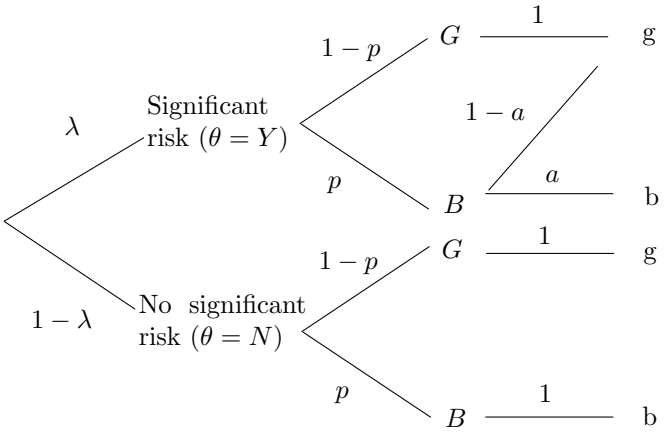

Figure 1: Information structure of audit report

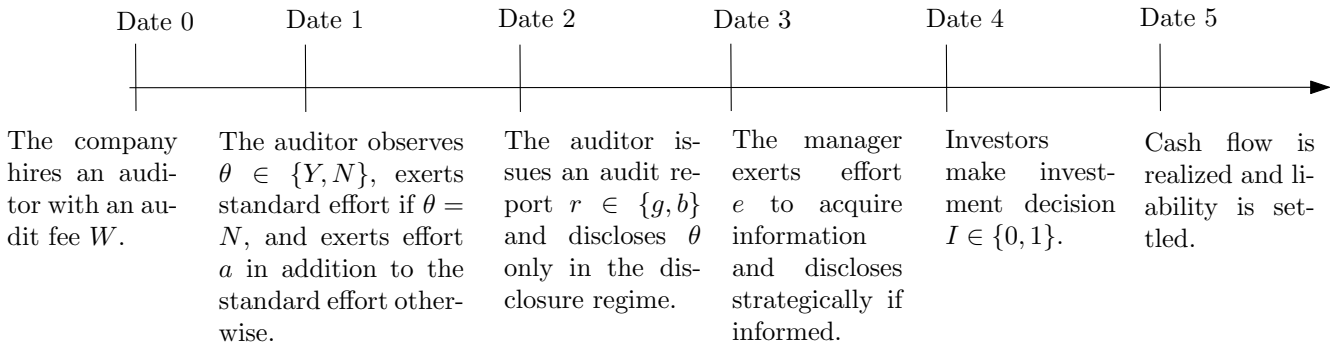

Figure 2: Timeline

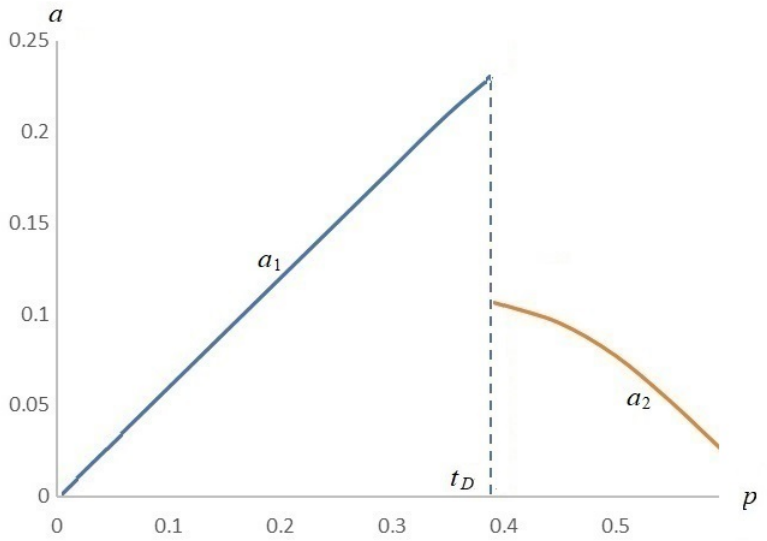

Figure 3: The effect of p on audit effort and disclosure threshold: $k = 1$, $\lambda = 0.5$, $\beta = 1$, $L = 0.6$, $X_h = 3$, $X_l = 0$, $c = 0.5$, and uniform distribution.

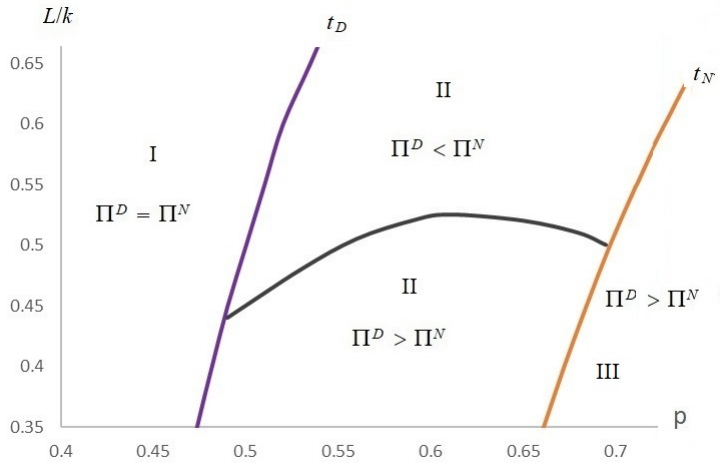

Figure 4: Comparison of investment efficiency under the two regimes: $k = 1$, $\lambda = 0.5$, $\beta = 1$, $X_h = 3.5$, $X_l = 0$, $c = 3$, and uniform distribution.

Table 1: Equilibrium under Each Regime

Scenario	Disclosure Regime	No-Disclosure Regime
Scenario I $p \leq t_D$	Case one	Case one
Scenario II $t_D < p \leq t_N$	Case two	Case one
Scenario III $p > t_N$	Case two	Case two

Table 2: Equilibria under each regime with expanded parameter space

Scenario		Disclosure Regime	No-Disclosure Regime
Scenario I	$p \leq t_D$	Case one	Case one
Scenario II	$t_D < p \leq \min(t_N, t_{D2})$	Case two	Case one
Scenario III	.1 $t_N < p \leq t_{D2}$ if λ is not very low	Case two	Case two
	.2 $t_{D2} < p \leq t_N$ if λ is very low	Case three	Case one
Scenario IV	$\max(t_N, t_{D2}) < p \leq t_{N2}$	Case three	Case two
Scenario V	$p > t_{N2}$	Case three	Case three