Financial Leverage, Information Quality, and Efficiency*

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ABSTRACT

We examine information quality and financial leverage when an entrepreneur needs financing to undertake a risky project and his effort input affects the project's outcome. We show that information quality and financial leverage interact to play active roles in both investment and effort decisions. Our analysis shows a positive association between leverage and optimal information quality—when leverage is low (high), low (high) information quality is optimal. This is because with low leverage, the entrepreneur is already motivated by his large share of the outcome to exert effort, and high information quality is not efficient as a precise bad signal discourages the entrepreneur's effort. In contrast, when leverage is high and thus the entrepreneur is less motivated by his residual cash flows, high information quality is optimal, because a precise good signal encourages the entrepreneur's effort. Our study highlights the joint effect of information quality and financial leverage on overall efficiency through firms' effort inputs as well as on defining investment efficiency.

Keywords: information quality, financial leverage, efficiency, effort decision

Levier financier, qualité de l'information et efficience

RÉSUMÉ

Les auteurs examinent la qualité de l'information et le levier financier lorsqu'un entrepreneur a besoin de financement pour entreprendre un projet risqué et que son effort affecte le résultat du projet. Ils montrent que la qualité de l'information et le levier financier interagissent pour jouer des rôles actifs dans les décisions d'investissement et d'effort. Leur analyse montre une association positive entre le levier financier et la qualité optimale de l'information—lorsque le levier financier est faible (élevé), la faible (haute) qualité de l'information est optimale. En effet, lorsque le levier est faible, l'entrepreneur est déjà motivé, par son importante part du résultat, à fournir des efforts, et une haute qualité de l'information n'est pas efficiente, car un mauvais signal précis entrave l'effort de l'entrepreneur. En revanche, lorsque le levier est élevé et que l'entrepreneur est donc moins motivé par ses flux de trésorerie résiduels, une haute qualité de l'information est optimale, car un bon signal précis encourage l'effort de l'entrepreneur. Cette étude met en évidence l'effet conjoint de la qualité de l'information et du

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levier financier sur l'efficience globale à travers l'effort des entreprises ainsi que sur la définition de l'efficience de l'investissement.

Mots-clés : qualité de l'information, levier financier, efficience, décision d'effort

1. Introduction

In this study, we examine the joint effects of accounting information quality and financial leverage on investment and effort decisions, and how firms' leverage influences accounting quality choices. Information quality and financial leverage are both important as they impact real decisions such as investments, contracting, and inputs; however, how they interact and their joint effects on those decisions remain under-explored. In addition, there is no clear empirical evidence of the association between information quality and leverage.[1]

We model financial leverage in a setting in which an entrepreneur needs external financing from a representative creditor in a competitive debt market to undertake a project. For convenience, we refer to the entrepreneur as "he" and the creditor as "she." The project can be either good or bad, which is not directly observable; however, a public signal reveals the project type with noise. The quality of the public signal is chosen ex ante by the entrepreneur. After observing the signal, if the entrepreneur decides to pursue the project, he seeks funds from a representative creditor. If the creditor is willing to provide the funds, she requests a debt repayment to break even. Once the project is undertaken, the entrepreneur may further exert productive effort to improve the project's cash flow.

Our analysis shows a positive association between leverage and optimal information quality. That is, with low financial leverage, the optimal information quality is low, whereas with high leverage, the optimal information quality is high. When the leverage is low, the entrepreneur is motivated by his large share of the outcome to exert effort. In this case, high information quality is not efficient because a precise bad signal induces the creditor to request a larger repayment, thus discouraging the entrepreneur from exerting effort. In contrast, when the leverage is high and thus the entrepreneur is less motivated by his residual cash flows, high information quality is optimal because a precise good signal induces a smaller debt repayment and encourages the entrepreneur's effort.

We also analyze how the prior probability that the project is good influences the optimal information quality. When the prior is very favorable, the entrepreneur can effectively commit to exert effort by choosing low information quality, and thus low information quality is optimal. However, when the prior is not as favorable, this commitment device no longer works, as even the lowest information quality cannot induce effort conditional on a bad signal. Hence in this case, perfect information quality is optimal when the prior is moderate, whereas an intermediate level of information quality is optimal when the prior is very unfavorable.

In addition, efficiency, which is represented by the entrepreneur's ex ante expected payoff, is more sensitive to financial leverage if the information quality is poor. With poor information quality, the creditor's requested debt repayment is barely affected by the noisy signal; rather, it is determined by the leverage level. Regardless of the signal realization, the entrepreneur is induced either to exert effort when leverage is low or shirk when leverage is high, which makes efficiency sensitive to financial leverage. In contrast, when the information quality is high, a precise signal helps distinguish between good and bad projects, and the creditor determines her requested repayment not only based on the leverage level but also on the signal. Thus, efficiency is less sensitive to financial leverage.

1. Although many empirical studies use leverage as a control variable and many examine accounting quality, we have not found studies that directly examine the association between information quality and leverage, and there is no consensus on the empirical evidence for this association.

In our setting, efficiency is determined by both the investment and the effort decisions. A good project should always be undertaken, whereas a bad one is still worthy of investment but only if the entrepreneur exerts effort. The information quality of the signal regarding the project type and financial leverage interact and play an active role in these two decisions. In particular, the entrepreneur's effort decision is jointly determined by both information quality and leverage, while the investment decision is jointly affected by both information quality and the entrepreneur's effort (which is also affected by leverage).

The impact of financial leverage is to determine the role of information quality: when leverage is so high that it discourages effort, higher information quality only has a positive impact through distinguishing good and bad projects and thus improves investment efficiency; however, when leverage is intermediate, it interacts with information quality in shaping the entrepreneur's effort decision, and higher information quality has both positive and negative impacts on efficiency.

The impact of information quality is twofold: on the one hand, higher information quality helps to distinguish project types and improves investment efficiency if no effort is exerted; on the other hand, higher information quality may reveal a bad project and discourage the entrepreneur from exerting effort, and thus decreases efficiency because a bad project with effort would still lead to a positive net present value (NPV).

2. Related literature

Numerous studies have been conducted on optimal information systems when firms are financially constrained. Many of these studies have considered financial constraints as background context to examine the role of information, while the focus has often been on designing an optimal information system (Jiang and Yang 2021; Goex and Wagenhofer 2009, 2010; Bertomeu and Cheynel 2015). These studies have focused on optimal accounting biases in disclosures (e.g., conservative vs. liberal accounting, and fair value vs. historical cost) and have typically assumed unrestricted information-structure choices. In contrast, our model does not focus on the question of optimal biases or cutoff thresholds of reporting, but on the general optimal information quality (i.e., accuracy of the signal) in the presence of leverage, without unlimited choices on information structure.

Our study also contributes to the literature on information quality. Many previous studies have shown, in various settings, that limiting the supply of information—for example, lower information quality, aggregation, and allowing manipulation—can be efficient by compensating for other inefficiency arising from lack of commitment, contracting problems, difficulties in motivating information acquisition, etc.[2] Although this literature stream is large, most studies do not focus on how financial leverage interacts with information quality. Among the studies that do consider information quality in the presence of debt, Burkhardt and Strausz (2009) show that although a more transparent accounting system reduces information asymmetry and thus increases the liquidation of assets, this type of system may worsen the asset substitution problem of debts. Deng et al. (2019) also examine the information quality regarding project types and input decision of a financially constrained firm. They find that higher information quality always reduces efficiency because of two driving forces—a concavity effect and an asymmetry effect. Neither of these driving forces exists in our study. In addition, in their study, all projects have positive NPVs regardless of the project types, and thus the investment decision is moot as there is no investment inefficiency.

Many empirical studies have examined debt contracting and accounting quality, and most have focused on how accounting quality influences debt contracting (Bharath et al. 2008; Li et al. 2021; Donelson et al. 2017). However, there is sparse research on the joint effects of

2. See, for example, Friedman et al. (2020, 2022), Goex and Michaeli (2022), Li et al. (2018), Michaeli (2017), Şabac and Tian (2015), Chen et al. (2011), Bertomeu et al. (2011), Christensen et al. (2005), Kanodia et al. (2005), and Arya et al. (2000).

accounting quality and leverage or the explicit association between them. Our study provides theoretical predictions for future empirical research.

3. The model

An entrepreneur has a project that requires capital I, and to pursue it, he borrows $I - A$ from a representative creditor, where A is the entrepreneur's own personal wealth. We use the size of the loan relative to the total investment, $\beta \equiv (I - A)/I$, to represent the entrepreneur's financial leverage. If successful, the project generates a cash flow, $z = X$; otherwise, the project fails and generates zero cash flow, $z = 0$.[3] Without any effort from the entrepreneur, the probability of project success is p_G for a good type and p_B for a bad one. The project type is unobservable to either the entrepreneur or outsiders; however, the prior belief is that the project is good with probability θ. We assume that $Xp_B < I$ and $Xp_G > I$; that is, without the entrepreneur's effort, the project yields a negative NPV if it is bad and a positive NPV if it is good.

There is a noisy signal, $S \in \{g, b\}$, about the unobservable project type, with quality $q = \Pr(g|G) = \Pr(b|B)$, where $q \in [1/2, 1]$.[4] The posterior probability that the project is good conditional on signal S is θ_S, $S \in \{g, b\}$, and we have

$$\theta_g \equiv \frac{q\theta}{q\theta + (1-q)(1-\theta)}, \quad \theta_b \equiv \frac{(1-q)\theta}{(1-q)\theta + q(1-\theta)}.$$

Conditional on observing S, the entrepreneur has the option to abandon the project. If the entrepreneur pursues the project, he borrows $I - A$ from the creditor. The creditor determines the loan repayment, D_S, $S \in \{g, b\}$, to break even. If the project is successful, the entrepreneur and creditor obtain $X - D_S$ and D_S, respectively. Otherwise, they both obtain zero.

After the project has been undertaken, the entrepreneur decides on whether to exert an unobservable, costly effort to improve the project outcome. If he exerts effort ($e = 1$), he increases the probability of project success by Δp, and he incurs a personal cost, c. If the entrepreneur exerts no effort ($e = 0$), the probability of project success does not change and there is no personal cost. We assume that $X(p_B + \Delta p) > I + c$. That is, with $e = 1$, a bad project can be improved to be profitable and to yield a positive NPV.

Finally, the project cash flow, $z \in \{0, X\}$, is realized, and the entrepreneur and creditor receive their respective payoffs. Notice that because the creditor always breaks even ex ante, the entrepreneur's ex ante expected payoff, denoted by Π, represents efficiency in the model.

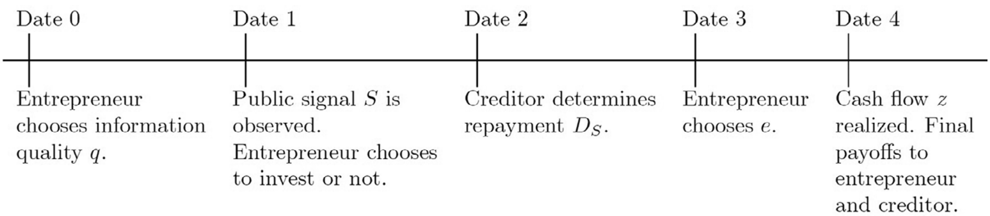
The timeline is illustrated in Figure 1.

A first-best benchmark

First, we analyze a first-best benchmark setting. In the first-best scenario, the entrepreneur always undertakes the project and exerts effort because his effort can turn even a bad project into a positive-NPV one. The first-best scenario can be achieved if the entrepreneur's own personal wealth is sufficient to fund the project (i.e., no need for external financing), or if the entrepreneur can commit to invest and exert effort regardless of the signal.[5] Obviously, information quality plays no role in this benchmark.

3. Our main results are robust to a continuous-outcome setting in which the project generates a cash flow that follows a continuous distribution. In this setting, although the creditor's requested debt repayment is determined by the continuous distribution of the outcome, the interaction between information quality and financial leverage remains the same. A detailed analysis is available upon request.
4. In section 6, we examine the scenario in which the precision of the signal is nonsymmetrical and contingent on the project type by assuming $\Pr(g|G) = q_G$ and $\Pr(b|B) = q_B$, with $q_G \neq q_B$.
5. With financial constraints but without the commitment to effort, even perfect information quality cannot guarantee the first-best scenario, as a perfect signal b implies an unfavorable debt repayment D_b, that discourages the entrepreneur's effort.

Figure 1 Timeline



LEMMA 1. *In the first-best benchmark, the entrepreneur always pursues the project and exerts effort. Information quality plays no role.*

Equilibrium analysis

To study the optimal information quality in the presence of leverage, we must understand the interactions between the two. We first examine the equilibrium investment and effort decisions, assuming that the information quality, q, is given.

By backward induction, we start with the entrepreneur's effort decision on date 3, given the creditor's requested repayment, D_S, $S \in \{g, b\}$. The entrepreneur exerts effort if, and only if, D_S is sufficiently low; that is, if $D_S < X - c/\Delta p$. Intuitively, the entrepreneur is more motivated to work hard if he can keep more of the project's realized cash flow after repaying the creditor. This is similar to Holmstrom and Tirole (1997) and Tirole (2006): too much external financing discourages an entrepreneur's effort.

On date 2, given the realized signal, S, if the creditor decides to fund the project, she requests a repayment, D_S, from the entrepreneur to break even, based on her conjecture about the entrepreneur's effort decision. Since the project's expected NPV is positive with effort regardless of its type, the creditor always funds the project if she anticipates that the entrepreneur will exert effort. However, if the creditor anticipates no effort, she will fund the project only if it still has an expected positive NPV without effort.

We find there are three cases depending on the level of financial leverage. We describe them in the following proposition as well as in Table 1.

PROPOSITION 1. *There are thresholds,* $T(\theta_S) \equiv [\theta_S(p_G - p_B) + p_B + \Delta p](X - c/\Delta p)/I$, $S \in \{g, b\}$, *and*

$$\theta^u \equiv \frac{I/X - p_B}{p_G - p_B}, \ \ \overline{q} \equiv \max\left\{\frac{\theta(1-\theta^u)}{\theta(1-\theta^u)+\theta^u(1-\theta)}, \frac{\theta^u(1-\theta)}{\theta(1-\theta^u)+\theta^u(1-\theta)}\right\},$$

such that,

(i) ***Always-effort*:** *When* $\beta < T(\theta_b)$, *the project is always undertaken, and* $e = 1$ *regardless of the realized signal.*

(ii) ***Effort-only-with-g*:** *When* $T(\theta_b) < \beta < T(\theta_g)$, *if* $S = g$, *the project is undertaken and* $e = 1$; *if* $S = b$, $e = 0$ *and the project is undertaken only if* $q < \overline{q}$ *and* $\theta > \theta^u$.

(iii) ***Never-effort*:** *When* $\beta > T(\theta_g)$, $e = 0$ *regardless of the realized signal. If* $S = g$, *the project is undertaken only if* $q > \overline{q}$ *or* $\theta > \theta^u$; *if* $S = b$, *the project is undertaken only if* $q < \overline{q}$ *and* $\theta > \theta^u$.

All the proofs are in the Appendix.

TABLE 1
Always-effort, effort-only-with-g, and never-effort cases

	$S = g$	$S = b$
Always-effort when $\beta < T(\theta_b)$	Project undertaken and $e = 1$	Project undertaken and $e = 1$
Effort-only-with-g when $T(\theta_b) < \beta < T(\theta_g)$	Project undertaken and $e = 1$	$q < \overline{q}$ and $\theta > \theta^u$: undertaken but $e = 0$ otherwise: foregone
Never-effort when $\beta > T(\theta_g)$	$q > \overline{q}$ and $\theta > \theta^u$: undertaken but $e = 0$ otherwise: foregone	$q < \overline{q}$ and $\theta > \theta^u$: undertaken but $e = 0$ otherwise: foregone

The threshold, $T(\theta_S)$, is the leverage below which the entrepreneur supplies effort ($e = 1$) after observing signal S. The higher the posterior beliefs that the project is good, θ_S, the higher this threshold. In particular, because $\theta_b < \theta_g$, $T(\theta_b) < T(\theta_g)$.[6]

When financial leverage is very low, $\beta < T(\theta_b)$, because the debt repayment is low, the entrepreneur is motivated to exert effort regardless of the signal because he will obtain most of the return from his effort (always-effort case). In this case, we achieve the first-best.

When financial leverage is intermediate, $T(\theta_b) < \beta < T(\theta_g)$, the entrepreneur still exerts effort if $S = g$, because the debt repayment, D_g, is not large enough to discourage him. However, if $S = b$, the entrepreneur no longer exerts effort, as D_b becomes so large that it jeopardizes his effort incentive (effort-only-with-g case). In addition, with a bad signal, the entrepreneur may not pursue the project. Specifically, if the prior belief is strong ($\theta > \theta^u$) and the signal is very noisy ($q < \overline{q}$), a bad signal does not overturn the strong prior belief of a good project; thus, the entrepreneur still pursues the project. However, if the bad signal is of a high quality, or if the prior belief is very low, the entrepreneur abandons the project because it is highly likely to be bad.

When financial leverage is very high, $\beta > T(\theta_g)$, the entrepreneur never exerts effort regardless of the realized signal (never-effort case), because the debt repayment takes away most of his effort's return and he loses the effort incentive. The entrepreneur pursues the project only when the posterior belief that it is a good project is sufficiently strong, which happens when (i) a good signal is highly accurate or a good signal confirms a strong prior belief that the project is good, or (ii) when a bad signal is very noisy and cannot overturn a strong prior belief that the project is good.

4. The effects of financial leverage and information quality on efficiency

The impact of leverage on efficiency

From Proposition 1 and Table 1, it is readily seen that efficiency, Π, weakly decreases in financial leverage, β, because as leverage increases, the equilibrium moves from the always-effort case (in which we achieve first-best) to the effort-only-with-g case and eventually reaches the never-effort case.

COROLLARY 1. Π *weakly decreases in* β.

The impact of information quality on efficiency

We now analyze how information quality affects efficiency in each of the cases described in Proposition 1.

6. When $\beta \in [T^{e_L}(\theta_S), T(\theta_S)]$, where $T^{e_L}(\theta_S) \equiv [\theta_S(p_G - p_B) + p_B](X - c/\Delta p)/I < T(\theta_S)$, there may exist two equilibria. In our analysis, we focus on the Pareto-dominant equilibrium. We provide a detailed analysis of the other equilibrium in the proof of Proposition 1.

PROPOSITION 2.

(i) In the always-effort case, efficiency is independent of q.

(ii) In the effort-only-with-g case, efficiency increases in q when $\theta > 1/2$, *and decreases in q when*

$$\theta < \frac{X(p_B + \Delta p) - I - c}{X(p_G + p_B + 2\Delta p) - 2I - 2c}.$$

(iii) In the never-effort case, efficiency weakly increases in q.

Information quality affects efficiency through the effort and investment decisions. First, information quality affects the effort decision, but only in the effort-only-with-g case, in which the entrepreneur exerts effort only conditional on a good signal but not on a bad signal. The larger the likelihood of obtaining a good signal, the higher the likelihood of effort. Higher information quality may increase or decrease the likelihood of a good signal. In particular, when the prior belief of a good project is strong ($\theta > 1/2$), higher information quality increases the likelihood of obtaining a good signal and thus increases the likelihood of effort, which improves efficiency. When the prior belief of a good project is weak ($\theta < 1/2$), higher information quality decreases the likelihood of obtaining a good signal and thus reduces the chance of effort, which results in lower efficiency.

Second, information quality influences the investment decision, but only in the effort-only-with-g and the never-effort cases. Conditional on a bad signal, in the effort-only-with-g and the never-effort cases, an inefficiency arises from either abandoning a good project or undertaking a bad one and supplying no effort. As higher information quality improves the accuracy of the signal, it increases efficiency by improving the investment decisions in both the effort-only-with-g and the never-effort cases.

In the always-effort case, because neither the effort decision nor the investment decision depends on the realized signal, information quality, q, plays no role in efficiency.

In the effort-only-with-g case, when the prior probability, θ, is high (i.e., $\theta > 1/2$), higher information quality improves efficiency through both the effort and investment decisions. First, higher information quality increases the likelihood of obtaining a good signal and therefore the likelihood of effort. Second, higher information quality improves the accuracy of the signal and leads to a more efficient investment decision. In contrast, when θ is low (i.e., $\theta < 1/2$), higher information quality still improves efficiency through the investment decision; however, it reduces efficiency through the effort decision because a bad signal is more likely. The net effect is determined by the trade-off between these two countervailing effects.

In particular, when θ is very low (i.e., $\theta < [X(p_B + \Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c]$), the negative effect through the effort decision is very strong and dominating, and thus efficiency decreases in q. When θ is low but not too low (i.e., $[X(p_B + \Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c] < \theta < 1/2$), there are two possible scenarios. One scenario is when $\theta > \theta^u$ and $q < \overline{q}$, in which the investment decision does not depend on the realized signal. In this case, information quality affects efficiency only through the effort decision. Since higher information quality given a relatively low θ implies that a good signal is less likely, it discourages effort and reduces efficiency. The other scenario is when $\theta > \theta^u$ and $q > \overline{q}$, or $\theta < \theta^u$, both the effort and investment decisions are based on the realized signal, and higher information quality discourages effort but still improves the investment decision. Since θ is not too low, the positive effect through the investment decision dominates, and efficiency increases in q.

In the never-effort case, information quality does not affect the entrepreneur's effort decision; however, it may affect the investment decision. When the signal is sufficiently precise, the entrepreneur only invests conditional on a good signal, and higher information quality improves efficiency.

Our analysis shows that efficiency may decrease in information quality in the effort-only-with-g case when the prior belief of a good project is very weak. Although higher information quality may improve the investment decision by better distinguishing good projects from bad ones, the negative effect through the effort decision is twofold when good projects are scarce. With a more precise signal (which is likely to be a bad signal), the entrepreneur is less likely to exert effort. Second, even if a bad project is accurately identified, it is not optimal to abandon it because a bad project can still generate a positive NPV with the entrepreneur's effort. This result highlights the importance of considering the effect of information quality on endogenous effort decisions.

Moreover, our analysis shows that the effect of information quality on efficiency depends on capital structure (leverage). For example, financial institutions, airline companies, and large manufacturing companies are extremely capital-intensive and typically have high leverage ratios (DeAngelo and Stulz 2015; Maverick 2015). Our results imply that in these companies, a higher-quality information environment improves their operating efficiency, whereas for companies with intermediate leverage, higher information quality may damage their efficiency.

The joint effects of information quality and leverage

We now examine the interaction between information quality and financial leverage as well as their joint effects on efficiency. In the preceding analysis, we showed how information quality, q, affects efficiency for given leverage levels in three separate ranges. The two thresholds separating these ranges also depend on information quality, q, as summarized in the following proposition:

Proposition 3. *With higher information quality, the parameter ranges for the always-effort and never-effort cases shrink, whereas the parameter range for the effort-only-with-g case expands (i.e., $T(\theta_b)$ decreases in q and $T(\theta_g)$ increases in q).*

In addition,

- *the always-effort case always exists regardless of q (i.e., $T(\theta_b) > 0$);*
- *the never-effort case does not exist if the information quality is high and the effort cost is low (i.e., $T(\theta_g) > 1$ when q is high and c is low).*

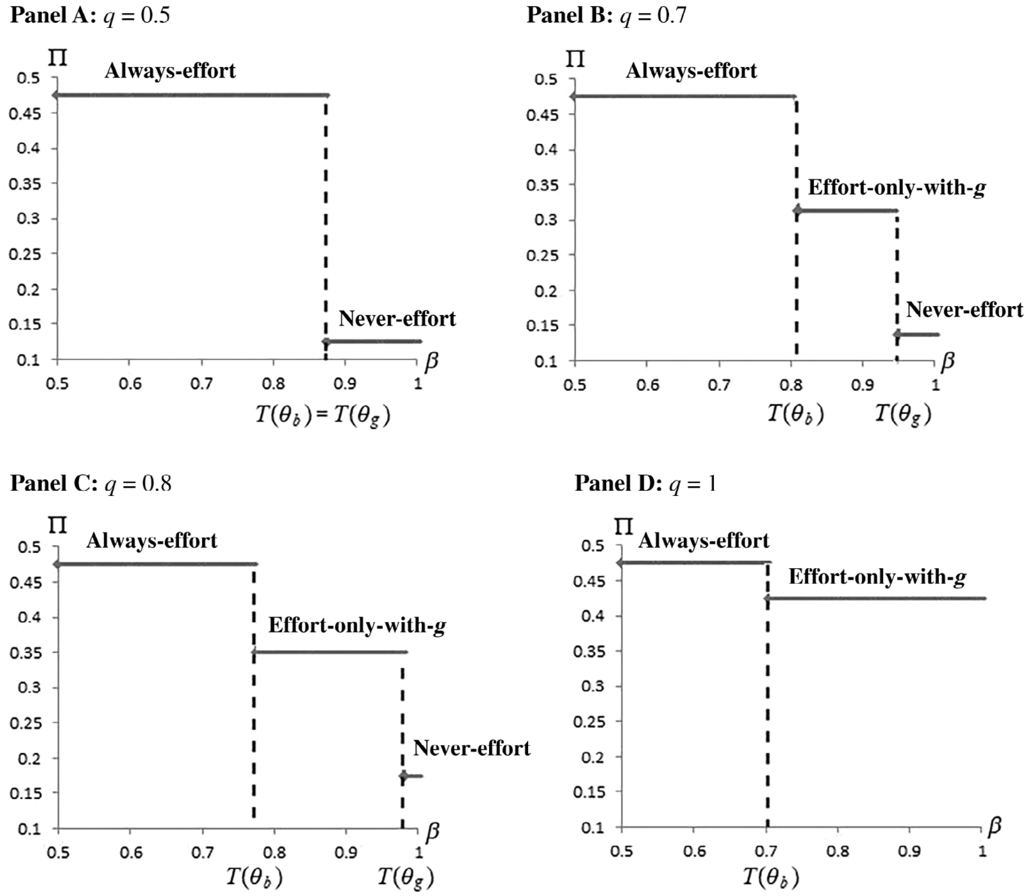
Recall that $T(\theta_b)$ is the leverage threshold below which the entrepreneur always exerts effort, even if he observes a bad signal. The threshold, $T(\theta_b)$, decreases in q, which indicates that higher information quality leads to a more stringent condition for effort with a bad signal. Intuitively, conditional on a more precise bad signal, the project is more likely a bad type, and the creditor will ask for a higher repayment, which discourages the entrepreneur's effort. This results in lower efficiency because a bad project could be converted to yield a positive NPV with the entrepreneur's effort.

Meanwhile, $T(\theta_g)$ is the leverage threshold above which the entrepreneur never exerts effort, even if he observes a good signal. $T(\theta_g)$ increases in q, which indicates that higher information quality leads to a less-stringent condition for effort with a good signal. The reason is that with higher information quality, the posterior belief conditional on a good signal is stronger, and the creditor asks for a lower debt repayment, which motivates the entrepreneur's effort. This leads to higher efficiency.

Proposition 3 also indicates that the never-effort case may disappear when the information quality is high and the effort cost is low, such that the entrepreneur always exerts effort conditional on a good signal. Intuitively, conditional on a precise good signal, the posterior belief of a good type is very strong, and the creditor asks for a low repayment to break even. The low debt repayment, combined with a low effort cost, motivates the entrepreneur's effort.

Importantly, information quality affects not only efficiency differently in each case (as indicated by Proposition 2), but also the range for each case through the leverage thresholds (as indicated by Proposition 3). We use a numerical example in Figure 2 to show the effects of information quality and leverage on efficiency. It is readily seen that efficiency reaches the highest,

Figure 2 The sensitivity of overall efficiency to financial leverage given different levels of information quality



Notes: $I = 1$, $X = 3$, $P_G = 0.5$, $P_B = 0.25$, $\Delta p = 0.2$, $\theta = 0.5$, and $c = 0.3$.

first-best level in the always-effort case while it is lower in the effort-only-with-g case, and drops to the lowest level in the never-effort case, as indicated by Corollary 1. Panel A in Figure 2 shows the extreme case when $q = 0.5$, in which the two thresholds, $T(\theta_b)$ and $T(\theta_g)$, merge and the effort-only-with-g case vanishes. In this situation, efficiency achieves the first-best level if the financial leverage is lower than the merged threshold, and the range of the financial leverage for the first-best level is the widest. However, once the financial leverage reaches beyond that merged threshold, efficiency dramatically "falls off the cliff" and down to the lowest level. In this case, we may say efficiency is very sensitive to financial leverage when the information quality, q, is very poor.

When the information quality, q, increases, the range for the effort-only-with-g case becomes increasingly wider, whereas the ranges for the always-effort and never-effort cases become increasingly narrower ($T(\theta_b)$ and $T(\theta_g)$ grow further apart), as shown in panels B and C of Figure 2. The two thresholds, $T(\theta_b)$ and $T(\theta_g)$, form a plateau area that is both less likely to achieve the first-best level of efficiency and less likely to plummet to the lowest level. In this situation, efficiency is less sensitive to financial leverage.

When the information quality becomes high, the never-effort case may disappear as shown in Proposition 3 (i.e., $T(\theta_g) > 1$). Panel D in Figure 2 illustrates the extreme case of $q = 1$. In this example, as the never-effort case vanishes, we either achieve the highest, first-best level of efficiency, or end up with a relatively high plateau. Although the likelihood of reaching the first-best efficiency is the lowest, there is not much efficiency loss. That is, efficiency is insensitive to financial leverage. We summarize this in the following remark:

REMARK 1. When information quality is lower (higher), efficiency is more (less) sensitive to financial leverage.

With low information quality, the creditor's decision on the requested debt repayment is barely affected by the noisy public signal, but mostly determined by the leverage level. Regardless of the signal realization, the entrepreneur is induced either to exert effort when leverage is low or shirk when leverage is high, which makes efficiency very sensitive to leverage levels.

When information quality is high, as the precise public signal helps distinguish the project types, the creditor determines her requested repayment not only based on the leverage level, but also on the public signal. With high information quality, the entrepreneur may still be induced to exert effort conditional on a good signal even with high leverage, and may shirk conditional on a bad signal even with low leverage. Therefore, efficiency becomes less sensitive to financial leverage.

Our analysis indicates that if very high standards are imposed on information quality in an economy, financial leverage is not important for efficiency; although the likelihood of achieving the first-best is smaller, efficiency remains high regardless of companies' capital structure. However, if the economy has a very poor information environment, the role of financial leverage becomes vital, and it is crucial to keep the leverage low to avoid a drop to the worst level of efficiency.

5. Optimal information quality

We are now ready to solve for the entrepreneur's ex ante optimal choice of information quality at date 0. As the entrepreneur's ex ante payoff represents efficiency, his choice will be the optimal information quality to maximize efficiency.

PROPOSITION 4. *There are two leverage thresholds,* $\beta_1 \equiv [\theta(p_G - p_B) + p_B + \Delta p][X - c/\Delta p]/I < \beta_2 \equiv [p_G + \Delta p][X - c/\Delta p]/I$, *and an intermediate level of information quality,*

$$q^o \equiv \left[1 + \frac{\theta}{1-\theta} \times \frac{(p_G + \Delta p)(X - c/\Delta p) - \beta I}{\beta I - (p_B + \Delta p)(X - c/\Delta p)}\right]^{-1},$$

such that,

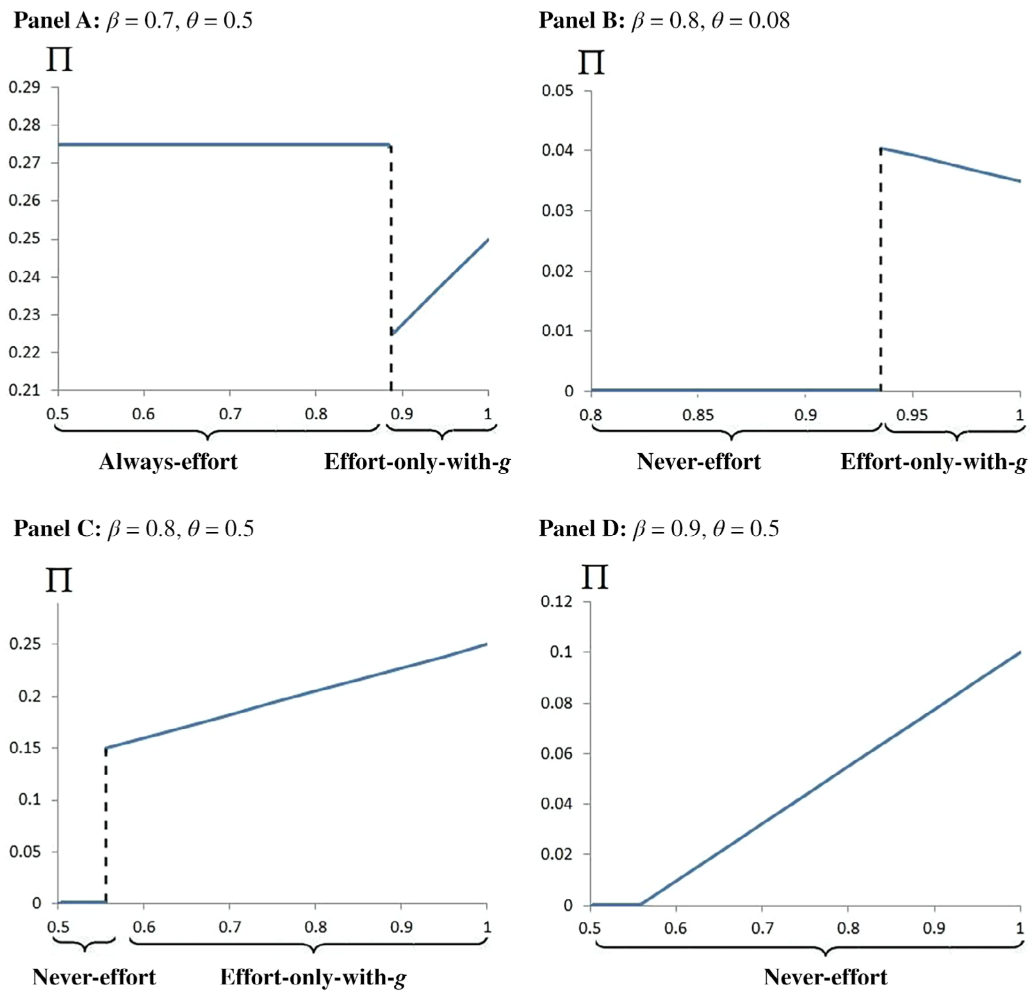
- *when leverage is low ($\beta < \beta_1$), it is optimal to have low information quality,*

$$q < \left[\frac{(1-\theta)[\beta I - (X - c/\Delta p)(p_B + \Delta p)]}{\theta[(X - c/\Delta p)(p_G + \Delta p) - \beta I]} + 1\right]^{-1};$$

- *when leverage is intermediate ($\beta_1 < \beta < \beta_2$), the intermediate q^o is optimal if θ is sufficiently low ($\theta < [X(p_B + \Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c]$), and perfect information quality ($q = 1$) is optimal if θ is sufficiently high ($\theta > 1/2$);*
- *and when leverage is high ($\beta > \beta_2$), perfect information quality ($q = 1$) is optimal.*

When leverage is low, it is optimal to choose low information quality, because the entrepreneur is motivated to exert effort in the first place, as he retains most of the realized cash flow from the project. High information quality is not desirable in this case because if the signal is a bad

Figure 3 The optimal information quality given different levels of financial leverage



Notes: $I = 1$, $X = 3$, $P_G = 0.4$, $P_B = 0.25$, $\Delta p = 0.2$, and $c = 0.3$.

one with high quality, the creditor will request a large D_b, which discourages the entrepreneur from exerting effort. The optimal choice is any quality level in the low range (indicated by the first case in Proposition 4), such that the always-effort case is achieved.

The numerical example in Figure 3 illustrates optimal information quality given financial leverage, and panel A shows the case of low leverage ($\beta < \beta_1$). As indicated by Proposition 3, the threshold for the always-effort case, $T(\theta_b)$, decreases in q. With low information quality, β is lower than $T(\theta_b)$, and thus the always-effort case and first-best efficiency are achieved.

When leverage is in an intermediate range, $\beta_1 < \beta < \beta_2$, the always-effort case can never be achieved. When information quality is very poor, the entrepreneur does not exert effort because the debt repayment is large even when conditional on a good signal. Once the information quality increases, the debt repayment will become lower conditional on a good signal, which encourages the entrepreneur's effort and improves efficiency. However, as the information quality further increases, it may not keep improving efficiency if the prior of a good-type project, θ, is low, because higher information quality results in a lower likelihood of a good signal as the signal becomes more accurate, which implies a lower likelihood of the entrepreneur's effort; therefore, the optimal information quality is at an intermediate level, q^o. In contrast, when θ is sufficiently high, higher information quality will keep improving efficiency, and thus perfect information quality is optimal.[7]

Panels B and C in Figure 3 illustrate cases of intermediate leverage ($\beta_1 < \beta < \beta_2$): panel B illustrates the scenario when θ is very low ($\theta = 0.08$) and shows that efficiency is maximized at an intermediate level of information quality; panel C shows the scenario when θ is high ($\theta = 0.5$), and we find efficiency maximized at the perfect information quality. When β is intermediate, the never-effort case is achieved when q is low, while the effort-only-with-g case is achieved when q is high. As the information quality increases, efficiency will be improved by switching from the never-effort case to the effort-only-with-g case. However, when the information quality further improves, efficiency in the effort-only-with-g case can increase or decrease in q depending on θ (Proposition 2, part (ii)). That is, if θ is low, efficiency decreases in q, which implies that efficiency is maximized at an interior information quality level, q^o, in which the never-effort case just switches to the effort-only-with-g case. If θ is high, efficiency keeps increasing in q, which implies that efficiency is maximized at the highest information quality level, $q = 1$.

When leverage is very high, the optimal choice is perfect information quality because the entrepreneur can never be induced to work regardless of the signal, and the information quality only affects investment efficiency. Perfect information quality therefore is optimal as it prevents investment in a bad project.

Panel D in Figure 3 shows that when leverage is very high, $\beta > \beta_2$, the never-effort case is achieved regardless of information quality.[8] According to Proposition 2, part (iii), in the never-effort case, efficiency weakly increases in q, indicating that perfect information quality is optimal.

The optimal information quality for different leverage levels indicates that if the economy has tight (loose) financial constraints, a high (low) standard for information quality or more (less) corporate governance is optimal. In addition, for different industries with different levels of financial leverage, regulators should consider different standards for information quality. For example, in high-leverage industries such as financial institutions and airlines, it is optimal to impose high standards for information quality, whereas for low-leverage industries such as high-tech companies, lower standards for information quality are optimal to maximize efficiency.

We further examine the optimal information quality from the perspective of the prior belief that the project is a good type, θ. The following corollary summarizes our findings:

Corollary 2.

- *When θ is high ($\theta > [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$), it is optimal to have low information quality,*

$$q < \left[\frac{(1-\theta)[\beta I - (X - c/\Delta p)(p_B + \Delta p)]}{\theta[(X - c/\Delta p)(p_G + \Delta p) - \beta I]} + 1\right]^{-1}.$$

7. When leverage is in an intermediate range and $[X(p_B + \Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c] < \theta < 1/2$, an intermediate level of information quality q^o is optimal if $q^o < \overline{q}$ and $\theta < 1 - (1 - q^o)/[2(1 - q^o) - (I - p_B X)/(\Delta p X - c)]$; otherwise, perfect information quality ($q = 1$) is optimal. As this case shares the properties that an intermediate q^o is optimal when θ is low while $q = 1$ is optimal otherwise, but is messy to present and does not provide additional insight, we omit it from Proposition 4 for a more concise presentation.

8. Please note that the threshold β_2 might be greater than one under certain circumstances. That is, it is possible that the case of $\beta > \beta_2$ does not exist.

- *When* $1/2 < \theta < [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$, *perfect information quality* ($q = 1$) *is optimal.*
- *When* $\theta < \min\{[X(p_B + \Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c],\ [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)\}$ *and* $\beta < \beta_2$, *an intermediate level of information quality,* q^o, *is optimal.*

Note that the first cases in Corollary 2 and Proposition 4 are the same, and that they indicate that when the prior of a good type is very strong (when $\beta < \beta_1$ with $\beta_1 \equiv [\theta(p_G - p_B) + p_B + \Delta p][X - c/\Delta p]/I$, or equivalently when $\theta > [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$), low information quality is optimal. The intuition is that with low information quality, the posterior belief remains very strong even with a bad signal, and the entrepreneur is always motivated to exert effort; that is, the always-effort case is achieved. Otherwise, if the information quality is high, the posterior belief will significantly shift downward following a bad signal, which will induce a larger requested repayment and discourage the entrepreneur's effort, and thus lower efficiency. This result implies that when the prior belief is very strong, the entrepreneur can commit to exert effort by choosing low information quality.

In contrast, when the prior belief is not strong, $\theta < [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$, we find that an intermediate level of information quality, q^o, is optimal if the prior is very weak, whereas perfect information quality is optimal if the prior is moderate. Interestingly, in this case, the very weak prior is paired with an intermediate level of information quality, yet a stronger (but not too strong) prior is paired with perfect information quality as optimal. The pattern here seems to be the opposite of the very strong prior case, in which the very strong prior is paired with low information quality as optimal.

To understand the different pattern, note that when the prior belief is not very strong, $\theta < [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$, the always-effort case can never be achieved even with the lowest information quality. That is, even with the lowest information quality, the posterior belief conditional on a bad signal is weak to the extent that the entrepreneur's effort cannot be induced. Therefore, choosing low information quality no longer works as a committing device. In this case, without the signal (or if the signal is uninformative), the entrepreneur would never exert effort. If we increase the information quality, a good signal positively shifts the belief such that the creditor's requested repayment decreases, which motivates the entrepreneur's effort and improves efficiency. However, for a bad-type project, higher information quality indicates that a bad signal is more likely, which preempts the entrepreneur from exerting effort although his effort may turn the bad project into a success. If the prior of a good type, θ, is strong enough, this negative effect is dominated and perfect information quality is optimal; however, if θ is very weak, the negative effect dominates because the likelihood of a bad signal is very high.

In summary, the entrepreneur's effort decision is jointly determined by both information quality and leverage, while the investment decision is jointly affected by both information quality and the entrepreneur's effort. The impact of information quality is twofold: on the one hand, higher information quality helps to distinguish project types and improves investment efficiency if no effort is exerted. On the other hand, higher information quality may reveal a bad-type project and discourage the entrepreneur from exerting effort, and thus decreases efficiency because a bad project with effort still leads to a positive NPV. The impact of financial leverage is to determine the role of information quality: When leverage is too high so that it discourages effort, higher information quality only has a positive impact of improving investment efficiency. However, when leverage is intermediate, it interacts with information quality in shaping the entrepreneur's effort decision, which in turn affects and defines investment efficiency, and higher information quality has both positive and negative impacts on efficiency. The prior belief that the project is good, θ, could also affect the role of information quality: When θ is very strong such that it encourages effort in the first place, higher information quality has a negative impact by discouraging effort conditional on a bad signal because it reveals a bad-type project. When θ is not strong, higher information quality may have a positive impact by encouraging effort conditional on a good signal.[9]

6. Extensions

Nonsymmetric precision

In our main setting, we assume that the signal's information quality/precision is q regardless of the project type; that is, $\Pr(g|G) = \Pr(b|B) = q$. It is also interesting to examine a scenario in which the signal precision is nonsymmetric and contingent on the type. For example, it may be that in a conservative accounting system, a bad type has a higher probability of receiving a bad signal than a good type has of receiving a good signal. In this section, we explore nonsymmetric precision by assuming $\Pr(g|G) = q_G$ and $\Pr(b|B) = q_B$, $q_G \neq q_B$, and $\Pr(g|G) \geq \Pr(g|B)$ (i.e., $q_G \geq 1 - q_B$) to make the analysis meaningful. We do not specify whether q_G is greater or less than q_B to cover the asymmetry in both directions.

Our analysis shows that we still have the always-effort, the effort-only-with-g, and the never-effort cases. We show how information quality affects efficiency below:

Proposition 5. *With nonsymmetric precision,*

(i) in the always-effort case, efficiency is independent of q_G and q_B;
(ii) in the effort-only-with-g case, efficiency increases in q_G and decreases in q_B;
(iii) and in the never-effort case, efficiency weakly increases in q_G and q_B.

With nonsymmetric precision, the effect of information quality (q_G and q_B) on efficiency remains the same with the exception of a slight difference that, in the effort-only-with-g case, efficiency increases in q_G and decreases in q_B. This is because we now have separate information quality levels for good and bad types of projects. Intuitively, because in the effort-only-with-g case the entrepreneur exerts effort only conditional on a good signal, efficiency increases in the likelihood of obtaining a good signal. With nonsymmetrical precision, a good type obtains a good signal with probability q_G and a bad type obtains a good signal with probability $1 - q_B$. Therefore, efficiency increases in q_G and decreases in q_B.

With this result, we now examine the optimal information quality with nonsymmetric precision and summarize the findings.

Proposition 6. *With nonsymmetric precision, there is*

$$K \equiv \frac{(p_G + \Delta p - \beta I/(X - c/\Delta p))\theta}{[\beta I/(X - c/\Delta p) - (p_B + \Delta p)](1-\theta)},$$

such that,

- *when β is low, $\beta < \beta_1$, low information quality, $q_B/(1 - q_G) < K$, is optimal;*
- *when β is intermediate, $\beta_1 < \beta < \beta_2$, the optimal information quality is $q_G = 1$ and $q_B = 1 - K$;*
- *and when β is high, $\beta > \beta_2$, perfect information quality, $q_G = q_B = 1$, is optimal.*

9. The entrepreneur may have some reputational benefit of a successful outcome, as he may not be able to access debt financing later if his project is not successful. We analyze the role of a nonpecuniary reputational benefit and find that a higher reputational benefit conditional on success results in a higher threshold, $T(\theta_S)$, which indicates that the reputational benefit strengthens the effort incentive and makes it easier to induce effort from the entrepreneur. Consequently, with a higher reputational benefit, low information quality is optimal in a larger parameter space whereas high information quality is optimal in a smaller parameter space. A detailed analysis is available upon request.

With nonsymmetrical precision, we still find that high (low) information quality is optimal for high (low) leverage. Because we can now choose different information quality for good versus bad types, when $\beta_1 < \beta < \beta_2$, the optimal information quality features $q_G = 1$, and q_B is at an interior level. Recall that when $\beta_1 < \beta < \beta_2$, the project is undertaken and the entrepreneur exerts effort only conditional on a good signal; therefore, the higher the likelihood of a good signal, the higher the efficiency. Therefore, $q_G = 1$ is optimal for a good type such that a good project always receives a good signal, and $q_B = 1 - K$ is optimal for a bad type such that a bad project still has a chance of receiving a good signal. In other words, with intermediate leverage, the optimal information system is a liberal system. Notice that it is not optimal for q_B to be too large: If a bad project also has a very large chance of receiving a good signal, the posterior belief conditional on a good signal, θ_g, will be very low, and no effort can be induced in equilibrium. To ensure that the entrepreneur exerts effort conditional on a good signal, the optimal q_B is at an interior, knife-edge level, such that the posterior belief with a good signal, θ_g, is at the weakest point to induce effort in equilibrium.

Although our study's focus is on the joint effect of information quality and financial leverage instead of optimal information system design, once we allow different information qualities for good and bad types, our result in the case with an intermediate β can be connected to prior studies in the persuasion literature on optimal information system design. Many studies in this line of literature have shown that an asymmetric, biased information system can be optimal. For example, in a setting with managerial private benefits from the continuation of a project, Jiang and Yang (2021) find that the optimal accounting system features less-conservative rules (i.e., a lower threshold to release good signals). Our analysis also shows that a liberal information system is optimal when leverage is intermediate but there are no private managerial benefits.

Goex and Wagenhofer (2009) focus on signals regarding a pledged asset's value (indirect signals about leverage). They show that a conditionally conservative system is optimal in impairment rules, in the sense that the system only adjusts the original book value of assets if the asset value falls below a threshold. Our analysis is different from theirs in two respects. First, in our model, the signal is about the project type while the leverage is publicly known, and a more precise signal in our model has a two-edged effect that does not exist in their study: (i) it helps to distinguish good types from bad types to improve investment efficiency, and (ii) it also negatively impacts efficiency because it may reveal bad types more accurately and discourages the entrepreneur's effort. Second, our conclusion is different, as we show a liberal information system is optimal, because a liberal system maximizes the likelihood of receiving a good signal and motivates the entrepreneur's effort.

Bertomeu and Cheynel (2015) expand Goex and Wagenhofer's (2009) work by allowing efficient liquidation and show that their result may be the opposite if financing needs are small: the optimal measurement should have more precise disclosures over high asset values (a liberal system). This is because a liberal system identifies assets whose external values are higher relative to the cash flows they generate if operated internally, while it protects assets whose external values are low from being inefficiently liquidated. In contrast, we find that the optimal information quality is very high (low) for a very high (low) level of financial leverage. When the leverage is intermediate, the optimal information quality for a good type project should be perfect, whereas the optimal information quality for a bad type should be imperfect; that is, a liberal information system is optimal. In addition, the driving force in our analysis is not efficient liquidation; rather, the optimal information quality for a bad type is set at an interior level such that effort is motivated by making good signals more likely—however, the signal cannot be too noisy to jeopardize effort in equilibrium.

Ex ante effort decision

We now consider a setting in which the entrepreneur's effort decision is made ex ante before the signal realization. Initially (date 0), the entrepreneur first makes his effort decision, $e \in \{0, 1\}$, and chooses the precision, q. The effort decision is unobservable to outsiders, while the precision decision, q, is publicly observed. The remaining setup is the same as in the main setting.

To maximize his expected payoff (and thus efficiency), it is always optimal for the entrepreneur to exert effort. Because the entrepreneur makes not only his effort decision but also the precision decision, his choice of precision functions as a signaling device to indicate having exerted effort. To analyze the optimal choice of precision for effort to be induced in equilibrium, we first consider q as given and assume that the creditor does conjecture the entrepreneur's effort. We then examine when the effort ($e = 1$) is a rational expectations equilibrium.

At date 1, conditional on the signal realization, S, if the creditor believes that the entrepreneur has exerted effort, her break-even condition is as follows:

$$[\theta_S p_G + (1-\theta_S)p_B + \Delta p]D_S = \beta I.$$

That is, the creditor asks for a repayment

$$D_S = \frac{\beta I}{\theta_S p_G + (1-\theta_S)p_B + \Delta p}.$$

At date 0, the entrepreneur decides on his effort before the realization of signal S. If the entrepreneur exerts effort at date 0, his ex ante expected payoff before the signal realization (denoted by $\Pi_{e=1}$) is as follows:

$$\Pi_{e=1} = [\theta p_G + (1-\theta)p_B + \Delta p]X - I - c.$$

Next, we check whether the entrepreneur, anticipating that the creditor conjectures his effort, will deviate from exerting effort ex ante. If he exerts no effort at date 0 while the creditor incorrectly conjectures effort, his ex ante expected payoff (denoted by $\Pi_{e=0}$) is as follows:

$$\Pi_{e=0} = \underbrace{[\theta p_G + (1-\theta)p_B]X - I}_{\text{project NPV without effort}} + \underbrace{\Delta p \beta I \left\{ \frac{q\theta + (1-q)(1-\theta)}{\theta_g p_G + (1-\theta_g)p_B + \Delta p} + \frac{(1-q)\theta + q(1-\theta)}{\theta_b p_G + (1-\theta_b)p_B + \Delta p} \right\}}_{\text{Over-valuation due to no effort}}.$$

That is, his ex ante payoff is the expected project NPV given no effort plus the creditor's over-valuation. Since the creditor incorrectly conjectures effort, the repayment, D_g/D_b, is lower than it should be. In other words, the creditor overvalues the project by assuming effort, and the entrepreneur enjoys the over-valuation by exerting no effort. Comparing $\Pi_{e=1}$ with $\Pi_{e=0}$, the entrepreneur chooses to exert effort when the effort return dominates the over-valuation from no effort. That is, the equilibrium with effort is achieved if

$$\Pi_{e=1} - \Pi_{e=0} = \underbrace{\Delta p X - c}_{\text{Effort return}} - \underbrace{\Delta p \beta I \left[\frac{q\theta + (1-q)(1-\theta)}{\theta_g p_G + (1-\theta_g)p_B + \Delta p} + \frac{(1-q)\theta + q(1-\theta)}{\theta_b p_G + (1-\theta_b)p_B + \Delta p} \right]}_{\text{Over-valuation due to no effort}} > 0.$$

The over-valuation increases in the leverage, β, because the more the entrepreneur borrows, the more the entrepreneur enjoys the over-valuation by the creditor. It is easy to see that when the leverage is sufficiently high such that the over-valuation always dominates, the only possible equilibrium is no effort; thus the choice of q does not matter. However, when the leverage is not too high, the entrepreneur may choose a q that makes the over-valuation small and dominated, and thus signals to the creditor that he has made effort. That is, the choice of q functions as a signaling device to the creditor to achieve the optimal equilibrium with effort. From Jensen's inequality, we show that the optimal q that minimizes the over-valuation is the lowest information quality, $q = 0.5$, that is,

$$\underset{q \in [0.5,\ 1]}{\arg\min} \frac{q\theta + (1-q)(1-\theta)}{\theta_g p_G + (1-\theta_g)p_B + \Delta p} + \frac{(1-q)\theta + q(1-\theta)}{\theta_b p_G + (1-\theta_b)p_B + \Delta p} = 0.5.$$

When β is so high that even the lowest information quality cannot make the over-valuation dominated, we cannot induce effort in equilibrium. With such high leverage, the creditor conjectures no effort, and thus at date 1, she asks for

$$D_S = \frac{\beta I}{\theta_S p_G + (1-\theta_S)p_B}$$

conditional on the realized signal to break even. The entrepreneur, given D_S, will pursue the project if $[\theta_S p_G + (1-\theta_S)p_B](X - D_S) - A > 0$, which is $\theta_S > \theta^u$. If $\theta_g > \theta^u > \theta_b$, the entrepreneur pursues the project only conditional on a good signal, and his ex ante payoff is $\theta q(p_G X - I) + (1-q)(1-\theta)(p_B X - I)$, which increases in q. It is easy to verify that in this case of very high leverage, the optimal information quality is the perfect information quality, $q = 1$, which is the same as in our main setting. This is because perfect information quality helps distinguish project types and induces the entrepreneur to pursue only a good-type project.

PROPOSITION 7. *In the ex ante effort setting, there exists a threshold*

$$\beta^* \equiv (\Delta p X - c)[\theta p_G + (1-\theta)p_B + \Delta p]/(\Delta p I),$$

such that,

- *if* $\beta < \beta^*$, *the optimal information quality is the lowest information quality* ($q = 0.5$)*; and*
- *if* $\beta > \beta^*$, *the optimal information quality is the perfect information quality* ($q = 1$).

Qualitatively, we find that in this ex ante effort setting, the results are similar to those in our main setting in the sense that the optimal level of information quality is high (low) when the level of financial leverage is high (low). Interestingly, we find that sometimes the entrepreneur can signal his effort decision to the creditor by choosing the lowest information quality. As lower information quality reduces his benefit from no effort, by choosing the lowest information quality, the entrepreneur can convince the creditor that he has exerted effort.[10]

7. Conclusions

In this study, we examine both information quality and financial leverage in a setting in which an entrepreneur needs financing to undertake a risky project, and the entrepreneur's effort affects the project's outcome. We show that information quality and financial leverage interact and play active roles in both the investment and effort decisions. We find that the optimal information quality has a positive association with leverage. Our study highlights the interaction of financial reporting information quality and financial leverage on efficiency through influencing firms' effort inputs.

10. With an ex ante effort decision, an interior information quality level is never optimal. This is because when the effort is determined ex ante, it is no longer contingent on the signal realization. In other words, either the always-effort case or never-effort case can be achieved, and the effort-only-with-g case cannot be achieved. As illustrated in panel B of Figure 3, an optimal interior information quality happens when the equilibrium switches from the never-effort case to the effort-only-with-g case. Because with ex ante effort there is no effort-only-with-g case, an interior information quality cannot be optimal.

Our study has some limitations that could be explored by future research. Many empirical studies that examine firms' accounting quality include leverage in their analysis, but as a control variable. In our model, we have a similar limitation that we treat leverage as exogenous. However, a firm's leverage may be affected by many factors and can be a result of endogenous decisions. For example, a firm may raise capital in other ways, such as issuing new equity or through a mixture of equity and debt. With financing choices, as information quality may play different roles in equity and debt markets, the association between information quality and leverage may change. Moreover, in our model, we assume that the entrepreneur can decide information quality ex ante, without any restrictions or costs. However, in reality, although a firm may have some control over its information system, it may not have full discretion on the information quality. The quality choice may be subject to certain restrictions from disclosure regulations as well as business environments. For example, in a complex business environment with many risk factors, firms may not be able to achieve perfect information quality. Strict disclosure regulations may also limit firms' choices of their information quality. Future work can extend our current model to obtain richer empirical predictions by considering the restrictions on information quality choice and examining the role of information quality when financial leverage is endogenous.

Appendix: Proofs

Proof of Lemma 1

When the entrepreneur has sufficient funds and does not need external debt financing, his expected payoff given signal S is (denoted by Π_S):

$$\Pi_S = \begin{cases} [\theta_S p_G + (1-\theta_S)p_B + \Delta p]X - c - I, & \text{if } e = 1; \\ [\theta_S p_G + (1-\theta_S)p_B]X - I, & \textit{if } e = 0. \end{cases}$$

Because $X(p_B + \Delta p) > I + c$ and $p_B X < I$, we have $\Delta p X > c$. It is easy to see that the entrepreneur always pursues the project and exerts effort, regardless of S. ■

Proof of Proposition 1

At date 2, the entrepreneur makes his effort decision to maximize his expected payoff conditional on signal S:

$$\Pi_S = \begin{cases} [\theta_S p_G + (1-\theta_S)p_B + \Delta p](X - D_S) - c - A, & \text{if } e = 1; \\ [\theta_S p_G + (1-\theta_S)p_B](X - D_S) - A, & \text{if } e = 0. \end{cases} \tag{1}$$

The entrepreneur makes his effort decision, e, to maximize his expected payoff. We can show that he will exert effort if

$$D_S < X - c/\Delta p. \tag{2}$$

Back to date 1, the creditor decides D_S based on her conjecture of the entrepreneur's effort decision. We first assume that the creditor conjectures effort from the entrepreneur, and the creditor's break-even condition is given by

$$[\theta_S p_G + (1-\theta_S)p_B + \Delta p]D_S = \beta I.$$

That is,

$$D_S = \frac{\beta I}{\theta_S p_G + (1-\theta_S)p_B + \Delta p}. \tag{3}$$

To sustain the creditor's conjecture of effort, we need (2) to hold, which can be rewritten as follows:

$$\beta < T(\theta_S) \equiv [\theta_S(p_G - p_B) + p_B + \Delta p]\frac{(X - c/\Delta p)}{I}. \tag{4}$$

There may exist another equilibrium in which the creditor requests a high repayment level and the entrepreneur does not make any effort. From (2), we show that the entrepreneur will not exert effort if

$$D_S > X - c/\Delta p. \tag{5}$$

We assume that the creditor conjectures that the entrepreneur exerts no effort and the creditor requires repayment D_S to break even. That is,

$$D_S = \frac{\beta I}{\theta_S p_G + (1-\theta_S)p_B}.$$

To sustain the creditor's conjecture of no effort, we need (5) to hold, which we rewrite as:

$$\beta > T^{e_L}(\theta_S) \equiv [\theta_S(p_G - p_B) + p_B]\frac{(X - c/\Delta p)}{I}.$$

Notice that $T^{e_L}(\theta_S) < T(\theta_S)$, and for any $\beta < T(\theta_S)$, there is an equilibrium with $e = 1$, whereas for any $\beta > T^{e_L}(\theta_S)$, there is an equilibrium with $e = 0$. Hence, for any $\beta \in [T^{e_L}(\theta_S), T(\theta_S)]$, both equilibria exist. In our analysis hereafter, we focus on the Pareto-dominant equilibrium, which is the equilibrium with effort $e = 1$. The no-effort equilibrium ($e = 0$) is dominated because it is inferior to the entrepreneur, and the creditor is indifferent.

Now, we consider the entrepreneur's initial investment decision on date 0, given the realized signal, S. We first consider the case of $\beta < T(\theta_S)$ (that is $e = 1$). Substituting (3) into (1) with $e = 1$, we have the entrepreneur's expected payoff conditional on signal S with effort as follows:

$$\Pi_S = [\theta_S p_G + (1-\theta_S)p_B + \Delta p]X - I - c > 0.$$

With a positive payoff, the entrepreneur always chooses to pursue the project and seek financing. If, instead, we are in the case of $\beta > T(\theta_S)$, anticipating no effort in equilibrium, the creditor requires repayment $D_S = \beta I/[\theta_S p_G + (1-\theta_S)p_B]$ to break even. Substituting D_S into (1) with $e = 0$, we have

$$\Pi_S = [\theta_S p_G + (1-\theta_S)p_B]X - I,$$

if he still decides to pursue the project and seek financing. It is easy to see that the entrepreneur will pursue the project and the creditor will fund it only when

$$\theta_S > \theta^u \equiv \frac{I/X - p_B}{p_G - p_B}. \tag{6}$$

To ensure the entrepreneur always exerts effort in equilibrium regardless of the signal, S, from (4), we need $\beta < T(\theta_b) < T(\theta_g)$. When $T(\theta_b) < \beta < T(\theta_g)$, the entrepreneur exerts effort only conditional on a good signal. Since the entrepreneur does not exert effort conditional on a bad signal, he will pursue the project and borrow only when $\theta_b > \theta^u$, which is possible only if $\theta > \theta^u$. When $\theta > \theta^u$, $\theta_b > \theta^u$ if, and only if, the signal is very noisy:

$$q < \overline{q} \equiv \max\left[\frac{\theta(1-\theta^u)}{\theta(1-\theta^u)+\theta^u(1-\theta)}, \frac{\theta^u(1-\theta)}{\theta(1-\theta^u)+\theta^u(1-\theta)}\right].$$

In this case, efficiency, represented by the entrepreneur's ex ante payoff, is given by

$$\begin{aligned}\Pi &= \Pr(S=g)\Pi_g + \Pr(S=b)\Pi_b \\ &= [\theta p_G + (1-\theta)p_B]X - I + [\theta q + (1-\theta)(1-q)](\Delta pX - c).\end{aligned}$$

Otherwise, we have $\theta_b < \theta^u$ and in equilibrium, the project is forgone conditional on a bad signal, where efficiency is given by

$$\Pi = \theta q(p_G X - I) + (1-\theta)(1-q)(p_B X - I) + [\theta q + (1-\theta)(1-q)](\Delta pX - c).$$

When $\beta > T(\theta_g)$, the entrepreneur never exerts any effort. He will pursue the project and borrow only when $\theta_S > \theta^u$. When $q > \overline{q}$, the signal is sufficiently precise to distinguish the project type and $\theta_g > \theta^u > \theta_b$. In this case, the entrepreneur chooses to pursue the project only conditional on a good signal. When $q < \overline{q}$ and $\theta > \theta^u$, the prior belief, θ, is high and the signal is very noisy, and thus $\theta_g > \theta_b > \theta^u$. In this case, the entrepreneur chooses to pursue the project. When $q < \overline{q}$ and $\theta < \theta^u$, the prior belief, θ, is low and the signal is also very noisy, and thus $\theta^u > \theta_g > \theta_b$. In this case, the entrepreneur forgoes the project. ■

Proof of Corollary 1 and Proposition 2

For Corollary 1, when $\beta < T(\theta_b)$, in equilibrium, the entrepreneur exerts effort and his ex ante expected payoff (denoted by $\Pi_{\beta < T(\theta_b)}$) is given by

$$\Pi_{\beta < T(\theta_b)} = [\theta p_G + (1-\theta)p_B]X - I + \Delta pX - c.$$

It is easy to show that $\Pi_{\beta < T(\theta_b)}$ is always strictly higher than the entrepreneur's ex ante expected payoff when $T(\theta_b) < \beta < T(\theta_g)$ (denoted by $\Pi_{T(\theta_b) < \beta < T(\theta_g)}$). Specifically, from Proposition 1, when $q < \overline{q}$ and $\theta > \theta^u$, we have

$$\Pi_{\beta < T(\theta_b)} - \Pi_{T(\theta_b) < \beta < T(\theta_g)} = [1 - \theta q - (1-\theta)(1-q)](\Delta pX - c) > 0.$$

Otherwise, we have

$$\Pi_{\beta < T(\theta_b)} - \Pi_{T(\theta_b) < \beta < T(\theta_g)} = \theta(1-q)(p_G X + \Delta pX - c - I) + (1-\theta)q(p_B X + \Delta pX - c - I) > 0.$$

Similarly, we can show that $\Pi_{T(\theta_b) < \beta < T(\theta_g)}$ is always strictly higher than the entrepreneur's ex ante expected payoff when $\beta > T(\theta_g)$ (denoted by $\Pi_{\beta > T(\theta_g)}$).

For Proposition 2, it is obvious that in the always-effort case, efficiency $\Pi_{\beta<T(\theta_b)} = [\theta p_G + (1-\theta)p_B]X - I + \Delta pX - c$ is independent of q. In the effort-only-with-g case, if $q<\overline{q}$ and $\theta>\theta^u$, we have

$$\frac{\partial}{\partial q}\Pi_{T(\theta_b)<\beta<T(\theta_g)} = (2\theta-1)(\Delta pX - c).$$

Otherwise, we have

$$\frac{\partial}{\partial q}\Pi_{T(\theta_b)<\beta<T(\theta_g)} = \underbrace{\theta(p_G X - I) + (1-\theta)(I - p_B X)}_{>0} + (2\theta-1)(\Delta pX - c).$$

One can easily see that in both cases, $\partial\Pi_{T(\theta_b)<\beta<T(\theta_g)}/\partial q > 0$ when $\theta > 1/2$. When $\theta < [X(p_B+\Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c]$, $\partial\Pi_{T(\theta_b)<\beta<T(\theta_g)}/\partial q < 0$ in both cases. When θ is in the moderate range (i.e., $[X(p_B+\Delta p) - I - c]/[X(p_G+p_B+2\Delta p) - 2I - 2c] < \theta < 1/2$), there are two possible situations depending on the level of θ^u. If $\theta>\theta^u$ and $q<\overline{q}$, $\partial\Pi_{T(\theta_b)<\beta<T(\theta_g)}/\partial q = (2\theta-1)(\Delta pX - c) < 0$ and a higher information quality reduces efficiency. Otherwise if $\theta>\theta^u$ and q is high or $\theta<\theta^u$, $\partial\Pi_{T(\theta_b)<\beta<T(\theta_g)}/\partial q = \theta(p_G X - I) + (1-\theta)(I - p_B X) + (2\theta-1)(\Delta pX - c) > 0$, and efficiency increases in q. In the never-effort case, efficiency $\Pi_{\beta>T(\theta_g)}$ is independent of q when $q<\overline{q}$, and increases in q when $q>\overline{q}$. That is efficiency $\Pi_{\beta>T(\theta_g)}$ weakly increases in q. ■

Proof of Proposition 3

Taking the first-order derivative of $T(\theta_b)$ with respect to q, we have

$$\frac{\partial T(\theta_b)}{\partial q} = -\frac{(X - c/\Delta p)}{I} \times \frac{(p_G - p_B)(1-\theta)\theta}{[(1-q)\theta + q(1-\theta)]^2} < 0.$$

That is, $T(\theta_b)$ decreases in q. Similarly, we have

$$\frac{\partial T(\theta_g)}{\partial q} = \frac{(X - c/\Delta p)}{I} \times \frac{(p_G - p_B)(1-\theta)\theta}{[q\theta + (1-q)(1-\theta)]^2} > 0.$$

That is, $T(\theta_g)$ increases in q.

One can easily see that $T(\theta_b)$ is always positive because $X - c/\Delta p > 0$. For the range of $T(\theta_g)$, as $\partial T(\theta_g)/\partial q > 0$, the highest possible $T(\theta_g)$ is achieved when q approaches 1. We show that when q approaches 1, $T(\theta_g)$ approaches $[Xp_G - cp_G/\Delta p + \Delta pX - c]/I$. As $Xp_G > I$ and $\Delta pX - c > 0$, it is easy to see that $[Xp_G - cp_G/\Delta p + \Delta pX - c]/I > 1$ if c is sufficiently low. ■

Proof of Proposition 4 and Corollary 2

From Proposition 3, the threshold, $T(\theta_b)$, decreases in q. The highest $T(\theta_b)$ is achieved when q is the lowest. That is, the highest $T(\theta_b)$ is at $q = 0.5$, which equals $\beta_1 \equiv [\theta(p_G - p_B) + p_B + \Delta p](X - c/\Delta p)/I$. If β is low ($\beta<\beta_1$), or equivalently, when θ is high ($\theta > [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$), the always-effort case can be achieved when q is sufficiently low. Therefore, the entrepreneur prefers low information quality. Specifically, the always-effort case is achieved when $\beta < T(\theta_b)$, which can be written as follows:

$$\theta_b > \frac{\beta I/(X - c/\Delta p) - (p_B + \Delta p)}{p_G - p_B}.$$

Because $\theta_b \equiv (1-q)\theta/[(1-q)\theta + q(1-\theta)]$, the condition for the always-effort case is

$$q < \left[\frac{(1-\theta)[\beta I - (X - c/\Delta p)(p_B + \Delta p)]}{\theta[(X - c/\Delta p)(p_G + \Delta p) - \beta I]} + 1\right]^{-1}.$$

When β is intermediate, $\beta_1 < \beta < \beta_2$, where β_2 is the highest value of $T(\theta_g)$ (i.e., $\beta_2 \equiv [p_G + \Delta p](X - c/\Delta p)/I$ at $q = 1$), the never-effort case is achieved when q is low and then switches to the effort-only-with-g case as q increases. According to Proposition 2, part (ii), if $\theta < [X(p_B + \Delta p) - I - c]/[X(p_G + p_B + 2\Delta p) - 2I - 2c]$, efficiency decreases in q. That is, efficiency is maximized at the level when the never-effort case just switches to the effort-only-with-g case, which is given by

$$q^o \equiv \left[1 + \frac{\theta}{1-\theta} \times \frac{(p_G + \Delta p)(X - c/\Delta p) - \beta I}{\beta I - (p_B + \Delta p)(X - c/\Delta p)}\right]^{-1}.$$

The set of conditions in Proposition 4,

$$\beta_1 < \beta < \beta_2;$$
$$\theta < \frac{X(p_B + \Delta p) - I - c}{X(p_G + p_B + 2\Delta p) - 2I - 2c},$$

is equivalent to the following set of conditions in Corollary 2:

$$\theta < \min\left\{\frac{X(p_B + \Delta p) - I - c}{X(p_G + p_B + 2\Delta p) - 2I - 2c}, \frac{\beta I/(X - c/\Delta p) - p_B - \Delta p}{p_G - p_B}\right\};$$
$$\beta < \beta_2.$$

If $\theta > 1/2$, efficiency increases in q, and is thus maximized at $q = 1$. The set of conditions,

$$\beta > \beta_1,$$
$$\theta > \frac{1}{2},$$

is equivalent to $1/2 < \theta < [\beta I/(X - c/\Delta p) - p_B - \Delta p]/(p_G - p_B)$.

When β is high, $\beta > \beta_2$, the never-effort case is always achieved regardless of q. From Proposition 2, part (iii), efficiency weakly increases in q which implies that efficiency is maximized at $q = 1$. ■

Proof of Propositions 5 and 6

As in the main setting, in the always-effort case, efficiency is independent of q_G and q_B. In the never-effort case, efficiency weakly increases in q_G and q_B. In the effort-only-with-g case, if $\theta_b = (1-q_G)\theta/[(1-q_G)\theta + q_B(1-\theta)] > \theta^u$, the project is undertaken but the entrepreneur makes no effort conditional on a bad signal, and we have

$$\Pi = \theta q_G((p_G + \Delta p)X - c) + \theta(1-q_G)p_G X + (1-\theta)(1-q_B)((p_B + \Delta p)X - c) + (1-\theta)q_B p_B X - I.$$

Otherwise (if $\theta_b < \theta^u$), the project is foregone conditional on a bad signal and we have

$$\Pi = \theta q_G((p_G + \Delta p)X - c - I) + (1-\theta)(1-q_B)((p_B + \Delta p)X - c - I).$$

In both cases, we have $\partial\Pi/\partial q_G > 0$ and $\partial\Pi/\partial q_B < 0$.

If $\beta < \beta_1$, the always-effort case can be achieved when information quality is sufficiently low, and it is optimal to have low information quality. More specifically, the always-effort case is achieved when $\beta < T(\theta_b)$, which can be written as follows:

$$\theta_b > \frac{\beta I/(X - c/\Delta p) - (p_B + \Delta p)}{p_G - p_B}.$$

Because $\theta_b = (1-q_G)\theta/[(1-q_G)\theta + q_B(1-\theta)]$, the condition for the always-effort case is

$$\frac{q_B}{(1-q_G)} < K \equiv \frac{[p_G + \Delta p - \beta I/(X - c/\Delta p)]\theta}{[\beta I/(X - c/\Delta p) - (p_B + \Delta p)](1-\theta)}.$$

If $\beta_1 < \beta < \beta_2$, the always-effort case cannot be achieved. To maximize efficiency, we must maximize the likelihood of receiving a good signal. The optimal information quality is thus $q_G = 1$ and an interior level of q_B, such that the posterior belief conditional on a good signal, θ_g, is the lowest to ensure effort, that is, $\beta = T(\theta_g)$, where $\theta_g = \theta/[\theta + (1-q_B)(1-\theta)]$. That is,

$$\beta = \left[\frac{\theta}{\theta + (1-q_B)(1-\theta)}(p_G - p_B) + p_B + \Delta p\right]\frac{(X - c/\Delta p)}{I}.$$

Thus, the optimal quality is given by

$$q_B = 1 - \frac{p_G + \Delta p - \beta I/(X - c/\Delta p)}{\beta I/(X - c/\Delta p) - (p_B + \Delta p)} \times \frac{\theta}{1-\theta} = 1 - K.$$

If $\beta > \beta_2$, the never-effort case is always achieved and perfect information quality ($q_G = q_B = 1$) is optimal. ■

Proof of Proposition 7

We define $f(x) = 1/[xp_G + (1-x)p_B + \Delta p]$, and obtain

$$f'(x) = \frac{-(p_G - p_B)}{[xp_G + (1-x)p_B + \Delta p]^2} < 0$$

and

$$f''(x) = \frac{2(p_G - p_B)^2}{[xp_G + (1-x)p_B + \Delta p]^3} > 0.$$

That is, $f(x)$ is a convex function.

From our text, the over-valuation with no effort equals

$$\Delta p \beta I\left[\frac{q\theta + (1-q)(1-\theta)}{\theta_g p_G + (1-\theta_g)p_B + \Delta p} + \frac{(1-q)\theta + q(1-\theta)}{\theta_b p_G + (1-\theta_b)p_B + \Delta p}\right],$$

which is related to the information quality, q. To find the optimal q that minimizes the over-valuation, we must solve

$$\underset{q \in [0.5,\ 1]}{\arg\min}\ [q\theta + (1-q)(1-\theta)]f(\theta_g) + [(1-q)\theta + q(1-\theta)]f(\theta_b).$$

When $q = 0.5$, $[q\theta + (1-q)(1-\theta)]f(\theta_g) + [(1-q)\theta + q(1-\theta)]f(\theta_b) = f(\theta)$. As $\theta = [q\theta + (1-q)(1-\theta)]\theta_g + [(1-q)\theta + q(1-\theta)]\theta_b$, from Jensen's inequality, we have $f(\theta) < [q\theta + (1-q)(1-\theta)]f(\theta_g) + [(1-q)\theta + q(1-\theta)]f(\theta_b)$ for any $q \in (0.5, 1]$. That is, the optimal q that minimizes the over-valuation is the lowest information quality, $q = 0.5$. ■

References

Arya, A., J. Fellingham, J. Glover, and K. Sivaramakrishnan. 2000. Capital budgeting, the hold-up problem, and information system design. *Management Science* 46 (2): 205–16.

Bertomeu, J., A. Beyer, and R. A. Dye. 2011. Capital structure, cost of capital, and voluntary disclosures. *The Accounting Review* 86 (3): 857–86.

Bertomeu, J., and E. Cheynel. 2015. Asset measurement in imperfect credit markets. *Journal of Accounting Research* 53 (5): 965–84.

Bharath, S. T., J. Sunder, and S. V. Sunder. 2008. Accounting quality and debt contracting. *The Accounting Review* 83 (1): 1–28.

Burkhardt, K., and R. Strausz. 2009. Accounting transparency and the asset substitution problem. *The Accounting Review* 84 (3): 689–712.

Chen, Q., T. Hemmer, and Y. Zhang. 2011. On the optimal use of loose monitoring in agencies. *Review of Accounting Studies* 16: 328–54.

Christensen, P. O., G. A. Feltham, and F. Şabac. 2005. A contracting perspective on earnings quality. *Journal of Accounting and Economics* 39 (2): 265–94.

DeAngelo, H., and R. M. Stulz. 2015. Liquid-claim production, risk management, and bank capital structure: Why high leverage is optimal for banks. *Journal of Financial Economics* 116 (2): 219–36.

Deng, M., L. Nan, and X. Wen. 2019. Information quality and endogenous project outcomes. *Contemporary Accounting Research* 36 (2): 732–57.

Donelson, D. C., R. Jennings, and J. Mcinnis. 2017. Financial statement quality and debt contracting: Evidence from a survey of commercial lenders. *Contemporary Accounting Research* 34 (4): 2051–93.

Friedman, H., J. Hughes, and B. Michaeli. 2020. Optimal reporting when additional information might arrive. *Journal of Accounting and Economics* 69 (2): 1–22.

Friedman, H., J. Hughes, and B. Michaeli. 2022. A rationale for imperfect reporting standards. *Management Science* 68 (3): 2028–46.

Goex, R., and B. Michaeli. 2022. Private predecision information and the pay-performance relation. *The Accounting Review*, forthcoming.

Goex, R. F., and A. Wagenhofer. 2009. Optimal impairment rules. *Journal of Accounting and Economics* 48 (1): 2–16.

Goex, R. F., and A. Wagenhofer. 2010. Optimal precision of accounting information in debt financing. *European Accounting Review* 19 (3): 579–602.

Holmstrom, B., and J. Tirole. 1997. Financial intermediation, loanable funds, and real sector. *Quarterly Journal of Economics* 112: 663–92.

Jiang, X. and M. Yang. 2021. Optimal accounting rules, private benefits of control, and efficient liquidation. Working paper.

Kanodia, C., R. Singh, and A. E. Spero. 2005. Imprecision in accounting measurement: Can it be value enhancing? *Journal of Accounting Research* 43 (3): 487–519.

Li, J., L. Nan, and R. Zhao. 2018. The corporate governance roles of information quality and corporate takeovers. *Review of Accounting Studies* 23: 1207–40.

Li, N., Y. Lou, C. Otto, and R. W. Moerman. 2021. Accounting quality and debt concentration. *The Accounting Review* 96 (1): 377–400.

Maverick, J. B. 2015. Why do debt to equity ratios vary from industry to industry? *Investopedia*, https://www.investopedia.com/articles/investing/083115/why-do-debt-equity-ratios-vary-industry-industry.asp

Michaeli, B. J. 2017. Divide and inform: Rationing information to facilitate persuasion. *The Accounting Review* 92 (5): 167–99.

Şabac, F., and J. Tian. 2015. On the stewardship value of soft managerial reports. *The Accounting Review* 90 (4): 1683–706.

Tirole, J. 2006. *The Theory of Corporate Finance*. Princeton, NJ: Princeton University Press.

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Online Appendix. Supporting information