Three Essays on Investment and Information Acquisition/Disclosure Decisions around Equity Offerings

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ABSTRACT

It is often believed that increased information flow can facilitate resource allocations and improve market efficiency in the capital market. Equity-issuing firms can play significant roles in the capital formation process, since they are a major provider of information and possess intimate knowledge about their business. Therefore it is important to understand factors that affect their disclosure incentives. In addition, regulators are concerned with formulating appropriate laws and policies to encourage more disclosure of credible information.

Previous disclosure models often assume a pure-exchange economy when analyzing equity-issuing firms' disclosure incentives. Such a setting might not be descriptive of equity offerings that involve production decisions. It is also commonly assumed that firm managers are exogenously endowed with private information. However, it usually takes efforts and resources to produce information. As stated in Christensen and Feltham (2003), "it is a manager's ability to acquire and process information efficiently that makes him an effective manager".

This thesis extends the standard "new equity" disclosure model in the literature by introducing production choices and endogenizing firms' information acquisition decisions. It studies the interaction between equity-issuing firms' productive activities and information acquisition/disclosure decisions. It consists of four parts. Chapter 1 provides a general discussion of theoretical disclosure literature, and briefly introduces the main features and results of the subsequent chapters. Chapter 2 examines how equity-issuing firms' disclosure incentives affect their investment decisions and their incentives to acquire pre-decision information. Chapter 3 examines the impact of different disclosure policies on firms' disclosure incentives and investment decisions. Chapter 4 introduces shareholder litigation, and analyzes the resulting disclosure equilibria and efficiencies of production decisions.

This research adds to our understanding of the subtle interplay of equity-issuing firms' disclosure and productions decisions. It also provides arguments for caution with respect to setting disclosure policies. It is shown that it is difficult to determine the *ex ante* optimal policy in a production economy.

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Chapter 1

Introduction

One well-known puzzle in the theoretical disclosure literature in accounting[1] is a counterintuitive but quite robust result on the inefficiencies of accounting disclosures. It is shown that in the pure exchange economy, full and partial disclosure equilibria are *ex ante* less efficient than non-disclosure equilibrium. Therefore, if shareholders could commit firm managers to a non-disclosure policy, they would actually be better off than granting managers discretion to voluntarily disclose.

The above result follows from the fact that in a pure exchange setting the only role that public information can play is to redistribute wealth among market players and if acquisition and/or disclosure of additional information is costly, efforts to create a more informative public information system are *ex ante* inefficient.[2]

[1] In addition to Verrecchia (2001) and Dye (2001)'s review papers, another excellent reference on disclosure literature is Christensen and Feltham (2003).

[2] In addition, if the market participants are risk averse, early disclosure can make all the participants collectively worse off if it precludes them from insuring their risks through trading (Hirshleifer 1971).

To solve this puzzle, previous literature has proposed several approaches (Verrecchia 2001). The first approach is to consider the role of public accounting information in reducing costly private information acquisition while maintaining the assumption of the pure exchange economy. The second approach tries to introduce production decisions so that better information can potentially improve social welfare by facilitating decision-making in productions. A third approach is to explore the impact of accounting disclosures on reducing the cost of capital.[3]

This thesis follows the second approach and adopts a productive setting to investigate the disclosure of pre-decision productivity information. As Christensen and Feltham (2003) point out, as long as the manager chooses production plans to maximize the firm's intrinsic value, the product markets are competitive, and investors are well-diversified, "*achievement of Pareto efficiency does not require that firm-specific productivity information be reported to investors*". Therefore, a non-disclosure equilibrium can continue to dominate a partial or full disclosure equilibrium even in a production economy.

However, firms might prefer to disclose their private information to outside investors under certain circumstances, such as when issuing new equity. This is because disclosure can affect market perception of firm value and firms with favorable private information may want to share the good news with investors to get better prices when selling their stocks.

The equity offering setting is adopted by many disclosure models in the existing ac-

[3]See, for example, Baiman and Verrecchia (1996) and Verrecchia (1999, 2001). These papers argue that more informative disclosure can lower the cost of raising equity capital by reducing the premium paid to the liquidity traders during equity issuances.

counting literature. In these "new equity" disclosure models, it is usually assumed that a risk-neutral entrepreneur (or a manager who represents the collective interests of risk-neutral shareholders), makes disclosure decisions to maximize the current market value of the firm's equity. One important result is that when disclosure is costless and truthful, and investors are certain that the manager has private information, a full disclosure equilibrium will prevail (Grossman 1981). On the other hand, when disclosure is costly, or investors are uncertain about the information endowment of the firm manager, there is a partial disclosure equilibrium, in which the manager discloses her private signal if, and only if, it exceeds a cutoff value. In addition, most of these previous studies assume a pure-exchange setting that involves no production.

The existing pure-exchange disclosure models have not considered the following features of the equity offerings in the real economy. First, one of the most common purposes for issuing equity is to raise capital to finance an investment project such as establishing a new business or expanding an existing business.[4] Therefore, equity offerings often involve production decisions. Second, private information held by an issuing firm is likely to be related to its future prospects, especially the profitability of the investment to be financed. This implies that managers can use the information both to facilitate internal production decisions, and to influence investors' perceptions of firm value.

Given these features, there can be interactions between a firm's investment and acquisition/disclosure of information in equity offerings. First, the private signal to be disclosed is

[4]Other reasons for issuing equity include debt repayment and distribution to pre-IPO shareholders, etc. See Leone et al (2003).

pre-decision information and knowledge of such information can lead the firm to change its production plan. Second, when a firm raises capital to finance a project, disclosure affects the firm's investment decision through its impact on investors' valuation and therefore the fraction of equity the firm has to provide in exchange for the capital. Whether an investment project is implemented depends on whether the firm is able to raise the required capital and the terms of the equity offering (i.e., the fraction of equity exchanged). Third, the firm makes the information acquisition decision in anticipation of its later investment and disclosure decisions. It trades off the acquisition cost against the productive value of the information and the potential misvaluation resulting from her inability to disclose if it has not acquired information before issuing equity. The misvaluation occurs since investors might be unable to distinguish whether the non-disclosure occurs because the firm is uninformed or it is withholding a bad signal.

The thesis extends prior research to analyze the interaction between firms' productive activities and information acquisition/disclosure decisions. It is organized as follows. Chapter 2 examines this issue by introducing production into a new-equity disclosure model and endogenizing firms' information acquisition decisions. Chapter 3 analyzes the impact of different disclosure policies on firms' disclosure incentives and investment decisions. Chapter 4 introduces shareholder litigation, and analyzes the resulting disclosure equilibria and efficiencies of production decisions. Each of these chapters is introduced in more detail as follows.

Brief Discussion of Chapter 2

The model developed in Chapter 2 has the following fundamental characteristics. There are two players, a risk-neutral entrepreneur (or a firm manager motivated to maximize the current shareholders' interests), and a group of risk-neural investors. Each player makes the following choices sequentially.

At $t = 0$, the entrepreneur has an investment opportunity that requires an investment of $\bar{q}$. She can choose to purchase a private signal y_i about the profitability of the new project, at a cost κ. At $t = 1$, a public report y_a is released. After observing the public report and the acquisition cost, the entrepreneur decides whether to acquire the signal. At $t = 2$, based on her information set, the entrepreneur decides whether to invest and/or disclose her private information. If she is uninformed, she has two decision choices: invest or not invest. If she is informed, she simultaneously decides whether to invest and whether to disclose the private signal.

If she decides to undertake the project, she raises capital from the stock market by offering investors a fraction α of the firm's equity in exchange for $\bar{q}$. Assume that δ is the maximum price the investors are willing to pay. The investors agree to provide the capital as long as $\alpha \geq \bar{q}/\delta$. In a competitive market, the entrepreneur offers $\alpha = \bar{q}/\delta$. The investors price the firm based on their information set at $t = 2$, $\Psi_2 = (y_a, m, q)$, where m is the entrepreneur's report ($m = y_i$ if the entrepreneur discloses, and $m = n$ if the entrepreneur does not disclose), and q is the entrepreneur's investment decision. At $t = 3$, if the entrepreneur has invested in the project, the payoff is realized and shared between the two players. Otherwise, the terminal cash flow is zero.

Some of the key assumptions are discussed below.

1. Following the work of Dye (1985) and Jung and Kwon (1988), the model imposes some uncertainty on the entrepreneur's information endowment. Specifically, it is assumed that the information acquisition cost is a random variable *ex ante* and realized before the entrepreneur makes the information purchase decision. We also assume that with a positive probability the entrepreneur will receive a null signal after incurring the acquisition cost. Under these assumptions, in equilibrium, there is a positive probability that the entrepreneur is uninformed. When the investors observe no disclosure from the entrepreneur, they cannot distinguish whether it is because the entrepreneur has not acquired information, or she has acquired information but received an uninformative signal, or she has received an informative signal but decides to withhold it due to the adverse content. Such uncertainty can prevent unravelling from happening, and result in a partial disclosure equilibrium.

2. We assume that the only sources of information for the investors are the public report, the entrepreneur's disclosure, and her investment decision. That is, we do not allow for the possibility that the investors could have access to alternative information sources, or the entrepreneur could convey her private information through other mechanisms (such as underwriter reputation or auditor quality). We believe that this assumption is valid as long as the investors could not fully infer or uncover the entrepreneur's private information. Direct disclosure can be important if it is incrementally informative be-

yond all the other alternative information. In addition, if other disclosure mechanisms are more costly, direct disclosure can have a positive role in the economy.

3. Both players are risk-neutral. If, instead, the entrepreneur is risk-averse, we have to consider the signalling role of the fraction of the equity offered to investors (or the fraction retained by the entrepreneur). Then in equilibrium the entrepreneur can use a combination of both equity retention and direct disclosure to convey her private information. By assuming the entrepreneur is risk-neutral, we simplify the analysis and also focus on the role of direct disclosure.

4. Disclosure is truthful whenever the entrepreneur reports her private information to the investors. First, this assumption is a standard assumption in the literature and is typically justified by the anti-fraud legislation and reputation concerns. Second, the chapter focuses on disclosure of truthful forward-looking information, and how such disclosures affect firms' productive decisions. Third, maintaining a balance between encouraging more disclosure and deterring misleading disclosure has always been one of the biggest challenges in disclosure regulation. This tension becomes even more severe in the case of management forecasts. The major reason is that determining the truthfulness of forward-looking information is difficult, since such information cannot be verified. The actual result might be used to verify the forecast, but a deviation between the two can be attributable to poor forecast skills, or various risk factors beyond managers' control. However, we admit that allowing for the possibility of lying could potentially shed more light on firms' incentive to misreport in the real economy.

5. There are no agency problems in the current setting. The model adopts an entrepreneurial setting, and therefore abstracts from many contracting and other agency issues, since the entrepreneur makes decisions to maximize her own interest. In the real world, firms can be managed by a manager hired by initial owners. There are studies which examine firms' disclosure in an agency setting, such as Gigler and Hemmer (1998 and 2001).

Let us now discuss the main characteristics of the equilibria. Depending on parameter values, there are two potential disclosure equilibria. One is a partial disclosure equilibrium, in which the entrepreneur discloses if, and only if, the private signal is above a certain threshold. This result is consistent with that of previous studies that assume investors are uncertain about the manager's information endowment. In the other equilibrium, the entrepreneur fully discloses whenever she issues equity. The latter equilibrium can be sustained if the investors can credibly threaten to offer a very low price if the entrepreneur issues equity but does not make any disclosure.

The analysis shows that firms' *ex post* disclosure incentives can distort their investment and *ex ante* information acquisition decisions. First, overinvestment can be induced when firms' shares are overvalued and the overpricing offsets the loss from undertaking a negative NPV project. Second, the entrepreneur has incentives to acquire too much private information so that she can strategically use the information to influence the share price of the offering. This result is consistent with that of Shavell (1994) and Pae (2002). Both show that voluntary disclosure results in sellers' socially excessive incentives to acquire information.

Our work contributes to both the theoretical disclosure and the corporate finance literature. We extend prior research on examining firms' disclosure practices in productive settings and reconfirm Dye's caution that a production economy is not an obvious setting for public disclosure to have a positive net social value.[5] Our analysis also reveals other "side effects" of equity-financing. In addition to the possible negative market reaction to the announcement of the equity issuing decision (Myers and Majluf, 1984), equity-financing can make the current shareholders worse off due to the inefficiencies associated with the issuing firm's suboptimal information acquisition and investment decisions during the offering.

Among a small number of papers in this area, Pae (2002) is most closely related to our work. Pae (2002) also analyzes the acquisition and disclosure of pre-decision information in a production-based model and shows that the production decisions are distorted by the entrepreneur's discretionary disclosure. However, our model differs from Pae's model in several aspects. First, Pae (2002) has a distinct model setting. In Pae's model, there is a competitive market with a large group of entrepreneurs selling their assets. Each entrepreneur puts in some effort before the sale of the asset, and after gaining the control rights the investors continue to make the capital investment decision. Therefore disclosure not only influences the investors' valuation of the asset, but also effects their post-purchase investment decision. If the private information is not disclosed, the investors will then have to make "uninformed" productive decisions. In contrast, in our setting there is only one entrepreneur who makes all the information acquisition, investment and disclosure decisions. This implies that the

[5]See Dye (2001), pages 191-197.

information can be used in the production even if it is not publicly disclosed. Another major difference between ours and Pae's model is that Pae assumes the fraction of uninformed entrepreneurs is exogenous and informed entrepreneurs can choose the informativeness of their signals, while we assume that the probability the entrepreneur is uninformed is endogenously determined in the equilibrium and the entrepreneur decides whether to acquire a signal with a given precision.

Brief Discussion of Chapter 3

In recognition of the importance of the legal environment and disclosure regulation for equity-issuing firms' disclosure practices, Chapter 3 investigates the impact of *ex ante* disclosure policies on IPO firms' incentives to acquire forward-looking information and their investment decisions. It examines three disclosure policies, Non-Disclosure, Voluntary Disclosure and Mandatory Disclosure Regimes. All these policies can be found in real countries.

The model is built upon the one developed in Chapter 2, with the following major differences. First, the entrepreneur might no longer be able to voluntarily choose whether to disclose her private information. Instead she has to comply with a certain disclosure policy that could enforce non-disclosure or full disclosure. Second, the entrepreneur is now assumed to own both an existing asset and a new investment project. In addition to the private forward-looking information about the profitability of the new project (y_i), there is also a signal about the performance of the existing asset (y_h). Such historical information is mandated to be disclosed in the offering. The sequence of decisions made by the two players is similar to what is described in Chapter 2. The entrepreneur chooses: (1) whether to acquire information at $t = 1$; (2) whether to invest and/or disclose at $t = 2$. The investors choose whether to provide the capital at $t = 2$. As to the information sets of the two players, the entrepreneur observes y_h, the realization of the random information cost κ, and y_i if she acquires information; the investors observe y_h, q (the entrepreneur's investment decision), and y_i if the entrepreneur discloses y_i.

The analysis shows that disclosure regulation plays an important role in IPOs. It not only affects the total information available to investors, but also has externalities on firms' real decisions. In addition, different disclosure policies are associated with different distortions in firms' information acquisition and investment decisions. Neither the Mandatory or the Voluntary Disclosure Regime is necessarily more efficient than the Non-Disclosure Regime in equity offerings that involve production decisions.

This chapter extends prior studies on how *ex post* disclosure decisions can distort firms' *ex ante* incentives to acquire information. Shavell (1994) examines this issue in a general sales transaction setting and one important insight from his study is that voluntary disclosure results in sellers' socially excessive incentives to acquire information. Our analysis confirms this finding in a financial reporting setting and generates additional insights by showing that a Non-Disclosure regime can instead reduce firms' incentives to produce information that has social value.

It also contributes to the literature on disclosure regulation. The prior studies with which we are familiar focus on the comparison of the voluntary disclosure and the mandatory disclosure policies. That is, the question considered is whether to force firms to disclose or to let them choose whether to disclose. This chapter also analyzes another policy choice, a Non-Disclosure Regime that inhibits disclosure.

Another feature is that the disclosure policies modelled in this chapter are not contingent on firms' information endowment. In particular, we assume that under the Full Disclosure policy, the firm has to satisfy the disclosure requirement even if it is uninformed. Prior studies such as Shavell (1994) and Admati and Pfleiderer (2000) consider a mandatary policy that forces firms to disclose only if they have private information. Such a policy will be difficult to enforce, since it requires that any concealment of private information be detected and punished. However, it is usually very difficult to prove in courts that a firm manager has received certain private information and intentionally withheld it from investors. On the other hand, the disclosure regimes modelled in our work are enforceable and are also consistent with the actual disclosure policies adopted in various countries.

Brief Discussion of Chapter 4

The last chapter explicitly models shareholder litigation as an important force that affects IPO firms' disclosure incentives. It is mainly motivated by the SEC's recent proposal to reform the communication process in securities offerings. The analysis is intended to shed light on issues such as whether the regulators should provide a safe harbor for IPO firms' disclosure of forward-looking information and whether IPO firms should be required to file a forecast in their filings.

The model has three risk-neutral players, an entrepreneur, a group of investors, and a lawyer. The players make the following choices. At $t = 1$, the entrepreneur observes y_i with a positive probability. Based on her information set, she decides whether to invest and/or disclose her private signal in the form of a management forecast. If she decides to invest, she offers a fraction of her firm's equity in exchange for $\bar{q}$. The investors choose whether to accept or reject the offer. At $t = 2$, if the project has been implemented, the terminal cash flow is realized and observed by all players. The investors can hire a lawyer to file a lawsuit against the entrepreneur, if the realized result falls below the forecast disclosed at $t = 1$. The lawyer decides whether to undertake the legal action based on the tradeoff of his litigation cost and the fee paid by the investors.

Unlike the previous chapters, the entrepreneur is assumed to be exogenously endowed with a private signal with a positive probability. In addition, disclosure is no longer costless. In this sense, the model is in line with Verrecchia (1983) which shows that a partial disclosure equilibrium can occur if disclosure incurs a cost. A major difference between our model and Verrecchia (1983)'s model is that the disclosure cost in our model is endogenously determined by the lawyer's actions, while he assumes that the cost is exogenous. Other disclosure models, such as Darrough (1993), also consider endogenous disclosure costs, but the costs are usually assumed to arise from product market competition.

The full and partial disclosure scenarios are endogenously determined in the equilibrium depending on the economy parameters. The results predict that if the legal liability is reduced (for example, if a safe harbor is provided for forward-looking information disclosed by IPO firms), there can be more information flow to the public. However, such a safe harbor could also lead to a higher rate of lawsuits and an increase in deadweight litigation costs. As for the issue on whether to require issuing firms to file projections, it is shown that a Full Disclosure policy is not necessarily optimal since it is associated with both a social loss due to underinvestment and a higher litigation-related deadweight cost.

Chapter 2

A New-Equity Disclosure Model

2.1 Introduction

In this chapter, we develop a simple one-period model to investigate the interaction between investment and acquisition/disclosure of pre-decision information. At the very beginning (date zero), a risk-neutral entrepreneur (or a firm manager motivated to act in the current shareholders' best interests) has an investment opportunity which requires an investment of $\bar{q}$. Assume that she tries to raise capital from the stock market by offering new investors part of the firm's equity in exchange for $\bar{q}$. A public report is released before any decisions are made. After observing the public report, the entrepreneur decides whether to acquire some private information about the project. We assume that the information acquisition cost is a random variable *ex ante* and realized before the entrepreneur makes the information purchase decision. We also assume that with a positive probability the entrepreneur will receive a null signal after incurring the acquisition cost.

The chapter first examines a benchmark case in which the entrepreneur self-finances the investment project. We show that the additional private information is always valuable since it improves economic welfare by helping the entrepreneur make better investment decisions. The entrepreneur makes the information acquisition decision according to a cutoff. If the realized value of the acquisition cost is lower than the cutoff, she acquires the information, and she does not acquire otherwise. We show that in the self-financing case, the acquisition cost cutoff equals the productive value of the additional private information.

We then analyze the case when the entrepreneur issues equity to finance the project. The entrepreneur has three possible decisions to make. First, she chooses whether to acquire additional information. If she acquires the information, then she decides whether to issue equity and undertake the project, and whether to disclose the private signal to the investors.

We have the following major findings. *Ex ante* (before observing the public report, and making all the decisions), the entrepreneur is worse off if she has to raise capital to finance the investment project. The equity-financing is associated with three potential efficiency losses. First, the entrepreneur's information acquisition decision can be inefficient. She might overinvest in acquiring private productivity information. Second, when the entrepreneur is uninformed and unable to disclose, she might have to give up profitable projects due to the severe underpricing by the investors. Third, when the entrepreneur is informed, she might invest in negative NPV projects.

Overall, such information acquisition and investment decisions make the entrepreneur worse off, because in the rational expectations equilibrium the investors on average break even and it is the entrepreneur herself who ultimately bears the efficiency losses incurred by her own decisions.

This chapter is organized as follows. The next section introduces the basic settings of the model. Then, as our benchmark case, we investigate the entrepreneur's information acquisition and investment decisions when she has ample internal capital to finance the project. Section 2.4 examines the information acqusition/disclosure and investment decisions when the entrepreneur employs outside-financing. Section 2.5 compares the entrepreneur's information acquisition and investment decisions with those in the benchmark case. The last section concludes this chapter.

2.2 Model Setting

Consider a setting in which a firm is owned by a risk-neutral entrepreneur.[1] The entrepreneur has an investment opportunity which requires an investment of $\bar{q}$ and will generate a gross payoff $\tilde{x}$. $\tilde{x} = (1+\theta)\bar{q} + \tilde{\epsilon}$, where θ is the net unit rate of return (a constant), and $\tilde{\epsilon}$ is the noise term.[2] Assume that $\tilde{\epsilon}$ is normally distributed, with mean 0 and variance σ^2. Both θ and $\bar{q}$ are assumed to be common knowledge.

At the beginning of the period, a report y_a about $\tilde{\epsilon}$ becomes publicly available.[3] Represent

[1]Alternatively, we can assume that the firm is owned by well-diversified investors, who hire a manager to operate their firm. The manager is assumed to be exogenously motivated to act on behalf of current shareholders.

[2]For a summary of notation used in this paper, please refer to the Appendix.

[3]Examples of such public reports are Consumer Confidence and Unemployment Report, etc., often issued by government agencies and business research groups.

y_a as $\tilde{\epsilon} = \tilde{y_a} + \tilde{\epsilon_a}$, where $\tilde{y_a} \sim \mathrm{N}(0, \sigma_{ya}^2)$ and $\tilde{\epsilon_a}$ is independent of $\tilde{y_a}$.[4] Under such a representation, y_a is also the entrepreneur's (also the investors') posterior mean with respect to the random component in the gross return of the investment project, i.e., $y_a = E[\tilde{\epsilon}|\tilde{y_a} = y_a]$.

After observing the public report, the entrepreneur can choose to acquire information about the remaining uncertainty, $\tilde{\epsilon_a}$, at a cost of κ. If she pays κ, she will privately observe a signal y_i, which is represented as $\tilde{\epsilon_a} = \tilde{y_i} + \tilde{\epsilon_{ai}}$, where $\tilde{y_i} \sim \mathrm{N}(0, \sigma_{yi}^2)$ and $\tilde{\epsilon_{ai}}$ is independent of $\tilde{y_i}$. The information acquisition cost, κ, is assumed to be a random variable *ex ante* with a cumulative distribution function of $S(\kappa)$. The entrepreneur observes the realized value of κ before making the information acquisition decision.

Assume that after acquiring information, there is a probability γ ($\gamma \in [0, 1)$) that the entrepreneur receives a null signal (or uninformative signal), $y_i^0 = 0$, which does not change the entrepreneur's belief about $\tilde{\epsilon_a}$, i.e., $E[\tilde{\epsilon_a}|y_i^0] = E[\tilde{\epsilon_a}] = 0$.

Assume that if the entrepreneur decides to invest, she raises capital from the stock market to finance the investment project. She offers the investors a fraction of her firm's equity in exchange for $\bar{q}$.

[4] We can also model $\tilde{y_a}$ as $\tilde{\epsilon}$ plus noise. These two representations are equivalent and one can be easily transformed into the other. However, the form adopted in the paper generally produces neater results. We can interpret $\tilde{\epsilon} = \tilde{y_a} + \tilde{\epsilon_a}$ as signal y_a resolving part of the uncertainty in $\tilde{\epsilon}$.

2.3 Benchmark Case: Self-Financing

2.3.1 Information Acquisition and Investment Decisions

In this section we briefly examine a benchmark case in which the entrepreneur self-finances the investment project. The time line of the model is shown in Figure 2.1.

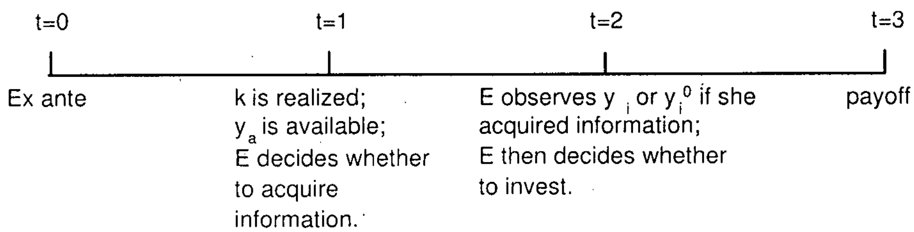

Figure 2.1: Sequence of Events when Project is Self-financed.

The entrepreneur's decisions are analyzed using backward induction. At $t = 2$, the entrepreneur observes the public report y_a and the realized value of the private information acquisition cost. Conditional on the public report y_a, if the entrepreneur has not acquired information, her expected payoff is $U_2^{ui}(y_a) = E[\tilde{x}|y_a, q = \bar{q}] - \bar{q} = \theta\bar{q} + y_a$ if investing ($q = \bar{q}$), and zero if she does not invest ($q = 0$). Therefore, she invests if $\theta\bar{q} + y_a > 0$ and not invest otherwise. Her expected payoff at $t = 1$ if not acquiring information then is $U_1^{na}(y_a) = Max\{0, \theta\bar{q} + y_a\}$.

If the entrepreneur has acquired private information and received an informative signal at $t = 1$, given y_a, y_i, and her decision to invest, her expected payoff at $t = 2$ is $U_2^i(y_a, y_i) = E[\tilde{x}|y_a, y_i, q = \bar{q}] - \bar{q} = \theta\bar{q} + y_a + y_i$. Her expected payoff is zero if she does not invest. Therefore, she invests if $\theta\bar{q} + y_a + y_i > 0$ and not invest otherwise. On the other hand, if she has received an uninformative signal, her investment decision is the same as when she has not acquired information and her indirect utility at $t = 2$ is $U_2^*(y_a, y_i^0) = Max\{0, \theta\bar{q} + y_a\}$. It follows that the entrepreneur's expected payoff at $t = 1$ from acquiring information is $U_1^a(y_a, \kappa) = \gamma \ Max\{0, \theta\bar{q} + y_a\} + (1-\gamma) \ \int_{-\theta\bar{q}-y_a}^{+\infty} \ (\theta\bar{q} + y_a + y_i) \ d \ F(y_i) - \kappa$, where $F(y_i)$ is the cumulative distribution function of y_i.

Denote the posterior mean of the project's NPV (net present value) given y_a and investment level $\bar{q}$ as $p(y_a)$, i.e., $p(y_a) \equiv E[\tilde{x}|y_a, q = \bar{q}] - \bar{q} = \theta\bar{q} + y_a$. The value of information, gross of the information acquisition cost, is represented as follows:

$$V(p) = \begin{cases} (1-\gamma) \ \int_{-\infty}^{-p}[-(p + y_i)] \ \mathrm{d} \ F(y_i) & \text{if } p > 0, \\ (1-\gamma) \ \int_{-p}^{+\infty}(p + y_i) \ \mathrm{d} \ F(y_i) & \text{if } p \leq 0. \end{cases}$$

It is easy to prove the following proposition regarding the value of the additional private information.[5]

Proposition 2.1 *When investment project is self-financed, additional costless private information is always valuable, i.e.,* $V(p(y_a)) > 0 \quad \forall y_a$.

In this setting, private information is valuable because it improves economic welfare through changes in investment decisions. When the project NPV given the public report is positive ($p > 0$), the entrepreneur, if uninformed, always invests, while if she is informed, she invests only if $E[\tilde{x}|y_a, y_i, \bar{q}] = p(y_a) + y_i > 0$. Therefore additional information y_i enables the entrepreneur to avoid investing in unprofitable projects. On the other hand, when

[5]The proofs for Proposition 2.1 and 2.2 are straightforward, and therefore not provided.

$p \leq 0$, the uninformed entrepreneur does not invest and therefore receives zero payoff. However, if she acquires private information and the signal is informative, she can earn a positive expected profit by investing in projects with $p + y_i > 0$. Therefore, as long as the value of the information exceeds its cost, the entrepreneur is better off by acquiring the private information. The following proposition characterizes the entrepreneur's information acquisition and investment decisions when the project is self-financed.

Proposition 2.2 *When the entrepreneur self-finances the investment project, given the public report, she acquires information according to a cost cutoff $\kappa^*(p)$ which equals the value of information $V(p)$ defined above. If $\kappa < \kappa^*(p)$, the entrepreneur acquires information, and invests only if $p + y_i > 0$. If $\kappa \geq \kappa^*(p)$, the entrepreneur does not acquire information, and invests only if $p > 0$.*

2.3.2 Comparative Statistics

Now we analyze the impact of exogenous parameters (p, σ^2_{yi} and γ) on the entrepreneur's decisions, holding the variance of $\tilde{\epsilon_a}$ constant.

Proposition 2.3 (i) *The value of information (or information acquisition cost cutoff) increases in p when $p \leq 0$ and decreases in p when $p > 0$, where $p \equiv \theta\bar{q} + y_a$. The information is most valuable when $p = 0$.* (ii) *Additional private information is more valuable and the entrepreneur is more likely to acquire information, if the signal is more informative, i.e., σ^2_{yi} is larger.* (iii) *Acquiring information is less beneficial, if there is a larger probability that the entrepreneur will receive a null signal.*

The intuition is straightforward. If the project NPV given the public report is positive, the value of information arises from the possibilities that it helps the entrepreneur identify posterior unprofitable projects. If the entrepreneur acquires further information and finds out the project is expected to lose money, she does not invest, while without such information, she would have invested in it. That is, the investment decision is revoked when $y_i \in (-\infty, -p]$. The larger the project NPV given the public report, the less room for the signal to improve production efficiency by avoiding unprofitable projects. On the other hand, when the project is negative NPV based on the public report, the entrepreneur, when uninformed, does not invest. But she invests and earns positive profits if she is informed and the project is expected to be profitable given both public and private signals. The no-investment decision is reversed when $y_i \in (-p, +\infty)$. The larger the project NPV based on the public report, the more room for the signal to improve production efficiency by recovering posterior profitable projects.[6] Figure 2.2 shows the value of information as a function of the project NPV based on the public report.

To understand the second part of Proposition 3, recall that we model the signal as $\tilde{\epsilon_a} = \tilde{y_i} + \tilde{\epsilon_{ai}}$. When the total uncertainty in $\tilde{\epsilon_a}$ is held constant, the larger the variance of $\tilde{y_i}$, the more uncertainty about $\tilde{\epsilon_a}$ is resolved by the private signal and the more informative the signal. An increase in σ_{yi} shifts y_i's probability density function towards the tails. Consequently, more unprofitable projects (i.e., projects in the left tail) can be avoided with the pre-decision information when the prior project NPV is positive, and more profitable

[6] Remember a larger negative number implies a smaller absolute value.

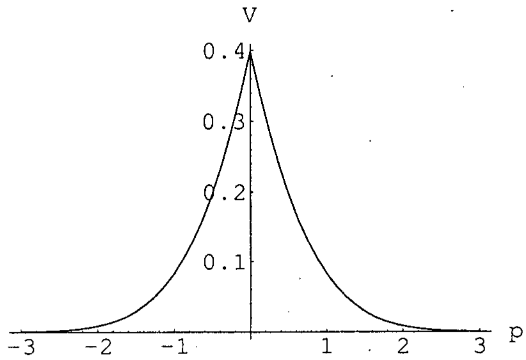

Figure 2.2: The Value of Information as a Function of the Project NPV based on the Public Report when Project is Self-financed ($\gamma = 0$, $\sigma_{yi}^2 = 1$).

projects (i.e., projects in the right tail) can be recovered when the prior project NPV is negative, which makes acquiring information more attractive. Figure 2.3 shows the relation between the value of the information and the informativeness (σ_{yi}) of the private signal.

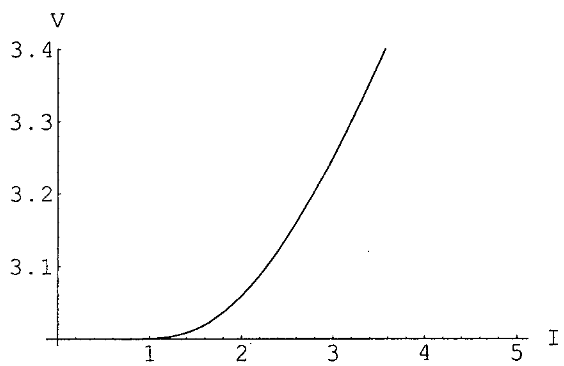

Figure 2.3: The Value of Information as a Function of Informativeness (I=σ_{yi}) of the Signal y_i when Project is self-financed ($\gamma = 0$, $p = 3$).

The third result of the proposition is quite obvious. The higher the probability that the entrepreneur receives a null signal when she acquires information, the more likely it is that she ends up making the same investment decisions as when she does not acquire information. Therefore, it is less beneficial for her to acquire the information.

2.4 Analysis of Equity-Financing

In this section, assume instead that if the entrepreneur decides to invest, she uses the stock market to raise all the capital required to finance the investment project . The entrepreneur offers a fraction α of the firm's equity to the investors in exchange for $\bar{q}$. The investors can either accept or reject the offer. Assume that δ is the maximum price the investors are willing to pay. Then the minimum fraction of shares the entrepreneur has to issue is $\alpha = \bar{q}/\delta$. The investors price the firm based on their information set at $t = 2$, $\Psi_2 = (y_a, m, q)$, where m is the entrepreneur's report ($m = y_i$ if the entrepreneur discloses, and $m = n$ if the entrepreneur does not disclose the information).[7] That is, $\delta = E[\tilde{x}|y_a, m, q]$.

Figure 2.4 shows the sequence of the events and various decisions the entrepreneur makes during the whole period.

At $t = 1$, the entrepreneur and the investors receive a public report about the noise term of the project's gross payoff ($\tilde{\epsilon}$). Based on the public report and the realization of the information acquisition cost, the entrepreneur decides whether to spend κ to acquire private information about the remaining uncertainty ($\tilde{\epsilon_a}$).

At $t = 2$, if the entrepreneur has not acquired the information (na) or she has received

[7] In our model, we assume that the only sources of information for the investors are the public report and the entrepreneur's disclosure/investment decisions.

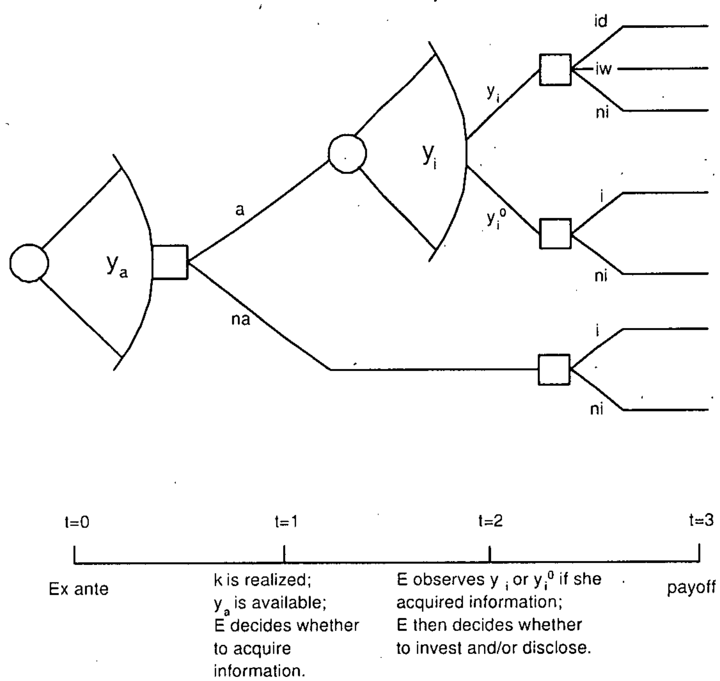

Figure 2.4: Sequence of Events when the Entrepreneur Raises Equity Capital to Finance the Project

a null signal (y_i^0), she chooses between investing (in) and not investing (ni). On the other hand, if she has acquired the private information (a) and received an informative signal, she decides whether to invest and whether to disclose her private information. She can choose among three sets of actions: investing and disclosing y_i (id), investing but withholding private information (iw), and not investing (ni).

At the end of the period ($t = 3$), if the entrepreneur has invested in the project, the project's payoff is realized. Otherwise there is zero payoff.

In the following parts, we analyze the sequential game using backward induction.

2.4.1 The Entrepreneur's Investment Decision when She is Uninformed

Represent the entrepreneur's information set at $t = 2$ as Ψ_E, where $\Psi_E = \{y_i\}$ if she is informed, $\Psi_E = \{y_i^0\}$ if she acquired private information but received a null signal, and $\Psi_E = \emptyset$ if she has not acquired private information. At $t = 2$, the entrepreneur is uninformed when either she has not acquired information or she has acquired information but received a null signal. Assume that the entrepreneur is not able to make any disclosure when she is uninformed. Therefore, when she issues equity, the investors observe no disclosure.

Rational investors know that there are three possibilities when they observe no disclosure and the entrepreneur's decision to invest: (1) the equity-issuing entrepreneur is uninformed because she has not acquired private information, (2) she has acquired information but received a null signal, (3) she has received an informative signal from her information acquisition but is withholding the information. The investors impound all these possibilities into their valuation of the firm.

Lemma 2.1 *Assume that the investors believe that with probability λ^c the entrepreneur has not acquired information. Their* ex investment *valuation of the firm given no disclosure $(m = n)$ and the entrepreneur's decision to invest $(q = \bar{q})$ is then represented as follows:*

$$\delta^n \equiv E[\tilde{x}|p, m = n, q = \bar{q}, \lambda^c] = p + \bar{q} + y_i^n(p, \lambda^c)$$

where

$$
\begin{aligned}
y_i^n(p,\lambda^c) &= \frac{\lambda^c \cdot 0 + (1-\lambda^c)\ \gamma \cdot 0 + (1-\lambda^c)\ (1-\gamma)\ E\left[\tilde{\epsilon}|p, q=\bar{q}, m=n, \Psi_E=\{y_i\}\right]}{\lambda^c\ P_1 + (1-\lambda^c)\ \gamma\ P_2 + (1-\lambda^c)\ (1-\gamma)\ P_3} \\
&= \frac{(1-\lambda^c)\ (1-\gamma)\ E\left[\tilde{\epsilon}|p, q=\bar{q}, m=n, \Psi_E=\{y_i\}\right]}{\lambda^c\ P_1 + (1-\lambda^c)\ \gamma\ P_2 + (1-\lambda^c)\ (1-\gamma)\ P_3} \\
P_1 &= Prob(q=\bar{q}, m=n, \Psi_E=\emptyset) \\
P_2 &= Prob(q=\bar{q}, m=n, \Psi_E=\{y_i^0\}) \\
P_3 &= Prob(q=\bar{q}, m=n, \Psi_E=\{y_i\}).
\end{aligned}
$$

To illustrate, $y_i^n(p,\lambda^c)$ is the weighted average of the investors' posterior beliefs about $\tilde{\epsilon}$ in the three possibilities, and the first equality of its expression follows because the investors' posterior mean about the noise term given that the entrepreneur is uninformed (either because she has no private information or she has a null signal) is zero.

Assume that the entrepreneur conjectures that the investors believe with probability λ^0 she has not acquired information. When the entrepreneur is uninformed, her expected payoff given the public report and the investment decision then is

$$
U_2^{ui}(p,\lambda^0,q) = \begin{cases} (p+\bar{q})(1-\frac{\bar{q}}{\delta^n}) & \text{if } q=\bar{q}, \\ 0 & \text{if } q=0, \end{cases}
$$

where p is the project NPV based on the public report ($p \equiv \theta\bar{q}+y_a$, which is *ex ante* normally distributed with mean $\theta\bar{q}$ and variance σ_{ya}^2).

Therefore, the entrepreneur invests and receives a positive expected payoff if and only if $p+\bar{q}>0$ and $\delta^n>\bar{q}$. When the investors' valuation of the firm given the entrepreneur's decision $q=\bar{q}$ and no disclosure is equal to or less than $\bar{q}$ (or equivalently, $y_i^n(p,\lambda^c)\leq -p$), the entrepreneur does not raise capital if she is uninformed, since she has to give up 100%

or more of her firm's equity to obtain $\bar{q}$. Without capital she cannot invest in the project even if her project is positive NPV.

2.4.2 The Entrepreneur's Investment/Disclosure Decisions when She is Informed

Suppose that the entrepreneur has acquired information and received an informative signal. At $t = 2$, she can choose from the following three strategies: investing and disclosing the information (id), investing and withholding the information (iw), and not investing (ni). Assume that disclosure is costless and truthful.[8] Conditional on λ^0, the public report and the private signal, the entrepreneur's expected payoff given different investment/disclosure decisions is:

$$U_2^i(p, y_i, \lambda^0, q) = \begin{cases} (p + \bar{q} + y_i)\ (1 - \dfrac{\bar{q}}{p + \bar{q} + y_i}) & \text{if } q = \bar{q} \text{ and } m = y_i; \\ (p + \bar{q} + y_i)\ [1 - \dfrac{\bar{q}}{p + \bar{q} + y_i^n(p, \lambda^c = \lambda^0)}] & \text{if } q = \bar{q} \text{ and } m = n; \\ 0 & \text{if } q = 0. \end{cases}$$

Denote $\hat{\lambda^0} \equiv \lambda^0 + (1 - \lambda^0)\ \gamma$, which is the entrepreneur's conjecture of the investors' belief of the probability that she is uninformed. The entrepreneur can withhold her information in the offering only when $\delta^n(p, \lambda^c = \lambda^0) > \bar{q}$, or alternatively $y_i^n(p, \lambda^c = \lambda^0) > -p$. Otherwise, if she issues equity without any disclosure, she has to offer investors more than 100% of her

[8]Following the disclosure literature, we assume that while the entrepreneur can withhold information, she discloses truthfully if she ever reports her private information.

firm's shares.[9]

Define a function $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) \equiv p\hat{\lambda^0} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{-p} (p+y_i)\, d\, F(y_i)$. It can be proved that $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) > 0$ is a sufficient condition for $y_i^n > -p$.[10] If this condition holds, the entrepreneur believes that rational investors will price the firm at a value higher than $\bar{q}$ even if she goes out to raise capital without disclosing the private signal.[11] Therefore, if the entrepreneur has received a signal $y_i > -p - \bar{q}$, she always invests, but chooses between disclosing and withholding her private information, while if $y_i \leq -p - \bar{q}$ she does not invest. When the entrepreneur decides to invest, her disclosure strategies are characterized by a cutoff (Jung and Kwon 1988).[12] On the other hand, if the entrepreneur holds a conjecture such that $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) \leq 0$, if the entrepreneur ever invests, such a decision signals to the investors that she must be informed. When disclosure is costless and the investors are certain that the entrepreneur is privately informed, the entrepreneur fully discloses her signal as long as she decides to invest.[13] Consequently, the entrepreneur invests and discloses for all signals above $-p$ and not invest otherwise.

The following proposition characterizes the entrepreneur's investment/disclosure decisions:

[9] Recall the fraction of shares is $\alpha = \frac{\bar{q}}{\delta^n}$. If $\delta^n \leq \bar{q}$, then $\alpha \geq 1$.

[10] Please refer to the Appendix for the proof.

[11] The investors can threaten to believe that the entrepreneur is hiding a very bad signal when she invests but does not disclose and therefore offer a price lower than $\bar{q}$. However, such threat is not credible in this case, since if the investors hold a belief $\hat{\lambda^c}$ such that $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) > 0$ and if they are rational, their posterior mean of the firm value given $q = \bar{q}$ and $m = n$ is higher than $\bar{q}$.

[12] Since the fraction of shares the entrepreneur has to offer in exchange for $\bar{q}$ is decreasing in y_i if she invests and discloses, and the fraction of share offered is independent of y_i if she invests but does not disclose, there must exist a lower bound of y_i such that she discloses if her signal is above the cutoff and withhold information otherwise.

[13] This is the standard "unravelling" result when disclosure is truthful and costless and the recipients are certain that the disclosing party is informed (see, e.g., Grossman 1981).

Proposition 2.4 *Given the public report and the entrepreneur's conjecture $\hat{\lambda^0}$, if $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) > 0$, there exists a cutoff $y_i^\dagger(p, \hat{\lambda^0})$ such that*

$$y_i^n = y_i^\dagger \tag{2.1}$$

$$y_i^n = \frac{(1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} y_i \; d\; F(y_i)}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} d\; F(y_i)} \tag{2.2}$$

The entrepreneur invests and discloses the private signal if $y_i \in [y_i^\dagger(p, \hat{\lambda^0}), +\infty)$, she invests but withholds the information if $y_i \in (-p-\bar{q}, y_i^\dagger(p, \hat{\lambda^0}))$, and she does not invest if she has a signal equal or worse than $-p-\bar{q}$.

If $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) \leq 0$, the entrepreneur invests and discloses if her signal is above $-p$, and does not invest if she has received a worse signal.

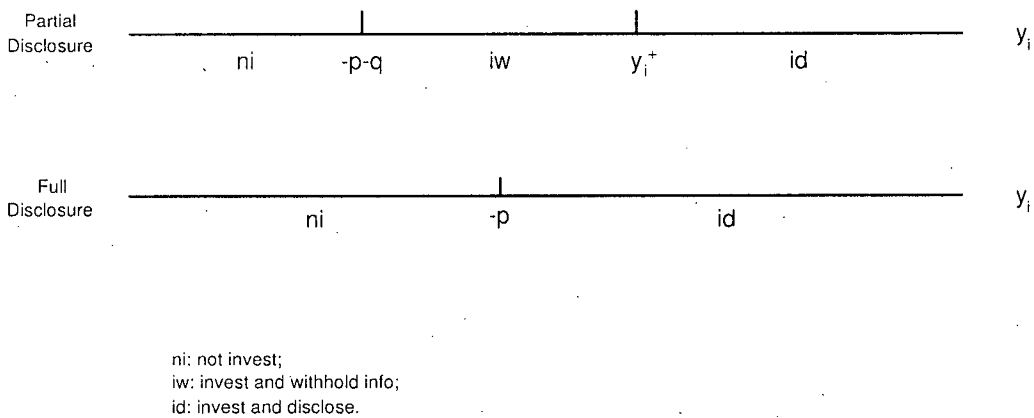

Figure 2.5: Investment/Disclosure Decisions given the Public Report and an Informative Private Signal

In the later analysis, the above two scenarios are referred to as "Partial Disclosure" and

"Full Disclosure" respectively (Figure 2.5). Let us analyze these two cases separately.

In the Partial Disclosure case, since $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) > 0$, the entrepreneur believes that rational investors will price the firm at a value higher than $\bar{q}$ given no disclosure and the investment decision $q = \bar{q}$. Therefore, if she withholds the information, she is still able to raise capital to implement the project. When $y_i \in (-p-\bar{q}, y_i^\dagger(p, \hat{\lambda^0}))$, the entrepreneur is better off investing but hiding the private signal than investing and disclosing. To see this, when the investors are unsure about whether the entrepreneur is informed, the entrepreneur's expected payoff if investing and withholding the private information is $(p+\bar{q}+y_i)\ (1-\frac{\bar{q}}{p+\bar{q}+y_i^n})$, which is larger than her expected payoff from investing and disclosing, $(p+\bar{q}+y_i)\ (1-\frac{\bar{q}}{p+\bar{q}+y_i}) = p+y_i$. When she receives a better signal than the disclosure cutoff, it is optimal for the entrepreneur to invest and disclose the information. If the entrepreneur receives a signal below $-p-\bar{q}$, investing in the project generates a negative expected payoff and therefore she does not invest.

The disclosure cutoff $y_i^\dagger$ is a function of p and $\hat{\lambda^0}$ (or function of y_a and λ^0). The following lemma describes its properties.

Lemma 2.2 *The disclosure cutoff $y_i^\dagger(y_a, \lambda^0)$ in the Partial Disclosure case has the following properties:*

(i) $y_i^\dagger \leq 0$;

(ii) $\frac{\partial y_i^\dagger}{\partial \lambda^0} > 0$;

(iii) $\frac{\partial y_i^\dagger}{\partial y_a} \leq 0$.

The first two comparative statistics are consistent with the results in Jung and Kwon

(1988) (Proposition 1 and 2).[14] First, the disclosure cutoff is no greater than the prior mean (0 in our model). Second, when the entrepreneur conjectures that the investors believe there is a high probability that she is uninformed, it is optimal for her to hide more information.[15]

Let us then explain why the disclosure cutoff is non-increasing in the public report y_a. If the entrepreneur conjectures that the investors believe she has not acquired information ($\lambda^0 = 1$), it must be true that $y_i^n(p, \lambda^0 = 1) = 0$. The entrepreneur discloses signals above 0 and the disclosure cutoff does not vary with respect to y_a. If $\lambda^0 \neq 1$, first holding $y_i^\dagger$ constant, an increase in y_a will lead to a higher probability of non-disclosure in the equity offering. That is, the denominator of the expression of y_i^n increases. At the same time, given $m = n$ and $q = \bar{q}$, the investors' posterior mean of the entrepreneur's private signal withheld (the numerator) is lower. This is because the non-disclosure region extends downward to include more worse signals. The overall effect is an decrease in y_i^n. Since $y_i^\dagger = y_i^n$, $y_i^\dagger$ must also decrease to maintain the equality. In sum, a less optimistic public report will drive down the investors' posterior belief y_i^n and also $y_i^\dagger$. Therefore, the entrepreneur is now induced to disclose more unfavorable signals.

In the Full Disclosure case, the entrepreneur is unable to raise the capital if she does not disclose her private information. Therefore, as long as the posterior project NPV based on both the public and private signals is positive ($p + y_i > 0$), the entrepreneur always invests

[14]An important difference between our model and that of Jung and Kwon is that they assume the probability that the entrepreneur is uninformed is exogenous, while in our model λ^0 and λ^c are endogenously determined.

[15]When the entrepreneur makes the investment and disclosure decisions, she bases her actions on her conjecture of the investors' beliefs of the probability that she has not acquired private information. In the rational expectations equilibria, such conjectures are consistent with the investors' actual beliefs, i.e., $\lambda^0 = \lambda^c$.

and discloses her private signal and also invest in the project.

2.4.3 The Entrepreneur's Information Acquisition Decision

At $t = 1$, in anticipation of the subsequent investment and disclosure decisions, the entrepreneur's expected payoff from not acquiring private information is:

$$U_1^{na}(p, \hat{\lambda^0}) = \begin{cases} (p+\bar{q})\ [1 - \dfrac{\bar{q}}{p+\bar{q}+y_i^n(p,\hat{\lambda^0})}] & \text{Partial Disclosure} \\ 0 & \text{Full Disclosure} \end{cases}$$

If the entrepreneur acquires information, her expected payoff is characterized as follows. In the Partial Disclosure case:

$$\begin{aligned} U_1^a(p, \hat{\lambda^0}, \kappa) \quad = \quad & \gamma\ (p+\bar{q})\ (1 - \frac{\bar{q}}{p+\bar{q}+y_i^n(p,\hat{\lambda^0})}) + (1-\gamma)\ [\int_{-p-\bar{q}}^{y_i^\dagger(p,\hat{\lambda^0})} (p+\bar{q}+y_i) \\ & (1 - \frac{\bar{q}}{p+\bar{q}+y_i^n(p,\hat{\lambda^0})})\ d\ F(y_i) + \int_{y_i^\dagger(p,\hat{\lambda^0})}^{+\infty} (p+y_i)\ d\ F(y_i)] - \kappa \end{aligned}$$

where $y_i^\dagger$ and y_i^n are determined by Equations 2.1 and 2.2.

In the Full Disclosure case:

$$U_1^a(p, \hat{\lambda^0}, \kappa) = (1-\gamma) \int_{-p}^{+\infty} (p+y_i)\ d\ F(y_i) - \kappa$$

Assume that with probability λ the entrepreneur does not acquire private information.

A rational expectations equilibrium is characterized by the following equations:

$$U_1^a(p, \hat{\lambda^0}, \kappa) = U_1^{na}(p, \hat{\lambda^0}) \quad \text{if } \kappa = \kappa^\dagger \tag{2.3}$$

$$1 - \lambda = S(\kappa^\dagger) = Prob(\kappa < \kappa^\dagger) \tag{2.4}$$

$$\lambda = \lambda^c = \lambda^0 \tag{2.5}$$

In the equilibrium, the entrepreneur acquires private information if, and only if, the associated incremental benefit exceeds the acquisition cost. She is indifferent between acquiring and not acquiring the pre-decision signal if the realized value of κ equals the cutoff (Equation 2.3), and does not purchase information if κ is higher than the cutoff. Therefore the equilibrium probability that the entrepreneur has acquired information equals $S(\kappa^\dagger)$ (Equation 2.4). Finally, in equilibrium the investors' and the entrepreneur's conjectures are self-fulfilling (Equation 2.5).

The following proposition describes the entrepreneur's information acquisition decisions in the rational expectations equilibrium.[16]

Proposition 2.5 *The entrepreneur acquires private information if the information acquisi-*

[16]Equating $U_1^a(p, \hat{\lambda^0}, \kappa)$ and $U_1^{na}(p, \hat{\lambda^0})$ and applying integration by parts yields the expression for $\kappa^\dagger$.

tion cost κ is below a cutoff $\kappa^{\dagger}(p)$, which is defined by:

$$\kappa^{\dagger}(p) = \begin{cases} (1-\gamma)\ [\int_{-p-\bar{q}}^{y_i^{\dagger}(p,\hat{\lambda^0})} (p+\bar{q}+y_i)(1-\frac{\bar{q}}{\delta^n})\ d\ F(y_i) & \\ \quad + \int_{y_i^{\dagger}(p,\hat{\lambda^0})}^{+\infty} (p+y_i)\ d\ F(y_i) - (p+\bar{q})\ (1-\frac{\bar{q}}{\delta^n})] & \text{Partial Disclosure} \\ (1-\gamma)\ \int_{-p}^{+\infty} (p+y_i)\ d\ F(y_i) & \text{Full Disclosure} \end{cases}$$

where $\delta^n = p + \bar{q} + y_i^n(p, \hat{\lambda^0})$, $y_i^{\dagger}$ and y_i^n are determined by Equation 2.1 and 2.2, and λs satisfy Equations 2.3, 2.4 and 2.5.

She does not acquire information if the cost is equal or above the cutoff.

Recall that the critical condition which distinguishes the Partial Disclosure case and the Full Disclosure case is whether $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) > 0$ where $\hat{\lambda^0} = \lambda^0 + (1-\lambda^0)\gamma$. Since the equilibrium λ^0 is determined in Equations 2.3, 2.4 and 2.5, it is a function of exogenous parameters p, q, and γ. In the following sections we rewrite the condition $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0})$ as $T(p, \bar{q}, \sigma_{yi}, \gamma)$.

2.5 Efficiency Analysis

2.5.1 After the Release of Public Report and Before the Entrepreneur Makes any Decisions ($t = 1$)

The efficiency analysis in this subsection is for $t = 1$, i.e., the time point after the public report is observed and before the entrepreneur makes any decisions. The previous sections examine the entrepreneur's information acquisition and subsequent investment and disclosure decisions. Even though we cannot explicitly solve for the equilibrium information acquisition cutoff $\kappa^\dagger$, we are able to compare it with the first-best cutoff κ^*, as shown in the following lemma.

Lemma 2.3 *$\kappa^\dagger > \kappa^*$ if $p > 0$, and $\kappa^\dagger = \kappa^*$ if $p \leq 0$.*

The comparisons of both the information acquisition and the investment decisions in the self-financing and the equity-financing are summarized below.

Proposition 2.6 *Given a public report y_a, there are three possible scenarios: (1) in economies with parameters satisfying $p > 0$ and $T(p, q, \sigma_{yi}, \gamma) > 0$, the entrepreneur overinvests in both information acquisition and investment projects when she issues equity to finance the project; (2) if the economic parameters are such that $p > 0$ and $T(p, \bar{q}, \sigma_{yi}, \gamma) \leq 0$, the entrepreneur overinvests in information acquisition but underinvests in projects, and; (3) if $p \leq 0$, the entrepreneur's information acquisition and investment decisions are efficient.*

Let us explore the implications of the above proposition in more details.

(1) $p > 0$ and $T(p, \bar{q}, \sigma_{yi}, \gamma) > 0$

When the entrepreneur raises equity capital to finance the project, her expected utility at $t = 1$ (after receiving the public report but before making information acquisition and investment decisions) is:[17]

$$U_{ef,1}(p) = \int_0^{\kappa^\dagger} U^a_{ef,1}(p, \kappa)\, d\, S(\kappa) + \int_{\kappa^\dagger}^{\infty} U^{na}_{ef,1}(p)\, d\, S(\kappa)$$

[17] We use "sf" to denote self-financing and "ef" to denote "equity-financing".

where $U^{a}_{ef,1}(p,\kappa)$ and $U^{na}_{ef,1}(p)$ are defined in Section 2.4.3.

If the entrepreneur self-finances the projects, her expected utility at $t = 1$ is

$$U_{sf,1}(p) = \int_0^{\kappa^*} U^{a}_{sf,1}(p,\kappa)\ d\ S(\kappa) + \int_{\kappa^*}^{\infty} U^{na}_{sf,1}(p)\ d\ S(\kappa)$$

where $U^{a}_{sf,1}(p,\kappa)$ and $U^{na}_{sf,1}(p)$ are defined in Section 2.3.

Before comparing the two above expressions, we first compare the social welfare in these two contexts. When the entrepreneur self-finances the project, the social welfare at $t = 1$ equals her own expected payoff:

$$U^{S}_{sf,1}(p) = U_{sf,1}(p) = \int_0^{\kappa^*} [\gamma p + (1-\gamma) \int_{-p}^{+\infty} (p + y_i)\ d\ F(y_i) - \kappa]\ d\ S(\kappa) + p\ [1 - S(\kappa^*)]$$

While when she has to raise capital to finance the project, the social welfare becomes:

$$U^{S}_{ef,1}(p) = \int_0^{\kappa^\dagger} [\gamma p + (1-\gamma) \int_{-p-\bar{q}}^{+\infty} (p + y_i)\ d\ F(y_i) - \kappa]\ d\ S(\kappa) + p\ [1 - S(\kappa^\dagger)]$$

It follows that[18]

$$\begin{aligned} L_1 &\equiv U^{S}_{sf,1}(p) - U^{S}_{ef,1}(p) \\ &= \int_{\kappa^*}^{\kappa^\dagger} (\kappa - \kappa^*)\ d\ S(\kappa) - \int_0^{\kappa^\dagger} [(1-\gamma) \int_{-p-\bar{q}}^{-p} (p + y_i)\ d\ F(y_i)]\ d\ S(\kappa) \end{aligned} \tag{2.6}$$

[18]Proof is included in the Appendix.

Notice the first term represents the efficiency loss due to the entrepreneur's excessive information acquisition under equity-financing. Such overinvestment occurs when the realized information cost is higher than the efficient information acquisition cutoff κ^* but lower than $\kappa^\dagger$. In this case the entrepreneur overinvests in acquiring the private signal since the cost paid (κ) exceeds the additional information's productive value (which equals κ^*).

Here is the intuition for this overinvestment result. The entrepreneur overinvests in information when she has to raise equity capital because her shares will be undervalued if she does not have information to disclose. To see this, recall that the investors' valuation of the firm given $m = n$ and $q = \bar{q}$ is $\delta^n = p + \bar{q} + y_i^n < p + \bar{q}$.[19]

The second term represents another type of inefficiency associated with equity-financing. When the entrepreneur issues equity capital, her investment decisions are also inefficient since she invests in unprofitable projects.

The following analysis reveals why the entrepreneur overinvests in negative NPV projects. When $\kappa < \kappa^\dagger$, if the entrepreneur employs equity-financing, she invests for signals $\in (-p - \bar{q}, -p)$ since she can take advantage of the investors' overvaluation of her firm's shares. To see this, when the investors are unsure about whether the entrepreneur is informed, the entrepreneur's expected payoff if investing and withholding the private information is $(p + \bar{q} + y_i)\left(1 - \frac{\bar{q}}{p+\bar{q}+y_i^n}\right) > (p + \bar{q} + y_i)\left(1 - \frac{\bar{q}}{p+\bar{q}+y_i}\right) = p + y_i > 0$. Therefore the entrepreneur can earn positive profits by withholding information and investing in unprofitable projects.

[19]From Lemma 2, we know $y_i^n \leq 0$ and $\frac{\partial y_i^\dagger}{\partial \hat{\lambda^0}} > 0$. The equilibrium $\hat{\lambda^0}$ is less than 1, since $\hat{\lambda^0} = 1 - S(\kappa^\dagger)$ (Equations 2.4 and 2.5) and $\kappa^\dagger$ is positive (Proposition 5). Also y_i^n achieves its maximum when $\hat{\lambda^0} = 1$. Then it must be true that the equilibrium disclosure cutoff $y_i^\dagger$ is negative.

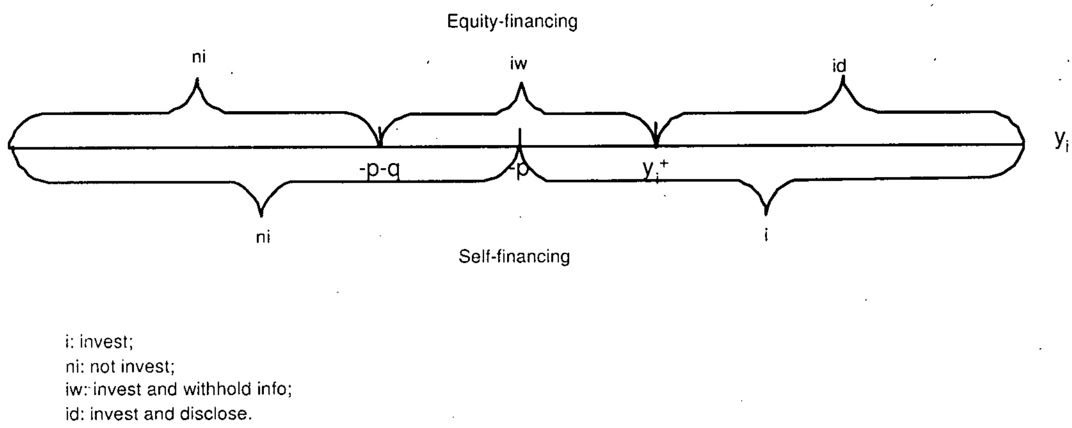

Figure 2.6: The Entrepreneur's Investment Decisions after She has Acquired Information and Received an Informative Signal ($p > 0$, $T(p, \bar{q}, \sigma_{yi}, \gamma) > 0$).

Does the entrepreneur gain from such investment strategy? The answer is No. Remember that in a rational expectations equilibrium, the investors are price-protected and on average break even.[20] It is true that the investors overpay for the shares when the entrepreneur issues equity to raise capital while withholding bad information. On the other hand, they pay less than the firm's intrinsic value when the entrepreneur is uninformed and not able to disclose either because she has not acquired information or she has acquired information but received an uninformative signal ($\delta^n = p + \bar{q} + y_i^n < p + \bar{q}$). On the whole, the investors break even.

Since the investors are price-protected, it is the entrepreneur who ultimately bears the losses incurred by her inefficient information acquisition and investment decisions. That is,

$$U_{ef,1}(p) = U^S_{ef,1}(p) < U^S_{sf,1}(p) = U_{sf,1}(p)$$

[20]For the proof, please refer to the Appendix.

In sum, the entrepreneur "shoots herself in the foot" in her attempt to exploit the investors and is worse off when she issues equity rather than self-financing the project.

(2) $p > 0$ and $T(p, \bar{q}, \sigma_{yi}, \gamma) \leq 0$

Under these conditions, after the entrepreneur observes the realization of the information acquisition cutoff κ, if $\kappa < \kappa^*$, she acquires private information under both types of financing. If she has received an informative signal, the entrepreneur's investment strategies is the same irrespective of the financing methods, i.e., investing if the private signal is above $-p$ and not investing otherwise. But this is not true if she has received an uninformative signal. In the self-financing case, she still invests in the project since the posterior NPV remains positive. However, if she relies on outside capital, she is unable to raise the capital required to carry out the project and therefore has to forgo the positive NPV project.

If $\kappa^* \leq \kappa < \kappa^\dagger$, she acquires private information when using equity-financing, but does not acquire information if she self-finances the project. If $\kappa \geq \kappa^\dagger$, the entrepreneur does not acquire information under either financing method.

As before, we compare the social welfare at $t = 1$ instead of directly comparing the entrepreneur's expected payoffs. When the entrepreneur self-finances the project, the social welfare at $t = 1$ equals her own expected payoff at $t = 1$:

$$U_{sf,1}^{S}(p) = U_{sf,1}(p) = \int_0^{\kappa^*} [\gamma p + (1-\gamma) \int_{-p}^{+\infty} (p + y_i) \; d \; F(y_i) - \kappa] \; d \; S(\kappa) + p[1 - S(\kappa^*)]$$

While when she raises capital to finance the project, the social welfare becomes:

$$U^S_{ef,1}(p) \;=\; \int_0^{\kappa^\dagger} [(1-\gamma) \int_{-p}^{+\infty} (p+y_i)\; d\; F(y_i) - \kappa]\; d\; S(\kappa)$$

It follows that

$$L_2 \equiv U^S_{sf,1}(p) - U^S_{ef,1}(p) \;=\; \int_{\kappa^*}^{\kappa^\dagger} (\kappa - \kappa^*)\; d\; S(\kappa) + p[\gamma S(\kappa^\dagger) + 1 - S(\kappa^\dagger)] \qquad (2.7)$$

Again the first term represents the inefficiency due to overinvestment in information acquisition in the equity-financing. The second term is the expected loss from underinvestment due to the entrepreneur's inability to disclose when she is uninformed, where p is the NPV she has to forgo, and $[\gamma S(\kappa^\dagger) + 1 - S(\kappa^\dagger)]$ is the equilibrium probability that she is uninformed. When the entrepreneur cannot disclose either because she has not acquired the private signal or she has acquired information but received a null signal, she is not able to invest and her expected payoff is zero. This is because when $p > 0$ and $T(p, \bar{q}, \sigma_{yi}, \gamma) \leq 0$, the investors are only willing to offer a price less than $\bar{q}$, if the entrepreneur tries to raise capital but does not disclose any information. Therefore, the entrepreneur is unable to implement the profitable NPV project. In cases when the loss from giving up profitable project is smaller than the acquisition cost of the private signal, the entrepreneur chooses to not acquire the information, and bear the loss from abandoning her project. In other cases when the entrepreneur does acquire private information, if she unfortunately receives an uninformative signal, even though she wants to convince the investors that she has a positive NPV project, she simply has no means to convey that information.

(3) $p \leq 0$

In this case, the entrepreneur's information acquisition and investment strategies are the same no matter what kind of financing methods she employs. Therefore *ex ante*, the entrepreneur enjoys the same expected payoffs in both contexts.

2.5.2 Before the Release of Public Report ($t = 0$)

Let us move further backward to $t = 0$. The *ex ante* expected payoffs of the entrepreneur under the self-financing and the equity-financing are

$$U_{sf,0} = \int_{-\infty}^{+\infty} U_{sf,1}(p(y_a)) \; d \; F(y_a),$$

and

$$U_{ef,0} = \int_{-\infty}^{+\infty} U_{ef,1}(p(y_a)) \; d \; F(y_a),$$

respectively.

Using the previous results, we can compute the difference as,

$$U_{sf,0} - U_{ef,0} = \int_{Y_a^1} L_1 \; dF(y_a) + \int_{Y_a^2} L_2 \; dF(y_a) < 0$$

where $Y_a^1 = \{y_a : \theta\bar{q}+y_a > 0, T(y_a, \theta, q, \sigma_{yi}, \gamma) > 0\}$, $Y_a^2 = \{y_a : \theta\bar{q}+y_a > 0, T(y_a, \theta, q, \sigma_{yi}, \gamma) \leq$

$0\}$, and L_1 and L_2 are defined in Equations 2.6 and 2.7, respectively.

The *ex ante* ($t = 0$) welfare analysis is summarized in the following proposition.

Proposition 2.7 Ex ante *(before observing y_a, making information acquisition and investment decisions), the entrepreneur is worse off if she issues equity to finance the investment project rather than using self-owned capital. The equity-financing is associated with three potential efficiency losses. First, her information acquisition decision can be inefficient. She might overinvest in searching for private productivity information. Secondly, when the entrepreneur is uninformed and unable to disclose, sometimes she has to forgo profitable projects due to the severe underpricing by the investors. Thirdly, when the entrepreneur is informed, she might invest in negative NPV projects.*

2.6 Conclusion

In this chapter we develop a new-equity disclosure model to investigate the interaction between equity-issuing firms' information acquisition/disclosure decisions and their investment activities. By introducing the possibility that the investors are unsure whether the entrepreneur is informed, we obtain interesting results regarding several inefficiencies that could arise when the firm raises equity capital to finance the projects.

As a benchmark case, when the entrepreneur self-finances the project, she is better off by acquiring additional private information as long as the value of pre-decision information exceeds the information acquisition cost. In addition, the entrepreneur invests only if the project has a posterior positive NPV based on her information set.

When the entrepreneur issues equity in the stock market, she potentially incurs three efficiency losses. She could excessively invest in information when the project NPV based on the public report is positive. Even though she is *ex ante* better off by precommitting to not acquiring private information when the acquisition cost is equal or above the efficient cutoff, *ex post* the entrepreneur has unavoidable incentives to acquire private information. This is because if she does not acquire information, she is unable to make disclosures at the time of equity issuance and her firm's shares are undervalued. If the information acquisition cost is smaller than the sum of productive value of the information and the expected mispricing resulting from the inability to disclose, *ex post* she purchases the private information.

Moreover, the entrepreneur's investment decisions can be inefficient. When the entrepreneur receives an informative private signal, under certain circumstances she overinvests in unprofitable projects in her attempt to take advantage of the investors' overvaluation. On the other hand, when she is uninformed, she might have to give up profitable projects due to her inability to correct the investors' underpricing.

These inefficient investment/disclosure decisions eventually make the entrepreneur worse off, because in the rational expectations equilibrium the investors on average break even and it is the entrepreneur herself who bears all the efficiency losses.

Chapter 3

Comparison of Three Disclosure Regimes

3.1 Introduction

Chapter 2 develops a new equity model to examine the interaction between firms' information acquisition/disclosure choices and their investment decisions. In that model, the equity-issuing entrepreneur/manager is assumed to **voluntarily** choose whether to disclose a forward-looking signal that she privately observes. In practice, however, equity-issuing firms and their underwriters' disclosure practices are often subject to securities laws and regulation. For example, countries such as Singapore, Malaysia, and Greece require their firms to disclose an earnings forecast when they go public. On the other hand, in the United States, equity-issuing firms are extremely cautious with their disclosures of prospective information, since a misstep could violate the so-called "Quiet Period" regulation and lead regulators to impose a delay on their offerings.[1]

This chapter extends the new equity disclosure model developed in the previous chapter to analyze the impact of different disclosure regimes on corporate decision-making during initial public offerings (IPOs).[2] Specifically, it investigates how disclosure rules affect firms' incentives to acquire forward-looking information, their disclosure practices and investment strategies. The disclosure regimes examined are Non-Disclosure, Voluntary, and Mandatory Disclosure.

The analysis yields a number of insights. It shows that a Non-Disclosure Regime for management forecasts, as is found in the US, can impair firms' ability to reduce information asymmetry through disclosure. By depriving firms of the opportunity to convey private information to investors, such a policy results in undervaluation of firms with profitable projects and overvaluation of firms without such projects. Misvaluation also alters the conditions under which firms make their investment decisions. In particular, investors' overvaluation can give firms incentives to invest in negative NPV projects. Furthermore, a non-disclosure rule

[1] Lang and Lundholm (2002) analyze several types of costs associated with a forced delay in the offering. First, the issuing firms have to postpone the investment plan. Second, the issuers have to incur additional costs to revise and refile the prospectus. Third, a delay might be interpreted negatively and reduce the proceeds from the offering.

[2] The insights generated by our model should also apply to seasoned equity offerings, and any other asset sales setting that involves productive decisions. We focus on IPOs mainly because the legal environment for SEOs is more complicated. For example, in the US, on one hand, SEO firms must not breach the gun jumping prohibition. On the other hand, they must also maintain their normal disclosures mandated by the 1934 Securities Exchange Act. That is, they should continue to send out periodic financial reports and make press releases with respect to firms' business and financial development etc. (Lang and Lundholm 2000). In addition, there is usually a much larger total mix of information around SEOs, such as previous press releases especially previous management forecasts, analysts' reports, etc. The incremental information content of management forecasts is likely to be smaller.

reduces equity-issuing firms' incentives to acquire valuable productive information. However, the other two disclosure regimes also induce distortions. Both overinvestment and underinvestment can occur under the Voluntary Disclosure Regime. In addition, with the discretion to disclose, firms tend to acquire too much information so that they can strategically use it in the later offerings. The Mandatory Disclosure Regime has the highest price efficiency, but it also imposes burden on firms to produce information to meet the disclosure requirement. Finally, a welfare analysis shows that each of the three disclosure regimes can emerge as the socially optimal regime under some conditions.

The chapter is organized as follows. Section 3.2 discusses the regulatory requirements and disclosure practices of forward-looking information around equity offerings in the United States, and also defines the three disclosure regimes. The basic settings of the model and the major assumptions are introduced in Section 3.3. Section 3.4 first briefly analyzes the entrepreneur's information acquisition and investment decisions when she has ample internal capital to finance the project as a benchmark case, and then examines the entrepreneur's decisions under each of the three regimes. Section 3.5 compares the *ex ante* efficiencies of different disclosure regimes and explains the policy implications of the results. The last section concludes the paper with a discussion of several key assumptions and limitations of the model, and provides suggestions for future research.

3.2 Institutional Background

In the United States, an equity-issuing firm and its underwriters are prohibited from making certain types of marketing efforts during a "quiet period" that roughly starts from the issuing firm's first meeting with the underwriters until 40 calendar days after the IPO.[3] Specifically, Section 5(c) of the 1933 Securities Act, entitled "Necessity of filing registration statement", prohibits any "offer to sell" a new security prior to filing a registration statement with the SEC. Violation of 5(c) is usually called "gun jumping".[4] The major basis of this regulation is to preclude issuers and their underwriters from hyping the stock and to encourage investors to consider the full disclosures contained within the prospectus and registration statement (Coffin 2002). In addition to Section 5(c), the SEC also provides some guidelines on information releases during the equity offerings. In particular, Release No. 5180 advises that issuers should maintain their normal and routine communications such as advertising products and services. However, they should avoid "**1. Issuance of forecasts, projections, or predictions relating but not limited to revenues, income, or earnings per share. 2. Publishing opinions concerning values**" by means other than a statuary prospectus.

Even though no forecasts are allowed outside the prospectus, firms can still legitimately

[3]In July 2002, the quiet period was extended from 25 to 40 calendar days after the IPO.

[4]The following incident highlights the SEC's strict enforcement on inappropriate or suspicious disclosure practices in the "quiet period". Salesforce.com, a customer relationship management software vendor, delayed its IPO due to an interview of its CEO with the New York Times just prior to its planned IPO. The interview was published on May 9, 2004. Eleven days later, a Wall Street Journal article reported that Salesforce would delay its IPO due to its potential violation of the "quiet period" regulation (Bank 2004). As a matter of fact, in the New York Times interview, the Salesforce CEO sidestepped questions relating to the pending IPO, citing the restrictions from the SEC (Rivlin 2004). However, because the article was high-profile and published within two weeks of the company's IPO date, the SEC and Salesforce "reached a mutual agreement" to delay the offering.

disclose such information in their SEC filings. However, a stylized fact about US IPOs is that forecasts are virtually non-existent in the prospectuses.[5] One frequently cited reason for this phenomenon is US's highly litigious environment. That is, if a firm included a forecast in its prospectus and ultimately failed to meet the target after the IPO, there would be a high risk of litigation.[6] In addition, disclosure of forward-looking information from IPO firms is excluded from the "Safe Harbor" protection introduced by the 1995 Private Securities Litigation Reform Act (PSLRA).[7] Finally, even though firms must provide sufficient and meaningful disclosure of their risk factors, they have no obligation to make forecasts or projections on future events, including their likely performance.[8] This shields firms that withhold private forward-looking information against potential charges of misrepresentation.[9]

A most recent move by the SEC revealed the policymakers' concern with the insufficient communication in the equity offerings caused by the "quiet period" regulation. In its November 3, 2004's Release 33-8501 on Securities Offering Reform, the SEC proposed to

[5]The IPO prospectus often contains some forward-looking information, mainly in the discussion of risk factors and/or the Management's Discussion and Analysis (MD&A) section. However, almost all of them are qualitative "soft information" or vague statements, such as "We anticipate sales and marketing expenses will increase in dollar amount and may increase as a percentage of net revenues in 2004 and future periods". See, for example, Google Inc.'s 2004 IPO Prospectus.

[6]Another possible reason is that, given the scarcity of forecasts or projections in the IPO prospectus in the US, it can be imprudent for an IPO firm to include a forecast to expose itself to the potential risk of becoming a conspicuous target in the securities litigations.

[7]The 1995 Act created a statutory safe harbor that applies to both written and oral forward-looking statements. Under this provision, a defendant is not liable with respect to any forward-looking statement if it is identified as forward-looking and is accompanied by "meaningful" cautionary language identifying the factors that could cause actual results to differ. However, this safe harbor does not apply to certain forward-looking statements such as those "made in connection with an initial public offering" (Section 27A of the 1993 Securities Act).

[8]See the September 1996's Corporate and Securities Litigation Bulletin of Hale and Dorr LLP, http://www.haledorr.com/publications/pub_detail.aspx?ID=251&type=5545.

[9]Misrepresentation in the equity offering settings is defined as the registration statement containing an untrue statement of a material fact or omitting to state a material fact required to be stated or necessary to make the statement not misleading. See Section 11(a) of the 1933 Securities Act.

eliminate "unnecessary and outmoded restrictions on offerings" and "provide more timely investment information to investors".[10] The SEC proposed to provide a safe harbor from the gun-jumping provisions for the release of forward-looking statements from reporting issuers (i.e., firms that file reports pursuant to the 1934 Securities Exchange Act), as long as they regularly disseminate such information prior to the offerings. However, the SEC is not planning to extend this safe harbor to non-reporting issuers (usually IPO firms) "because of the lack of such information or history for these issuers in the marketplace", and the potential abuse of the safe harbor to inflate the market prices.

To summarize, in the United States, IPO firms' disclosure of forward-looking information is constrained by the quiet period regulation, and is vulnerable to shareholder litigation due to the lack of safe harbor protection for IPO forecasts. The overall time between the beginning of an issuing firm's preparation of the registration statement and the closing of its IPO could easily exceed six months, and is rarely less than three months.[11] Given the usually limited alternative public information around an IPO and the considerable length of the quiet period, the disclosure regulation and the legal environment could significantly affect the information mix available to investors. As a matter of fact, in the United States, investors (especially small investors) have very limited access to numerical forward-looking information from IPO firms and their affiliated analysts.[12] We characterize such a legal environment that inhibits IPO forecasts as a "Non-Disclosure Regime".

[10] The full text of this release is available on the SEC's official web site: http://www.sec.gov/rules/proposed/33-8501.htm.

[11] See, for example, http://www.boselaw.com/biz_faq.shtml.

[12] It is alleged that the issuing firms could privately disclose information such as management forecasts, to selected institutional investors during closed-door meetings (see, e.g., Hennessey and Plitch 2004).

On the other hand, IPO firms in the UK, Canada, Australia, and other British Commonwealth countries in the Asia-Pacific region, can voluntarily choose whether to issue forecasts in the prospectus, while the inclusion of forecasts in the IPO prospectus is mandatory in countries such as Greece, Singapore and Malaysia (How and Yeo 2000; Bilson et al 2003; Gounopoulos 2002). We refer to these two types of disclosure environments as "Voluntary Disclosure Regime" and "Mandatory Disclosure Regime" respectively.

3.3 The Model Setting

To explore the impact of different disclosure regimes on firms' real decisions, we use a modified version of the simple one-period New Equity disclosure model developed in Chapter 2. Assume that there is a risk-neutral entrepreneur who considers issuing equity to finance a new project. The entrepreneur has one existing asset, which generates a terminal cash flow $\tilde{u}$, which is normally distributed with mean $\bar{u}$ and variance σ_u^2.[13] The new project requires an investment of $\bar{q}$ and generates a gross payoff $\tilde{x} = (1+\theta)\bar{q} + \tilde{\epsilon}$, where θ is the net unit rate of expected return (a constant), and $\tilde{\epsilon}$ is the noise term. Assume that $\tilde{\epsilon}$ is normally distributed, with mean 0 and variance σ_x^2. Both θ and $\bar{q}$ are assumed to be common knowledge.

Prior to the investment decision, the entrepreneur has an opportunity to acquire a signal about the new project at a cost of κ. If she pays κ, she will receive a signal y_i, which is represented as $\tilde{\epsilon} = \tilde{y}_i + \tilde{\nu}_i$, where $\tilde{y}_i \sim \mathrm{N}(0, \sigma_i^2)$ and $\tilde{\nu}_i$ is independent of $\tilde{y}_i$. We can interpret this as the signal y_i resolving part of the uncertainty in $\tilde{\epsilon}$. In addition, under such

[13]For a summary of the notation used in this chapter, please refer to Appendix A.

a representation, the realized value of $\tilde{y_i}$ is also the entrepreneur's posterior mean about the noise in the project's return, i.e., $E[\tilde{\epsilon}|\tilde{y_i} = y_i] = y_i$. The information acquisition cost, κ, is assumed to be a random variable *ex ante* and has a cumulative distribution function of $S(\kappa)$. The entrepreneur observes the realized value of κ before making the information acquisition decision.

If the entrepreneur decides to invest in the project, she issues equity and offer the investors a fraction of her firm's shares in exchange for $\bar{q}$. During the equity offering, the entrepreneur is required to disclose her firm's previous years' operating results. Assume that the entrepreneur observes these historical financial results from the firm's accounting system.[14] The historical information is represented as a signal y_h which is informative about $\tilde{u}$. Specifically, $\tilde{u} = \tilde{y_h} + \tilde{\nu_h}$, where $\tilde{y_h} \sim \mathrm{N}(\bar{u}, \sigma_h^2)$ and $\tilde{\nu_h}$ is independent of $\tilde{y_h}$. It follows that y_h is the entrepreneur's posterior mean with respect to the return of the asset-in-place, i.e., $E[\tilde{u}|\tilde{y_h} = y_h] = y_h$. To simplify, assume that $cov(\tilde{y_h}, \tilde{y_i}) = 0$, $cov(\tilde{u}, \tilde{y_i}) = 0$, and $cov(\tilde{x}, \tilde{y_h}) = 0$. That is, the two signals are uncorrelated; in addition, the historical accounting information is informative only about the return of the old asset, while the private signal to be acquired is informative only about the future cash flows of the new investment project.[15] Under these assumptions, we have $E[\tilde{\epsilon}|y_h] = 0$ and $E[\tilde{u} + \tilde{x}|y_h, y_i] = E[\tilde{u}|y_h] + E[\tilde{x}|y_i]$. Further, to focus on the acquisition of the productive information about the new project, we assume that the entrepreneur does not acquire or have any private information about the

[14]The setup cost of the accounting system is sunk and therefore y_h can be regarded as a signal with which the entrepreneur is exogenously endowed.

[15]These three assumptions do not imply that the returns of the asset-in-place and the new project are uncorrelated. To see this, $cov(\tilde{u}, \tilde{x}) = cov(\tilde{y_h} + \tilde{\nu_h}, \tilde{y_i} + \tilde{\nu_i})$, which can be nonzero even if $cov(\tilde{y_h}, \tilde{y_i}) = 0$.

future return of the asset-in-place other than y_h.

t=0	t=1	t=2	t=3
Ex ante	▪ E receives y_h; ▪ k is realized and observed by E; ▪ E decides whether to acquire y_i.	▪ E observes y_i if she acquired information; ▪ E decides whether to invest in the project; ▪ If E decides to invest, she will issue equity; ▪ In the offering, E must disclose y_h, but she may or may not disclose y_i	Payoffs are realized

Information Sets:

E observes:
- k and y_h prior to the information acquisition at t=1;
- following a decision to acquire information -- the value of the signal y_i prior to the investment decision at t=2.

Investors observe:
- E's investment decision (q), a signal about the existing asset (y_h), and a signal about the new project (y_i) if E discloses y_i.

Figure 3.1: Sequence of Events.

The sequence of the events and various decisions the entrepreneur makes during the whole period are summarized in Figure 3.1. Specifically, at $t = 1$, the entrepreneur observes the historical information about the old asset, y_h. She also observes the realized value of the information cost, κ. Based on κ, she then decides whether to acquire private information about the new project. At $t = 2$, if the entrepreneur has acquired information, she observes a private signal y_i about the project. Based on her information set, she decides whether to invest. If she decides to invest, she issues equity to the public with a prospectus which contains previous years' financial results and possibly her private signal about the new project. At $t = 3$, the payoffs are realized.

3.4 The Entrepreneur's Information Acquisition and Investment Decisions

3.4.1 The Benchmark Case

We first briefly examine the case in which the entrepreneur self-finances the project. The entrepreneur's decisions are analyzed using backward induction.

In this benchmark case, the only decision that the entrepreneur makes at $t = 2$ is whether to invest in the project. Let $q \in \{0, \bar{q}\}$ represent her investment decision.

At $t = 2$, if the entrepreneur has not acquired information about the project, she is informed with only one signal, y_h. Her expected payoff is $U_2(y_h) = E[\tilde{u} + \tilde{x}|y_h, q = \bar{q}] - \bar{q} = y_h + \theta\bar{q}$ if she invests ($q = \bar{q}$), and $U_2(y_h) = y_h$ if she does not invest ($q = 0$).[16] Therefore, she invests if $\theta > 0$ and does not invest otherwise.

If the entrepreneur acquired private information about the new project at $t = 1$, she is informed with both y_h and y_i at $t = 2$. Given these two signals, her expected payoff is

[16]For expositional ease, throughout the paper, mathematical expressions are represented only as a function of a few key parameters. For example, in addition to y_h, $U_2(\cdot)$ is also a function of two other parameters $\bar{q}$ and θ. However, only y_h is made explicit in the expression since it is a key parameter on which we want to focus.

$U_2(y_h, y_i) = E[\tilde{u} + \tilde{x}|y_h, y_i, q = \bar{q}] - \bar{q} = y_h + \theta\bar{q} + y_i$ if she invests, and y_h if she does not invest. Therefore, she invests if $\theta\bar{q} + y_i > 0$ and does not invest otherwise.

At $t = 1$ the entrepreneur decides whether to acquire y_i in anticipation of the subsequent investment decisions. Represent the entrepreneur's information acquisition decision at $t = 1$ as a function of the realized acquisition cost, $a : K \rightarrow \{0, 1\}$. That is, the information acquisition strategy maps from the acquisition cost into a choice of either acquiring private information ($a = 1$) or not acquiring ($a = 0$). The entrepreneur expects that acquiring information generates an expected payoff of $U_1(y_h, a = 1, \kappa) = y_h + \int_{-\theta\bar{q}}^{+\infty} (\theta\bar{q} + y_i)\ d\ F(y_i) - \kappa$, where $F(y_i)$ is the cumulative distribution function of y_i. Her expected payoffs from not acquiring information is $U_1(y_h, a = 0) = y_h + Max\{0, \theta\bar{q}\}$. Denote the prior mean of the NPV of the new project as s, i.e., $s \equiv \mathrm{E}[\tilde{x}|q = \bar{q}] - \bar{q} = \theta\bar{q}$. The entrepreneur's information acquisition and investment decisions are characterized in the following proposition.[17]

Proposition 3.1 *When the entrepreneur can self-finance the investment project, she decides whether to acquire information about the new investment project by comparing the realized value of $\tilde{\kappa}$ with a cutoff $\kappa^*(s)$. The cutoff is represented by*

$$\kappa^*(s) = \begin{cases} \int_{-\infty}^{-s}[-(s + y_i)]\ d\ F(y_i) & \text{if } s > 0, \\ \int_{-s}^{+\infty}(s + y_i)\ d\ F(y_i) & \text{if } s \leq 0. \end{cases}$$

At $t = 1$, the entrepreneur acquires y_i if $\kappa < \kappa^*(s)$, and does not acquire otherwise.

At $t = 2$, if the entrepreneur is informed with y_i, she invests if, and only if, $s + y_i > 0$.

[17] For a more detailed analysis, please refer to Chapter 2.

If the entrepreneur is uninformed about the project, she invests if, and only if, $s > 0$.

In the following analysis, we analyze the entrepreneur's decisions if she raises capital from the equity market to finance the new project.

3.4.2 Non-Disclosure Regime

In this section, assume that the entrepreneur never discloses her private signal to the investors. Represent the entrepreneur's information set as Ψ_E, where $\Psi_E = \{y_h, y_i\}$ if she has acquired private information and $\Psi_E = \{y_h\}$ otherwise. The investors' information set is $\Psi_I = (y_h, q)$, i.e., the historical results disclosed in the prospectus and the entrepreneur's investment decision.[18] If the entrepreneur decides to invest and goes public, the investors price the firm as $V^n \equiv \mathrm{E}[\tilde{u} + \tilde{x} | y_h, q = \bar{q}] = y_h + s + \bar{q} + \mathrm{E}[\tilde{\epsilon} | q = \bar{q}]$.[19]

Assume that the investors believe that with probability λ^c the entrepreneur has not acquired private information. Based on the entrepreneur's decision to issue the stock, the investors cannot tell whether she is uninformed or withholding her private signal.[20] Under the assumption that the investors are rational and update their beliefs according to the Bayes Rule, their posterior belief about $\tilde{\epsilon}$ given $q = \bar{q}$ is the weighted average of their posteriors in these two possible situations. Denote the investors' posterior mean about the noise term in

[18] If the entrepreneur is risk-averse, it is possible that she could communicate her private information through costly signals, such as equity retention. However, we assume away this possibility to focus on the impact of direct disclosure. We believe that the results on the Non-Disclosure Regime are valid as long as the signalling device does not perfectly reveal the entrepreneur's private information.

[19] To be complete, V^n is a function of y_h, s, $\bar{q}$, λ^c, σ_i^2. In particular, it depends on not only what the investors observe (i.e., y_h) but also what they believe (i.e., λ^c as defined later). However, for expositional ease, V^n is referred to as $V^n(y_h, \lambda^c)$, or sometimes simply as V^n.

[20] Assume that the entrepreneur only issues stock if she decides to invest in the project.

the new project's return given $q = \bar{q}$ as y_i^n, which can be represented as:

$$\begin{aligned} y_i^n(\lambda^c) &\equiv \mathrm{E}[\tilde{\epsilon}|q = \bar{q}, \lambda^c] \\ &= \frac{(1-\lambda^c)\ \mathrm{E}\ [\tilde{\epsilon}|q = \bar{q}, a = 1]}{\lambda^c\ Prob(q = \bar{q}|a = 0) + (1-\lambda^c)\ Prob(q = \bar{q}|a = 1)}, \end{aligned}$$

where $a \in \{0, 1\}$ represents the entrepreneur's information acquisition decision.

The Entrepreneur's Investment Decisions at $t = 2$

Assume that the entrepreneur's conjecture of λ^c is λ. Given λ, the entrepreneur believes that the investors' valuation of the firm is $V^n(y_h, \lambda) \equiv y_h + s + \bar{q} + y_i^n(\lambda)$, if she decides to invest and issues the stock.

If the entrepreneur is uninformed, given λ, her expected payoff at $t = 2$ is

$$U_2(y_h, \lambda, q) = \begin{cases} (y_h + s + \bar{q})[1 - \frac{\bar{q}}{V^n}] & \text{if } q = \bar{q}, \\ y_h & \text{if } q = 0. \end{cases}$$

If the entrepreneur is informed with a signal y_i, given λ, her expected payoff then is

$$U_2(y_h, y_i, \lambda, q) = \begin{cases} (y_h + s + \bar{q} + y_i)[1 - \frac{\bar{q}}{V^n}] & \text{if } q = \bar{q}, \\ y_h & \text{if } q = 0. \end{cases}$$

Therefore, if she is informed, she invests if, and only if, $(y_h + s + \bar{q} + y_i)(1 - \frac{\bar{q}}{V^n}) > y_h$. Denote the investment cutoff as t^N, which is the worst signal with which the entrepreneur invests. It is easy to show $t^N = -s - \frac{\bar{q}}{V^n - \bar{q}}(s + y_i^n)$. The posterior mean of the private signal y_i^n, given the entrepreneur's decision to invest, should then equal

$$y_i^n(\lambda) = \frac{(1-\lambda) \int_{t^N}^{+\infty} y_i \; d\; F(y_i)}{\lambda \; Prob(q = \bar{q} | a = 0) + (1-\lambda) \int_{t^N}^{+\infty} d\; F(y_i)} \tag{3.1}$$

The following lemma characterizes the investment cutoff t^N.[21]

Lemma 3.1 *Under the Non-Disclosure Regime, when the entrepreneur is informed, she invests in negative NPV projects, i.e.,* $t^N < -s$.

The intuition is as follows. Under the Non-Disclosure Regime, the entrepreneur's investment choice q is the only mechanism for her to convey the private information to the investors. Since higher investments lead to inferences of higher profitability, the lower-type entrepreneur has incentives to mimic the higher-type by overinvesting, as long as the gain from the investors' overpricing exceeds the loss from undertaking the unprofitable project. Further, because the investment level is dichotomous while the private information is a continuum, there does not exist a separating signalling equilibrium. The investment decision only serves as a very coarse signal for the entrepreneur's private information.

The Entrepreneur's Information Acquisition Decision at $t = 1$

In anticipation of her investment decisions, the entrepreneur makes the information acquisition decision by comparing the following expected payoffs.

[21] The proof is provided in the Appendix.

If she does not acquire private information y_i, her expected payoff at $t = 1$ is

$$U_1(y_h, \lambda, a = 0) = Max\{(y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}), y_h\}.$$

On the other hand, if the entrepreneur acquires y_i, her expected payoff at $t = 1$ is

$$U_1(y_h, \lambda, a = 1, \kappa) = y_h\ F(t^N) + \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) - \kappa.$$

Assume that with probability λ^N the entrepreneur does not acquire private information. A rational expectations equilibrium is characterized as follows:

$$U_1(y_h, \lambda, a = 1, \kappa) = U_1(y_h, \lambda, a = 0) \quad \text{if } \kappa = \kappa^N \tag{3.2}$$

$$1 - \lambda^N = S(\kappa^N) = Prob(\kappa < \kappa^N) \tag{3.3}$$

$$\lambda = \lambda^c = \lambda^N \tag{3.4}$$

In the rational expectations equilibrium, the entrepreneur acquires private information if, and only if, the incremental benefit from acquiring information exceeds the information cost. She is indifferent between acquiring and not acquiring if the realized value of κ equals the cutoff (Equation 3.2), and does not acquire if κ is higher than the cutoff. Therefore the equilibrium probability that the entrepreneur has acquired information equals $S(\kappa^N)$ (Equation 3.3). Also, in equilibrium, the investors' and the entrepreneur's conjectures are self-fulfilling (Equation 3.4).

The following proposition describes the entrepreneur's information acquisition decision in the rational expectations equilibrium.

Proposition 3.2 *Under the Non-Disclosure Regime, the entrepreneur acquires private information y_i if the information acquisition cost κ is below a cutoff κ^N, which is defined by:*

$$\kappa^N = y_h\ F(t^N) + \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) - Max\{(y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}), y_h\},$$

where y_i^n is determined by Equation 3.1, and λs satisfy Equations 3.2, 3.3 and 3.4.

And she does not acquire information if the cost is equal to or above the cutoff.

Comparing the information acquisition cost cutoff with that of the first-best case, we have the following proposition:

Proposition 3.3 $\kappa^N < \kappa^*$, *i.e., the entrepreneur underinvests in the acquisition of the productive information under the Non-Disclosure Regime.*

To understand this result, recall that under the Non-Disclosure Regime, the entrepreneur is not able to disclose her private information about the new project to the investors. Therefore, information has only one type of value: facilitating production decisions. However, as shown previously, even though her private signal indicates the project is negative NPV, the entrepreneur invests as long as the investors' overvaluation exceeds the loss from the project. Therefore, the acquired information has not been efficiently incorporated into investment decisions. As a result, these *ex post* inefficient investment decisions make the information less valuable *ex ante*, which reduces the entrepreneur's incentives to acquire information.

3.4.3 Voluntary Disclosure Regime

In this section, 'assume that the entrepreneur can choose whether to disclose her private signal about the new project in the prospectus. Chapter 2 has analyzed a similar model and the results can be easily adapted to the current setting.

The investors' information set in the equilibrium is $\Psi_I = (y_h, m, q)$, i.e., the historical results disclosed in the prospectus, the entrepreneur's disclosure of the private signal ($m = y_i$ if the entrepreneur discloses and $m = n$ if the entrepreneur does not disclose), and the entrepreneur's investment decision. If the entrepreneur decides to invest and issues equity but does not disclose any forward-looking information, the investors price the firm as $V^n(y_h, \lambda^c) \equiv \mathrm{E}[\tilde{u} + \tilde{x}|y_h, m = n, q = \bar{q}, \lambda^c] = y_h + s + \bar{q} + \mathrm{E}[\tilde{\epsilon}|m = n, q = \bar{q}, \lambda^c]$. If the entrepreneur issues equity with a disclosure of both historical results and a forward-looking signal about the new project, her firm's shares are valued as $V^d(y_h, y_i) \equiv \mathrm{E}[\tilde{u}+\tilde{x}|y_h, m = y_i, q = \bar{q}] = y_h+s+\bar{q}+y_i$.

Assume that the investors believe that with probability λ^c the entrepreneur has not acquired information. Given the entrepreneur's decision to issue the stock but not disclose, the investors update their beliefs on $\tilde{\epsilon}$ according to the Bayes Rule. That is,

$$\begin{aligned} y_i^n(\lambda^c) &\equiv \mathrm{E}[\tilde{\epsilon}|m = n, q = \bar{q}, \lambda^c] \\ &= \frac{(1-\lambda^c)\ \mathrm{E}\left[\tilde{\epsilon}|m = n, q = \bar{q}, a = 1\right]}{\lambda^c\ Prob(m = n, q = \bar{q}|a = 0) + (1-\lambda^c)\ Prob(m = n, q = \bar{q}|a = 1)}, \end{aligned}$$

where $a: K \to \{0,1\}$ represents the entrepreneur's information acquisition decision.

The Entrepreneur's Investment Decisions at $t = 2$

Assume that the entrepreneur's conjecture of λ^c is λ. Given λ, the entrepreneur believes that the investors' valuation of the firm is $V^n(y_h, \lambda) \equiv y_h + s + \bar{q} + y_i^n(\lambda)$, if she decides to invest and issues the stock.

If the entrepreneur is uninformed, given λ, her expected payoff is

$$U_2(y_h, \lambda; q) = \begin{cases} (y_h + s + \bar{q})(1 - \frac{\bar{q}}{V^n}) & \text{if } q = \bar{q}, \\ y_h & \text{if } q = 0. \end{cases}$$

If the entrepreneur has acquired information and received a signal y_i, she can make three possible decisions: invest and disclose y_i (id), invest and withhold the information (iw), and not invest (ni). Assume that disclosure is costless and truthful.[22] Given λ, y_h, and the private signal, the entrepreneur's expected payoff is

$$U_2(y_h, y_i, m, \lambda, q) = \begin{cases} (y_h + s + \bar{q} + y_i)(1 - \frac{\bar{q}}{V^d}) = y_h + s + y_i & \text{if } m = y_i \text{ and } q = \bar{q}, \\ (y_h + s + \bar{q} + y_i)(1 - \frac{\bar{q}}{V^n}) & \text{if } m = n \text{ and } q = \bar{q}, \\ y_h & \text{if } q = 0. \end{cases}$$

Depending on different parameter values, there are two possible equilibria.

[22]Following the disclosure literature, we assume that while the entrepreneur can withhold information, she discloses truthfully if she ever reports her private information.

Partial Disclosure Equilibrium

If $V^n > \bar{q}$ and $(y_h + s + \bar{q})(1 - \frac{\bar{q}}{V^n}) > y_h$, the entrepreneur invests if she is uninformed, and if she is informed, she invests and discloses her private signal if $y_i \geq y_i^\dagger$, invests and withholds private information if $y_i \in (t^V, y_i^\dagger)$, where $t^V = -s - \frac{\bar{q}}{V^n - \bar{q}}(s + y_i^n)$, and does not invest otherwise.

The following lemma characterizes the necessary condition for a Partial Disclosure Equilibrium.[23]

Lemma 3.2 *Under the Voluntary Disclosure Regime, the Partial Disclosure Equilibrium only exists for $s > 0$.*

In this equilibrium, when the investors observe the entrepreneur issuing equity but only disclosing historical results, they infer that the entrepreneur is either uninformed or informed with a signal above the investment cutoff but below the disclosure cutoff. The disclosure cutoff $y_i^\dagger$, and the investors' posterior mean of $\tilde{\epsilon}$ given $q = \bar{q}$ and no disclosure about the project in the offering, y_i^n, are determined by

$$y_i^\dagger = y_i^n = \frac{(1-\lambda) \int_{t^V}^{y_i^\dagger} y_i \; d\, F(y_i)}{\lambda + (1-\lambda) \int_{t^V}^{y_i^\dagger} d\, F(y_i)} \tag{3.5}$$

The following lemma characterizes the disclosure and investment cutoffs.

Lemma 3.3 *In the Partial Disclosure Equilibrium under the Voluntary Disclosure Regime,*

[23] As proved later, $y_i^\dagger > -s$. Also from Lemma 3.3, $y_i^\dagger \leq 0$. It follows that $s > 0$. That is, the Partial Disclosure Equilibrium only exists for $s > 0$.

when the entrepreneur is privately informed, both her investment and disclosure decisions are characterized by cutoffs, which have the following properties:

(i) The disclosure cutoff is below the prior mean of the private signal, i.e., $y_i^\dagger \leq 0$*;*

(ii)The investment cutoff is lower than the efficient cutoff, i.e., $t^V < -s$*. That is, the entrepreneur invests in negative NPV projects when she is informed.*

These results are similar to those in Chapter 2. The first result in Lemma 3.2 is a standard result for the disclosure cutoff when disclosure is costless and there is uncertainty about the entrepreneur's information endowment (Jung and Kwon 1988).[24] The second part of Lemma 3.2 is the "overinvestment" result, which is induced by the investors' overpricing of the firm's equity. Again, overvaluation occurs due to the investors' inability to distinguish whether the non-disclosure is because the entrepreneur has no private information about the new project, or because she is withholding bad information.

Full Disclosure Equilibrium

If $V^n > \bar{q}$ and $(y_h + s + \bar{q})(1 - \frac{\bar{q}}{V^n}) \leq y_h$, the entrepreneur does not invest if she is uninformed. Therefore, if the entrepreneur issues stock but does not disclose forward-looking information, the investors infer that the entrepreneur must be withholding private information. In other words, issuing stock signals to the market that the entrepreneur is informed with a private signal. In equilibrium, when the entrepreneur is informed, she always discloses her private signal if she issues equity and invests .[25] In addition, the investment

[24]The proof for $y_i^\dagger \leq 0$ is provided in the appendix for Chapter 2, with only minor changes in the notation.
[25]This is the standard "unravelling" result when disclosure is costless and the investors are certain that

cutoff is $t^V = -s$, (i.e., her investment decisions are efficient).

If $V^n \leq \bar{q}$, it is not optimal for the entrepreneur to raise the capital to undertake the project since she has to offer the investors more than 100% of her firm's shares, if she invests but does not disclose any forward-looking information. Therefore, the entrepreneur issues equity and invests in the project if, and only if, she is privately informed with a signal $y_i > -s$. In addition, when she issues equity, she always reports her private signal.

Under each of these two scenarios, the entrepreneur fully discloses her private information when she issues equity.[26] However, when the entrepreneur is uninformed, she is unable to invest even though her project can be positive NPV.

The Entrepreneur's Information Acquisition Decision at $t = 1$

In anticipation of her investment decisions, the entrepreneur makes the information acquisition decision by comparing the following expected payoffs.

If the entrepreneur does not acquire private information, her expected payoff at $t = 1$ is

$$U_1(y_h, \lambda, a = 0) = \begin{cases} (y_h + s + \bar{q})\left(1 - \frac{\bar{q}}{V^n}\right) & \text{Partial Disclosure} \\ y_h & \text{Full Disclosure} \end{cases}$$

---

the entrepreneur is informed.

[26]Both cases can be sustained by a threat from the investors that they will believe the entrepreneur is hiding a very bad signal and offer a price $V^n \leq \bar{q}$ if the entrepreneur issues stocks but does not disclose forward-looking information about the new project.

And if the entrepreneur acquires the private signal, her expected payoff is

$$U_1(y_h, \lambda, a=1, \kappa) = \begin{cases} \int_{-\infty}^{t^V} y_h \; d\; F(y_i) + \int_{t^V}^{y_i^\dagger} (y_h + s + \bar{q} + y_i) \; (1 - \frac{\bar{q}}{V^\pi}) \; d\; F(y_i) & \\ \qquad + \int_{y_i^\dagger}^{+\infty} (y_h + s + y_i) \; d\; F(y_i) - \kappa & \text{Partial Disclosure} \\ \int_{-\infty}^{-s} y_h \; d\; F(y_i) + \int_{-s}^{+\infty} (y_h + s + y_i) \; d\; F(y_i) - \kappa & \text{Full Disclosure} \end{cases}$$

Assume that with probability λ^V the entrepreneur does not acquire privation information. The following conditions characterize a rational expectations equilibrium:

$$U_1(y_h, \lambda, a=1, \kappa) = U_1(y_h, \lambda, a=0) \quad \text{if } \kappa = \kappa^V \tag{3.6}$$

$$1 - \lambda^V = S(\kappa^V) = Prob(\kappa < \kappa^V) \tag{3.7}$$

$$\lambda = \lambda^c = \lambda^V \tag{3.8}$$

The following proposition describes the entrepreneur's information acquisition decisions in the rational expectations equilibrium.

Proposition 3.4 *Under the Voluntary Disclosure Regime, the entrepreneur acquires private information if the information acquisition cost* κ *is below a cutoff* κ^V*, which is represented by:*

$$\kappa^V = \begin{cases} \int_{-\infty}^{t^V} y_h \; d\; F(y_i) + \int_{t^V}^{y_i^\dagger} (y_h + s + \bar{q} + y_i) \; (1 - \frac{\bar{q}}{V^\pi}) \; d\; F(y_i) & \\ \qquad + \int_{y_i^\dagger}^{+\infty} (y_h + s + y_i) \; d\; F(y_i) - (y_h + s + \bar{q}) \; (1 - \frac{\bar{q}}{V^\pi}) & \text{Partial Disclosure} \\ \int_{-s}^{+\infty} \; (s + y_i) \; d\; F(y_i) & \text{Full Disclosure} \end{cases}$$

where $y_i^\dagger$ and y_i^n are determined by Equation 6, and λs satisfy Equations 3.6, 3.7, and 3.8. She does not acquire information if the cost is equal or above the cutoff.

Comparing the information acquisition cost cutoff with that of the first-best case, we have the following proposition:

Proposition 3.5 *Under the Voluntary Disclosure Regime, if $s > 0$, then $\kappa^V > \kappa^*$; and if $s \leq 0$, then $\kappa^V = \kappa^*$.*

That is, under the Voluntary Disclosure Regime, the entrepreneur has incentives to excessively acquire private information prior to the offering. Intuitively, information has two types of values in this case. First, it can still facilitate production decisions, but is less valuable. The lower productive value results from the entrepreneur's *ex post* inefficient decisions. However, information also has a second role. The entrepreneur can use it to influence the investors' valuation. As shown previously, in the Partial Disclosure Equilibrium, shares are overpriced when the entrepreneur withholds her private information, and underpriced when she is uninformed. Therefore, with the information, the entrepreneur can avoid underpricing and can even take advantage of overvaluation. In the Full Disclosure Equilibrium, the entrepreneur has to forgo positive NPV projects when she is uninformed. Therefore, by acquiring information, she can avoid losing profitable investment opportunities. Overall, under the Voluntary Disclosure Regime, the private value of information exceeds its social value (i.e., its productive value),[27] which induces the entrepreneur to overinvest in her information acquisition.

[27]In the benchmark case, the private value of information equals its social value.

3.4.4 Mandatory Disclosure Regime

In this section, assume that the entrepreneur is required to include an **informative** forward-looking signal in the prospectus (either in the form of a forecast about the cash flows generated by the new project, or in the form of a forecast about the firm's total future cash flows).[28] Therefore if the entrepreneur has not acquired the private signal, she is not able to issue equity at $t = 2$ since she fails to satisfy the disclosure requirement.[29] Her expected payoff at $t = 1$ then is $U_1(y_h, a = 0) = y_h$.

If the entrepreneur has acquired private information, given y_h, y_i, and her decision to invest, her expected payoff at $t = 2$ from investing is $U_2(y_h, y_i, q = \bar{q}) = E[\tilde{u} + \tilde{x}|y_h, y_i, q = \bar{q}] - \bar{q} = y_h + s + y_i$, and her expected payoff is y_h if she does not invest. Therefore, she invests if $s + y_i > 0$ and does not invest otherwise. Her expected payoff from acquiring information at $t = 1$ then is $U_1(y_h, a = 1, \kappa) = y_h + \int_{-s}^{+\infty} (s + y_i)\, d\, F(y_i) - \kappa$. The entrepreneur's information acquisition and investment decisions are characterized in the following proposition.

Proposition 3.6 *Under the Mandatory Disclosure Regime, when the entrepreneur issues equity to finance the investment project, she acquires information according to a cost cutoff*

[28] An "informative" signal refers to a signal that leads the investors to revise their beliefs about the firm value. On the other hand, an "uninformative" or a null signal results in no revisions of beliefs.

[29] When analyzing the Voluntary Disclosure Regime, we implicitly assume that the entrepreneur who does not acquire information cannot convince the investors the fact she is uninformed. To be consistent, we assume that the entrepreneur cannot credibly disclose a null forecast in the prospectus. Otherwise, the entrepreneur, when uninformed, could simply issue a null signal to convince the investors that she indeed has no private information. We will discuss later how things change if this assumption is relaxed.

κ^M, *which is represented by*

$$\kappa^M = \int_{-s}^{+\infty} (s + y_i) \; d\, F(y_i).$$

If $\kappa < \kappa^M$, *the entrepreneur acquires information, and invests if, and only if,* $s + y_i > 0$. *If* $\kappa \geq \kappa^M$, *the entrepreneur does not acquire information, and not invest.*

3.5 Comparisons of Disclosure Regimes

Table 3.1 and Proposition 3.7 summarize the comparisons of the *ex ante* efficiencies of the investment and information acquisition decisions in the three disclosure regimes.

Proposition 3.7 *If* $s > 0$, *then* $\kappa^N < \kappa^* < \kappa^V \leq \kappa^M$, *and if* $s \leq 0$, *then* $\kappa^N < \kappa^* = \kappa^V = \kappa^M$.

As can be seen in Panel A of Table 3.1, the investment decisions are inefficient relative to the first-best case in all disclosure regimes, except in the Voluntary and Mandatory Disclosure Regimes with $s \leq 0$.

Furthermore, Panel B of Table 3.1 and Proposition 3.7 compare the entrepreneur's information acquisition decisions in different equilibria. When $s > 0$, the entrepreneur underinvests in her acquisition of productive information in the Non-Disclosure regime, and overinvests in information in both the Voluntary and Mandatory Disclosure Regimes. The excessive information acquisition in the Mandatory Disclosure Regime tends to be more severe than that in the Voluntary Disclosure Regime ($\kappa^V \leq \kappa^M$). When $s \leq 0$, the Voluntary and Mandatory Disclosure Regimes induce the socially optimal incentives to acquire information, while the Non-Disclosure Regime motivates the entrepreneur to produce less information.

The intuition is as follows. If firms are mandated to include numerical forward-looking information in the offering prospectus, they tend to overinvest in the information acquisition to comply with the disclosure regulation. However, if the information is too costly (possibly due to the high uncertainties around their future cash flows), firms will choose not to acquire information. These uninformed firms will have to give up positive NPV projects since they are unable to make a forecast that is required by the Regulators.

On the other hand, under the Non-Disclosure Regime, firms are not allowed to share their private forward-looking information with investors. Therefore, when their shares are misvalued, they are deprived of the opportunity to achieve a fair valuation through disclosure. The mispricing can distort firms' investment decisions, which ultimately results in a decrease in the value of the information to firms' internal production decisions and makes firms less inclined to acquire additional information.

The Voluntary Disclosure Regime induces excessive incentives to acquire information. This is because information has a second role in addition to its value of improving production decisions. Firms could also strategically use the information to influence investors' valuation. When their shares are undervalued relative to their private knowledge, firms disclose the information to achieve a higher price; however, they withhold their private information when their shares are overvalued.

The following proposition summarizes the welfare comparisons of the *ex ante* efficiencies of three disclosure regimes.

Proposition 3.8 *When $s > 0$, each of the three regimes can emerge as the efficient regime under some conditions. However, when $s \leq 0$, the Mandatory and Voluntary Disclosure Regimes dominate the Non-Disclosure Regime.*

The welfare analysis of the regimes involves complex tradeoffs of productive value of information, information acquisition costs and efficiency losses from investment and information acquisition decisions associated with equity financing. Proposition 3.8 shows that neither Mandatory nor Voluntary Disclosure Regime is necessarily more efficient than the Non-Disclosure Regime. This finding supports Dye's (2001) argument that a production economy is not an obvious setting for public disclosure to have a net positive social value and the interplay between disclosure and production is subtle.

Our results also have policy implications on the disclosure regulation of initial public offerings. In addition to concerns for market efficiency and investor protection, regulators should also take into account the impact of disclosure policies on firms' real decisions. These policies not only affect the total information available to the general public, but also have other externalities. Our analysis shows that firms' production plans and information acquisition decisions can be distorted under different disclosure rules, and the direction of the distortion varies.

Second, it is difficult to determine which disclosure regime should be preferred from an *ex ante* point of view. The Mandatory and Voluntary Disclosure Regimes are associated with efficiency losses resulting from excessive information acquisitions and inefficient investment decisions, while the Non-Disclosure Regime suffers from the efficiency losses from under-production of information and overinvestment in unprofitable projects. The tradeoffs of excessive and inadequate information production, and various forms of investment inefficiencies depend on different parameter values, and none of the disclosure regimes dominates the other two in all situations.

However, our results also show that a Non-Disclosure Regime can compromise firms' ability to reduce information asymmetry and correct potential misvaluation through disclosure[30] and such restrictions can be detrimental. Proposition 3.8 shows that when $s \leq 0$, the Mandatory and Voluntary Disclosure Regimes are *ex ante* more efficient than Non-Disclosure Regime. Recall that s is the prior mean of the project NPV, i.e., the market's prior belief about the profitability of the new investment project. Therefore this proposition implies that firms facing unfavorable prior public opinion should be allowed to truthfully disclose their private forward-looking information. Otherwise, issuing firms not only have less incentives to acquire valuable productive information, but also invest inefficiently.

[30]An example in the appendix of Lang and Lundholm (2000) illustrates how firms generally feel about the strict "quiet period" regulation. When facing negative news reports about his firm's proposed IPO, the CEO of Wired Ventures emailed his employees complaining how he felts hampered in his ability to defend their firm by the SEC regulation. Similar remarks have also been made by Salesforce's CEO in his May 2004 interview with the New York Times.

3.6 Discussion and Conclusion

In this chapter, it is assumed that the uninformed entrepreneur cannot credibly disclose that she has no private information about the project.[31] If this assumption were relaxed, the results of both the Voluntary Disclosure and the Mandatory Disclosure regimes would change. It is straightforward to show that the Mandatory Disclosure Regime would be the same as the first-best case. Further, it is not difficult to show that when disclosure of forward-looking signal is voluntary, the entrepreneur fully discloses her private signal whenever she issues equity.[32] Therefore, both the Mandatory and Voluntary Disclosure Regimes would dominate the Non-Disclosure Regime.

Another key assumption is that disclosure is truthful if the entrepreneur ever reports to the investors. This assumption is usually warranted by the threat of litigation imposed on the misleading or untruthful IPO prospectus. This assumption is imposed to focus on the impact of disclosure policies on the availability of truthful forward-looking information to the investors and how too much or too little information affects the production efficiency of the economy.

Our analysis is a partial equilibrium analysis since we take all the other factors which might affect firms' decisions as exogenous. In particular, we have not explicitly modelled the

[31]The same assumption is made by previous studies such as Dye (1985), Jung and Kwon (1988), and Pae (1999, 2002).

[32]If the entrepreneur is uninformed, her firm's shares are correctly priced and her *ex ante* expected payoff is the same as in the first-best case. And if she is informed but issues equity without disclosing, the investors know that she is withholding information. A credible threat of offering a very low price will force the entrepreneur to fully disclose if she ever wants to issue equity. Therefore a Full Disclosure Equilibrium will prevail under the Voluntary Disclosure Regime.

threat of securities litigation. Moreover, we have not considered the signalling effect of owners' decisions (such as the equity retention and the amount of capital investment), and other information accessible to the public around initial public offerings (such as economic-wide and industry-specific information, and unaffiliated analysts' reports and forecasts, etc.). For example, one relevant question is to what extent management forecasts add to investors' knowledge given these alternative information sources.[33] Another question is if the firm managers can convey their private information through alternative mechanisms, how important disclosure policies are in the capital market. Richer insights may be obtained if future research extends this line of research by incorporating these elements.

[33]That is, there can be a substitution effect between these other mechanisms and direct disclosure.

Table 3.1: Efficiencies of Decisions in Three Disclosure Regimes

Panel A: Investment Decisions

<table>
<tr><th></th><th>Non-Disclosure Regime</th><th>Voluntary Disclosure Regime</th><th>Mandatory Disclosure Regime</th></tr>
<tr><td rowspan="2">$s > 0$</td><td rowspan="2">overinvest in negative NPV projects.</td><td>Partial Disclosure Equilibrium: overinvest in negative NPV projects.</td><td rowspan="2">Underinvest in positive NPV projects.</td></tr>
<tr><td>Full Disclosure Equilibrium: underinvest in positive NPV projects.</td></tr>
<tr><td>$s \leq 0$</td><td>overinvest in negative NPV projects.</td><td>Full Disclosure Equilibrium: no efficiency loss.</td><td>No efficiency loss.</td></tr>
</table>

Panel B: Information Acquisition Decisions

	Non-Disclosure Regime	Voluntary Disclosure Regime	Mandatory Disclosure Regime
$s > 0$	Underproduction of information.	Excessive information acquisition.	Excessive information acquisition.
$s \leq 0$	Underproduction of information.	No efficiency loss.	No efficiency loss.

Chapter 4

Impact of Shareholder Litigation

4.1 Introduction

As mentioned previously, the threat of shareholder litigation is a major force that affects an equity-issuing firm's disclosure incentives. It is often alleged that firm managers are reluctant to issue forecasts since they might be sued by shareholders if the actual results fall short. Litigations can be very costly to firms. The costs of defending against lawsuits, even those without merits, could be substantial. There can also be damage to corporate and personal reputations and distraction of management from productive activities (Revsine et al. 2001).

Policymakers have long been aware of the negative impact of the litigation risk on firm managers' incentives to provide voluntary disclosure of forward-looking information. One of the most important legal reforms to address this issue is the 1995 Private Securities Litigation Reform Act (PSLRA). This act created a statutory safe harbor that applies to both written and oral forward-looking statements. Under such a safe harbor, a defendant is not liable with respect to any forward-looking statement if it is identified as forward-looking and is accompanied by "meaningful" cautionary language identifying the factors that could cause actual results to differ.[1] However, this safe harbor does not apply to initial public offerings (IPOs).[2]

On November 3, 2004, the SEC proposed a new rule to reform the registration, communications, and offering processes of the securities offerings (SEC Release No. 33-8501).[3] The major intent of this proposal is to promote more timely investment information to the investors, and to continue the efforts to integrate disclosure requirements on equity-issuing firms and public firms. One of the SEC's proposals is to grant safe harbor protection from the gun-jumping provisions for forward-looking information disclosed by reporting issuers (i.e., existing public firms) if they regularly release such information before the offering.[4] However, the SEC did not propose a same safe harbor for non-reporting issuers (mainly IPO firms). But it remains an open question whether the SEC should provide a safe harbor for forward-looking information released by IPO firms. In the release, the SEC specifically requested comments on the following issues:[5]

- "In initial public offerings by non-reporting issuers, should we consider using our au-

[1]For a detailed review of the 1995 Private Securities Litigation Reform Act, please refer to Johnson, Kasznik, and Nelson (2001).

[2]Other forward-looking statements excluded from the safe harbor provision include those statements in connection with tender offers, or made by firms issuing penny stock.

[3]The full text of this release is available on the SEC's official web site: http://www.sec.gov/rules/proposed/33-8501.htm.

[4]Please refer to Section 3.2 in Chapter 3 for a discussion of the "gun-jumping" provisions.

[5]See Section III of SEC Release No. 33-8501.

thority,... to propose a projections and forward-looking information safe harbor from liability for the forward-looking statements that would be similar to the liability safe harbor ... in Securities Act Section 27A?"

- "If we (the SEC) determine to propose a safe harbor of this type for initial public offerings, what kinds of conditions should we consider for its use?"
- "As a condition for this safe harbor or one for initial public offerings, should we require the issuer to file projections or other forward-looking information as part of the registration statement? Should the projections be required to follow Item 10 of Regulation S-K or S-B as applicable? Should projections be required to be accompanied by an accountant's report on the projections or forecasts?"
- "Would a liability safe harbor for initial public offerings cause issuers to provide more projections publicly? Would there be concerns about the quality of these projections in light of the safe harbor?"

Motivated by these questions, this chapter investigates the potential impact of shareholder litigation on the voluntary disclosure of forward-looking information in initial public offerings. It also analyzes the implications of legal liabilities on firms' production decisions. Specifically, we introduce a potential cost of a law suit for "failure to meet the forecast". We assume that shareholders could hire a lawyer to file lawsuits against the equity-issuing firm if the subsequent actual performance falls below the management forecast disclosed during the offering. With an exogenous positive probability, the court will rule in favor of the shareholders and award damages to them. This positive probability is used to capture the litigiousness of the legal environment, or the legal liability associated with the issuance of a forecast.[6]

The paper has the following major findings. First, under different sets of economic parameters, the entrepreneur has two possible equilibrium disclosure strategies: Full Disclosure and Partial Disclosure. Specifically, in a Full (Partial) Disclosure Equilibrium, all (part) of the signals will be disclosed when the informed entrepreneur issues equity. Of particular interest is the latter equilibrium, in which shareholder litigation plays a significant role. The litigation threat can give the entrepreneur incentives to only partially disclose her private prospective information.[7] When the legal environment is sufficiently litigious, the entrepreneur rarely discloses a forecast in the offering, which is descriptive of the situation in the United States.

Second, the entrepreneur's production decisions might be distorted by her disclosure incentives. In the Full Disclosure Equilibrium, the entrepreneur, if informed, could give up some positive NPV projects if the expected litigation cost outweighs the expected investment profit. On the other hand, if she is uninformed and unable to issue a forecast, she has to forgo the investment opportunity even though the project is positive NPV, since the investors severely underprice the firm's stock when they observe no disclosure.[8] In contrast, in

[6]These two are not mutually exclusive, since a higher legal liability on firms could induce investors to file lawsuits more often, which in turn makes the legal environment more litigious.

[7]By "partially", we mean that the entrepreneur discloses only if her signal is above a certain threshold.

[8]It is assumed that if the entrepreneur is uninformed, she cannot issue a "null" forecast which does not change investors' prior beliefs about the firm value. Alternatively, we can assume a "null" forecast and a "no disclosure" are treated as equivalent by the investors.

the Partial Disclosure Equilibrium, the entrepreneur could invest in negative NPV projects. This is because when the investors have uncertainty about the entrepreneur's information endowment, in equilibrium they overpay for the firm's shares when the privately-informed entrepreneur issues equity.[9] Such overvaluation induces the entrepreneur to take on unprofitable projects and incur an efficiency loss.

The model is then used to examine the effect of regulatory polices on firms' disclosure incentives. The analysis shows that relaxing the legal liability (for example, by providing a safe harbor for forward-looking information disseminated by IPO firms) can result in more information flow to the public and facilitate the capital formation process. On the cost side, however, such a safe harbor could lead to a higher rate of lawsuits and an increase in deadweight litigation costs. As to the issue on whether to require issuing firms to file projections, the study suggests that the Full Disclosure policy is not necessarily optimal since it is associated with both a social loss due to underinvestment and a higher litigation-related deadweight cost.

We extend previous analytical research on the link between shareholder lawsuits and managerial disclosure of prospective information. The study is most closely related to Trueman (1997), but our model differs from his in the following important ways. Trueman examines a setting in which the manager has an affirmative duty to disclose forward-looking information, and **failure to disclosure** will potentially trigger lawsuits when there is a stock price decline after the actual result reveals the information that was withheld. But in our

[9] The investors on average breaks even, since they also underpay for the firm's shares when the entrepreneur is uninformed and issues the equity.

setting, the firm manager has no legal obligation to make a forecast and it is the **disclosure of the prospective information** that can lead to future lawsuits if the actual result falls below the forecast. Our results also differ significantly. Trueman demonstrates shareholder litigation can motivate managers to disclose bad news. In contrast, we show that litigation risk can suppress managerial disclosure of forward-looking information.

Our work complements the empirical literature on the relation between shareholder litigation and voluntary disclosure. Earlier studies (Skinner 1994, 1997) have investigated the impact of shareholder litigation on firm management's voluntary disclosures of forecasts, and produce two general findings (as summarized in Baginski, Hassell, and Kimbrough 2002). First, the threat of litigation reduces the manager's incentives to voluntarily disclose management forecasts. Second, fear of legal liability motivates managers to hasten disclosure of bad news to "preempt" potential lawsuits.[10] Later, Johnson, Kasznik, and Nelson (2001) examine how the safe harbor provision introduced by the 1995 Private Securities Litigation Reform Act changes the managers' disclosure practices of prospective information. Baginski et al. (2002) compare the characteristics of management forecasts in two different legal environments, U.S. and Canada. Almost all these studies examine management forecasts from existing public companies, and how litigation affects IPO firms' disclosure incentives are largely unexplored. This could be attributable to the fact that IPO forecasts are virtually non-existent in the United States. This chapter employs a theoretical approach and thereby circumvents the data problem. We argue that in the IPO settings shareholder litigation

[10] For example, Skinner (1994) provides evidence that managers voluntarily disclose bad news to preempt bad quarterly earnings news.

deters disclosure of prospective information, rather than induces more disclosure. Furthermore, this approach also allows us to provide **predictions** for the **potential consequences** of alleviating the legal liability for forecasts associated with initial public offerings.

This chapter is organized as follows. Section 4.2 introduces the basic settings of the model and the major assumptions, and briefly analyzes a benchmark case. Section 4.3 investigates the entrepreneur's possible disclosure strategies if she is informed. Then the entrepreneur's investment decisions in different disclosure equilibria (Full and Voluntary Disclosure Equilibria) are examined. Section 4.4 compares the *ex ante* efficiencies of different disclosure equilibria and discusses the policy implications of the results. The last section concludes.

4.2 Model Setting and Benchmark Case

4.2.1 Setting and Major Assumptions

We incorporate the features of the U.S.'s legal environment into the new equity disclosure model developed in previous chapters to analyze the impact of shareholder litigation on firm managers' disclosure strategies. Specifically, we consider a setting with a risk-neutral entrepreneur who owns a private firm, and a group of well-diversified investors. The firm has an investment opportunity, which requires an initial investment of $\bar{q}$ and generates a gross payoff $\tilde{x} = (1+\theta)\bar{q} + \tilde{\epsilon}$, where θ is the net unit rate of return (a constant), and $\tilde{\epsilon}$ is the noise term.[11] Assume that $\tilde{\epsilon}$ is normally distributed, with mean 0, variance σ^2 and a cumulative distribution function of $G(\epsilon)$.

Assume that the entrepreneur decides to issue equity to finance her project. She will offer investors a fraction of her firm's shares in exchange for $\bar{q}$. Before she makes the investment decision, however, with a probability $1 - \lambda$, the entrepreneur receives a signal about the project's future return. The signal, denoted as y_i, is represented as $\tilde{\epsilon} = \tilde{y}_i + \tilde{\nu}$, where $\tilde{y}_i \sim \mathrm{N}(0, \sigma_i^2)$ and $\tilde{\nu}$ is independent of $\tilde{y}_i$. The residual uncertainty is captured by $\tilde{\nu}$, which follows a normal distribution $\mathrm{N}(0, \sigma_\nu^2)$ with $\sigma_\nu^2 = \sigma^2 - \sigma_i^2$. The cumulative distribution functions of $\tilde{y}_i$ and $\tilde{\nu}$ are denoted as $F(y_i)$ and $H(\nu)$ respectively.

At $t = 1$, based on her information set, the entrepreneur decides whether to invest. If she decides to invest, she will issue equity to the public with a prospectus that includes general information about her firm's business and possibly a forecast of her firm's terminal cash flow. Denote the forecast as F. Under the truthful disclosure assumption, it must be true that $F = E[\tilde{x}|y_i] = (1+\theta)\bar{q} + y_i$. Since F is informationally-equivalent to y_i, in the later analysis, we will sometimes refer to the inclusion of a forecast as disclosing y_i.

At the end of the period, if the entrepreneur did not invest in the project at the previous date ($t = 1$), the cash flow is zero; otherwise the firm's cash flow is realized as $x = (1+\theta)\bar{q}+\epsilon$. If the realized cash flow falls short of the prior forecast F, the shareholders who purchased the shares at $t = 1$ might successfully sue the entrepreneur for the "inflated forecast". Following Trueman [1997], we assume that the shareholders who want to take legal action against the

[11] For a summary of the notation used in this paper, please refer to the Appendix.

entrepreneur will approach a risk-neutral lawyer who decides whether to take on the suit. Assume that θ, $\bar{q}$, and the structure of the game are common knowledge. The time line of the model is shown in Figure 4.1.

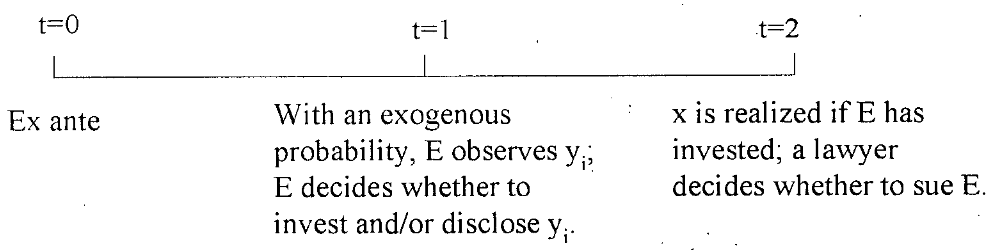

Figure 4.1: Sequence of Events.

4.2.2 Self-Financing – the Benchmark Case

We first briefly examine the case in which the entrepreneur self-finances the project. Let $q \in \{0, \bar{q}\}$ represent the entrepreneur's investment decision. At $t = 1$, if the entrepreneur has no private information about the investment's profitability, her expected payoff is $U_1 = E[\tilde{x}|q = \bar{q}] - \bar{q} = \theta\bar{q}$ if she invests, and $U_1 = 0$ if she does not invest. Therefore, she invests if $\theta > 0$ and does not invest otherwise.

If the entrepreneur is privately informed, her expected payoff at $t = 1$ is $U_1(y_i) = E[\tilde{x}|y_i, q = \bar{q}] - \bar{q} = \theta\bar{q} + y_i$ if she invests, and 0 if she does not invest. Therefore, she invests if $\theta\bar{q} + y_i > 0$ and does not invest otherwise. Denote the prior mean of the NPV of the investment project as s, i.e., $s = \mathrm{E}[\tilde{x}|q = \bar{q}] - \bar{q} = \theta\bar{q}$. Then when the entrepreneur is informed, her investment decisions are characterized by an investment cutoff $-s$. That is, investment is undertaken if, and only if, $y_i \in (-s, +\infty)$.

4.3 Analysis of the Equity Offering

From now on, assume that the entrepreneur decides to raise capital from the equity market to finance the project.

4.3.1 The Lawyer's Litigation Decision at t=2

Using backward induction, we first analyze the lawyer's suing decision at date 2. Assume that the necessary conditions for a lawsuit are that (1) the entrepreneur issued a forecast at $t = 1$, and (2) at the end of the period the realized cash flow x falls below the forecast. Such an assumption is based on the following two observations. First, many disclosure-related lawsuits are filed following a sharp decline in the stock price and firms are rarely sued after large stock price increases (Trueman 1997; Brown et al. 2004). Secondly, in the United States, IPO firms have no affirmative duty to disclose numerical forward-looking information in the prospectus.[12]

The above assumption implies that the entrepreneur will not be sued if she did not include a forecast in the prospectus when she issued equity at date 1. On the other hand, if a forecast was included in the prospectus (i.e., y_i was disclosed) and the realized cash flow is x, the lawyer agrees to take on the lawsuit if the fee he receives from the shareholders

[12] An affirmative duty to disclose exists either because the manager's information pertains to MD&A statement or would serve to update or correct a previous disclosure (Trueman 1997).

exceeds his litigation cost (denoted as C_L). Assume that the shareholders pay the lawyer a fraction γ of the damage award.[13] γ is assumed to be an exogenous constant, which implies that the market for legal services is not competitive and in equilibrium the lawyer could earn a positive profit.

It is also assumed that when a lawsuit is filed, the court holds the entrepreneur liable with a positive probability β.[14] We can interpret β as a measure of the litigiousness of the legal environment, or the legal liability for disclosure of a forecast. The damage award to the shareholders is assumed to be set to equal to $max\{0, E[\tilde{x}|y_i] - x\}$, i.e., the alleged "price inflation".[15] If the lawsuit is unsuccessful, the shareholders receive nothing.

The lawyer's expected payoff from pursuing a lawsuit is

$$\pi_L = \gamma\ \beta\ max\{0, E[\tilde{x}|y_i] - x\} - C_L.$$

It is easy to show that he will agree to sue the entrepreneur if, and only if, $\epsilon \leq y_i - \underline{L}$, where ϵ is the realized noise term in $\tilde{x}$ and $\underline{L} \equiv \frac{C_L}{\gamma\beta}$.

[13]How the damage award is determined will be discussed later.

[14]Firm managers could be held liable for forecasts that are truthful but in hindsight are too optimistic. This is because firm managers have the legal responsibility to make the forecasts with best judgement and reasonable care and skill. However, what constitutes "due care" is not specifically stated in the current law. Therefore, a manager can be held liable for failure to forewarn the investors about the future poor performance, even though the forecast was consistent with the manager's private information set at the time of making the projection. The legal rules on auditor liabilities are also ambiguous in defining "due care".

[15]Damages in securities litigation cases are most commonly based on the difference between the security's alleged inflated purchase price and a subsequent price that reflects the correct information (Schwartz 1997).

4.3.2 The Entrepreneur's Disclosure Decision at $t = 1$ if She is Informed

Recall that we assume that the entrepreneur can choose whether to disclose her private signal in the prospectus. We can follow the same procedure used in Chapter 2 to analyze the entrepreneur's decisions.

Represent the entrepreneur's information set as Ψ_E, where $\Psi_E = \{y_i\}$ if she is informed and $\Psi_E = \emptyset$ otherwise. The investors' information set is $\Psi_I = \{m, q\}$, i.e., the entrepreneur's disclosure of the private signal ($m = y_i$ if the entrepreneur discloses and $m = n$ if the entrepreneur does not disclose), and the entrepreneur's investment decision. If the entrepreneur decides to invest and issues stocks but does not disclose any forward-looking information, the investors price the firm as $\delta^n \equiv \mathrm{E}[\tilde{x}|m = n, q = \bar{q}] = s + \bar{q} + \mathrm{E}[\tilde{\epsilon}|m = n, q = \bar{q}]$. If the entrepreneur issues equity and also discloses a forward-looking signal about the project, her firm's share is valued as $\delta^d \equiv \mathrm{E}[\tilde{x}|m = y_i, q = \bar{q}] = s + \bar{q} + y_i$.

Given the entrepreneur's decision to issue the stock but not disclose, the investors update their beliefs on $\tilde{\epsilon}$ according to the Bayes Rule as follows,

$$\begin{aligned} y_i^n &\equiv \mathrm{E}[\tilde{\epsilon}|m = n, q = \bar{q}] \\ &= \frac{(1-\lambda)\ \mathrm{E}\left[\tilde{\epsilon}|m = n, q = \bar{q}, \Psi_E = \{y_i\}\right]}{\lambda\ Prob(m = n, q = \bar{q}, \Psi_E = \emptyset) + (1-\lambda)\ Prob(m = n, q = \bar{q}, \Psi_E = \{y_i\})}. \end{aligned}$$

In anticipation of the investors' responses, the entrepreneur believes that the investors' valuation of the firm is $\delta^n \equiv s + \bar{q} + y_i^n$, if she decides to invest and issues equity but makes no forecast.

If the entrepreneur is uninformed, her expected payoff is

$$U_1^{ui}(\lambda, q) = \begin{cases} (s+\bar{q})(1-\frac{\bar{q}}{\delta^n}) & \text{if } q = \bar{q}, \\ 0 & \text{if } q = 0. \end{cases}$$

If the entrepreneur is informed with a signal y_i, she can make three possible decisions: invest and disclose y_i (id), invest and withhold the information (iw), and not invest (ni). Assume that disclosure is truthful. The entrepreneur's expected payoffs from these alternative actions can be characterized as follows.

Given y_i, and in anticipation of the potential future litigation, the entrepreneur's expected payoff at $t = 1$ is

$$U_1^i(y_i, m, \lambda, \beta, q) = \begin{cases} s + y_i - \gamma\ D(y_i, \beta) & \text{if } m = y_i \text{ and } q = \bar{q}, \\ (s+\bar{q}+y_i)(1-\frac{\bar{q}}{s+\bar{q}+y_i^n}) & \text{if } m = n \text{ and } q = \bar{q}, \\ 0 & \text{if } q = 0, \end{cases}$$

where $D(y_i, \beta) \equiv \beta \int_{-\infty}^{y_i - L} (y_i - \epsilon)\ d\ G(\epsilon|y_i)$, i.e., the expected damage award.[16]

There are two points worth noting. First, let us try to understand the expected payoff when the entrepreneur issues equity and discloses her signal in the form of a forecast. The term $\gamma\ D(y_i, \beta)$ represents the portion of expected damage award that the investors use to pay the lawyer. In a rational expectations equilibrium, the investors endogenize their expected

[16]The proof for this expected payoff functions is provided in the Appendix.

legal fees into their pricing function, and get fully reimbursed from the entrepreneur for this legal expenditure.

Second, it can be shown that the expected damage award $D(y_i, \beta)$ is independent of the forecast disclosed, as summarized in the following lemma.[17]

Lemma 4.1 *The expected damage award $D(y_i, \beta)$ is independent of y_i.*

This might sound counterintuitive. Intuition suggests that the more optimistic the forecast is, it is more difficult for the entrepreneur to meet or beat the target. The expected damage award should also be larger, since it is more likely that the actual result falls widely below the forecast. However, recall that y_i is informative about the noise term ϵ. When the entrepreneur issues a favorable forecast and the forecast is truthful, it implies that the terminal cash flow is expected to be higher. As a matter of fact, the signal shifts the mean of ϵ from zero to y_i.[18] Therefore, the conditional probability that the terminal cash flow falls below the forecast is independent of the forecast. So is the expected damage award. In the subsequent analysis, we refer to the expected damage award as $D(\beta)$.

If $s+q+y_i \leq 0$, the entrepreneur does not invest. Nor does she need to access the capital market or make any disclosure. If $s+q+y_i > 0$ and $\delta^n \leq \bar{q}$, the entrepreneur fully discloses her signal whenever she issues equity, since the fraction of shares she has to sell is equal to or larger than 100% if she makes no disclosure.

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[17]The proof is as follows. Recall that $\tilde{\epsilon} = \tilde{y}_i + \tilde{\nu}$. Therefore, $D(y_i, \beta) \equiv \beta \int_{-\infty}^{y_i - L} (y_i - \epsilon)\ d\ G(\epsilon|y_i) = \beta \int_{-\infty}^{-L} (-\nu)\ d\ H(\nu) = \beta\ \sigma_\nu\ \phi(-\frac{L}{\sigma_v})$, where $\phi(\cdot)$ is the P.D.F. of a standard normal distribution. It follows that $D(y_i, \beta)$ is independent of y_i. We are thankful to Prof. Jerry Feltham for raising this point.

[18]Given $\tilde{\epsilon} = \tilde{y}_i + \tilde{\nu}$, it must be true that $E[\tilde{\epsilon}|y_i] = y_i$.

If $s + q + y_i > 0$ and $\delta^n > \bar{q}$, she invests in the project and also chooses whether to issue a forecast to the investors. Her disclosure strategy is characterized by the following lemma.

Lemma 4.2 *If $s + q + y_i > 0$ and $\delta^n > \bar{q}$, the entrepreneur's disclosure strategy is characterized by a lower bound.*

To understand this lemma, note that the entrepreneur makes the disclosure decision by comparing $U_1(y_i, m = y_i, \lambda, \beta, q = \bar{q})$ with $U_1(y_i, m = n, \lambda, \beta, q = \bar{q})$. It is easy to see that both expected utilities are a linear increasing function of y_i for all $y_i > -s - \bar{q}$.[19] The two straight lines intersect once and the disclosure region must be characterized by a single lower cutoff.

Lemma 4.3 *If the parameters are such that $\delta^n > \bar{q}$, the disclosure cutoff increases in the litigation risk, i.e., $\frac{\partial y_i^\dagger}{\partial \beta} > 0$.*

To explain, in our setting, disclosure of the private signal involves a cost. That is, it can result in shareholder lawsuits at the end of the period. Several previous studies (such as Verrecchia 1983) show that a partial disclosure equilibrium exists when there is a disclosure cost. A major difference between our model and Verrecchia (1983)'s model is that the disclosure cost in our model is endogenously determined by the lawyer's actions, while he assumes that the cost is exogenous.[20] In addition, the disclosure cost is increasing in the litigation risk. Therefore, when the litigation risk is higher, the entrepreneur has less incentive to disclose her private signal.

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[19]Note that $s + \bar{q} + y_i^n$ is a constant.

[20]Some disclosure models have considered endogenous disclosure costs arising from product market competition. See, for example, Darrough (1993).

Figure 4.2 shows a numerical example on the impact of the litigation risk on the disclosure cutoff. The vertical axis represents the value of the function $T(y_i) = (p+\bar{q}+y_i)\ \dfrac{\bar{q}}{\bar{q}+\gamma D(\beta)} - (p+\bar{q}+y_i^n(y_i))$, and the intercepts are disclosure cutoffs under different values of β. It can be shown that $\beta = 0.45$ results in a disclosure cutoff $y_i^\dagger = 1.65$. The equilibrium probability that the entrepreneur issues a forecast when issuing equity is about 5%.[21] That is, when the threat of litigation is sufficiently high, it can result in little disclosure of forward-looking information, which is consistent what we now observe in initial public offerings in the United States.

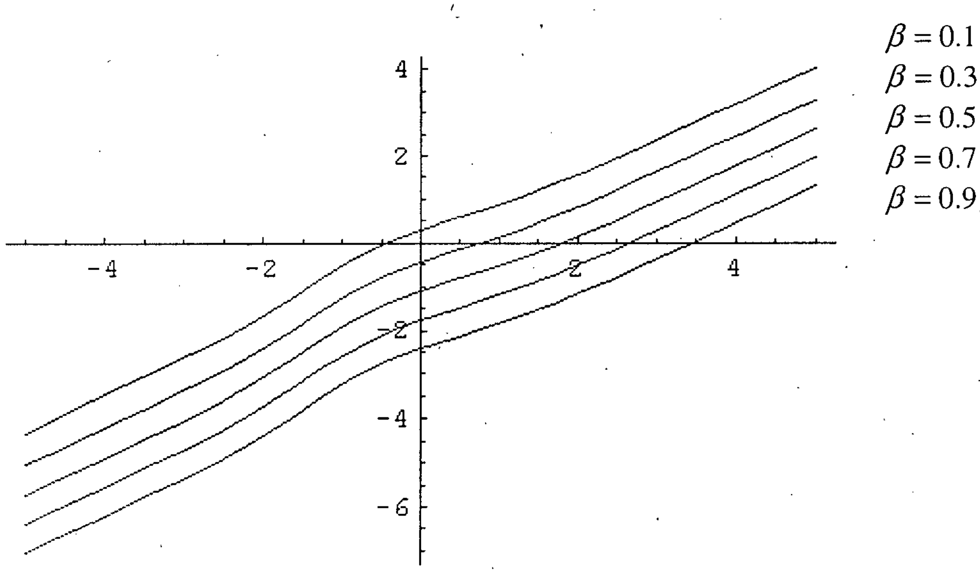

Figure 4.2: Impact of Litigation Risk on Disclosure Cutoff ($s = 2$, $\bar{q} = 10$, $\lambda = 0.2$, $\gamma = 0.9$, $\sigma = 10$, $\sigma_i = 1$, $C_L = 1$).

The following proposition fully characterizes the entrepreneur's disclosure decisions:

[21] In the numerical example, the signal y_i follows a standard normal distribution. When $\beta = 0.45$, the probability that the entrepreneur issues equity is $Prob(y_i > -s - \bar{q}) = Prob(y_i > -12) \doteq 1$, and the probability that she discloses a forecast is $Prob(y_i > y_i^\dagger) = Prob(y_i > 1.65) = 0.05$. Therefore, the conditional probability of observing a forecast in the offering is about 5%.

Proposition 4.1 *If the entrepreneur is informed and decides to raise capital to invest in the project, she could possibly make the following disclosure decisions:*

(1) ***Full Disclosure****: If the parameters are such that* $\delta^n \leq \bar{q}$*, the entrepreneur always discloses her private signal if she is informed.*[22]

(2) ***Partial Disclosure****: If the parameters are such that* $\delta^n > \bar{q}$*, the entrepreneur makes disclosure decisions according to a cutoff. Specifically, the entrepreneur's disclosure strategy* m *is as follows,*

$$m(y_i) = \begin{cases} y_i & \text{if } y_i \in [y_i^\dagger, +\infty), \\ n & \text{if } y_i \in (-s-\bar{q}, y_i^\dagger), \end{cases}$$

where $y_i^\dagger$ *is determined by the following two equations:*

$$s + y_i^\dagger - \gamma\ D(\beta) = (s + \bar{q} + y_i^\dagger)(1 - \frac{\bar{q}}{s + \bar{q} + y_i^n}) \tag{4.1}$$

$$y_i^n = \frac{(1-\lambda)\displaystyle\int_{-s-\bar{q}}^{y_i^\dagger} y_i\ d\ F(y_i)}{\lambda\ Prob(m = n, q = \bar{q}, \Psi_E = \emptyset) + (1-\lambda)\displaystyle\int_{-s-\bar{q}}^{y_i^\dagger} d\ F(y_i)} \tag{4.2}$$

4.3.3 The Entrepreneur's Investment Decision at $t = 1$

Full Disclosure

If $\delta^n \leq \bar{q}$, the entrepreneur is not able to raise the capital needed, if she invests but does not disclose any forward-looking information. Therefore, if the entrepreneur is not informed, she does not invest. When the entrepreneur is informed, she invests and discloses her private

[22]The complete list of parameters includes s, $\bar{q}$, σ^2, σ_i^2, γ, λ, C_L, and β.

signal if $s + y_i - \gamma D(\beta) > 0$ and does not invest otherwise. Denote the solution to $s + y_i = \gamma D(\beta)$ as $\underline{y_i}$, which is both the investment cutoff and the disclosure cutoff.

Lemma 4.4 *In the Full Disclosure Equilibrium, $\underline{y_i} > -s$. That is, the entrepreneur under-invests in positive NPV projects.*

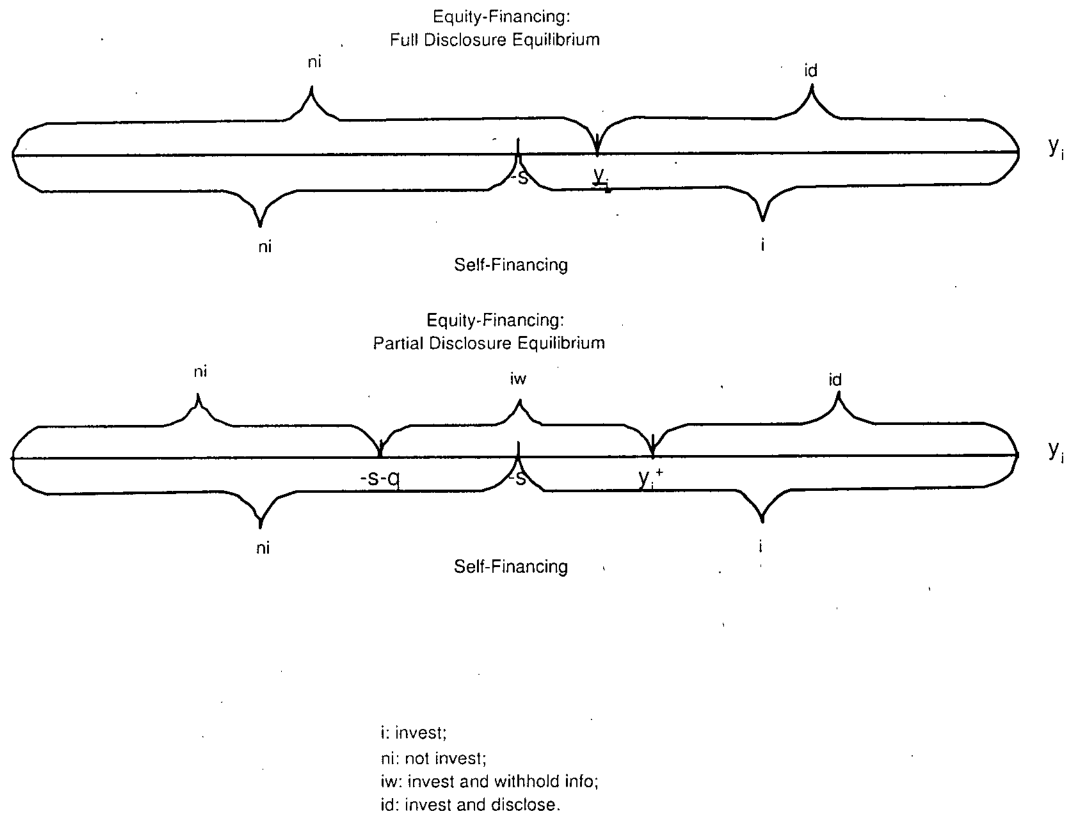

Figure 4.3: The Entrepreneur's Investment Decisions in Different Disclosure Equilibria when She is Informed.

Intuitively, since the entrepreneur can only invest if she discloses her private signal, she has to weigh the expected investment payoff against the potential future loss caused by shareholder litigation. If the project's expected return is not large enough to compensate for the expected litigation cost, the entrepreneur does not invest.

Partial Disclosure

If $\delta^n > \bar{q}$, the investment cutoff for the informed entrepreneur is $-s - \bar{q}$. To explain, when $\delta^n > \bar{q}$, if the entrepreneur is informed with a signal better than $y_i^\dagger$, she receives a positive expected payoff from investing. The proof is as follows.

$$\begin{aligned} U_1^i(y_i, m = y_i, \lambda, q = \bar{q}) &> U_1^i(y_i, m = n, \lambda, q = \bar{q}) \\ &= (s + \bar{q} + y_i)(1 - \frac{\bar{q}}{\delta^n}) \\ &> 0 = U_1^i(y_i, m = y_i, \lambda, q = 0). \end{aligned}$$

Similarly, when the private signal is between $-s - \bar{q}$ and $y_i^\dagger$, the entrepreneur is better off by investing than not investing, since $U_1^i(y_i, m = y_i, \lambda, q = \bar{q}) > 0$.

On the other hand, if the entrepreneur is uninformed, she chooses to invest in the project if $s + \bar{q} > 0$ and does not invest otherwise.[23]

To summarize, if the entrepreneur is uninformed, she invests in project if, and only if, $s + \bar{q} > 0$. If she is informed, she invests and discloses her private signal if $y_i \geq y_i^\dagger$, invests and withholds private information if $y_i \in (-s - \bar{q}, y_i^\dagger)$, and does not invest otherwise.

[23] Recall that $U_1^{ui}(\lambda, q = \bar{q}) = (s + \bar{q})(1 - \frac{\bar{q}}{\delta^n})$. If $s + \bar{q} \leq 0$, the investors infer that the entrepreneur must be informed and withholding the private signal if she invests but does not make any forecast. In this case, even though the investors are certain that the entrepreneur is informed if they observe $m = n$ and $q = \bar{q}$, partial disclosure continues to be an equilibrium since there exists an endogenous disclosure cost.

4.4 Welfare Analysis and Policy Implications

4.4.1 Social Welfare

We can compare the *ex ante* efficiencies of investment decisions in the two disclosure equilibria. The *ex ante* efficiency, or equivalently, *ex ante* social welfare, is defined as the sum of expected utilities at $t = 0$ of the three players: the entrepreneur, the investors and the lawyer. For each disclosure equilibrium, its social welfare is compared to the social welfare in the first-best (i.e., self-financing) case. The decrease in social welfare is called a social loss or inefficiency. Proposition 4.2 summarizes our findings from the previous section.

Proposition 4.2 *In the Partial Disclosure Equilibrium, the entrepreneur overinvests in negative NPV projects relative to the first-best case; she underinvests in positive NPV projects in the Full Disclosure Equilibrium.*

We can further calculate the *ex ante* inefficiency of the investment decisions as below:

$$L_1 = \begin{cases} \lambda\ max\{s, 0\} + (1-\lambda)[\int_{-s}^{\underline{y_i}} (s + y_i)\ d\ F(y_i)] & \text{Full Disclosure,} \\ -\lambda\ s\ I - (1-\lambda)[\int_{-s-\bar{q}}^{-s} (s + y_i)\ d\ F(y_i)] & \text{Partial Disclosure,} \end{cases}$$

where $I = 1$ if $s \in (-\bar{q}, 0]$ and $I = 0$ otherwise.

To explain, in the Full Disclosure Equilibrium, there are two scenarios in which the entrepreneur underinvests: (1) when the project NPV is positive ($s > 0$), but she has no private information and cannot issue equity; (2) when she is privately informed, but the expected investment payoff cannot offset the expected litigation cost ($-s < y_i < \underline{y_i}$). In the

Partial Disclosure Equilibrium, recall that the entrepreneur's expected payoff from investing when she is uninformed is $(s+\bar{q})(1-\frac{\bar{q}}{\delta^n})$. Since $\delta^n > \bar{q}$, the entrepreneur invests in the project as long as $s+\bar{q}>0$ when she uses equity-financing, while she invests only when $s>0$ in the first-best case. Therefore overinvestment occurs when $s \in (-\bar{q}, 0]$ and the resulting efficiency loss is the project's net loss $-s$. On the other hand, when the entrepreneur is informed, she invests in a negative NPV project when her private signal falls between $-s-\bar{q}$ and $-s$.[24]

The other inefficiency is related to the deadweight loss incurred in shareholder lawsuits, which is represented by

$$L_2 = \begin{cases} (1-\lambda)\ H(-\underline{L})\ C_L\ [1-F(\underline{y_i})] & \text{Full Disclosure,} \\ (1-\lambda)\ H(-\underline{L})\ C_L\ [1-F(y_i^{\dagger})] & \text{Partial Disclosure.} \end{cases}$$

where $\underline{y_i}$ is the solution to $s+y_i = \gamma D(\beta)$, and $y_i^{\dagger}$ is the disclosure cutoff established in Equations 4.1 and 4.2.

To understand, recall that a lawsuit will be filed whenever the entrepreneur is informed and issues a forecast in the equity offering ($y_i > \underline{y_i}$ in the Full Disclosure Equilibrium, and $y_i > y_i^{\dagger}$ in the Partial Disclosure Equilibrium), and the portion of the damage award paid to the lawyer exceeds her litigation cost ($\gamma\beta(y_i-\epsilon) \geq C_L$ or equivalently, $\nu \leq -\underline{L}$). Recall that the C.D.F. of ν is $H(\nu)$. Then, $H(-\underline{L})$ is the equilibrium probability that a lawsuit occurs conditional on disclosure of a forecast and C_L is the deadweight loss caused by the

[24]Conditional on the private signal y_i, the intrinsic project NPV equals y_i+s. Thus a private signal $y_i \in (-s-\bar{q}, -s)$ implies that the project is negative NPV.

litigation.

It is easy to compare the expected litigation-related efficiency loss in the two equilibria.

Proposition 4.3 *The Full Disclosure Equilibrium is associated with a higher expected deadweight litigation cost than the Partial Disclosure Equilibrium.*[25]

The above proposition follows from the fact that $y_i^\dagger > \underline{y_i}$.[26] The total inefficiency associated with the equity-financing setting relative to the self-financing setting is

$$L = U_{sf,0} - U_{ef,0} = L_1 + L_2.$$

4.4.2 Implications for SEC's Proposed Securities Offering Reform

Safe Habor for Prospective Information Disclosure from IPO Firms

Given the scarcity of management forecasts in the initial public offerings, the SEC is considering whether to relax the current legal liability and provide a safe harbor for the disclosure of forward-looking information by IPO firms. Such a policy corresponds to reducing the parameter β in the context of our model. As shown in both Lemma 4.3 and Figure 4.2, a decrease in β could induce the issuing firms to publicly issue more forecasts and the investors would have more access to prospective information to facilitate their investment decisions.

[25]Endogenizing the entrepreneur's information acquisition could make it difficult to compare the expected litigation welfare loss in the Full and Partial Disclosure Equilibria. This is because relative to the Partial Disclosure Equilibrium, in the Full Disclosure Equilibrium, the entrepreneur could be less inclined to acquire information (the equilibrium λ is higher), even though she discloses more often ($\underline{y_i} < y_i^\dagger$).

[26]The proof is provided in the Appendix.

However, the overall effect of a safe harbor policy on the social welfare is ambiguous. The reasons are as follows.

First, when the market is efficient and investors are rational, they on average break even. More information available to investors has no impact on their collective welfare. Second, the production efficiency remains the same as well, as can be seen from our previous analysis. Last but most importantly, under certain circumstances the imposition of a safe harbor could induce an increase in shareholder lawsuits, and more social resources expended in the litigation process. Recall that the equilibrium probability of lawsuits equal $H(-\underline{L})\,[1-F(y_i^{\dagger})]$ where $\underline{L} = \frac{C_L}{\gamma\beta}$. It is easy to see that a lower litigation risk will decrease the probability that the lawyer files a lawsuit against the forecast, but also increase the probability that the entrepreneur discloses a forecast. When the second effect dominates the first effect, relaxing the legal liability on voluntary disclosure of prospective information could actually decrease the social welfare.

Optimal Ex Ante Disclosure Policy

One of the issues for which the SEC is seeking comments is whether it should require the issuer to file projections or other forward-looking information as part of the registration statement. To answer this question, we have to determine whether a Full Disclosure is the optimal *ex ante* disclosure policy in the IPO setting.

Under such a policy, full disclosure of forward-looking information is enforced if a firm ever wants to raise equity. It can be easily seen that the social welfare under this *ex ante* disclosure policy is the same as that under the Full Disclosure Equilibrium analyzed previously. However, compared to the welfare under the Partial Disclosure Equilibrium, the Full Disclosure policy might not be optimal *ex ante*.

First of all, even though the Partial Disclosure Equilibrium is associated with an efficiency loss in production due to overinvestments, a Full Disclosure policy induces underinvestments. Second, the Full Disclosure is also associated with a larger litigation-related social loss than the Partial Disclosure Equilibrium. Therefore, there exists conditions in which each equilibrium could be optimal *ex ante*. To sum up, it might not be optimal for the regulators to mandate all issuing firms to include projections of their future performances.

4.5 Discussion and Conclusion

We conclude our paper with the following remarks. First, one major limitation of this paper is that we assume disclosure is truthful if the entrepreneur ever discloses. Even though this assumption is warranted by the integrity requirements on the IPO prospectus, the possibility of lying can still arise if the legal liability for forward-looking information is relaxed and firms start to issue projections. Therefore, an interesting extension of the analysis is to draw on cheap-talk or persuasion game models to introduce untruthful reporting, and reinvestigate the effect of shareholder litigation on IPO firms' disclosure incentives of prospective information and the potential consequences of providing a safe harbor for forecasts in connection with initial public offerings.

Secondly, we have assumed that capital markets are competitive and investors are rational. As a consequence, the investors are indifferent to different liability rules on disclosure since they are assumed to always break even in the equilibrium and it is the entrepreneur who ultimately bears all the consequences of the change in the legal system. To the extent that this assumption is not descriptive of the real world, we might underestimate the potential benefits of providing a safe harbor to induce more managerial disclosure of forward-looking information.

Finally, one salient feature of this paper is that we have explicitly modelled shareholder litigation and its role in affecting issuing firms' incentive to disclose prospective information. However, the probability that the firm is held liable by the court (the measure of the litigation risk) is assumed to be an exogenous constant, which could actually be a function of the magnitude of the forecast error. Richer insights may be obtained if these elements are incorporated.

Table 4.1: Efficiencies of Decisions in Different Disclosure Equilibria

Parameters	$\delta^n \leq \bar{q}$	$\delta^n > \bar{q}$
Equilibrium	Full Disclosure	Partial Disclosure
Investment-related social loss	$\lambda\ max\{s, 0\} + (1-\lambda)[\int_{-s}^{\underline{y_i}} (s + y_i)\ d\ F(y_i)]$ (Underinvestment)	$-\lambda\ s\ I - (1-\lambda)[\int_{-s-\bar{q}}^{-s} (s + y_i)\ d\ F(y_i)]$ (Overinvestment)
Deadweight litigation cost	$(1-\lambda)\ H(-\underline{L})\ C_L\ [1 - F(\underline{y_i})]$	$(1-\lambda)\ H(-\underline{L})\ C_L\ [1 - F(y_i^{\dagger})]$

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APPENDIX

Appendix 1 Notation and Proofs for Chapter 2

Appendix 1.1 Summary of Notation

$\bar{q}$	=	the required investment capital of the project.
q	=	the entrepreneur's investment decision.
$\tilde{x}$	=	the gross terminal payoff of the investment project, $\tilde{x} = (1+\theta)\bar{q} + \tilde{\epsilon}$.
θ	=	the net unite rate of return of the investment project.
$\tilde{\epsilon}$	=	the noise term in the gross payoff of the project, $\tilde{\epsilon} \sim N(0, \sigma^2)$.
$\tilde{y_a}$	=	the public report about the noise term in the gross payoff of the project, $\tilde{\epsilon} = \tilde{y_a} + \tilde{\epsilon_a}$, where $\tilde{y_a} \sim N(0, \sigma_{ya}^2)$.
$\tilde{y_i}$	=	the private signal acquired by the entrepreneur about the remaining uncertainty in the noise term. $\tilde{\epsilon_a}$. That is, $\tilde{\epsilon_a} = \tilde{y_i} + \tilde{\epsilon_{ai}}$, where $\tilde{y_i} \sim N(0, \sigma_{yi}^2)$. The cumulative distribution function of $\tilde{y_i}$ is $F(y_i)$.
p	=	the posterior mean of the project's net payoff given the public report and an investment level of $\bar{q}$, i.e., $p(y_a) \equiv E[\tilde{x}\|y_a, q = \bar{q}] - \bar{q} = \theta\bar{q} + y_a$. *Ex ante* p is normally distributed with mean $\theta\bar{q}$ and variance σ_{ya}^2.
κ	=	the information acquisition cost, which is assumed to be a random variable *ex ante* with a cumulative distribution function of $S(\kappa)$.
y_i^0	=	the null signal (or uninformative signal), which does not change the entrepreneur's belief about $\tilde{\epsilon_a}$.
γ	=	the probability that after acquiring the private information, the entrepreneur will receive a null signal.
λ^c	=	the investors' conjectured probability that the entrepreneur has not acquired private information.
δ^n	=	the investor's *ex investment* valuation of the firm given no disclosure and the entrepreneur's decision to invest.

Appendix 1.2 Proofs

Proof for Proposition 2.4

The investors' posterior belief about the entrepreneur's private signal given the investment decision and no disclosure is (Lemma 1):

$$y_i^n(p,\lambda^c) = \frac{(1-\lambda^c)\ (1-\gamma)\ \mathrm{E}\ [y_i|p, q=\bar{q}, m=n]}{\lambda^c\ P_1 + (1-\lambda^c)\ \gamma\ P_2 + (1-\lambda^c)\ (1-\gamma)\ P_3}$$

If $y_i^n(p,\lambda^c) > -p$ and $p+\bar{q} > 0$, the entrepreneur will always invest if she is uninformed and both P_1 and P_2 equal 1. Also, if she is informed, the entrepreneur will invest for all signals above $-p-\bar{q}$. Assume the entrepreneur conjectures that the investors believe with probability λ^0 that she has not acquired private information. Given the public report and her conjecture λ^0, if the entrepreneur believes investors will price the firm at a value higher than $\bar{q}$ (or alternatively $y_i^n(p,\lambda^c=\lambda^0) > -p$), she will make disclosure decisions according to a cutoff $y_i^\dagger(p,\hat{\lambda^0})$, which is determined by the following equations:

$$\begin{aligned} y_i^n &= y_i^\dagger \\ y_i^n &= \frac{(1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{y_i^\dagger} y_i\ d\ F(y_i)}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{y_i^\dagger} d\ F(y_i)} \end{aligned}$$

where $\hat{\lambda^0} = \lambda^0 + (1-\lambda^0)\gamma$.

To be consistent with the entrepreneur's belief, the solution to the above equations must satisfy $y_i^n(p,\hat{\lambda^0}) > -p$.

Define the following function:

$$
\begin{aligned}
H(x) &= x - \frac{(1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{x} y_i \; d\; F(y_i)}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{x} d\; F(y_i)} \\
&= \frac{\hat{\lambda^0} x + (1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{x} (x - y_i) \; d\; F(y_i)}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{x} d\; F(y_i)}
\end{aligned}
$$

Denote its numerator as $G(x)$. It can be shown that $G(x)$ is increasing in x, since $G'(x) = \hat{\lambda^0} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{x} dF(y_i) > 0$. Given $y_i^n = y_i^{\dagger}$, $G'(x) > 0$ and $G(y_i^{\dagger}) = 0$, the necessary and sufficient condition for $y_i^n > -p$ is $G(-p) < 0$. That is, $p\, \hat{\lambda^0} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{-p} (p+y_i)\; d\; F(y_i) > 0$ (or $T(p, q, \sigma_{yi}, \hat{\lambda^0}) > 0$).

If the above condition does not hold and if the entrepreneur believes that the investors' posterior belief of her private signal given no disclosure and the investment decision $q = \bar{q}$ is no greater than $-p$, she cannot invest if she is uninformed or withholding private information and she will invest and disclose for all signals above $-p$. In equilibrium, the investors will always see disclosure if the entrepreneur ever invests. Therefore investing but not disclosing is an off-equilibrium action. If the investors can threaten to believe that the entrepreneur is hiding a very bad signal and therefore offer a price less than $\bar{q}$ if the entrepreneur invests but does not disclose, a Full Disclosure equilibrium can be sustained.

Q.E.D.

Proof for Lemma 2.2

(i) $G'(x) \geq 0$, $G(0) > 0$ and $G(y_i^{\dagger}) = 0$ implies that $y_i^{\dagger} \leq 0$ ($G(x)$ is defined as in the above proof).

(ii) Proof for $\frac{\partial y_i^{\dagger}}{\partial \hat{\lambda^0}} > 0$.

$$y_i^\dagger = \frac{(1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{y_i^\dagger} y_i \; d \; F(y_i)}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \displaystyle\int_{-p-\bar{q}}^{y_i^\dagger} d \; F(y_i)}$$

$$\Rightarrow \hat{\lambda^0} \; y_i^\dagger - (1-\hat{\lambda^0}) \; F(-p-\bar{q}) \; (p+\bar{q}+y_i^\dagger) + (1-\hat{\lambda^0}) \; \textstyle\int_{-p-\bar{q}}^{y_i^\dagger} F(y_i) \; d \; y_i = 0 \qquad (**)$$

Differentiate the above equation with respect to $\hat{\lambda^0}$ and solve for $\frac{\partial y_i^\dagger}{\partial \hat{\lambda^0}}$:

$$\frac{\partial y_i^\dagger}{\partial \hat{\lambda^0}} = \frac{-y_i^\dagger + \displaystyle\int_{-p-\bar{q}}^{y_i^\dagger} [F(y_i) - F(-p-\bar{q})] \; d \; y_i}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \; [F(y_i^\dagger) - F(-p-\bar{q})]}$$

It is easy to see that both the denominator and the numerator are positive. Therefore, $\frac{\partial y_i^\dagger}{\partial \hat{\lambda^0}} > 0$. And since $\hat{\lambda^0} \equiv \lambda^0 + (1-\lambda^0) \; \gamma$, it must be true that $\frac{\partial y_i^\dagger}{\partial \lambda^0} > 0$.

(iii) Proof for $\frac{\partial y_i^\dagger}{\partial y_a} \leq 0$.

Differentiate equation (**) with respect to y_a and solve for $\frac{\partial y_i^\dagger}{\partial y_a}$:

$$\frac{\partial y_i^\dagger}{\partial y_a} = -\frac{(1-\hat{\lambda^0}) \; f(-p-\bar{q}) \; (y_i^\dagger + p + \bar{q})}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \; [F(y_i^\dagger) - F(-p-\bar{q})]} \leq 0$$

Q.E.D.

Proof for Lemma 2.3

If $p \leq 0$, it must be true that $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) \leq 0 \quad \forall \hat{\lambda^0}$. Therefore, $\kappa^\dagger = (1-\gamma) \int_{-p}^{+\infty} (p+y_i) \; d \; F(y_i) = \kappa^*$, according to Proposition 2 and 5.

If $p > 0$ and $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) \leq 0$, $\kappa^\dagger = (1-\gamma) \int_{-p}^{+\infty} (p+y_i) \; d \; F(y_i)$, while $\kappa^* =$

$-(1-\gamma)\ \int_{-\infty}^{-p}\ (p+y_i)\ d\ F(y_i)$. Using integration by parts,

$$\begin{aligned}\kappa^{\dagger} &= (1-\gamma)\ [p+\int_{-\infty}^{-p}\ F(y_i)\ d\ y_i]\\ \kappa^{*} &= (1-\gamma)\ \int_{-\infty}^{-p}\ F(y_i)\ d\ y_i\end{aligned}$$

It is easy to see that $\kappa^{\dagger} > \kappa^{*}$.

If $p > 0$ and $T(p, \bar{q}, \sigma_{yi}, \hat{\lambda^0}) > 0$, the two cutoffs are,

$$\begin{aligned}\kappa^{\dagger} &= (1-\gamma)\ [\int_{-p-\bar{q}}^{y_i^{\dagger}}\ (p+\bar{q}+y_i)(1-\frac{\bar{q}}{\delta^n})\ d\ F(y_i)\\ &\quad + \int_{y_i^{\dagger}}^{+\infty}\ (p+y_i)\ d\ F(y_i) - (p+\bar{q})\ (1-\frac{\bar{q}}{\delta^n})],\\ \kappa^{*} &= -(1-\gamma)\ \int_{-\infty}^{-p}\ (p+y_i)\ d\ F(y_i).\end{aligned}$$

Using integration by parts, they can be rewritten as

$$\begin{aligned}\kappa^{\dagger} &= (1-\gamma)\ [\int_{-\infty}^{-p-\bar{q}}\ F(y_i)\ d\ y_i + \frac{\bar{q}}{p+\bar{q}+y_i^n}\ (\int_{-p-\bar{q}}^{y_i^{\dagger}}\ F(y_i)\ d\ y_i - y_i^n)],\\ \kappa^{*} &= (1-\gamma)\ \int_{-\infty}^{-p}\ F(y_i)\ d\ y_i.\end{aligned}$$

Thus,

$$\begin{aligned}\kappa^{\dagger}-\kappa^{*} &= (1-\gamma)\ [\frac{\bar{q}}{p+\bar{q}+y_i^n}\ (\int_{-p-\bar{q}}^{y_i^{\dagger}}\ F(y_i)\ d\ y_i - y_i^n) - \int_{-p-\bar{q}}^{-p}\ F(y_i)\ d\ y_i]\\ &= \frac{1-\gamma}{p+\bar{q}+y_i^{\dagger}}\ [\bar{q}\ (\int_{-p-\bar{q}}^{y_i^{\dagger}}\ F(y_i)\ d\ y_i - y_i^{\dagger}) - (p+\bar{q}+y_i^{\dagger})\ \int_{-p-\bar{q}}^{-p}\ F(y_i)\ d\ y_i]\end{aligned}$$

Denote the numerator of the above expression as $(1-\gamma)J(y_i^{\dagger})$. It can be shown that

$$J'(y_i^{\dagger}) = \bar{q}\ [F(y_i^{\dagger})-1] - \int_{-p-\bar{q}}^{-p}\ F(y_i)\ d\ y_i < 0$$

Since $y_i^\dagger \leq 0$ (Lemma 2), it must be true that $J(y_i^\dagger) \geq J(0) = \bar{q} \int_{-p-\bar{q}}^{0} F(y_i)\, d\, y_i - (p + \bar{q}) \int_{-p-\bar{q}}^{-p} F(y_i)\, d\, y_i$.

Let us then examine the sign of $J(0)$. Define the following function: $B(x) = \bar{q} \int_{-x-\bar{q}}^{0} F(y_i)\, d\, y_i - (x + \bar{q}) \int_{-x-\bar{q}}^{-x} F(y_i)\, d\, y_i$. $B(x)$ is increasing in x, since

$$\begin{aligned}
B'(x) &= \bar{q}\, F(-x-\bar{q}) - \int_{-x-\bar{q}}^{-x} F(y_i)\, d\, y_i + (x+\bar{q})\, [F(-x) - F(-x-\bar{q})] \\
&\geq (x+\bar{q})\, F(-x) - x\, F(-x-\bar{q}) - \bar{q}\, F(-x) \\
&= x\, [F(-x) - F(-x-\bar{q})] \\
&> 0
\end{aligned}$$

Since $B(0) = 0$, $B'(x) > 0$, it must be true that $B(p) > 0$ if $p > 0$. It follows that $J(y_i^\dagger) \geq J(0) = B(p) > 0$. Therefore, $\kappa^\dagger(p) > \kappa^*(p)$.

Q.E.D.

Proof for Equation 2.6

Rewrite $U^S_{ef,1}(p)$ as

$$\begin{aligned}
U^S_{ef,1}(p) &= \int_0^{\kappa^\dagger} [\gamma p + (1-\gamma) \int_{-p}^{+\infty} (p + y_i)\, d\, F(y_i) - \kappa]\, d\, S(\kappa) \\
&+ \int_0^{\kappa^\dagger} [(1-\gamma) \int_{-p-\bar{q}}^{-p} (p + y_i)\, d\, F(y_i)]\, d\, S(\kappa) + p\, [1 - S(\kappa^\dagger)]
\end{aligned}$$

Then,

$$
\begin{aligned}
L_1 &\equiv U^S_{sf,1}(p) - U^S_{ef,1}(p) \\
&= -\int_{\kappa^*}^{\kappa^\dagger} [\gamma p + (1-\gamma) \int_{-p}^{+\infty} (p+y_i)\ d\ F(y_i) - \kappa]\ d\ S(\kappa) \\
&\quad - \int_0^{\kappa^\dagger} [(1-\gamma) \int_{-p-\bar{q}}^{-p} (p+y_i)\ d\ F(y_i)]\ d\ S(\kappa) + p\ [S(\kappa^\dagger) - S(\kappa^*)] \\
&= \int_{\kappa^*}^{\kappa^\dagger} \{\kappa - [\gamma p + (1-\gamma) \int_{-p}^{+\infty} (p+y_i)\ d\ F(y_i) - p]\}\ d\ S(\kappa) \\
&\quad - \int_0^{\kappa^\dagger} [(1-\gamma) \int_{-p-\bar{q}}^{-p} (p+y_i)\ d\ F(y_i)]\ d\ S(\kappa) \\
&= \int_{\kappa^*}^{\kappa^\dagger} (\kappa - \kappa^*)\ d\ S(\kappa) - \int_0^{\kappa^\dagger} [(1-\gamma) \int_{-p-\bar{q}}^{-p} (p+y_i)\ d\ F(y_i)]\ d\ S(\kappa),
\end{aligned}
$$

where the last equality follows from $\kappa^* = \gamma p + (1-\gamma)\ \int_{-p}^{+\infty}\ (p+y_i)\ d\ F(y_i) - p$ when $p > 0$.

Q.E.D.

Proof for Footnote 19

Given the public report y_a, the investors' *ex ante* expected payoff is

$$
\begin{aligned}
U^I_{ef,1}(p) &= \int_0^{\kappa^\dagger} \{\gamma[(p+\bar{q})\frac{\bar{q}}{\delta^n} - \bar{q}] + (1-\gamma) \int_{-p-\bar{q}}^{y_i^\dagger} [(p+\bar{q}+y_i)\frac{\bar{q}}{\delta^n} - \bar{q}]\ d\ F(y_i)\}\ d\ S(\kappa) \\
&\quad + \int_{\kappa^\dagger}^{+\infty} [(p+\bar{q})\frac{\bar{q}}{\delta^n} - \bar{q}]\ d\ S(\kappa)
\end{aligned}
$$

Rearranging terms we have

$$
U^I_{ef,1}(p) = -[\gamma S(\kappa^\dagger) + 1 - S(\kappa^\dagger)]\ \bar{q}\ \frac{y_i^n}{\delta^n} + S(\kappa^\dagger)\ (1-\gamma) \int_{-p-\bar{q}}^{y_i^\dagger}\ (y_i - y_i^n)\frac{\bar{q}}{\delta^n}\ d\ F(y_i)
$$

Using the results in Equations 2.4 and 2.5,

$$\begin{aligned} U^I_{ef,1}(p) &= -\hat{\lambda^0}\ \bar{q}\ \frac{y_i^n}{\delta^n} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} (y_i - y_i^n)\frac{\bar{q}}{\delta^n}\ d\ F(y_i) \\ &= \frac{\bar{q}}{\delta^n}\ [(1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} y_i\ d\ F(y_i) - y_i^n\ (\hat{\lambda^0} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} d\ F(y_i))] \end{aligned}$$

It must be true that $U^I_{ef,1}(p) = 0$, since $y_i^n = y_i^\dagger = \dfrac{(1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} y_i\ d\ F(y_i)}{\hat{\lambda^0} + (1-\hat{\lambda^0}) \int_{-p-\bar{q}}^{y_i^\dagger} d\ F(y_i)}$ (Equations 2.1 and 2.2). Therefore, even though investors overpay when the entrepreneur invests and withholds private information and underpay when the entrepreneur is uninformed, in the rational expectations equilibrium they on average break even because they are price-protected.

Q.E.D.

Appendix 2 Notation and Proofs for Chapter 3

Appendix 2.1 Summary of Notation

$\bar{q}$	=	the required investment capital of the investment project.
q	=	the entrepreneur's investment decision.
$\tilde{u}$	=	the terminal cash flow generated by the asset-in-place.
$\tilde{x}$	=	the gross payoff of the investment project. $\tilde{x} = (1+\theta)\bar{q} + \tilde{\epsilon}$.
θ	=	the net unite rate of return of the investment project.
$\tilde{\epsilon}$	=	the noise term in the gross payoff of the project, $\tilde{\epsilon} \sim N(0, \sigma^2)$.
$\tilde{y_h}$	=	the public report about the noise term in the payoff of the asset-in-place, $\tilde{u} = \tilde{y_h} + \tilde{\epsilon_h}$, where $\tilde{y_h} \sim N(0, \sigma_h^2)$.
$\tilde{y_i}$	=	the private signal acquired by the entrepreneur about the noise term in the gross payoff of the project, $\tilde{\epsilon}$. That is, $\tilde{\epsilon} = \tilde{y_i} + \tilde{\nu_i}$, where $\tilde{y_i} \sim N(0, \sigma_i^2)$. The cumulative distribution function of $\tilde{y_i}$ is $F(y_i)$.
s	=	the prior mean of the net payoff (or NPV) of the project given an investment level of $\bar{q}$. $s = \mathrm{E}[\tilde{\epsilon}\mid q = \bar{q}] - \bar{q} = \theta\bar{q}$.
κ	=	the information acquisition cost, which is assumed to be a random variable *ex ante* and its cumulative distribution function is $S(\kappa)$.
λ^c	=	the investors' conjectured probability that the entrepreneur has not acquired private information.

Appendix 2.2 Proofs

Proof for Lemma 3.1

Depending on different parameter values, there are two possible equilibria, in both of which the investors' valuation of the firm is greater than $\bar{q}$. It can be shown that $V^n \leq \bar{q}$ will not exist in the equilibrium. If $V^n \leq \bar{q}$, the entrepreneur will never issue equity, since she has to yield 100% or more of her firm's equity in exchange for the capital needed, no matter whether she is informed or not. Given this investment strategy, the market price V^n is not rational. This is because if the entrepreneur never issues equity, the investors will not make any conjectures on the firm's value. Therefore there is no basis for a valuation as $V^n \leq \bar{q}$.

The two equilibria differ in that in Case N1 the entrepreneur invests when she is uninformed, while in Case N2 she does not invest if she has no private information.

(i) Case N1:

The necessary and sufficient conditions for Case N1 are

$$V^n > \bar{q} \quad \text{and} \quad U_2(y_h, \lambda, q = \bar{q}) > U_2(y_h, \lambda, q = 0),$$

or equivalently,

$$V^n > \bar{q} \quad \text{and} \quad (y_h + s + \bar{q})(1 - \frac{\bar{q}}{V^n}) > y_h,$$

where $V^n = y_h + s + \bar{q} + y_i^n$ and y_i^n is represented in Equation 3.1.

Rearranging the terms yields,

$$\begin{cases} y_i^n > \max[-y_h - s, -\frac{s}{s+\bar{q}}y_h - s] & \text{if} \quad s > -\bar{q} \\ y_i^n > -y_h - s \quad \text{and} \quad y_h < 0 & \text{if} \quad s = -\bar{q} \\ y_i^n \in (-y_h - s, -\frac{s}{s+\bar{q}}y_h - s) \quad \text{and} \quad y_h < 0 & \text{if} \quad s < -\bar{q} \end{cases}$$

In this case, the entrepreneur invests if she is uninformed. If she is informed, she invests only if $(y_h + s + \bar{q} + y_i)(1 - \frac{\bar{q}}{V^n}) > y_h$. Hence, when investors observe the entrepreneur issuing equity, they infer that the entrepreneur is either uninformed or informed with a signal above the investment cutoff t^N. The posterior mean of the private signal y_i^n, given the entrepreneur's decision to invest, equals

$$y_i^n = \frac{(1-\lambda)\displaystyle\int_{t^N}^{+\infty} y_i \, d\, F(y_i)}{\lambda + (1-\lambda)\displaystyle\int_{t^N}^{+\infty} d\, F(y_i)}. \tag{A2.1}$$

It is easy to show that $y_i^n > 0$, since

$$\int_{t^N}^{+\infty} y_i \, d\, F(y_i) > 0 \quad \text{if} \quad t^N \geq 0;$$
$$\int_{t^N}^{+\infty} y_i \, d\, F(y_i) = -\int_{-\infty}^{t^N} y_i \, d\, F(y_i) > 0 \quad \text{if} \quad t^N < 0.$$

If $s \geq 0$, then $y_i^n > 0 \geq -s$. If $s \in (-\bar{q}, 0)$ and $y_h \geq 0$, then

$$\begin{aligned} y_i^n > \max[-y_h - s, -\frac{s}{s+\bar{q}} y_h - s] &\Rightarrow y_i^n > -\frac{s}{s+\bar{q}} y_h - s \\ &\Rightarrow y_i^n > -s \end{aligned}$$

If $s < 0$ and $y_h < 0$, then

$$\begin{aligned} V^n > \bar{q} &\Leftrightarrow y_i^n > -y_h - s \\ &\Rightarrow y_i^n > -s \end{aligned}$$

Since $t^N = -s - \frac{\bar{q}}{V^n - \bar{q}}(s + y_i^n)$, it must be true that $t^N < -s$.

(ii) Case N2:

The necessary and sufficient conditions for Case N2 are

$$V^n > \bar{q} \quad \text{and} \quad (y_h + s + \bar{q})(1 - \frac{\bar{q}}{V^n}) \leq y_h,$$

where y_i^n is represented in Equation 3.1.

Rearranging the terms yield,

$$\begin{cases} y_i^n \in (-y_h - s, -\frac{s}{s+\bar{q}}y_h - s] \quad \text{and} \quad y_h \geq 0 & \text{if} \quad s > -\bar{q} \\ y_i^n > -y_h - s \quad \text{and} \quad y_h \geq 0 & \text{if} \quad s = -\bar{q} \\ y_i^n > -y_h - s \quad \text{and} \quad y_i^n \geq -\frac{s}{s+\bar{q}}y_h - s & \text{if} \quad s < -\bar{q} \end{cases}$$

In this case, the entrepreneur does not invest if she is uninformed, and if she is informed, she invests only if $(y_h+s+\bar{q}+y_i)(1-\frac{\bar{q}}{V^n}) > y_h$. Therefore, issuing stock signals to the market that the entrepreneur is informed with a signal above the investment cutoff t^N. Therefore the posterior mean of the private signal y_i^n based on the stock issuance decision is

$$y_i^n = \frac{\int_{t^N}^{+\infty} y_i \, d\, F(y_i)}{\int_{t^N}^{+\infty} d\, F(y_i)}. \qquad \text{(A2.2)}$$

To prove $t^N < -s$, let us assume instead $t^N \geq -s$. Since $t^N = -s - \frac{\bar{q}}{V^n - \bar{q}}(s + y_i^n)$, it follows that $y_i^n \leq -s$.

From the above expression of y_i^n, we have

$$\int_{t^N}^{+\infty} y_i^n \, d\, F(y_i) = \int_{t^N}^{+\infty} y_i \, d\, F(y_i).$$

However, $\int_{t^N}^{+\infty} y_i^n \, d\, F(y_i) \leq \int_{t^N}^{+\infty} (-s) \, d\, F(y_i) \leq \int_{t^N}^{+\infty} t^N \, d\, F(y_i)$, while $\int_{t^N}^{+\infty} y_i \, d\, F(y_i) > \int_{t^N}^{+\infty} t^N \, d\, F(y_i)$. Contradiction! Therefore it must be true that $t^N < -s$.

Q.E.D.

Proof for Proposition 3.3

(i) Case N1.

The information acquisition cost cutoff is determined by $U_1(y_h, \lambda, a = 1, \kappa) = U_1(y_h, \lambda, a = 0)$. Therefore,

$$\begin{aligned}
\kappa^N &= \int_{-\infty}^{t^N} y_h dF(y_i) + \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n}) dF(y_i) - (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}) \\
&= \int_{-\infty}^{t^N} [y_h - (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})]\ d\ F(y_i)
\end{aligned}$$

If $s > 0$, the first-best information acquisition cost cutoff is $\kappa^* = \int_{-\infty}^{-s} [-(s + y_i)]\ \mathrm{d}\ F(y_i)$.

It can be proved that the shares of the firm are overvalued if the entrepreneur issues equity when uninformed. To see this,

$$\begin{aligned}
U_2(y_h, \lambda, q = \bar{q}) &= (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}) \\
&= (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{y_h + s + \bar{q} + y_i^n}) \\
&> (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{y_h + s + \bar{q}}) \\
&= y_h + s
\end{aligned}$$

since $y_i^n > 0$.

On the other hand, when the entrepreneur is informed, *ex ante* her shares are undervalued. To see this, from Equation A2.1,

$$
\begin{aligned}
y_i^n &= \frac{(1-\lambda^c) \displaystyle\int_{t^N}^{+\infty} y_i dF(y_i)}{\lambda^c + (1-\lambda^c) \displaystyle\int_{t^N}^{+\infty} dF(y_i)},\\
\Rightarrow \quad y_i^n &< \frac{\displaystyle\int_{t^N}^{+\infty} y_i dF(y_i)}{\displaystyle\int_{t^N}^{+\infty} dF(y_i)}\\
\Rightarrow \quad \int_{t^N}^{+\infty} y_i^n dF(y_i) &< \int_{t^N}^{+\infty} y_i dF(y_i)
\end{aligned}
$$

It follows that

$$
\begin{aligned}
& \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) \\
= & \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ d\ F(y_i) - \bar{q} \frac{(1 - F(t^N)) \displaystyle\int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ d\ F(y_i)}{\displaystyle\int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i^n)\ d\ F(y_i)} \\
< & \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ d\ F(y_i) - \bar{q}\ (1 - F(t^N)) \\
= & \int_{t^N}^{+\infty} (y_h + s + y_i)\ d\ F(y_i) \qquad \text{(A2.3)}
\end{aligned}
$$

The information acquisition cost cutoff κ^N must satisfy

$$
\begin{aligned}
\kappa^N &= \int_{-\infty}^{t^N} y_h dF(y_i) + \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n}) dF(y_i) - (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}) \\
&< \int_{-\infty}^{t^N} y_h dF(y_i) + \int_{t^N}^{+\infty} (y_h + s + y_i) dF(y_i) - (y_h + s) \\
&= \int_{t^N}^{+\infty} (s + y_i) dF(y_i) - s \\
&< \int_{-s}^{+\infty} (s + y_i) dF(y_i) - s \\
&= \int_{-\infty}^{-s} [-(s + y_i)] dF(y_i) \\
&= \kappa^*
\end{aligned}
$$

since $t^N < -s$.

If $s \leq 0$, the first-best information acquisition cost cutoff is $\kappa^* = \int_{-s}^{+\infty} (s + y_i)\ \mathrm{d}\ F(y_i)$.

In Case N1, when the entrepreneur is uninformed, her expected payoff from investing is larger than the expected payoff from not investing, i.e.,

$$
U_2(y_h, \lambda, q = \bar{q}) = (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}) > U_2(y_h, \lambda, q = 0) = y_h \qquad \text{(A2.4)}.
$$

The information acquisition cost cutoff κ^N must satisfy

$$
\begin{aligned}
\kappa^N &= \int_{-\infty}^{t^N} y_h\ d\ F(y_i) + \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) - (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}) \\
&< \int_{-\infty}^{t^N} y_h\ d\ F(y_i) + \int_{t^N}^{+\infty} (y_h + s + y_i)\ d\ F(y_i) - y_h \\
&= \int_{t^N}^{+\infty} (s + y_i)\ d\ F(y_i) \\
&< \int_{-s}^{+\infty} (s + y_i)\ d\ F(y_i) \\
&= \kappa^*
\end{aligned}
$$

since $t^N < -s$ (where the first inequality follows from inequalities A2.3 and A2.4.).

(ii) **Case N2.**

First we can prove that Case N2 only exists for $s < 0$.

Recall that when the entrepreneur is uninformed, her expected payoff from investing is $U_2(y_h, \lambda, q = \bar{q}) = (y_h + s + \bar{q})(1 - \frac{\bar{q}}{V^n})$. It is easy to shown that $U_2(y_h, \lambda, q = \bar{q}) > y_h + s$, because $V^n = y_h + s + \bar{q} + y_i^n > y_h + s + \bar{q}$ (since $y_i^n > 0$).

Therefore, if the prior mean of the NPV of the new project is zero or positive ($s \geq 0$), it must be true that $U_2(y_h, \lambda, q = \bar{q}) > y_h$. That is, it is always optimal for the uninformed entrepreneur to invest because the firm's shares are overvalued and investing generates a higher expected payoff than not investing. However, this contradicts the second condition that sustains Case N2. To be consistent, we must have $s < 0$.

Since Case N2 only exists for $s < 0$, the first-best information acquisition cost cutoff is $\kappa^* = \int_{-s}^{+\infty}(s + y_i)\ \mathrm{d}\ F(y_i)$.

In this case, in the rational expectations equilibrium, the entrepreneur's shares will be on average correctly priced. To see this, from Equation (**),

$$y_i^n = \frac{\displaystyle\int_{t^N}^{+\infty} y_i\ d\ F(y_i)}{\displaystyle\int_{t^N}^{+\infty} d\ F(y_i)}$$

$$\Rightarrow \int_{t^N}^{+\infty} y_i^n\ d\ F(y_i) = \int_{t^N}^{+\infty} y_i\ d\ F(y_i)$$

It follows that

$$
\begin{aligned}
& \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) \\
= & \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ d\ F(y_i) - \bar{q} \frac{(1 - F(t^N)) \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ d\ F(y_i)}{\int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i^n)\ d\ F(y_i)} \\
= & \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ d\ F(y_i) - \bar{q}(1 - F(t^N)) \\
= & \int_{t^N}^{+\infty} (y_h + s + y_i)\ d\ F(y_i)
\end{aligned}
$$

The information acquisition cost cutoff κ^N is determined by $U_1(y_h, \lambda, a = 1, \kappa) = U_1(y_h, \lambda, a = 0)$. Therefore,

$$
\begin{aligned}
\kappa^N & = \int_{-\infty}^{t^N} y_h\ d\ F(y_i) + \int_{t^N}^{+\infty} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) - y_h \\
& = \int_{t^N}^{+\infty} (y_h + s + y_i)\ d\ F(y_i) - \int_{t^N}^{+\infty} y_h\ d\ F(y_i) \\
& = \int_{t^N}^{+\infty} (s + y_i)\ d\ F(y_i) \\
& = \int_{t^N}^{+\infty} (s + y_i^n)\ d\ F(y_i)
\end{aligned}
$$

As proved in the main text, $t^N < -s < y_i^n$, it follows that

$$
\begin{aligned}
\kappa^N & = \int_{t^N}^{+\infty} (s + y_i)\ d\ F(y_i) \\
& < \int_{-s}^{+\infty} (s + y_i)\ d\ F(y_i) \\
& = \kappa^*
\end{aligned}
$$

Q.E.D.

Proof for Proposition 3.5

(i) Partial Disclosure Equilibrium

If $s > 0$, the first-best information acquisition cost cutoff is $\kappa^* = \int_{-\infty}^{-s}[-(s + y_i)]\ \mathrm{d}\ F(y_i)$.

The information acquisition cost cutoff κ^V is determined by $U_1(y_h, \lambda, a = 1, \kappa) = U_1(y_h, \lambda, a = 0)$. Therefore,

$$\begin{aligned}\kappa^V &= \int_{-\infty}^{t^V} y_h\ d\ F(y_i) + \int_{t^V}^{y_i^\dagger} (y_h + s + \bar{q} + y_i)\ (1 - \frac{\bar{q}}{V^n})\ d\ F(y_i) \\ &+ \int_{y_i^\dagger}^{+\infty} (y_h + s + y_i)\ d\ F(y_i) - (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n})\end{aligned}$$

Applying integration by parts yields

$$\begin{aligned}\kappa^V &= y_h F(t^V) + (y_h + s + y_i^\dagger) F(y_i^\dagger) - y_h F(t^V) - \int_{t^V}^{y_i^\dagger} (1 - \frac{\bar{q}}{V^n})\ F(y_i) dy_i \\ &+ (y_h + s) - \int_{-\infty}^{y_i^\dagger} (y_h + s + y_i) dF(y_i) - (y_h + s + \bar{q})\ (1 - \frac{\bar{q}}{V^n}) \\ &= \int_{-\infty}^{t^V} F(y_i)\ d\ y_i + \frac{\bar{q}}{y_h + s + \bar{q} + y_i^n}\ (\int_{t^V}^{y_i^\dagger} F(y_i)\ d\ y_i - y_i^n)\end{aligned}$$

Thus,

$$\begin{aligned}\kappa^V - \kappa^* &= \frac{\bar{q}}{y_h + s + \bar{q} + y_i^n}\ (\int_{t^V}^{y_i^\dagger} F(y_i)\ d\ y_i - y_i^n) - \int_{t^V}^{-s} F(y_i)\ d\ y_i \\ &= \frac{1}{V^n}\ [\bar{q}\ (\int_{t^V}^{y_i^\dagger} F(y_i)\ d\ y_i - y_i^\dagger) - (y_h + s + \bar{q} + y_i^\dagger)\ \int_{t^V}^{-s} F(y_i)\ d\ y_i]\end{aligned}$$

Denote the numerator of the above expression as $J(y_i^\dagger)$. Using $t^V = -s - \frac{\bar{q}}{V^n - \bar{q}}(s + y_i^n)$

and $y_i^\dagger = y_i^n$, we can show that

$$\begin{aligned}
J'(y_i^\dagger) &= \bar{q}\ [F(y_i^\dagger) - 1] + (y_h + s + y_i^\dagger) F(t^V) \frac{\partial t^V}{\partial y_i^\dagger} - \int_{t^V}^{-s} F(y_i)\ d\ y_i \\
&= \bar{q}\ [F(y_i^\dagger) - 1] + F(t^V) \frac{-\bar{q} y_h}{y_h + s + y_i^\dagger} - \int_{t^V}^{-s} F(y_i)\ d\ y_i \\
&< \bar{q}\ [F(y_i^\dagger) - 1] + F(t^V) \frac{-\bar{q} y_h}{y_h + s + y_i^\dagger} - (t^V + s) F(t^V) \\
&= \bar{q}\ [F(y_i^\dagger) - 1] - \bar{q} F(t^V) \\
&< 0
\end{aligned}$$

Since $y_i^\dagger \leq 0$ (Lemma 3.3), it must be true that $J(y_i^\dagger) \geq J(0) = \bar{q}\ \int_{-s-\frac{\bar{q}s}{y_h+s}}^{0} F(y_i)\ d\ y_i - (y_h + s + \bar{q})\ \int_{-s-\frac{\bar{q}s}{y_h+s}}^{-s} F(y_i)\ d\ y_i$.

Let us then examine the sign of $J(0)$. Define a function $B(x) = \bar{q}\ \int_{-x-\frac{\bar{q}x}{y_h+x}}^{0} F(y_i)\ d\ y_i - (y_h + x + \bar{q})\ \int_{-x-\frac{\bar{q}x}{y_h+x}}^{-x} F(y_i)\ d\ y_i$. $B(x)$ is increasing in x, since

$$\begin{aligned}
B'(x) &= \bar{q}\ F(-x - \frac{\bar{q}x}{y_h + x})(1 + \frac{\bar{q} y_h}{(y_h + x)^2}) - \int_{-x-\frac{\bar{q}x}{y_h+x}}^{-x} F(y_i)\ d\ y_i + (y_h + x + \bar{q})\ [F(-x) \\
&\quad - F(-x - \frac{\bar{q}x}{y_h + x})(1 + \frac{\bar{q} y_h}{(y_h + x)^2})] \\
&= -(y_h + x) F(-x - \frac{\bar{q}x}{y_h + x})[1 + \frac{\bar{q} y_h}{(y_h + x)^2}] + (y_h + x + \bar{q}) F(-x) - \int_{-x-\frac{\bar{q}x}{y_h+x}}^{-x} F(y_i)\ d\ y_i \\
&> -(y_h + x) F(-x - \frac{\bar{q}x}{y_h + x})[1 + \frac{\bar{q} y_h}{(y_h + x)^2}] + (y_h + x + \bar{q}) F(-x) + \frac{\bar{q}x}{y_h + x} F(-x - \frac{\bar{q}x}{y_h + x}) \\
&= (y_h + x + \bar{q})[F(-x) - F(-x - \frac{\bar{q}x}{y_h + x})] \\
&> 0 \qquad \forall x > \max[0, -y_h]
\end{aligned}$$

Since $B(0) = 0$, $B'(x) > 0$, it must be true that $B(s) > 0$ if $s > 0$. It follows that $J(y_i^\dagger) \geq J(0) = B(s) > 0$. Therefore, $\kappa^V > \kappa^*$.

(ii) Full Disclosure Equilibrium

The information acquisition cost cutoff κ^V is determined by $U_1^a = U_1^{na}$. Therefore,

$$\kappa^V = \int_{t^N}^{+\infty} (s + y_i) \; d \; F(y_i)$$

If $s > 0$, the first-best information acquisition cost cutoff is $\kappa^* = \int_{-s}^{+\infty} (s+y_i) \; \mathrm{d} \; F(y_i) - s$. Thus $\kappa^V > \kappa^*$. If $s \leq 0$, the first-best information acquisition cost cutoff is $\kappa^* = \int_{-s}^{+\infty} (s + y_i) \; \mathrm{d} \; F(y_i)$. It follows that $\kappa^V = \kappa^*$.

Q.E.D.

Proof for Proposition 3.7

Since comparisons of other cost cutoffs are provided in proofs in Proposition 3.3 and 3.5, and it is obvious that $\kappa^V = \kappa^M$ for the Full Disclosure Equilibrium, we only need to show $\kappa^V \leq \kappa^M$ for the Partial Disclosure Equilibrium.

Using the expression $\kappa^V - \kappa^*$ and the result $\kappa^M = \kappa^* + s$ (if $s > 0$) in the proof for Proposition 3.5,

$$\kappa^V - \kappa^M = \frac{1}{V^n} \; [\bar{q} \; (\int_{t^V}^{y_i^\dagger} F(y_i) \; d \; y_i - y_i^\dagger) - (y_h + s + \bar{q} + y_i^\dagger) \int_{t^V}^{-s} F(y_i) \; d \; y_i] - s$$

Denote the numerator of the above expression as $W(y_i^\dagger)$. We can show that

$$\begin{aligned} W'(y_i^\dagger) &= \bar{q} \; [F(y_i^\dagger) - 1] - \bar{q}F(t^V) - s \\ &< 0 \end{aligned}$$

the Partial Disclosure Equilibrium only exists for $s > 0$.

Since $y_i^\dagger > -s$ (see proof for Lemma 4), it must be true that $W(y_i^\dagger) < W(-s) = \bar{q}s - sV^n < 0$. It follows that $W(y_i^\dagger) < W(-s) < 0$. Therefore, $\kappa^V < \kappa^M$.

Q.E.D.

Appendix 3 Notation and Proofs for Chapter 4

Appendix 3.1 Summary of Notation

$\bar{q}$	=	the required investment capital of the investment project.
q	=	the entrepreneur's investment decision.
$\tilde{x}$	=	the gross payoff of the investment project. $\tilde{x} = (1+\theta)\bar{q} + \tilde{\epsilon}$.
θ	=	the net unite rate of return of the investment project.
$\tilde{\epsilon}$	=	the noise term in the gross payoff of the project, $\tilde{\epsilon} \sim N(0, \sigma^2)$. The cumulative distribution function of $\tilde{\epsilon}$ is $G(\epsilon)$.
$\tilde{y}_i$	=	the private signal acquired by the entrepreneur about the uncertainty in the noise term. $\tilde{\epsilon}$. That is, $\tilde{\epsilon} = \tilde{y}_i + \tilde{\nu}$; where $\tilde{y}_i \sim N(0, \sigma_i^2)$, $\tilde{\nu} \sim N(0, \sigma_\nu^2)$ and $\sigma^2 = \sigma_\nu^2 + \sigma_i^2$. The cumulative distribution functions of $\tilde{y}_i$ and $\tilde{\nu}$ are denoted as $F(y_i)$ and $H(\nu)$ respectively.
F	=	the informed entrepreneur's forecast of the firm's terminal flow based on her private signal $F = E[\tilde{x}\|y_i] = (1+\theta)\bar{q} + y_i$
s	=	the prior mean of the net payoff (or NPV) of the project, i.e., $s \equiv \theta\bar{q} + y_a$.
λ	=	the exogenous probability that the entrepreneur is uninformed.
γ	=	the lawyer's share of the damage award paid by the investors.
β	=	the probability that the court will hold the entrepreneur liable when a lawsuit is filed due to a fall in the stock price.

Appendix 3.2 Proofs

Proof for Footnote 16

We only provide the proof for the case when the entrepreneur invests and discloses her private signal, since the proof of the other two cases are straightforward.

Since the investors are rational, they will endogenize their damage awards from the future lawsuits into their pricing of the firm's shares at $t = 2$. Denote the fraction of the shares the entrepreneur will offer the investors in exchange for $\bar{q}$ as α. Under the competitive market assumption, it must be true that

$$\bar{q} = \alpha[s + \bar{q} + y_i - D(y_i, \beta)] + (1 - \gamma)\ D(y_i, \beta), \qquad (A3.1)$$

where $s + \bar{q} + y_i - D(y_i, \beta)$ is the firm's expected residual cash flow after deducting the litigation damages.

The entrepreneur's expected payoff at $t = 2$ if she invests and discloses y_i will be $(1 - \alpha)$ of the firm's expected residual cash flow:

$$U_1^i(y_i, m = y_i, \lambda, q = \bar{q}) = [s + \bar{q} + y_i - D(y_i, \beta)]\ (1 - \alpha).$$

Substituting α from the Equation A3.1 into the above utility function yields,

$$U_1^i(y_i, m = y_i, \lambda, q = \bar{q}) \quad = \quad s + y_i - \gamma D(y_i, \beta).$$

Q.E.D.

Proof for Lemma 4.3

In the Partial Disclosure Equilibrium, the disclosure cutoff $y_i^\dagger$ is determined by the following equations:

$$s + y_i^\dagger - \gamma\ D(\beta) \;=\; (s+\bar{q}+y_i^\dagger)(1-\frac{\bar{q}}{s+\bar{q}+y_i^n}) \qquad (A3.2)$$

$$y_i^n \;=\; \frac{(1-\lambda)\ \int_{-s-\bar{q}}^{y_i^\dagger} y_i\ d\ \mathrm{F}(y_i)}{\lambda\ Prob(m=n, q=\bar{q}, \Psi_E=\emptyset) + (1-\lambda)\ \int_{-s-\bar{q}}^{y_i^\dagger} d\ \mathrm{F}(y_i)} \qquad (A3.3)$$

Rewrite Equation A3.2 as

$$[s+y_i^\dagger - \gamma\ D(\beta)]\ (s+\bar{q}+y_i^n) = (s+\bar{q}+y_i^\dagger)\ (s+y_i^n).$$

Differentiate it with respect to β, keeping in mind that both $y_i^\dagger$ and y_i^n are functions of β. We have

$$[\frac{\partial y_i^\dagger}{\partial\beta} - \gamma\ \frac{\partial D(\beta)}{\partial\beta}]\ (s+\bar{q}+y_i^n) + [s+y_i^\dagger-\gamma\ D(\beta)]\ \frac{\partial y_i^n}{\partial\beta} \;=\; \frac{\partial y_i^\dagger}{\partial\beta}\ (s+y_i^n) + (s+\bar{q}+y_i^\dagger)\ \frac{\partial y_i^n}{\partial\beta},$$

or alternatively,

$$\bar{q}\ \frac{\partial y_i^\dagger}{\partial\beta} = \gamma\ \frac{\partial D(\beta)}{\partial\beta}\ \delta^n + [\bar{q}+\gamma\ D(\beta)]\ \frac{\partial y_i^n}{\partial\beta}.$$

It is easy to show that $\frac{\partial D(\beta)}{\partial\beta} > 0$ and $D(\beta) > 0$. It must be true that

$$\frac{\partial y_i^\dagger}{\partial\beta} > \frac{\partial y_i^n}{\partial\beta}.$$

Then differentiate Equation A3.3 with respect to β. We have

$$\frac{\partial y_i^n}{\partial\beta}\ [\lambda\ Prob(m=n, q=\bar{q}, \Psi_E=\emptyset) + (1-\lambda)\ \int_{-s-\bar{q}}^{y_i^\dagger} d\ \mathrm{F}(y_i)] = (1-\lambda)\ (y_i^\dagger - y_i^n)\ f(y_i^\dagger)\ \frac{\partial y_i^\dagger}{\partial\beta}.$$

From Equation A3.2, it is easy to see that $y_i^\dagger > y_i^n$. Then it must be true that $sign(\frac{\partial y_i^\dagger}{\partial\beta}) = sign(\frac{\partial y_i^n}{\partial\beta})$. It follows that either $\frac{\partial y_i^\dagger}{\partial\beta} > \frac{\partial y_i^n}{\partial\beta} > 0$ or $\frac{\partial y_i^n}{\partial\beta} < \frac{\partial y_i^\dagger}{\partial\beta} < 0$.

Define a function

$$M(t) \equiv t \{\lambda\ Prob(m = n, q = \bar{q}, \Psi_E = \emptyset) + (1-\lambda) \int_{-s-\bar{q}}^{t} d\,F(y_i)\} - (1-\lambda) \int_{-s-\bar{q}}^{t} y_i\, d\,F(y_i).$$

It can be proved that $M(t)$ is an increasing function. Define $\hat{y_i^\dagger} \equiv y_i^\dagger(\beta = 0)$. It is easy to see that $M(y_i^\dagger) > 0$ when $\beta > 0$, and $M(\hat{y_i^\dagger}) = 0$ when $\beta = 0$. Since $M'(\cdot) > 0$, it must be true that $y_i^\dagger(\beta) > \hat{y_i^\dagger}$ when $\beta > 0$. We must have $\frac{\partial y_i^\dagger}{\partial \beta} > \frac{\partial y_i^n}{\partial \beta} > 0$. That is, the disclosure cutoff is increasing in the litigation risk.

Q.E.D.

Proof for Proposition 4.3

Recall that one necessary condition for the existence of the Partial Disclosure Equilibrium is $\delta^n > \bar{q}$, which also implies that $s + y_i^\dagger > \gamma D(\beta)$ (from Equation 4.1).

Since $J(y_i) = s + y_i - \gamma D(\beta)$ is increasing in y_i and $J(\underline{y_i}) = 0$, it must be true that $y_i^\dagger > \underline{y_i}$. Therefore L_2 is higher in the Full Disclosure Equilibrium than in the Partial Disclosure Equilibrium.

Q.E.D.