Optimal Disclosure and Litigation Rules Around IPOs and SEOs

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Abstract

We develop a model to analyze the optimality of allowing firms to disclose various kinds of information prior to initial public offerings (IPOs) and seasoned equity offerings (SEOs), and of alternative rules to govern private securities litigation. In our model, firm insiders, with private information about variables affecting their future firm performance, may make disclosures (claims) about their future realization prior to selling new equity to outsiders. The issue price of firms' equity is affected by their disclosures; by the demand for equity from institutional investors, who may conduct costly (and noisy) verifications of firm disclosures; and by the demand from retail investors, who do not have access to such an informative verification technology. There may also exist an agency with the power to regulate firm disclosures; and private securities litigation, as a result of which the courts are able to penalize firms *ex post* for making optimistic disclosures without a strong basis in fact. We develop several new results in the above setting. First, even in the absence of an agency regulating firm disclosures, equity issuing firms have incentives to self-regulate in some situations, resulting in more conservative disclosures. Second, whether allowing an item of disclosure prior to an equity issue is desirable or not depends upon the proportion of institutional investors in the equity market, their cost of verifying that disclosure item, the informativeness of their verification technology, and the participation rate of retail investors in the equity issue. Third, whether relaxing rules for bringing private securities lawsuits against firms falling short on disclosed variables encourages or discourages firm disclosures prior to an equity issue depends on whether the litigation regime is more or less sensitive to firm insiders' private information at the time of disclosure.

JEL classification: G24, G28, G32, G38.

Keywords: Disclosure rules; initial public offerings (IPOs); seasoned equity offerings (SEOs); private securities litigation.

1 Introduction

Issues related to the disclosures that are allowed to be made by firms around security offerings (and in particular, around the initial public offerings (IPOs) and seasoned equity offerings (SEOs) of equity), have been long debated by both academics and practitioners. Under current securities law, prospective issuers are prohibited from undertaking efforts at publicizing the offering (for example, through newspaper, radio, or television advertisements) during the "pre-filing period," which starts when the firm has decided to make an offering and chosen an underwriter and ends when it has filed its registration statement for the offering with the Securities and Exchange Commission (SEC).[1] Even after the registration statement is filed, issuers are severely restricted in the kind of activities they may undertake to promote the offering during the time they are waiting for the SEC to "qualify" or "make effective" their registration statement (the "waiting period").[2] Further, even after the SEC has qualified the firm's registration statement (at which point the "post-effective" period, during which the sale of securities occurs, begins), firms are severely restricted in the kinds of forward-looking statements (forecasts of future performance) they may make (typically, no written forecasts of future performance other than those included in the prospectus are allowed).

However, the SEC has, over the years, considered and partially implemented several proposals to significantly relax some of the above restrictions on disclosure. One proposal was to allow all firms intending to go public to ascertain investor interest ("test the waters") by allowing them to distribute promotional materials related to the offering during the pre-filing period.[3] Another

[1] Section 5(c) of the Securities Act effectively prohibits such communication by sellers during the pre-filing period.

[2] The three main laws governing security offerings are the Securities Act of 1933, the Securities Exchange Act of 1934, and the Investment Company Act of 1940. While some of the above prohibitions on disclosures are not explicitly mentioned in these laws, they are forbidden in the regulations and subsequent written guidelines offered by the SEC.

[3] This was already the case for security offerings satisfying SEC regulation A, which exempted certain small firms from full registration in security offerings. Such firms were allowed to test the waters to ascertain demand for their equity in the pre-filing period, and were exempt from prohibitions on extraordinary pre-offering publicity. However, the size of the offering was limited to \$5 million in the case of regulation A equity offerings: this limit has been raised to \$50 million after the passage of the JOBS Act of 2012, with the revised regulation referred to as "Regulation A-Plus".

proposal was to allow firms to undertake considerably more promotion (e.g., advertise their equity offerings in the newspapers) during the waiting period.[4] A third proposal was to give firms considerably more room to make forward-looking projections both during the waiting period and the post-effective periods prior to IPOs.

These and other disclosure regime modification proposals have been partially incorporated into two important reforms on disclosure around equity issues enacted over the past decade, the first one related to SEOs and the second one related to IPOs.[5] In 2005, the SEC enacted the Securities Offering Reform (SOR) which relaxed restrictions on disclosures by firms prior to SEOs. While the SEC argued that the reform would increase the flow of information to investors prior to SEOs, critics of this reform argued that the reform of these disclosure rules through safe harbors would increase managerial incentives to "hype" their stock prior to issuing equity (see, e.g., Lang and Lundholm (2000) or Morrissey (2007)). The second important reform related to disclosure was the "Jumpstart our Business Start-ups" (JOBS) Act passed by Congress and enacted into law in April 2012, whereby a certain category of firms going public ("Emerging Growth Companies (EGCs)," defined as firms with less than $1 billion in revenue) were allowed for the first time to file their IPO draft registration statements confidentially and engage in oral or written communication with qualified institutional investors and individual accredited investors prior to the public disclosure of their IPO registration statements (see, e.g., Dembra, Field, and Gustafson (2015) or Chaplinsky, Hanley, and Moon (2017)).[6,7]

[4]Several foreign countries allow all firms to aggressively promote their shares before IPOs. For example, in Germany, the shoe company Adidas ran a large advertising campaign during its IPO explicitly promoting its stock, running ads with the tag-line, "Adding value to your portfolio." When Deutsche Telecom went public, it ran ads with the slogan, "a share you cannot afford to miss" (see, e.g., the Wall Street Journal, October 1996). Such policies in other countries clearly underline the need for a re-evaluation of the optimality of various rules governing disclosure around equity issues, both in the U.S. and elsewhere.

[5]While we view our model as being most directly applicable to IPOs, the implications of our model are also broadly applicable to SEOs and other public security offerings.

[6]Both the SOR of 2005 and the JOBS Act of 2012 were relaxations of the "gun-jumping" rules imposed by the SEC on firms' disclosures prior to public equity offerings. Before the passage of the JOBS Act, the gun-jumping rules imposed by the SEC prohibited firms and underwriters from communicating with potential investors prior to publicly disclosing their IPO registration statement.

[7]The SOR and the JOBS Act seem to be only the beginning of reforms of disclosures around public equity

A closely related and equally prominent topic of ongoing debate has been securities litigation reform, which deals, among other things, with the rules under which issuers may be sued and held liable by investors in a firm's securities for making "forward-looking statements" about the firm's future performance which subsequently turn out to have been incorrect.[8] One early result of this debate was the passage of the Private Securities Litigation Reform Act of 1995, which significantly expanded the "safe harbor" provisions of securities laws, thus considerably increasing the protection enjoyed by companies accused of making inaccurate forward-looking statements from legal liability.[9] However, this act explicitly excludes forward-looking statements made in the context of IPOs. The debate over securities litigation reform has continued for a long time, occasionally leading to other attempted reforms of private securities litigation rules, such as the attempt (ultimately unsuccessful) in California to pass Proposition 211, which would have made it significantly easier for investors to file suit and win punitive damages against corporate officers (of firms operating in California) for making inaccurate or misleading forward-looking statements. The risk of litigation after new equity issues and the reform of litigation rules around such equity issues continue to be an important topic of debate among both academics and practitioners.[10]

offerings initiated by the SEC. Recently, newly appointed SEC Chairman Jay Clayton, announced in his first speech after taking office in May 2017 that his agency is preparing rule-making proposals to ease the burden on public firms. In particular, he called for the agency to find ways to encourage growing companies to go public instead of relying on less regulated private markets that are closed to retail investors (see, e.g., the Wall Street Journal, *"SEC's Clayton Calls on Agency to Ease Disclosure Burdens on Public Companies,"* WSJ, July 12, 2017). Following up on this, on November 1, 2017, the House of Representatives passed H.R.3903 or the "Encouraging Public Offerings Act of 2017," which would expand the confidential registration provisions and the "testing the waters" provision in the JOBS Act that previously applied only to emerging growth companies (EGCs) to all issuers of securities.

[8]The term "forward-looking statement" is defined under the securities laws as including any economic projection, statement of management's plans and objectives for future operations, statement of future performance, and assumptions underlying the above.

[9]The safe-harbor provisions for forward-looking statements are described under rule 175 of the Securities Act of 1933 and Rule 3b-6 under the Securities Exchange Act of 1934. The Private Securities Litigation Reform Act of 1995 considerably expanded these safe harbor provisions for forward looking statements, if they are accompanied by cautionary statements identifying important risk factors that could cause actual outcomes to differ from these statements.

[10]See, for example, the significant empirical literature showing that practitioners take litigation risk into account when pricing equity in IPOs and that the underpricing of IPOs is significantly affected by litigation risk: e.g., Hanley and Hoberg (2012). There is also some empirical research analyzing whether or not disclosures trigger litigation: see, e.g., Haley and Palepu (2001), who review the empirical research relating early disclosure and litigation and point out that the evidence on this relationship is mixed; and Field, Lowry, and Shu (2005) for more recent evidence.

The two issues of the content of allowable disclosures around security issues and the ease with which investors can sue and win judgements against companies whose projections of future performance turn out to be inaccurate are intimately related. This is because, even when firms are free to make various projections of future performance (i.e., there is no regulation forbidding them from making such disclosures), they would not make such disclosures if doing so would make them highly vulnerable to being found liable and penalized with large judgements subsequently. In fact, one of the arguments often made by those who would like to make it harder for plaintiffs to succeed in such lawsuits is the potential chilling effects of lawsuits on disclosures, which, they argue, is crucial if investors are to correctly value the securities issued by the firm. On the other hand, opponents of such litigation reform argue that it makes it easier for issuers and their underwriters to take advantage of uninformed investors by making glowing projections about the future performance of their firms with very little fear of being held to account subsequently in the courts.

Even though the above issues are crucial in determining the ease and efficiency with which firms can access the capital markets, finance, accounting, and economic theorists have been relatively silent on these issues. Thus, to the best of our knowledge, there has not been an adequate theoretical analysis of the optimality of various disclosure and litigation rules around new equity issues. While there is a large theoretical literature dealing with disclosures by firms in the context of financial as well as other markets, much of this literature does not directly impinge on the above debates. Further, the existing theoretical literature implies that it is desirable to allow and even encourage all types of disclosures by firms on the principle that they make the financial markets informationally more efficient (since rational investors can decide for themselves whether or not to give any credibility to these). However, such answers seem to be quite inadequate, since, from a purely commonsensical point of view, one can imagine several situations where unfettered disclosures with no legal recourse against false claims may be quite detrimental to the welfare of retail and even institutional investors and thereby ultimately affect the ease with which firms are able to raise financing in the capital markets. The objective of this paper, therefore, is to fill this gap in the literature by developing a simple theoretical framework to analyze some of the above issues.

We develop a two date model in which firm insiders have private information at time 0 about the state of nature to be realized at time 1, and may make disclosures at time 0 about the economic variables which determine this state, prior to selling new equity in the firm to outside investors in order to raise external financing to implement its positive net present value project. The firm's disclosure (claim) may be high (optimistic), medium (conservative), or low (pessimistic). The equity market consists of two kinds of investors: institutional investors, who have the ability to (and may choose to) make a noisy verification of the above disclosure by incurring a cost; and retail investors, who do not have the ability to make such a verification.[11] We assume that, depending on firm characteristics, only a fraction of the retail investors trading in a given equity market may choose to participate in a given equity issue ("retail investor participation rate" from now on). The price of the firm's equity is determined by the interaction between these two kinds of investors, and by the resulting incentives of corporate insiders to make (or not to make) various disclosures.

We first study a situation where there are no restrictions at all on the disclosures that are allowed to be made by the firm, and no litigation is allowed *ex post* if the announcements made by the firm turn out to be inaccurate. We show in this part of the paper that the absence of any regulations or threat of litigation does not necessarily imply that firms have an incentive to make the most optimistic disclosure possible; in fact, we show that, in some situations, the firm may choose not to make any disclosure at all. The self-regulation on disclosures made by firms arises from the fact that the firm has to rely at least partially on investment from institutional investors who are able to verify (with some noise) the disclosures made by the firm. If an institutional investor assesses

[11] We model retail investors as being similar to liquidity traders in market microstructure models such as Kyle (1985), in the sense that their demand for the IPO firm's equity (i.e., whether they buy a share in the IPO or not) is purely driven by their liquidity, and not by their evaluation of the firm.

that a disclosure made by the firm before its equity issue is false, he will not buy its shares, which, in turn, imposes a cost on the firm due to its not being able to raise its full investment amount, forcing it to scale back investment in its positive net present value project. However, disclosures also enable high intrinsic value firms to reduce the extent of their pooling with lower intrinsic value firms (given that the disclosures made by higher intrinsic value firms are more likely to be verified as true compared to those made by lower intrinsic value firms), thereby increasing the price at which such firms are able to sell shares in their new equity issues. The above cost-benefit trade-off also affects the type of disclosures made by higher intrinsic value firms: i.e., whether the firm chooses an optimistic (high), or a conservative (medium) disclosure, or no disclosure at all depends on which action is most effective in minimizing the extent of pooling by lower intrinsic value firms.[12] It is also worth noting that the above cost to benefit trade-off of making disclosures depends upon the proportion of institutional investors in a given equity market, the cost incurred by these investors to verify a given piece of disclosure, and the participation rate of retail investors in the equity issue.

Next, we study the case where there is a regulatory agency like the SEC in the U.S. with the power to restrain disclosures, and whose objective is to minimize the "information risk" faced by uninformed investors (institutional or retail) when investing in the equity issue due to adverse selection.[13] We show here that, depending on the ease (cost) with which a particular piece of information can be verified by institutional investors, and the participation rate of retail investors in the equity market, disclosure of that item may increase or decrease information risk. In particular, if the piece of information that is disclosed may be verified at a relatively low cost, the disclosure reduces information risk. Even in a market dominated by institutional investors, a piece of disclosure may increase information risk if the verification cost of institutional investors is larger than a certain threshold value (so that the extent of verification is low in equilibrium). This is because, while

[12]We show that it is weakly optimal for a firm to make no disclosure at all rather than to make a pessimistic disclosure (in the absence of some regulations mandating that the firm makes *some* disclosure).

[13]We define "information risk" formally in section 5.

some information is always released when a firm makes a disclosure, such disclosure also enables the firm to set a larger equilibrium price for its equity compared to the case when it does not make any disclosure. Thus, the information risk faced by uninformed investors may in fact increase following the disclosure by a firm. Consequently, the information risk following a disclosure will be lower if, and only if, the extent of verification by institutional investors is large enough (i.e., above a certain threshold value). We show that, depending on the characteristics of a particular equity market (in terms of the proportion of institutional investors), the participation rate of retail investors in the equity issue, and the nature of the particular piece of disclosure being considered, forbidding certain disclosures may or may not dominate allowing these disclosures from the point of view of the regulatory agency.

Finally, we study a situation where investors are allowed to bring private lawsuits against firms if their disclosures turn out to be inaccurate. We show in this section that, while allowing such lawsuits with the potential for large penalties being imposed on firms may indeed discourage disclosures, there are also certain settings where the threat of such lawsuits may encourage disclosures. However, we also show that, since private securities litigation often acts a substitute for disclosure verification by institutional investors, the information risk faced by uninformed investors may in fact increase when litigation is allowed, even under a liability regime which provides highly informative court verdicts: i.e., where the courts are able to correctly judge *ex post* (to a significant degree) whether the firm making the disclosure had a sound (honest) basis in fact for making the disclosure (claim) it made. Thus, whether relaxing the rules for bringing private lawsuits against equity issues will increase or decrease information risk depends on two factors: first, whether such changes in private securities litigation rules will encourage or discourage disclosures by firms; and second, whether the additional disclosures will themselves increase or decrease information risk.

The rest of the paper is organized as follows. Section 2 presents a review of the related literature.

Section 3 presents the basic structure of our model. Sections 4, 5 and 6 study the equilibria of our model under alternative disclosure and litigation regimes. Section 7 discusses some of the implications of our model. Section 8 concludes. The proofs of all propositions are confined to the Appendix.

2 Relation to the Existing Literature

There are a number of papers which study disclosures by firms in various settings, particularly in the context of the product markets: see, e.g., Grossman (1981) and Milgrom (1981) for early examples of this literature. The well-known "unravelling" result of Grossman (1981) demonstrates that if an informed party could costlessly make a fully verifiable disclosure of its private information, it will always do so (since the absence of disclosure is taken to be bad news by consumers in equilibrium).[14] Seidmann and Winter (1997) generalize this result with more general sender preferences; the implication of this generalized analysis remains the same as in the previously cited papers, namely, that firms will disclose all their private information in equilibrium. However, this intuition based on the product market context does not translate readily to the setting of disclosures around new equity issues, which is our focus here.

Jovanovic (1982), Verrechia (1982), and Dye (1986) study models in which the informed party must incur a cost to make fully verifiable disclosures. In this case the information is disclosed only if it is sufficiently favorable, and withheld otherwise. Fishman and Hagerty (1990) study a problem of limited disclosure, where the number of signals that can be disclosed is exogenously specified to be less than the number of unknown parameters. They show that the set of signals chosen by the firm to disclose is the one involving the most favorable news possible. Diamond (1985) studies the optimal information release policy of a firm, and demonstrate that there is, in general, an

[14] See also Ross (1979) and Verrechia (2001) for other analyses of the incentive of firms to disclose all their private information voluntarily.

information release policy which increases the ex-ante expected utility of all traders (compared to a policy of not releasing information). A key assumption in all of the above papers is that the pieces of information that are disclosed may be costlessly and perfectly verified by the uninformed party, an assumption that does not seem to be appropriate for analyzing the issues we study here. Finally, Boot and Thakor (2001) also analyze voluntary disclosures by firms and study whether greater disclosures will always make all firms better off. Unlike our paper, their focus is on the effects of disclosure on trading and information acquisition incentives in the financial markets and on security design incentives.[15]

There is also a large accounting literature on disclosures by firms in various settings. Much of this literature, however, is only indirectly related to our paper, in that the focus of these papers is not on disclosures around new security issues, but on issues surrounding "discretionary" disclosures of earnings-related information by firms in settings where such disclosure is costly to the firm (for various reasons): see, e.g., Verrechia (1983), Trueman (1986), Darrough and Stoughton (1990), Wagenhofer (1990), and Teoh and Hwang (1991). Three papers in this literature, namely, Trueman (1997), Evans and Sridhar (2002), and Hughes and Sankar (2006), have focused on the impact of securities litigation on discretionary disclosures by firm managers.[16]

[15] Fishman and Hagerty (2003) focus on the product market and analyze the rationale for mandating disclosure in the product market, an issue which is clearly not the focus of our paper. Another paper focusing on the rationale for mandating disclosure is Admati and Pfleiderer (2000). The latter paper assumes that all disclosures are truthful. This assumption, while not particularly problematic for the issues analyzed in that paper, is clearly not appropriate for the context studied here. Two more recent papers in this literature are Ferreira and Rezende (2007), who analyze managers' choice of whether to reveal their firm's corporate strategies only to partnering firms or to other outsiders as well; and Thakor (2015), who analyzes the strategic information disclosure policies of firms in an environment where disclosures are subject to alternative interpretations: i.e., in an environment where disagreement may arise across economic agents.

[16] Another related literature is that on the pricing of IPOs. A number of authors have argued that the "underpricing" of IPOs is the result of an attempt by insiders either to signal private information to outsiders (e.g., Allen and Faulhaber (1989) or Welch (1989)), or to induce information production by outsiders (Chemmanur (1993)). See also Welch (1992) on the effect of information cascades on the pricing and the distribution of IPOs. Hughes and Thakor (1992) study the impact of potential litigation on the pricing of IPOs by financial intermediaries. In particular, it is related to the empirical literature on the decline in the number of IPOs in the U.S. and the possible reforms of the IPO process: see, e.g., Gao, Ritter, and Zhu (2013) and Dodge, Karolyi, and Stulz (2013). Finally, it is related to, though more distantly, to the theoretical and empirical literature on SEOs: see, e.g., Chemmanur and Jiao (2011) for an example of the theoretical literature and Chemmanur, He, and Hu (2009) for an example of the empirical literature.

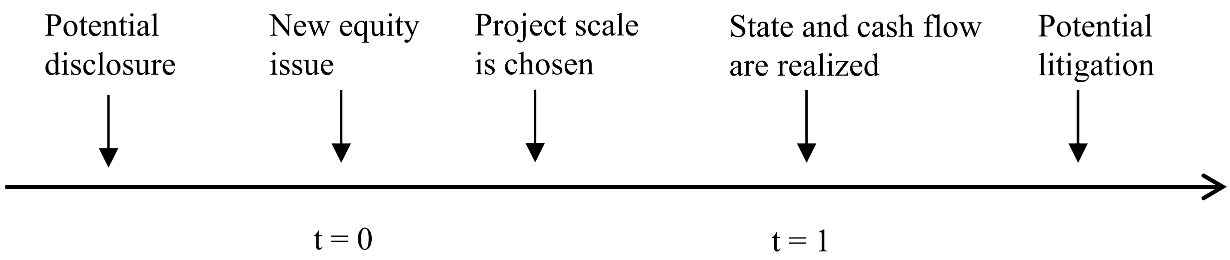

Figure 1: Sequence of Events

3 The Model

The model has two dates. At time 0, a risk-neutral firm (the entrepreneur in the case of a private firm planning an IPO, or the firm insider managing the firm in the case of a public firm planning an SEO) has monopoly access to a single project. The project requires a certain investment, which is scalable, and which insiders, having zero wealth to invest in the project at time 0, wish to raise by selling new equity to outside investors. Preparatory to selling equity, firm insiders may choose to make a disclosure or "claim," d, about the future realization of some variable relevant to firm value (firm insiders may also choose to make no disclosure whatsoever). Subsequently, they sell equity in the firm to outside investors in a new equity issue, thus diluting their own initial equity stake of w shares, and invest the proceeds in the firm's project. At time 1, the project pays off a certain cash flow, which depends on the "state of nature," s, realized at that date, as well as the amount invested in the project at time 1. The sequence of events is depicted in Figure 1. For simplicity, we normalize the risk-free rate of return to be equal to zero.[17]

The state of nature realized at time 1 can take on one of three possible values: "high" (H), "medium" (M) or "low" (L). Each state can be thought of as one of the possible realizations of an economic variable which affects the productivity of the firm's investment (e.g., the outcome of large scale clinical trials in the case of a medical drug, or the market share the firm is able to capture for

[17]The assumption that firm insiders have no wealth (or internal firm financing) to invest in the new project is simply a normalization. Our results go through qualitatively unchanged even if the firm has some internal financing available, as long as it needs to raise significant external financing by making a new equity issue.

a consumer product, or the cost realizations of raw materials and other inputs in a manufacturing process), and therefore its time 1 cash flow. Denoting by $v_s(\iota)$ the value of the time 1 cash flow corresponding to an investment level ι, we assume:

$$
\begin{aligned}
v_s(\iota) &= k_s\iota \quad \text{for } \iota < I, \\
v_s(\iota) &= k_s I \quad \text{for } \iota \geq I; \\
k_s \in \{k_H, k_M&, k_L\},\ k_H > k_M > k_L.
\end{aligned}
\tag{1}
$$

From (1), we can see that the firm's technology is such that any amount invested at time 0, ι, lower than or equal to a certain upper limit I yields a time 1 cash flow k_s times ι, with the value of the productivity parameter k_s depending on the realization at time 1 of the state of nature s, $s \in \{H, M, L\}$. For investment amounts above I, however, the cash flow generated remains at $k_s I$ (so that no insider will choose an investment level above this full-investment level I). Further, for any given level of investment, the firm's time 1 cash flow will be greater if the state of nature realized is higher. For convenience, we will denote the cash flow realization of the firm corresponding to the full investment level I by $V_s \equiv k_s I$, for $s \in \{H, M, L\}$.

3.1 Information Structure and Disclosure

While the state s is realized and becomes publicly observable only at time 1, firm insiders have information superior to outsiders about this future realization at time 0. For simplicity, we will assume that this private information can be one of only two possible types (f): "good" ($f = G$) or "bad" ($f = B$). Let δ_H^G, δ_M^G, or δ_L^G denote the probability assessment of a type G firm insider at time 0 about the realization of a high, medium, or low state; let δ_H^B, δ_M^B, and δ_L^B respectively denote the corresponding probabilities for a type B firm insider. We assume that $\delta_H^G > \delta_H^B$, $\delta_M^G = \delta_M^B$, and $\delta_L^G < \delta_L^B$. In other words, the private information of a type G firm insider is that, for any common investment level ι the cash flow distribution from his firm dominates that from a type B firm by first order stochastic dominance. Thus, based on the insiders' private information, the expected cash flow at the full investment level from a type G and a type B firm are respectively $V^G = k^G I$, and $V^B = k^B I$, where $k^G = \delta_H^G k_H + \delta_M^G k_M + \delta_L^G k_L$, and $k^B = \delta_H^B k_H + \delta_M^B k_M + \delta_L^B k_L$. Clearly, $V^G > V^B$.

Before selling equity, the firm insider (managing the firm) may choose to make a disclosure (a "projection" or claim) about the time 1 realization of the state variable regarding which he has private information, if allowed to do so by the regulatory agency. He may make an optimistic or "high" claim ($d = h$), a conservative or "medium" claim ($d = m$) or a pessimistic or "low" claim ($d = l$) respectively ($h > m > l$).[18] Alternatively, he may simply refrain from making any claim ($d = \varphi$).[19, 20]

3.2 Outside Investors and Verification Technology

The equity market is dominated by a cohort of risk-neutral investors. Of the Q investors in the equity market, a fraction π are institutional investors, while the remaining fraction $(1 - \pi)$ are

[18] We use lower case letters for disclosures, in order to distinguish between the claims made by the firm insider at time 0 about the future realization of the state variable s, and the actual time 1 realization values of this variable, H, M, or L.

[19] If the insider announces $d = m$, investors and courts will interpret this in equilibrium as a claim that the relevant state variable will have a time 1 realized value of at least M (i.e., its value will be either H or M). Similarly, if the firm insider announces $d = l$, this will be interpreted in equilibrium as a claim that the state variable will have a realized value of at least L (i.e., it will be H, M, or L); and if the insider announces $d = h$, this will be interpreted in equilibrium as a claim that the state variable will have a realized value of at least H. Note that, in our discussion here, we are not making any additional assumptions on the structure of the disclosure, but simply giving readers a preview of how various economic agents: institutional investors who attempt to verify the firms' disclosure (in sections 4, 5, and 6) and the courts (in section 6) will interpret a firm's disclosure in equilibrium. Thus, if a firm announces $d = m$, and institutions verify this as true, they will be happy that they bought shares in the firm's equity issue even if the true state realized *ex post* is in fact H (rather than M); similarly, if the actual state realized *ex post* is H, there is no ground for investors to file suit against the firm on the grounds that the firm filed an overoptimistic disclosure (since it announced $d = m$). For example, a pharmaceutical company might make a claim about the annual number of prescriptions that will be attained by their new drug, currently awaiting FDA approval, based on their currently available test and other data. If $H = 30$ million, $M = 20$ million, and $L = 10$ million, an announcement of $d = 20$ million essentially implies a claim that the new drug will attain *at least* 20 million prescriptions per year subsequent to FDA approval, a claim that clearly will hold true if the actual number of prescriptions attained is *either* 20 or 30 million.

[20] It is easy to extend our analysis to the case where the insider's claim about the particular variable being disclosed is allowed to be in the form of a probability distribution over $\{h, m, l\}$ rather than a simple announcement of h, m, or l. The basic requirement for the intuition behind our model to go through is only that it should be possible to order such claims in terms of their impact on the firm's future cash flows.

retail investors. When faced with a firm selling equity without making any disclosure, all investors behave in an identical manner, buying the equity if the price is below their expectation of the firm's time 1 cash flow, and ignoring the equity issue otherwise. We assume that each investor is allowed to buy only one share each of the equity in the firm. The prior probability of all investors of any firm entering the equity market being of type G is denoted by ω.

When faced with a firm making a disclosure, institutional and retail investors behave differently. Institutional investors have access to a verification (information production) technology which they may use to ascertain the veracity of the information released by the firm. Thus, by incurring a certain cost, each institutional investor may obtain an evaluation "e" of the information disclosed by the firm. The outcome of this evaluation may be "true" (T) or "false" (F), so that $e \in \{T, F\}$. This evaluation is noisy, but informative; the disclosures made by a truly type G firm are verified as true ($e = T$) with the following probabilities:

$$Pr\{e = T \mid d = h, f = G\} \equiv r_h,\ Pr\{e = T \mid d = m, f = G\} \equiv r_m,\ Pr\{e = T \mid d = l, f = G\} \equiv r_l, \tag{2}$$
$$r_h \leq r_m < r_l = 1,$$

with a "false" outcome ($e = F$) obtained with the complementary probabilities $(1 - r_h)$, $(1 - r_m)$, and $(1 - r_l)$ for the high, medium and low states respectively. Similarly, the disclosures made by a type B firm are verified as true ($e = T$) with the following probabilities:

$$Pr\{e = T \mid d = h, f = B\} \equiv q_h,\ Pr\{e = T \mid d = m, f = B\} \equiv q_m,\ Pr\{e = T \mid d = l, f = B\} \equiv q_l, \tag{3}$$
$$q_h \leq q_m < q_l = 1,$$

with a false outcome obtained with the complementary probabilities $(1 - q_h)$, $(1 - q_m)$, and $(1 - q_l)$ respectively. We further assume that, when a number of institutional investors verify a disclosure made by a type G firm, a fraction r_d, obtain an outcome $e = T$, with the remaining fraction $(1 - r_d)$,

$d \in \{h, m, l\}$, obtaining an outcome of $e = F$ (the corresponding fractions will be q_d and $(1 - q_d)$ when evaluating a disclosure made by a type B firm).[21]

One can think of the verification process by outsiders as a fact-finding mission: an attempt to check independently whether there are indeed enough facts to support the claim made by firm insiders. Consistent with this, we assume that the verification technology has two important properties which has to characterize any such fact-finding mission if it is to be informative. First, for a given firm type (i.e., holding the insider's private information constant), a highly optimistic disclosure has a smaller chance of being verified as true by outsiders than a moderately optimistic (or conservative) claim. Thus, a disclosure $d = h$ made by a type G firm insider will be verified as true with only a lower probability than a claim of $d = m$ by the same insider (since, for a given firm type, it will clearly be always harder for outsiders to find facts to justify a more optimistic claim). This assumption is captured by equations (2) and (3) (for the type G and the type B firm respectively). Second, we assume that, for a given claim, the probability of being verified as true is greater for the better firm type. Thus, we assume that $r_h > q_h$, and $r_m > q_m$: the probability that a disclosure $d = h$ or a disclosure $d = m$ will be verified by outsiders as true is always greater for the type G firm than for the type B (recall that, by definition, the type G firm is that one about whose future prospects its insiders have more favorable private information).[22]

If an institutional investor chooses to verify a disclosure by a firm, he engages in Bayesian updating about the firm's value based on the outcome of his evaluation of the veracity of this disclosure made by the firm, $e \in \{T, F\}$. Thus, when faced with the new equity issue of a firm making a disclosure, each institutional investor in the new issues market has three alternatives: he

[21] If, instead, we were to assume that institutional investors evaluating a disclosure obtain independent signals, the *expected value* of the fraction of these investors obtaining outcomes of $e = T$ will remain r_d and q_d, for the type G and type B firm respectively. However, in this case, many of our expressions will involve the *distributions* of this fraction of institutional investors who obtain outcomes of $e = T$. This would add unnecessary computational complexity to the model without generating any commensurate economic insights, and we have therefore adopted the correlated information structure above.

[22] Since a disclosure $d = l$ is always verified as true (since L is lowest possible value attained by the state s), the probability of such a disclosure being verified as true is the same for both types.

may choose to ignore the disclosure as well as the equity issue altogether and invest his wealth in the risk-free asset; he may choose to engage in uninformed bidding for shares in the new equity issue; or he may conduct a costly verification of any disclosure made by the firm using the technology (2)-(3), and, based on the outcome of his verification, bid (if he gets an outcome of "true") or not bid (if he gets an outcome of "false") for a share in the new equity issue.[23] If an institutional investor decides to verify a disclosure made by a firm, he incurs a cost c per dollar of investment made in the firm's equity.[24] We assume that the objective of each institutional investor in deciding between these alternatives is to maximize his time 1 expected cash flow from investing their time 0 wealth. Further, the alternative investment opportunity of each investor is the risk-free asset.[25]

Retail investors, unlike institutional investors, do not have access to an informative verification technology to evaluate the disclosures made by any firm: whether they buy a share of equity in the firm is based purely on their liquidity. In other words, their investment behavior in the firm's equity is similar to that of liquidity traders in market microstructure models: see, e.g., Kyle (1985). When faced with a firm making an equity issue (accompanied by a disclosure or not) a fraction z of retail investors will buy one share of equity in the firm as long as the offer price is lower than or equal to their estimate of its expected cash flow. The remaining fraction $(1 - z)$ do not invest in the firm's equity. We use z to capture the participation rate of retail investors in the new issues

[23]Clearly, no investor will incur the cost of verifying a disclosure, and then choose not to bid for a share in the new equity issue even after getting a "true" outcome; conversely, no investor will incur the cost of verifying a disclosure and then bid for a share in the firm upon observing a false outcome. For any investor to have an incentive to incur the cost of verifying disclosure made by a firm, verifying a firm's disclosure must yield him *some* benefit in terms of discriminating between type G and type B firms; for parameter values for which this is not the case, no investor will choose to produce information, and all investors will prefer either to engage in uninformed bidding, or elect not to participate in the new equity issue altogether (depending on the offer price of each share of equity, and the investors' prior beliefs about the proportion of type G firms in the pool).

[24]Given our assumption that all investors hold equal shares in the firm, the total verification cost incurred by all institutional investors who choose to verify disclosures is the same in this model. Consequently, assuming that the verification cost per dollar of investment made in the firm's equity is fixed rather than a fixed *total* verification cost serves only to make our computations less cumbersome, and does not drive any of our results.

[25]We assume that no institutional investor is prevented from investing in a firm or verifying the disclosure made by it due to a wealth constraint: i.e., all investors have at least enough wealth to buy one share in the firm making the new equity issue. Then, given our assumption that each investor holds at most one share in the firm, and that investors are risk-neutral, the magnitude of any time 0 wealth that the investor may have in addition to the amount that he invests in the firm does not affect his equilibrium strategy; we will therefore not be concerned with the investors' total time 0 wealth here.

market. Clearly, z may vary according to macroeconomic conditions in general (e.g., z may be higher during stock market boom periods) or according to the type of the firm making the new equity issue (e.g., it may be greater in the equity issues of firms engaged in the manufacturing and selling of well-known products in wide retail use) or conditions in the new issues market (e.g., it may be higher in industries experiencing a "hot IPO" market or "IPO wave"), and may also vary across countries (e.g., it may be higher in countries where the participation rate of households in the stock market is greater).

We assume that the proportion of retail investors in the equity market is small enough that no firm finds it optimal to raise their entire capital requirements from such investors alone, so that any equity offering has to rely at least partially on demand from institutional investors. This means that, while the equilibrium price of equity may be affected by the proportion of retail investors, it will never be determined solely by their investment behavior. Retail investors affect the equilibrium in our model primarily through their impact on the magnitude of two important costs: First, they affect the cost imposed on either type of firm if it makes a more rather than a less optimistic disclosure. Second, they affect the cost imposed on the type B firm if it mimics the type G firm in equilibrium (we will see later that, the greater the proportion of retail investors in the equity market, the lower the magnitude of both of these costs in equilibrium).

Denote by α_d, the proportion of those institutional investors participating in the new equity issue who choose to incur the cost and verify any disclosure d made by a firm prior to making its equity issue (we will use the subscript d with α as well as many other equilibrium variables as a convenient way to capture the dependence of these variables on the disclosure d made by the firm). We model the determination of α_d as follows. After observing the disclosure made by the firm at time 1, and the price and number of shares offered by the firm in the equity issue, each institutional investor chooses between not participating in the equity issue at all and participating as an informed investor with a probability α_d. In other words, if an institutional investor decides to participate in the equity issue, he conducts a costly verification of the disclosure made by the firm with a probability α_d (and subsequently bids for a share if he gets a good evaluation, and not bid if he gets a bad evaluation), or makes an uninformed bid for a share in the equity issue with the complementary probability $(1-\alpha_d)$. The probability α_d therefore measures the extent of verification among institutional investors who are participants in the firm's new equity issue. At one extreme, $\alpha_d = 0$ implies that all institutional investors engage in uninformed bidding (no verification of any disclosures made by the firm); at the other extreme, $\alpha_d = 1$ implies that all institutional investors verify the firm's claims. For $0 < \alpha_d < 1$, a fraction α_d of institutional investors verify the firm's claims, while the remaining fraction $(1 - \alpha_d)$ make an uninformed bid for a share of equity in the firm (in equilibrium, institutional investors will be indifferent between verifying and not verifying the disclosure made by the firm).[26]

3.3 The Insider's Objective

To begin with, firm insiders own w shares in the firm. The insider managing the firm makes a disclosure $d \in \{h, m, l, \varphi\}$ at time 0, and subsequently sells shares to outsiders at a price p_d. Since the insider is risk-neutral, his objective in making the choice of disclosure d, the share price p_d and the number of shares sold (denoted by n_d for the type G firm, and $\hat{n}_d$ for the type B) is to

[26]Since, in equilibrium, each institutional investor will be indifferent between informed and uninformed bidding in the equity issue, and investors have identical information production costs, the exact identity of disclosure-verifiers and uninformed bidders is irrelevant here. Formally, we assume that investors follow a randomized strategy, with a proportion α_d choosing to produce information and the remaining $(1 - \alpha_d)$ choosing to bid uniformed, based on the outcome of a collectively observed randomization device. This way of modeling the investors' choice between informed and uninformed bidding, where investors choose to produce information with a certain probability (rather than confining them to pure strategies) seems to be the most elegant modeling approach here, since it yields a *symmetric equilibrium* (where identical agents make identical choices), similar to the modeling approach adopted in Chemmanur and Fulghieri (1999). An alternative modeling approach, involving only pure strategies, would measure the extent of information production in the new issues market by the number of investors producing information in equilibrium (see, e.g., Chemmanur (1993)). However, this alternative approach would require that some members of an otherwise identical cohort of investors choose to produce information, while others do not, so that the equilibrium would be *asymmetric*. (See also Milgrom (1982), who uses both of these approaches to model auctions with information production, and demonstrates the essential equivalence of these two alternative approaches.)

maximize his time 1 expected cash flow, given by:

$$W_d^f = \frac{w}{w+n} k^f p_d n, \text{ for } f \in \{G, B\}, \ \ d \in \{h, m, l, \varphi\}, \qquad (4)$$
$$\text{with } n \equiv n_d \text{ for } f = G, \text{ and } n \equiv \hat{n}_d \text{ for } f = B.$$

From (4), the insider's objective depends on both his private information (i.e., whether he is type G or type B), as well as the disclosure d he makes at time 0 (which itself will be a function of his private information).

4 Self-Regulation in Disclosure

In this section we study the equilibrium in an environment of self-regulation in disclosure: i.e., in the absence of any regulatory agency, or *ex post* litigation. In this case, the firm insider managing the firm is free to make whatever disclosure he chooses to at time 0, preparatory to making the equity issue. We assume that the equity issue is such that the offering goes forward even if not all the equity offered to investors is sold (in this case, the firm raises only an amount less than I).

Definition of equilibrium: An equilibrium consists of: (i) A choice made by the firm insider managing the firm of the disclosure to make at time 0, along with a combination of prices and number of shares to be offered to outsiders; (ii) A decision by each institutional investor in the equity market (in the case where the firm insider chooses to take the firm public) about whether or not to participate in the new equity issue, and if the decision is to participate, a choice by each investor about the probability of his incurring the verification cost and evaluating the disclosure (if any) made by the firm; (iii) A choice by retail investors, upon observing the disclosure made by the firm as well as the price per share and the number of shares offered, regarding whether or not to bid for shares in the new equity issue; (iv) a set of beliefs for institutional investors and for retail investors. Each of the above choices made by the firm insider managing the firm and by equity market investors and their beliefs must satisfy the following conditions: (a) The choices of each party maximizes their objective, given the equilibrium beliefs and choices of the other parties; (b) The beliefs of all players are rational and consistent with the equilibrium choices of others; along the equilibrium path, these beliefs are formed using Bayes' rule; (c) Any deviation from equilibrium strategies by any player is met by other players' out-of-equilibrium beliefs which yield him a lower expected payoff compared to that he obtains in equilibrium.[27]

Proposition 1 ***(Equilibrium with Disclosure)*** *If the outsiders' prior of a type G firm, $\omega < \hat{\omega}$, with the verification cost $\underline{c} < c < \overline{c}$ and the number of investors in the equity market $Q > \underline{Q}$, then there exists an equilibrium involving the following.*

(i) The type G firm: It makes a disclosure $d \in \{h, m\}$ at time 0, and offers n_{od} shares to investors, each at a price p_d, of which a number n_d is sold to investors.

(ii) The type B firm: With probability β_d, $0 < \beta_d \leq 1$, it pools with the type G firm by making the same disclosure d as the type G firm, $d \in \{h, m\}$, and offers n_{od} shares to investors, each at a price p_d, of which a number $\hat{n}_d$ is sold to investors; with the remaining probability $(1 - \beta_d)$, it does not make any disclosure (revealing itself as type B), and offers (and sells) n_B shares at a price p_B.

(iii) Institutional Investors: A fraction α_d of the institutional investors verify the disclosure at a cost c, bidding for a share of equity if they get an outcome of $e = T$ (and not bidding for a share if they get an outcome of $e = F$); the remaining fraction $(1 - \alpha_d)$ engage in uninformed bidding for a share of equity.

(iv) Retail Investors: A fraction z of these investors bid for a share of equity in the firm if the offer price is at or below their expectation of its intrinsic value, while the remaining fraction $(1 - z)$ does not bid for a share of equity in the new equity issue.

The out-of-equilibrium beliefs supporting this equilibrium are that outsiders believe any firm setting a share price other than p_d, offering a number of shares other than n_{od}, or making a disclosure other than that would be made by a type G firm to be a type B firm with probability 1.[28]

[27] Our equilibrium definition is based on the Perfect Bayesian Equilibrium (PBE) concept, formally defined for dynamic games with incomplete information by Fudenberg and Tirole (1991). While, in later sections, we characterize the equilibrium allowing for a regulatory agency (section 5), and also for *ex post* private securities litigation (section 6), the general definition of equilibrium used in these sections will be the same as that described above.

[28] Throughout this paper, our main focus will be on partially pooling equilibria, where the type B firm mimics the type G with a positive probability (less than one) by making a disclosure identical to that made by the type G and making an equity issue with characteristics similar to that made by the type G (in terms of number of shares and price per share), so that there is some need for costly verification of such disclosures by institutional investors. Depending on parameter values, two other types of equilibria may arise in our model: (i) Fully pooling equilibria, where the type B firm mimics the type G firm with probability one. This type of equilibrium arises when the institutional investors' verification technology is so costly (for a given amount of noise in the technology) that there is no incentive for any institutional investor to verify the disclosures made by firms in equilibrium, in turn implying that there is no penalty imposed on the type B firm if it attempts to mimic the type G; (ii) Fully separating equilibria, where the type B firm does not mimic the type G firm at all (by not making any disclosure prior to an equity issue with

In the above partially pooling equilibrium, the type G firm always sets the high price p_d, offering n_{od} shares at this price (both of which will depend on the disclosure it makes at time 0). The type B firm follows a mixed strategy, mimicking the type G firm by making the same disclosure as the type G and offering n_{od} shares at the high price p_d with probability β_d; and revealing itself by making no disclosure at time 0 and then selling n_B shares at a price p_B, equal to its true value (i.e., the expected value of time 1 cash flow conditional on insiders' private information). Thus, in this equilibrium, if an institutional investor observes a firm making a disclosure d at time 0, and offering n_{od} shares at a price p_d at time 1, and does not choose to verify the disclosure, then he will infer that the firm is of type G with probability θ_d, given (using Bayes' rule) by:

$$\theta_d \equiv Pr\{f = G \,|\, d, p_d\} = \frac{\omega}{\omega + \beta_d(1-\omega)}, \tag{5}$$

and of type B with the complementary probability $(1-\theta_d)$. Since θ_d can be interpreted as capturing the assessment of investors (conditional on disclosure) about the proportion of firms making new equity issues that are of type G, we will sometimes refer to θ_d as the "pool quality" in our discussion below. If, on the other hand, the investor incurs the cost to verify the firm's disclosure, he engages in Bayesian updating based on the outcome of this evaluation (T or F). His posterior probability

probability one), while the type G firm always makes such a disclosure. This occurs when the institutional investors' cost of verification of any disclosures made by firms is small enough (for a given amount of noise in this technology), resulting in the penalty imposed on the type B firm if it attempts to mimic the type G firm being so large that it is never optimal for it to do so. Note that the partially pooling equilibrium we study in detail here may be viewed as the most general one, since the fully pooling and fully separating equilibria are the limiting (extreme) cases of the equilibrium we study here when the institutional investors' verification cost of firm disclosures is extremely large or extremely small, respectively. While, due to space limitations, we choose not to characterize these two extreme types of equilibria in detail in this paper, detailed characterizations of these two types of equilibria are available to interested readers upon request. It is also worth pointing out that, in the event that the parameter values prevailing in an equity market are such that either a fully pooling or a fully separating equilibrium prevails, our model does not have any substantial policy recommendations to make, since all our conclusions are based on the partially pooling equilibrium where the type B firm mimics the type G with a positive probability (less than one).

of the firm being of type G will then be given by:

$$Pr\{f = G \mid d, p_d, T\} = \frac{r_d \theta_d}{r_d \theta_d + q_d(1-\theta_d)},$$
$$Pr\{f = G \mid d, p_d, F\} = \frac{(1-r_d)\theta_d}{(1-r_d)\theta_d + (1-q_d)(1-\theta_d)}. \tag{6}$$

A fraction z of retail investors participate in the equity issue by buying a share of stock, since the equilibrium price, which is set to appeal to uninformed institutional investors (who choose not to verify the disclosure) as well as to retail investors, is, in general, below their expectation of the intrinsic value per share. The remaining fraction $(1-z)$ of retail investors do not participate in the new equity issue and therefore do not bid for a share of equity in the firm.

Of the n_{od} shares offered, the type G firm sells n_d shares at the price p_d per share of equity. The buyers of these shares consist of the fraction $(1-\alpha_d)$ of the institutional investors who choose to bid uninformed for a share of equity; the fraction $r_d \alpha_d$ of the institutional investors who choose to verify the firm's disclosure and obtain an outcome $e = T$ upon verification; and the fraction z of retail investors who choose to participate in the equity issue. Similarly, if the type B firm pools by setting the same price p_d, the number of shares sold will be $\hat{n}_d$. These are given by:

$$n_d = [1 - \alpha_d \pi (1-r_d) - (1-\pi)(1-z)]\, n_{od},$$
$$\hat{n}_d = [1 - \alpha_d \pi (1-q_d) - (1-\pi)(1-z)]\, n_{od}. \tag{7}$$

The corresponding amounts raised are given by $n_d p_d$ (for the type G firm) and $\hat{n}_d p_d$ (for the type B firm, when it pools with the type G).

For any uninformed (institutional) investor to bid for a share of equity in the new equity issue, the equilibrium pooling price p_d cannot be greater than the expected value per share conditional only on the disclosure d (so that an uninformed investor is at least able to recoup the price paid, in terms of expected value). Thus:

$$p_d \leq \theta_d \frac{p_d n_d k^G}{w + n_d} + (1 - \theta_d) \frac{p_d \hat{n}_d k^B}{w + \hat{n}_d}. \tag{8}$$

At the same time, for any (institutional) investor to verify the disclosure made by the firm, the cost of doing so cannot be greater than the expected benefit. The expected benefit from disclosure verification is the net of two components. It is the expected gain arising from obtaining an outcome of $e = F$ when evaluating the disclosure made by a type B firm and thus avoiding the loss arising from overpaying for a share in that firm; minus the expected loss from getting an outcome of $e = F$ when verifying the disclosure made by a type G firm and thus not buying a share in that (undervalued) firm. Therefore, the following inequality must hold in any equilibrium where some institutional investors verify the firm's disclosure:

$$c \leq 1 - \theta_d r_d - (1 - \theta_d) q_d - (1 - r_d)\theta_d \frac{n_d k^G}{w + n_d} - (1 - q_d)(1 - \theta_d)\frac{\hat{n}_d k^B}{w + \hat{n}_d}. \tag{9}$$

Since, from (7), the number of shares sold is smaller than the number of shares offered for sale, the type G firm will "gross up" the number of shares initially offered for sale in an equilibrium with disclosure, n_{od}, such that it is able to raise an amount I, if possible. If the number of potential participants (market size) is large enough, it will be able to raise the full investment amount I; otherwise, it will have to scale back its investment to some degree, since those institutional investors who obtain an outcome of $e = F$ from disclosure verification do not bid for shares in the firm. We assume throughout that Q is large enough that if all institutional investors buy shares, either firm type can raise as large an amount I as they desire. However, in a disclosure equilibrium, since only those institutional investors who obtain an outcome $e = T$ buy shares in the firm, either type of firm may nevertheless face a quantity constraint in that they may not be able to "gross up" the number of shares offered to as great a degree as they desire. The number of shares offered for sale, n_{od}, can therefore be expressed as:

$$n_{od} = \min\left[Q, \frac{I}{p_d\left(1 - \alpha_d \pi (1 - r_d) - (1 - \pi)(1 - z)\right)}\right]. \tag{10}$$

Since $q_d < r_d$ in (7), n_d will be greater than $\hat{n}_d$ in equilibrium. Therefore, the type B firm always has to scale back its investment level if it pools with the type G firm by offering the same number of shares n_{od}. Further, if the type G firm also has to scale back its investment from the full investment level, the type B firm has to scale back to an even greater extent if it pools with the type G. If, however, the type B chooses to separate itself from the type G firm by setting a different price p_B (and equal to its true full-information value) it is able to raise the full investment amount I, selling a certain number of shares n_B. These values p_B and n_B are given by:

$$n_B = \frac{w}{k^B - 1}, \;\; p_B = \frac{I}{n_B} = \frac{\left(k^B - 1\right) I}{w}. \tag{11}$$

It now remains to see how the fraction of investors verifying the disclosure made by the firm, α_d, and the probability of the type B firm pooling with the type G firm, β_d, are determined in equilibrium. To see how α_d is determined, consider first the extreme case where most institutional investors in the new issues market engage in uninformed bidding. In this case, the cost imposed on the type B firm (in terms of having to scale back its investment) is very low, so that it has an incentive to pool with the type G firm very often (thus creating an incentive for more institutional investors to produce information). At the other extreme, if most institutional investors in the new issues market choose to verify the firm's disclosure, the cost to the type B firm from pooling with the type G firm will then be very high, so that it rarely mimics the type G firm (thus creating an incentive for more institutional investors to refrain from verifying the firm's disclosure). The equilibrium α_d will be such that the type B firm is indifferent between selling $\hat{n}_d$ shares at price p_d, and selling n_B shares at price p_B. The type B firm is indifferent between mimicking the type G firm (and thereby having to scale back its project) and funding the project in full by setting a lower price p_B, so that the following equation is satisfied:

$$\left(k^B - 1\right) I = \frac{w}{w + \hat{n}_d}\, \hat{n}_d p_d k^B. \tag{12}$$

At the same time, β_d, the equilibrium probability with which the type B firm sets the high price p_d, is such that each institutional investor is indifferent between producing and not producing information.

To see the relationship between the equilibrium β_d and the equilibrium value of the fraction α_d of institutional investors who produce information, consider first the extreme case where β_d is close to 1. In this case, since the type B firm mimics the type G most of the time, the benefits of verifying any disclosures made by the firm are very high, thereby creating an incentive for a large fraction of institutional investors to do so (thus imposing a high cost on the type B firm for mimicking the type G, and inducing it to reduce the mimicking probability β_d). At the other extreme, if β_d is close to zero (implying that the type B firm almost never mimics the type G), there is almost no benefit to outsiders from producing information about the firm, thus driving down the fraction of institutional investors who verify disclosures (thereby reducing the cost imposed on the type B firm if it mimics the type G, and inducing it to increase the mimicking probability β_d). Therefore, the equilibrium value of β_d will be such that institutional investors are indifferent between producing and not producing information, so that (8) and (9) hold as equalities.

Finally, it is worth pointing out that retail investors are fully rational in our setting, since the retail investors who participate in the new equity issue break even on their investment in the firm's equity (see equation (8)). This is because, as discussed above, the participation of institutional investors in the equity issue acts as a disciplining mechanism on the behavior of the type B firm, so that the price p_d paid by retail (as well as institutional) investors for each share in the firm's new equity issue does not exceed the expected intrinsic value of these shares.[29]

In summary, in a partial pooling equilibrium with disclosure, the equilibrium values of d, α_d, β_d, θ_d, p_d, n_d, $\hat{n}_d$, p_B, n_B, and n_{od} satisfy the equations (5) to (12) simultaneously. (We will discuss in detail the firm's equilibrium choice of the disclosure d under Proposition 2.) In the following lemma, we relate the properties of an equilibrium with disclosure with the various characteristics of the new issues market.

Lemma 1 ***(Comparative Statics)*** *Let $\underline{Q} < Q < \overline{Q}$ (where the thresholds $\underline{Q}$ and are defined $\overline{Q}$ in the Appendix). The following comparative statics results hold for a partially pooling equilibrium (PPE) with disclosure:*

(a) $\frac{\partial \alpha_d^*}{\partial \pi} \lesseqgtr 0, \frac{\partial \beta_d^*}{\partial \pi} < 0, \frac{\partial \theta_d^*}{\partial \pi} > 0$;

(b) $\frac{\partial \alpha_d^*}{\partial c} < 0, \frac{\partial \beta_d^*}{\partial c} > 0, \frac{\partial \theta_d^*}{\partial c} < 0$;

(c) $\frac{\partial \alpha_d^*}{\partial r_d} > 0, \frac{\partial \beta_d^*}{\partial r_d} < 0, \frac{\partial \theta_d^*}{\partial r_d} > 0$;

(d) $\frac{\partial \alpha_d^*}{\partial q_d} < 0, \frac{\partial \beta_d^*}{\partial q_d} > 0, \frac{\partial \theta_d^*}{\partial q_d} < 0$;

(e) $\frac{\partial \alpha_d^*}{\partial z} > 0, \frac{\partial \beta_d^*}{\partial z} < 0, \frac{\partial \theta_d^*}{\partial z} > 0$.

Part (a) of Lemma 1 studies how the proportion of institutional investors affects the equilibrium in the equity market. As the proportion π of institutional investors increases, there are two opposing effects on β_d, the probability with which the type B firm mimics the type G. First, since retail investors are not capable of verifying the disclosures made by the firm (and therefore do not have any discriminating power between the two types of firms), and $r_d > q_d$, an increase in the proportion π of institutional investors (who are capable of verifying the disclosures made by firms) adversely affects the type B firm much more than it impacts the type G. Therefore, for any given value of

[29] In this sense, the retail investors in our setting are slightly different from liquidity traders in market microstructure models such as Kyle (1985). In general, in such models, the profits made by the informed trader comes at the expense of liquidity traders (who make negative expected profits). In contrast, in our setting, retail investors break even in equilibrium.

α_d, an increase in π decreases the incentive of the type B firm to mimic the type G, reducing β_d. Such a decrease in β_d, however, would (in general) reduce the benefit to verification for institutional investors, motivating a decrease in α_d. While the latter effect partly offsets the first effect, the net effect of an increase in π can shown to be an increase in the cost imposed on the type B firm if it mimics the type G, resulting in a lower equilibrium value of β_d^* (and a higher equilibrium value of θ_d^*, since, from (5), β_d and θ_d always move in opposite directions).[30]

Part (b) of the above lemma arises from the fact that, as the cost of verification c goes up, a smaller fraction α_d^* of institutional investors verify the disclosure made by the firm, thereby reducing the cost imposed on the type B firm from mimicking the type G, increasing the type B firm's mimicking probability β_d^* and decreasing the quality of the pool θ_d^*. Parts (c) and (d) arise from the fact that, if the informativeness of the verification technology increases (i.e., if r_d goes up or q_d goes down), the fraction of institutional investors who engage in informed bidding, α_d^*, increases, with the consequent decrease in β_d^* and increase in θ_d^*.

Finally, part (e) follows from the fact that an increase in the participation rate z of retail investors in the equity market increases the size of the pool of capital that can be tapped by both types of firms. If more capital is available to invest due to greater retail investor demand for the firm's shares, this reduces underinvestment by both type G and type B firms. However, this increase in the intrinsic value of the type G firm from a higher investment scale is substantially greater than that of the type B firm, because the type G firm is more productive in its investments than the type B firm. This leads to the difference between the intrinsic values of the type G and

[30]While we are able to compute the effect of an increase in π on β_d^* and θ_d^* unambiguously, the impact on the fraction α_d^* of institutional investors who choose to verify the disclosure made by the firm is ambiguous. This is because α_d^* depends not only on the relative impacts of an increase in π on the pool of capital available to the two types of firms (through β_d^*), but also on the magnitude of the size of this pool of capital. Thus, in the special case where the participation rate z among retail investors is small (and r_d and q_d are large), an increase in π may lead to an increase in the size of the pool of capital that can be tapped by both types of firms; this, in turn, would lead to an increase in the benefit to institutional investors from verifying the disclosures made by the firm. This second effect may overcome the reduction in the benefit from verifying disclosure which accompanies the reduction in β_d^* with π (discussed before), in which case there may be a net increase in α_d^* with π.

type B firms to become greater as the retail investor participation rate z increases. This, in turn, means that institutional investors have a greater benefit from distinguishing between type G and type B firms that disclose information, which leads to an increase in the fraction α_d^* of institutional investors who verify the disclosures made by the firm. This greater verification by institutional investors decreases the type B firm's mimicking probability β_d^*, and therefore increases the pool quality θ_d^* of firms that disclose information in equilibrium.

In the rest of this paper, we will assume that the model parameters are such that a partially pooling equilibrium with disclosure exists. Further, we will assume throughout that the size of the new issues market is such that the number of potential investors Q is less than a finite upper bound $\overline{Q}$.[31]

Proposition 2 ***(Choice of Disclosure)*** *Let $\underline{Q} < Q < \overline{Q}$.*

(a) The equilibrium firm disclosure is $d = m$ if the type G verification probability for the medium state, r_m, is significantly greater than that for the high state, r_h, such that it exceeds a certain threshold value $\hat{r}_m = f(r_h, q_h, q_m)$, defined in the Appendix. The disclosure is $d = h$ if r_m is less than $\hat{r}_m$.

(b) The equilibrium firm disclosure is $d = h$ if $r_m = r_h$ (but $q_m > q_h$); the firm discloses $d = m$ if $q_m = q_h$ (but $r_m > r_h$).

(c) No firm chooses to disclose $d = l$ in equilibrium.

The benefit to the type G firm from announcing $d = h$ rather than $d = m$ arises from the ability to use the disclosure to reduce the level of pooling with the type B firm, thus commanding a greater price for its shares in the equity market. The cost of disclosing $d = h$ rather than $d = m$ to the type G firm is that it may also involve making a smaller equity issue (since the firm knows that

[31]Recall that, throughout this paper, we allow Q to be large enough that if all institutional investors buy equity in the firm, the firm can always raise its full investment amount. The restriction that $Q < \overline{Q}$ is therefore simply made to preclude the case where Q is so large that, even when the chances of any given investor buying shares in the firm is very small, the firm can still raise the full investment amount by offering shares to an unlimited number of investors. Thus, by assuming that $Q < \overline{Q}$, we are in essence assuming a certain transaction cost (however small) in offering shares to each additional investor. If there are such non-zero transaction costs, then the firm will not find it optimal to gross up its offering to such a tremendous degree (even in the absence of any explicit upper bound on Q), since the total transaction cost incurred in doing so will then be prohibitively large.

those institutional investors who obtain $e = F$ upon verifying a disclosure do not buy equity), thus imposing costs on the firm by forcing it to scale back investment in its project to a greater extent. In an equilibrium with disclosure, the choice between disclosing h and m depends on the net benefit (benefit minus cost) from making each claim. For example, consider the case where r_h is much larger than q_h, but r_m is very close to q_m.[32] In this case, announcing $d = h$ allows the type G firm to reduce the level of pooling with the type B firm much more efficiently than announcing $d = m$, since mimicking the type G firm would be much costlier for the type B firm in the former case (since it will have to scale back its project to much greater degree if it mimics the type G firm when it announces $d = h$ than when it announces $d = m$). However, since $r_h < r_m$, setting $d = h$ also imposes a larger cost on the type G firm itself compared to setting $d = m$, through having to scale back its own project to a greater degree. Thus, whether the firm ultimately makes a claim of h or m depends on the relative magnitudes of the parameters r_h, r_m, q_h and q_m (which characterize the institutional investors' verification technology), which determine whether the net benefit from disclosure is larger for $d = h$ or $d = m$.

Result (b) presents special cases of (a) which helps to clarify the above intuition. If $r_h = r_m$, there is no additional cost to the type G from claiming $d = h$ rather than $d = m$ (since project scale will be the same in either case), while there is an additional benefit from doing so (since $q_h < q_m$, the type B firm will have to scale back to a greater extent if it mimics when $d = h$, so that it mimics less often). The type G firm therefore sets $d = h$. At the other extreme, where $q_h = q_m$, there is no additional benefit to the type G firm from announcing $d = h$ rather than $d = m$ (the type B firm's project scale will be the same regardless of whether it mimics the type G firm when it announces $d = h$ or $d = m$, so that it mimics to the same extent in either case). However, given $r_h < r_m$, there

[32]Recall from our discussion of institutional investors' verification technology in section 3.2 that the parameter r_d refers to the probability that the disclosure d (where $d \in \{h, m, l\}$) made by a type G firm is verified as true by institutional investors who choose to verify the disclosure d made by the firm. Similarly, q_d refers to the probability that the disclosure d made by a type B firm is verified as true by institutional investors who choose to verify the disclosure d made by the firm.

is an additional cost to the type G arising from announcing $d = h$ rather $d = m$ (the type G firm will have to scale back its own project to a greater degree in the former case). The type G firm therefore sets $d = m$. Finally, as mentioned in (c), no firm will make a disclosure of $d = l$, since this is weakly dominated by a policy of not making any disclosure at all. This is because there is no additional benefit to a disclosure of $d = l$ (relative to no disclosure) in terms of minimizing the extent of pooling with the type B firm (recall that $r_l = q_l = 1$, so that a disclosure of $d = l$ will always be verified as true).

Proposition 3 ***(Equilibrium without Disclosure)***

(a) If the ex-ante pool quality ω of firms is greater than a threshold value $\hat{\omega}$, i.e., if $\omega > \hat{\omega}$ (with other parameters remaining the same as in Proposition 1), the equilibrium involves no disclosure by either type of firm, with both types pooling by setting a common price with probability 1.

(b) The threshold value $\hat{\omega}$ under which a partially pooling equilibrium involves disclosures by both types of firms is increasing in the participation rate z of retail investors in the equity market.

The benefit from disclosure to the type G firm is that it allows it to separate partially from (or minimize the level of pooling with) the type B firm. The cost to the type G firm of making a disclosure is two-fold. First, those institutional outsiders who obtain an outcome of $e = F$ will not bid for a share in the firm. This may force the firm to scale back the firm's investment project, to a greater or a lesser degree, depending on the size of the equity market. Also, in equilibrium, the cost incurred by outsiders in evaluating the firm's disclosure is paid by the firm in equilibrium through a lower share price. In the absence of a regulatory agency explicitly forbidding disclosure, this trade-off between the benefits and costs of disclosure to the type G firm determines whether or not it makes a disclosure. Now, a larger value of ω implies that the extent of undervaluation of the type G firm is smaller to begin with (since investors' prior belief about the firm being of type G is higher), so that the additional benefit to the type G from making a disclosure is also smaller.

If ω exceeds a certain threshold value $\hat{\omega}$, the costs of making a disclosure outweigh the benefits, so that there is no disclosure in equilibrium.

Part (b) of Proposition 3 follows from the fact that an increase in the participation rate z of retail investors in the equity market increases the size of the pool of capital that can be tapped by both types of firms. If more capital is available to invest due to greater retail investor demand for the firm's shares, the more productive type G firm has a greater benefit in partially separating itself from the type B firm by selling new shares at a higher price, as the greater availability of capital from retail investors reduces the type G firm's extent of underinvestment in the new project in the case it makes a disclosure relative to the fully pooling equilibrium with no information disclosure by either type of firm. This means that the type G firm prefers to make a disclosure before its equity issue for a greater range of the parameter ω if the participation rate z of retail investors in the equity market is greater.

In this section, we have established that in a new issues market where there are a significant number of institutional investors who can at least noisily verify the disclosures made by the firm at a cost, there is some self-regulation on the disclosures made by firms, even in the absence of any regulation or litigation threat. This self-regulation effect arises from the fact that, if an institutional investor assesses that the disclosure made by a firm prior to a new equity issue is false, then that investor will not invest in the equity issue, which, in turn, imposes a cost on the firm due to the fact that it may have to scale back its investment in its positive net present value project. As we showed in Lemma 1, however, this self-regulation effect will be mitigated under three conditions: First, if the verification cost c of institutional investors is larger, since, in this case, only s smaller fraction of institutional investors will verify firm disclosures; second, if the verification technology of institutional investors participating in the equity issue is less informative (i.e., r_d is smaller and/or q_d is larger) so that it is more difficult for institutional investors to distinguish between type G and type B firms even after disclosure verification; third, if the proportion π of institutional investors in the equity market is smaller, since, in this case, it is less costly for type B firms to mimic type G firms in equilibrium. In contrast, an increase in the participation rate z of retail investors in the equity issue strengthens this self-regulation effect: by increasing the pool of uninformed capital available to both types of firms, an increase in retail investor participation rate causes the intrinsic values of the type G and type B firms to diverge to a greater extent, leading to a larger fraction of institutional investors to engage in disclosure verification, thus imposing a larger penalty on the type B firm if it mimics the type G (thereby increasing the pool quality of firms in the equity market).

5 Disclosure with a Regulatory Agency but no Private Securities Litigation

In this section, we assume that there is an agency, somewhat like the Securities and Exchange Commission (SEC) in the U.S. (or the Securities and Exchange Board of India or the China Securities Regulatory Commission), which has the power to allow or forbid certain kinds of disclosure. In order to derive policy implications from our analysis, it is useful to think of the policy variable that such an agency would be most concerned about (i.e., its objective). Providing "investor protection" and "allowing efficient access to the capital markets" have been avowed policy goals of such regulatory agencies.[33] Minimizing the information risk faced by uninformed investors in the equity market (i.e., the return variability faced by uninformed (both retail and institutional) investors due to adverse selection) would accomplish both these policy goals to a significant degree, so that we assume that this is the objective function of the regulatory agency. Further, reducing the

[33] The "About" section of the SEC website states: "The mission of the U.S. Securities and Exchange Commission is to protect investors, maintain fair, orderly, and efficient markets, and facilitate capital formation. As more and more first-time investors turn to the markets to help secure their futures, pay for homes, and send children to college, our investor protection mission is more compelling than ever."

information risk seems to be a more appropriate objective for such a regulatory agency rather than objectives based on other policy variables. For example, maximizing firm investment would not be an appropriate policy objective here, since the policy that maximizes short-term (one period) investment might involve considerable exploitation of uninformed investors. In contrast, minimizing information risk is consistent with maximizing long-term economic efficiency, since an increase in information risk might lead to retail investors leaving the new equity market permanently, thus leading to a worsening of the terms under which firms are able to raise equity capital (thereby reducing long-term investment). We will therefore study below how allowing or forbidding various kinds of disclosure will impact the information risk faced by an uninformed investor in the equity market.[34]

Conditional on a disclosure made by the firm d^*, we define the information risk as the return variability faced by an uninformed investor (who pays the price p_d for a share of the firm's equity) arising purely from the private information possessed by the firm insider.[35] This is given by:

$$\sigma_d^2 = \theta_d \left(R_d^G - \bar{R}\right)^2 + (1 - \theta_d)\left(R_d^B - \bar{R}\right)^2; \tag{13}$$

where

$$\bar{R} = \theta_d R_d^G + (1 - \theta_d) R_d^B; \; R_d^G = \frac{p_d n_d k^G}{p_d (w + n_d)} \text{ and } R_d^B = \frac{p_d \hat{n}_d k^B}{p_d (w + \hat{n}_d)} \tag{14}$$

denote the expected value of returns conditional on firm type on each dollar invested in the type G and type B firm respectively. It is useful to note that, since (13) is the return variability faced by uninformed investors solely due to the insider's private information, the insider himself would not face this component of return variability (in contrast to the component of return variability arising

[34]However, it should be noted that we focus on information risk as only one of several important benchmark variables which may be used to study the effects of alternative policies governing disclosure.

[35]The uninformed investor we are referring to here may either be a retail investor (unable to verify firm disclosures), or an institutional investor (who chooses not to incur the cost to verify disclosures made by the firm).

simply from the uncertainty about the time 1 realization of the state variable, which will be faced by the insider as well as outside investors).

We now analyze the trade-off facing a regulatory agency when it is deciding whether or not disclosure is good for a given equity market: i.e., whether the disclosure, if made, will increase or decrease information risk. In such an equity market, in particular, if the piece of information that is disclosed may be verified by institutional investors at a relatively low cost, the disclosure reduces information risk. Even in a market dominated by institutional investors, disclosure may increase information risk if the verification cost c is larger than a certain threshold value (so that the extent of verification by institutional investors is low). This is because, while some information is always released when the firm makes a disclosure, making a disclosure also enables the firm to set a larger equilibrium price for its equity in the the new equity issue compared to the case when there is no disclosure. Thus, the information risk faced by uninformed investors may in fact increase following a disclosure by a firm. Consequently, the information risk following a disclosure will be lower if, and only if, the extent of verification by institutional investors is large enough (i.e., above a certain threshold value). This is depicted in Figure 2, which gives the relationship between information risk σ_d^2 and the quality of the pool θ_d (which, in turn, is increasing in the informativeness of the verification technology $(r_d - q_d)$ and decreasing in the cost of verification c). Point A in the figure represents the situation without a disclosure by the firm, with information risk equal to σ_ω^2. Even though the pool quality θ_d always increases subsequent to a disclosure, the information risk will fall below σ_ω^2 if and only if the value of θ_d post-disclosure is larger than a certain threshold value θ_0.

In the next two propositions, we study how the nature of the information being disclosed (and therefore the cost of verifying that disclosure) and the participation rate of retail investors in the equity market affects the impact of disclosure on information risk. We compare the information risk

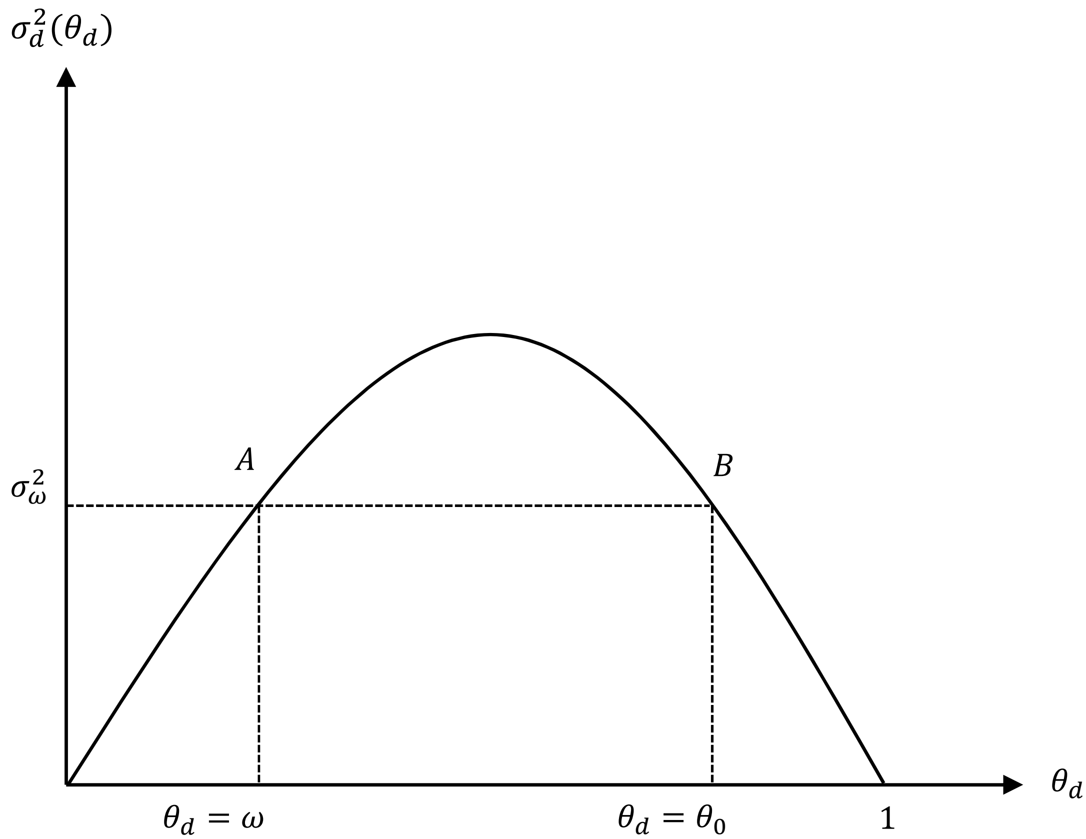

Figure 2: Relationship between information risk σ_d^2 and pool quality θ_d

$\sigma_d^2(\theta_d^*)$ in a partially pooling equilibrium with disclosure to that $(\sigma_\varphi^2(\omega))$ which would have been obtained in an equilibrium without disclosure. This will lead directly to the appropriate action to be taken by the regulatory agency, which we characterize in Proposition 7.

Proposition 4 ***(Verification Cost and Information Risk)*** *Let $d \in \{h, m\}$ be the type of disclosure preferred by the type G firm. Let $\underline{c} < c < \overline{c}$ and $\underline{\omega} < \omega < \overline{\omega}$. Then, in the absence of any disclosure regulation, if the verification cost c is less than a certain threshold value $c_1(\omega, d)$: i.e., if $\underline{c} < c < c_1(\omega, d)$, disclosure occurs in equilibrium and reduces information risk. Disclosure occurs in equilibrium and increases information risk if c is greater than $c_1(\omega, d)$, but smaller than a certain upper bound $c_2(\omega, d)$; i.e., if $c_1(\omega, d) < c < c_2(\omega, d)$.*

Proposition 4 demonstrates that, in a market with both institutional and retail investors, the cost with which institutional investors are able to verify any disclosure made by the firm significantly affects whether such a disclosure decreases or increases information risk. When institutional investors' cost of verifying the information released by firms is low, then the extent of information production (verification) by outsiders is large enough that the information risk is reduced by the disclosure (for the reasons discussed above). Conversely, for large values of c, a disclosure leads to an increase in information risk, since the extent of verification by institutional investors (and consequently the extent of information released) is lower than the threshold level required to reduce the information risk. Proposition 4 shows that, in a given equity market (with the associated *ex-ante* pool quality ω), there is a threshold value $c_1(\omega, d)$ of the verification cost c, below which releasing information reduces information risk while it increases information risk for disclosures for which c is above this threshold value.

Proposition 5 ***(Retail Investors and Information Risk)*** *Let $d \in \{h, m\}$ be the type of disclosure preferred by the type G firm. Let $c < \hat{c}$. Then, in the absence of any disclosure regulation, there exists for each $c \in (0, \hat{c})$ an interval $(\omega_0(c), \omega_1(c))$ with the following property. For each $\omega \in (\omega_0(c), \omega_1(c))$, if the participation rate z of retail investors in the equity market is greater than a certain threshold value $z_1(c, \omega)$; i.e., if $z > z_1(c, \omega)$, disclosure occurs in equilibrium and increases information risk. Disclosure occurs in equilibrium and reduces information risk if z is less than $z_1(c, \omega)$, but greater than a lower bound $\underline{z}_c$; i.e., if $\underline{z}_c < z < z_1(c, \omega)$.*

Proposition 5 shows that for a given piece of information (and the associated value of the verification cost c), there is a critical value $z_1(c, \omega)$ of the participation rate z of retail investors in the equity market, above which the disclosure of that piece of information by the firm increases information risk while it decreases information risk if z is below this critical value.[36] While an increase in the participation rate of retail investors in the equity market leads to an increase in the quality θ_d^* of the equilibrium pool of firms (recall this improvement in pool quality effect from part (e) of Lemma 1), this also leads to a situation in which the type B firm scales back its investment in its positive-NPV project to a much greater extent than the type G firm. This underinvestment effect of a greater value of z on the type B firm substantially reduces the stock return to uninformed

[36]The critical c and z values in the above propositions will also depend on the specific disclosure, h or m, made by the firm, since the institutional investors' verification probabilities for these two levels of disclosure will be different from each other.

investors who participate in the new equity issue in case the firm is of type B (with probability $(1-\theta_d^*)$), increasing the return variability of uninformed investors due to adverse selection.

Proposition 6 ***(Comparative Statics on Disclosure and Information Risk)*** *Let $c < \tilde{c}$. The extent of information risk subsequent to the disclosure occurring in equilibrium with disclosure is:*

(a) Greater if the disclosure is more costly to verify (c is larger): i.e., $\frac{\partial \sigma_d^2}{\partial c} > 0$.

(b) Greater if the participation rate of retail investors in the equity market is larger: i.e., $\frac{\partial \sigma_d^2}{\partial z} > 0$.

(c) Smaller if the institutional investors' verification technology is more informative: i.e., $\frac{\partial \sigma_d^2}{\partial r_d} < 0$; $\frac{\partial \sigma_d^2}{\partial q_d} > 0$.

In the above proposition, result (a) follows from the fact that the extent of disclosure verification in the market decreases when the verification cost c is larger. As a smaller fraction of institutional investors verify disclosures for a larger cost c, this significantly decreases the quality of the pool of firms making disclosures (releasing information), which increases the information risk of uninformed investors participating in the new equity issue. Result (b) follows from the strong underinvestment effect on the partially pooling type B firms of a greater participation rate z of retail investors (who do not possess a verification technology), which drives down the effective proportion of institutional investors among all investors participating in the equity issue and increases the return variability of uninformed investors. Further, result (c) follows from the fact that the effectiveness of disclosure verification in reducing the extent of pooling between the two firm types is better as the institutional investors' verification technology is more informative (the penalty imposed on the type B if it mimics the type G is larger in this case, thus forcing it to reduce its equilibrium mimicking probability).[37]

Proposition 7 ***(Equilibrium Behavior of the Regulatory Agency)*** *When disclosure increases information risk for both $d = h$ and $d = m$, the regulatory agency forbids disclosure. This will be the case when either one of the following two conditions hold:*

[37]While an increase in the extent of disclosure verification in the equity market because of a lower verification cost or a more informative verification technology also increases the underinvestment penalty imposed on type B firms, the underinvestment effect on type B firm's stock return (which increases the stock return variability faced by uninformed investors) in these cases is not large enough to dominate the improvement in pool quality effect (higher θ_d^*) that reduces information risk.

(i) *Institutional investors' verification cost* c *is greater than a threshold value* $c_1(\omega)$ *for a given ex-ante pool quality* $\omega \in (\underline{\omega}_0, \overline{\omega}_0)$*; or*

(ii) *The participation rate* z *of retail investors in the equity issue is greater than a threshold value* $\overline{z}_1(c, \omega)$*, with the ex-ante pool quality* $\omega \in (\tilde{\omega}_0(c), \tilde{\omega}_1(c))$ *and the verification cost* $c < \hat{c}_0$*.*

The above proposition discusses the situation under which the regulatory agency may allow or forbid disclosure, even when the firm insiders wish to disclose a certain piece of information. Recall that the firm insiders' objective is to maximize their expected payoff from the firm's long-run cash flows, while the objective of the regulatory agency is to minimize the information risk faced by uninformed investors, either institutional or retail. When the piece of information that the firm wishes to disclose is verifiable by institutional investors at a reasonable cost, and when the participation rate of retail investors trading in that equity market is not too high, then the disclosure of that piece of information would reduce the information risk faced by uninformed investors in that market (as we showed in the earlier propositions in this section) so that the regulatory agency allows such disclosure. In contrast, when the piece of information that the firm wishes to disclose is such that it is very costly to verify (verification cost above a certain threshold value), or when the participation rate of retail investors in that equity market is above a certain threshold value, then the disclosure of that piece of information increases the information risk faced by uninformed investors, prompting the regulatory agency to forbid that disclosure.[38]

[38] One may wonder whether, in the setting of our model, it is optimal for the regulatory agency to mandate (require) that the firm makes a certain disclosure. The answer to this question is "no" in the setting of our model (in the sense that such a mandate will not reduce the information risk facing uninformed investors beyond that resulting from voluntary disclosures). To see why this is the case, consider the two possible scenarios that arise in the case of a mandated disclosure. The first scenario is that the properties of the piece of information that the regulatory agency requires the firm to disclose (verification cost c and the noisiness of the verification, r_d and q_d) and the equity market setting (ω, π, and z) are such that the firm wishes to make the disclosure voluntarily (i.e., making the disclosure maximizes the type G firm's objective function), then the firm will go ahead and make that disclosure even in the absence of a disclosure requirement (as characterized in section 4). The second scenario is that the piece of information that the regulatory agency requires the firm to disclose and the equity market setting are such that the firm would not choose to make that disclosure voluntarily. In this scenario, if the firm faces a mandate to disclose a piece of information, it would make the most pessimistic disclosure possible ($d = l$) about that piece of information. Since such a disclosure will be verified as true if made by either type of firm, there will be no reduction in information risk arising from the disclosure mandate under this second scenario either. In summary, mandating a disclosure (claim) about the future realization of a performance variable is not optimal for the regulatory agency in our setting. Of course, in practice, regulatory agencies may mandate the disclosure of other variables related to the equity issue such

6 Disclosure with Private Securities Litigation

We now allow private securities litigation by investors against the firm *ex post*. For simplicity, we assume that investors sue the insiders of the firm collectively at time 1 for making false or misleading claims whenever the realized value of the disclosure variable d is less than the announced (claimed) value (in the event that the firm has made a disclosure or claim). Then, depending on the standards mandated by law, courts investigate the merits of the shareholders' lawsuit and impose a penalty with a probability $\gamma^f, f \in \{G, B\}$. We assume that $\gamma^B > \gamma^G > 0$: type G firms get penalized with positive probability, but less often than type B firms (reflecting the fact that, while courts cannot fully know the private information that was in the possession of corporate officers at time 0, they are able to partially ascertain this private information *ex post*, so that there will be a certain amount of "informativeness" or "fairness" in the courts' judgement). In the event the firm is found liable, the court imposes a penalty μ (per share sold) on firm insiders. For tractability, we assume that this penalty is in the form of a transfer of a certain number of shares of equity from firm insiders to outsiders; clearly, the larger the number of shares of equity sold, the larger the size of this transfer.[39] Thus, since n_d is the number of shares sold by a type G firm, the penalty in the event the insiders of a type G firm are found liable will require μn_d shares to be transferred from firm insiders to outsiders. The corresponding transfer for the type B firm will be given by $\mu \hat{n}_d$.

Given the above, the probability of a firm making a disclosure $d = h$ being sued at time 1 will be $\lambda_h^f = \delta_M + \delta_L^f$; the corresponding probability for a firm which has made a disclosure of $d = m$ is $\lambda_m^f = \delta_L^f$. Taking into account the possibility that the firm will be sued and found liable *ex post*,

as the number of shares sold; underwriter(s) of the equity issue; etc. for reasons (in our view) unrelated to reductions in information risk. Further, when the firm is mandated to make disclosures somewhat related to future performance (such as risks involved; use of proceeds), firms usually make the most general and pessimistic statements, broadly consistent with the predictions of our analysis.

[39]We do not assume that the magnitude of the penalties levied are different for the two types of firms. We choose not to complicate the model in this way, since, even when the magnitude of this penalty is the same, the *expected* penalty (given a lawsuit) on a type B firm will be larger than that on a type G firm (given $\gamma^B > \gamma^G$).

the insider's objective (4) is now modified to:

$$W_d^f = \left(w - \mu\lambda_d^f\gamma^f n\right)\frac{k^f p_d n}{w+n}, \text{ for } f \in \{G, B\}, \ \ d \in \{h, m, l, \varphi\},$$
$$\text{with } n \equiv n_d \text{ for } f = G, \text{ and } n \equiv \hat{n}_d \text{ for } f = B. \tag{15}$$

The probability of obtaining some remedy in court also affects investors' payoffs from investing in the firm's equity. There is a positive probability now that investors will be compensated at least partially if the announced state is not realized, leading to two effects. First, this increases the expected payoff to institutional investors from investing in a share of equity in the firm, so that the weak inequality (8) is now modified to:

$$p_d \le \theta_d\left(1 + \mu\gamma^G\lambda_d^G\right)\frac{p_d n_d k^G}{w + n_d} + (1-\theta_d)\left(1+\mu\gamma^B\lambda_d^B\right)\frac{p_d\hat{n}_d k^B}{w+\hat{n}_d}. \tag{16}$$

Second, this affects the net benefit to institutional investors from verifying disclosures, so that the weak inequality (9) is now modified to:

$$c \le 1 - \theta_d r_d - (1-\theta_d)q_d - (1-r_d)\theta_d\left(1+\mu\gamma^G\lambda_d^G\right)\frac{n_d k^G}{w+n_d} - (1-q_d)(1-\theta_d)\left(1+\mu\gamma^B\lambda_d^B\right)\frac{\hat{n}_d k^B}{w+\hat{n}_d}. \tag{17}$$

Finally, equation (12) also is modified to account for the change in the insider's objective to account for the possibility of being sued, found liable, and getting penalized:

$$\left(k^B - 1\right)I = \frac{\left(w - \mu\gamma^B\lambda_d^B\hat{n}_d\right)}{w+\hat{n}_d}\hat{n}_d p_d k^B. \tag{18}$$

With these modifications, the basic trade-offs driving the equilibrium are similar to those discussed under Proposition 1. Thus, in a partially pooling equilibrium with disclosure, the equilibrium values of d, α_d, β_d, θ_d, p_d, n_d, $\hat{n}_d$, p_B, n_B, and n_{od} are now determined by this modified set of equations:

(5) to (7), (10), (11), and (18), along with (16) and (17) holding as equalities. We now discuss how the features of the equilibrium are modified in this case, given the added possibility here of the firm being sued, found liable, and penalized.

Proposition 8 ***(Litigation Choking Off Disclosure)*** *Let $\omega < \hat{\omega}(d)$ for any $d \in \{h, m\}$ so that an equilibrium with disclosure is preferred to non-disclosure in the absence of any litigation (when $\mu = 0$). If court verdicts are not informative enough so that for given values of γ^B, λ_d^G, and λ_d^B, γ^G is greater than a certain threshold value $\hat{\gamma}_d^G$, and the magnitude of the penalty μ is sufficiently large, i.e., if $\mu > \overline{\mu}(d)$, then allowing lawsuits motivates the firm not to make disclosure d.*

The conventional wisdom has favored the argument that private securities litigation stifles disclosure. The above proposition characterizes the conditions under which this is indeed the case. Recall that (for a given value of γ^B) court verdicts are more informative as γ^G gets smaller (equivalently, court verdicts are less informative when γ^G is larger), since a larger difference between γ^B and γ^G indicates that the verdicts are more responsive to the private information that firm insiders had at time 0. If the informativeness of court verdicts is small enough that γ^G (the probability of a type G firm being found liable) exceeds a threshold value $\hat{\gamma}_d^G$, the type G firm's incremental expected benefit from disclosure d (in terms of better separating itself from the type B firm) will be small. The above proposition demonstrates that, in this case, there exists a certain value of the penalty μ beyond which the expected penalty on the type G firm exceeds its expected benefit from disclosure d. Thus, if γ^G is sufficiently large, and the penalty μ exceeds a threshold value, the type G firm will refrain from making any disclosures.

Proposition 9 ***(Litigation Promoting Disclosure)*** *Let $\mu < \overline{\mu}_0(d)$. If court verdicts are informative enough so that for given values of γ^B, λ_d^G, and λ_d^B, γ^G is less than a certain threshold value $\hat{\gamma}_d^G$; then allowing lawsuits promotes disclosure d: i.e., the threshold $\hat{\omega}(d, \mu)$ is increasing in μ.*

The above proposition characterizes situations under which, in contrast to the conventional wisdom, allowing lawsuits *promotes* disclosure. This occurs when the liability regime is such that there is a significant amount of informativeness in court verdicts. Assuming that the size of penalties imposed on firms if found liable are not too large, allowing litigation in the above circumstances increases the benefit of making a disclosure to the type G firm (since the type B would mimic less often than in a situation where investors are not allowed to sue the firm) thereby inducing the firm to make a disclosure even under situations where, absent this possibility, they would not make such a disclosure.

Proposition 10 ***(Securities Litigation Substituting for Disclosure Verification)*** *Consider an equilibrium with disclosure. As the informativeness of court verdicts increases (i.e, if γ^B increases for a given γ^G, or γ^G decreases for a given γ^B), the extent of disclosure verification by institutional investors declines.*

This proposition demonstrates the substitution effect between the informativeness of court verdicts delivered after *ex post* litigation and *ex ante* disclosure verification by institutional investors. For concreteness, consider the case where γ^B increases (for given γ^G). In this case, investors are able to recover from the type B firm with a greater probability in the event that the disclosure made by firm insiders at time 0 turns out to be too optimistic. This results in a fall in the expected benefit to institutional investors from verifying the disclosure made by the firm, since they can recover *ex post* if their investment decision at the time of the equity issue turns out to have been unwise. This, in turn, leads to a fall in the fraction of institutional investors verifying disclosures at time 0. Conversely, if the informativeness of the litigation regime declines, the proportion of institutional investors verifying disclosures increases, thus taking up some of the "slack" left by the litigation regime. Thus, this proposition highlights the fact that informative litigation regimes are most important in equity markets where the proportion of institutional investors is small.

7 Implications of the Model

We now discuss some of the implications of our model.

(i) Incentives for self-regulation in disclosure: The first implication of the model relates to the

incentives of firms to make conservative disclosures in the absence of any regulatory agency or *ex post* litigation. Our results in section 4 imply that such incentives exist only in markets where a large proportion of the demand for new equity issues arises from institutional (sophisticated) investors, who are able to verify the claims made by firms effectively, and at a low cost. On the other hand, if the offering size is small relative to potential market size, the firm is able to raise a relatively large proportion of the required external financing from retail investors (unable to independently verify the claims made, unlike institutional investors). In this case, the firm has an incentive to "hype" the equity offering by making tall claims (in an unregulated environment), since any market-imposed costs of hyping the offering will be small.

(ii) Ex ante information verifiability, institutional investors, and allowable disclosures: When there is an agency regulating allowable disclosures, propositions 4 and 5 have implications for the kinds of disclosures that it may be beneficial to allow prior to new equity issues. If the proportion of institutional investors in the equity market is relatively large, and if the claims made by the firm can be verified by institutions with sufficient precision at a relatively low cost at the time of the offering, then it is beneficial (from the point of view of minimizing information risk) to allow the information to be disclosed. However, even in settings where the proportion of institutional investors is large, disclosures which are very costly to verify should be restricted. Further, such restrictions on disclosure need to be more stringent in equity market settings where the participation rate of retail investors in the equity issue is greater. This implication supports the current practice in the U.S. of confining certain disclosures to oral statements made during IPO "road-shows" where only institutional (sophisticated) investors are allowed to attend.[40]

(iii) Relationship between the liability regime and incentives to disclose: Proposition 8 charac-

[40] In an instance reported in the Wall Street Journal (*"'Cheat Sheets' on IPOs Raise Fairness Issue,"* WSJ, July 21, 1997), handouts given to sophisticated investors in a road-show were collected back at the end of the presentation; this handout included an aggressive projection showing a doubling of the firm's earnings in the coming year. Some have argued that such information should be made available to all investors, rather than being given (usually orally) only to institutional and other sophisticated investors at road-shows.

terizes the conditions under which the conventional wisdom that private securities litigation stifles disclosure is borne out. However, proposition 9 demonstrates that this conventional wisdom is not always correct. When it is easy for investors to file lawsuits against firms for making inaccurate forward looking statements and win large penalties, and the litigation regime is rather uninformative, firms will be deterred from making disclosures. However, when penalties are moderate, and the litigation regime is such that court verdicts are informative (i.e., insiders with better grounds for making a particular forward looking statement are found liable and penalized less often), private securities litigation will not have a stifling effect on disclosure. In such a litigation regime, the potential for private securities litigation makes disclosures more credible to investors, thus promoting disclosure.[41] Therefore, our model implies that considerations of investor protection and those of promoting disclosure are not diametrically opposed.[42]

(iv) Ex post information verifiability and allowable disclosures: Our analysis in section 6 demonstrates that, in many situations, private securities litigation acts as a substitute for institutional investor verification. This means that, even when a certain piece of information is not verifiable *ex ante*, allowing the disclosure of this information may nevertheless be beneficial. This will be the

[41]One criticism that has often been made of the litigation regime in the U.S. is that it is easy, regardless of the merits, for certain law-firms to file lawsuits against issuing firms in the name of figurehead shareholders. It is argued that, since the executives of these target firms may not wish to expend either the time or the expense required for legal maneuvering, such law-firms are able to extract substantial settlements (see, e.g., the Wall Street Journal, Editorial page, April 18, 1999). The remedy suggested by our model for such a situation is to make the litigation regime more informative, perhaps by requiring plaintiffs to provide stronger evidence to establish preliminary grounds for such a case to go forward (and in the absence of which the case would be dismissed, without significant costs to the target firm). The 1995 Private Securities Litigation Reform Act moved the U.S litigation regime partially in this direction by stipulating that the investor with the biggest losses should pick the lead counsel (thus making it more difficult for certain law firms thriving on frivolous securities litigation to gain standing in such suits).

[42]Forsythe, Lundholm, and Rietz (1999) provide experimental evidence relevant to these implications of our model. They examine a laboratory asset market characterized by adverse selection and welfare gains from trading, where a seller with a single unit of an asset for sale knows its true quality with certainty, while the buyer knows only the *ex ante* probability distribution of possible quality levels. They study three settings: in the first setting, no communication is allowed between buyer and seller; in the second, the seller can make any statement he wishes to the buyer (including a fraudulent one); in the third setting, an anti-fraud rule is imposed on the statements made by the seller. While they use a very simple laboratory setting with no uncertainty on the part of the seller, the paper provides two interesting findings which broadly support the implications of our model. First, relative to the no-communication setting, even the setting where the seller's statements are unregulated leads to an improvement in efficiency, though in this case such efficiency gains come at the buyer's expense. Second, the setting with communication along with an anti-fraud rule improves efficiency even further.

case if: (i) Such information is verifiable *ex post* (i.e., the nature of the information is such that firms making the disclosure are able to prove in court, after the information is publicly observed, that, while their disclosure was inaccurate, the private information they had at the time of disclosure prompted them to make the disclosure in good faith); and (ii) the liability regime is such that firm insiders who make good-faith disclosures, and only those, escape being held liable in court with a high probability.

(v) Institutional investors and safe harbor provisions: Another implication of the analysis in section 6 deals with the coverage of safe-harbor provisions protecting firms from private securities litigation based on the fact that the forward-looking statements made by them prior to new equity issues subsequently turned out to be inaccurate. This analysis indicates that, since *ex ante* investor verification and penalties as a result of private securities litigation may act as substitutes, such safe-harbor provisions providing protections against private securities litigation need to be more narrowly defined in settings where the proportion of institutional investors is small. Further, such safe-harbor provisions should exclude claims relating to variables which are very costly to verify *ex ante*, since the fear of penalties imposed in court as a result of litigation *ex post* is required to deter firms from making overly optimistic claims about these variables.

(vi) Implications for Regulation A-plus Public Equity Offerings and for Direct Listings of Equity: Our analysis has consequences for IPOs made under the SEC regulation A-plus (referred to as regulation A prior to the passage of the JOBS Act). These small-firm IPOs, which are restricted to equity issues raising less than fifty million dollars over a 12 month period, are exempt from many of the restrictions on disclosures faced by larger IPOs.[43] The rationale given for such exemptions from

[43] On June 19, 2015, SEC Rules aimed at implementing congressionally-mandated amendments to section 3(b) of the Securities Act of 1933 (incorporated into the JOBS Act), modernizing Regulation A and thus launching "Regulation A-Plus" became effective. Regulation A-plus provided for two tiers of public equity offerings of previously unregistered securities: Tier 1, for offerings of securities up to $20 million in a 12 month period; and Tier 2, for offerings up to $50 million in a 12 month period. While certain basic requirements are applicable to both tiers, Tier 2 offerings are subject to additional disclosure and ongoing reporting requirements. Equity crowdfunding platforms StartEngine and SeedInvest have facilitated Regulation A-plus offering campaigns. The first successful Regulation A-plus offering was completed by automotive startup Elio Motors, raising nearly $17 million from 6,600 investors. Elio Motors closed

various regulations is that it is usually more difficult for such firms to bear the costs associated with complying with these regulations. However, our analysis indicates that, since such small equity issues may expect to meet a large portion of their capital requirements simply by selling stock to retail investors, it is precisely these IPOs where the restraints on allowable disclosures need to be the most stringent (since the incentives of firms making such IPOs to self-regulate their disclosures arising from verification of their disclosures by institutional investors are small). A similar implication applies to "direct equity listings," which involve the listing of firms' equity on an exchange without raising any capital. Since no capital is raised in these direct listings, the incentives to self-regulate their disclosures do not apply to firms making such listings, so that exchanges need to apply more stringent restrictions against such firms hyping their equity around direct listings.[44]

(vii) The contrasting effects of the SOR and the JOBS Act on equity market information asymmetry: Our analysis suggests a possible explanation for the contrasting effects documented by the recent empirical literature around these two disclosure reforms. In the case of the SOR (regulating disclosures around SEOs), the empirical evidence indicates that firms make significantly more pre-offering disclosures after the reform, and that such disclosures lead to a significant reduction in information uncertainty and reductions in the cost of raising equity capital: see, e.g., Shroff, Sun, White, and Zhang (2013) and Clinton, White, and Woidtke (2013). In contrast, the empirical evidence regarding the effects of the JOBS Act (regulating disclosures around IPOs) indicates that, after the passage of the act, the information uncertainty around firms going public by taking advantage of the EGC provision of the act became greater (relative to comparable firms going public prior to the passage of the JOBS Act): see, e.g., Barth, Landsman, and Taylor (2017).[45] Since the

out their Regulation A-plus offering in February 2016, and subsequently listed on the OTCQX.

[44]One example of a firm reported to be planning a direct listing in the immediate future is Spotify, the Stockholm-based streaming-music company, as reported by the Wall Street Journal ("*What Spotify's Un-IPO Means for Wealth Management*," WSJ, August 18, 2017).

[45]As briefly discussed in the introduction, two important provisions of the JOBS Act allow emerging growth

firms affected by the SOR are more established firms making SEOs (subject to regular reporting requirements even prior to the offering), their disclosures are likely to be verifiable at a lower cost by institutional investors than disclosures made by private firms going public. Given this, our theoretical analysis predicts that allowing greater pre-offering disclosures by established firms making SEOs will decrease the information uncertainty faced by investors in these firms, while allowing greater (less restricted) pre-offering disclosures by EGC firms going public will increase the information uncertainty faced by investors in these firms. Our analysis thus provides an explanation for the contrasting evidence of the SOR and the JOBS act on the information uncertainty facing firms making new equity issues.

8 Conclusion

We have developed a model to analyze the optimality of allowing firms to disclose various kinds of information prior to new equity issues, as well the desirability of alternative rules governing private securities litigation. In our model, firm insiders, with private information about variables affecting their future firm performance, may make disclosures (claims) about their future realization prior to selling new equity to outsiders. The issue price of firms' equity is affected by their disclosures, and by the demand for equity from institutional investors, who may conduct costly (and noisy) verifications of firm disclosures; and retail investors, who do not have access to such an informative verification technology. There may also exist an agency with the power to regulate firm disclosures; and private securities litigation, as a result of which the courts are able to penalize firms *ex post* for making optimistic disclosures without a strong basis in fact. We developed several new results in the above setting. First, even in the absence of an agency regulating firm disclosures, equity issuing

companies (EGCs) to "test-the-waters" before an IPO and file their registration statements confidentially. Testing the waters permits an issuer to gauge interest in their potential offering with accredited investors ahead of filing for the offering, eliminating quiet period restrictions on communications to investors prior to an offering.

firms may have incentives in some situations to self-regulate and to make conservative disclosures. Second, whether a particular item of disclosure is allowable prior to an equity issue depends upon the proportion of institutional investors in the equity market, their cost of verifying that disclosure item, and the participation rate of retail investors in the equity issue. Third, allowing for private securities litigation may encourage or discourage disclosures depending on whether the litigation regime is more or less sensitive to firm insiders' private information at the time of disclosure.

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Appendix: Proofs of Propositions

Proof of Proposition 1. In this proof, we will first determine the conditions under which a partially pooling equilibrium (PPE) with an active disclosure policy exists. Then, we will show that a firm will prefer a PPE with active disclosure to a fully pooling equilibrium without disclosure if and only if $\omega < \hat{\omega}$. Consider the conditions (5)–(12) for the existence of a PPE with an active disclosure $d \in \{h, m\}$, where (8) and (9) hold as equalities. After repeated substitutions, we obtain that (8) and (9) may be rewritten as:

$$X(\theta_d, \alpha, n_{od}) \equiv \theta_d g(\alpha, n_{od}) + (1-\theta_d) b(\alpha, n_{od}) - 1 = 0, \tag{A.1}$$

$$Y(\theta_d, \alpha, n_{od}) \equiv (1-\theta_d)(1 - b(\alpha, n_{od}))(r_d - q_d) - c = 0, \tag{A.2}$$

where $g(\alpha, n_{od}) \equiv \frac{n_d(\alpha, n_{od}) k^G}{w + n_d(\alpha, n_{od})}$, and $b(\alpha, n_{od}) \equiv \frac{\hat{n}_d(\alpha, n_{od}) k^B}{w + \hat{n}_d(\alpha, n_{od})}$; note that $n_d(\alpha, n_{od})$ and $\hat{n}_d(\alpha, n_{od})$ have been defined in (7). Given a number of shares n_{od} offered for sale by the firm and a disclosure policy $d \in \{h, m\}$, a PPE with information verification exists if there is a pair $\{\alpha_d^*, \theta_d^*\} \in \{(0,1) \times (\omega, 1)\}$ that solves (A.1)–(A.2). After solving (A.1) for θ_d, we obtain:

$$\theta_d = x(\alpha, n_{od}) \equiv \frac{1 - b(\alpha, n_{od})}{g(\alpha, n_{od}) - b(\alpha, n_{od})}. \tag{A.3}$$

Similarly, solving (A.2) for θ_d yields:

$$\theta_d = y(\alpha, n_{od}) \equiv 1 - \frac{c}{[1 - b(\alpha, n_{od})](r_d - q_d)}. \tag{A.4}$$

From implicit differentiation of (A.1) and (A.2), we can immediately verify that $x(\alpha, n_{od})$ and $y(\alpha, n_{od})$ are strictly increasing in α, since $\frac{\partial g(\alpha, n_{od})}{\partial \alpha} < 0$, $\frac{\partial b(\alpha, n_{od})}{\partial \alpha} < 0$, and $g(\alpha, n_{od}) > b(\alpha, n_{od})$.

Consider first $x(\alpha, n_{od})$. Let $\alpha_x^L(n_{od})$ be the greatest solution to $x(\alpha, n_{od}) = \omega$ where $\alpha \in (-\infty, 1)$. Define $\alpha^L \equiv \max(\alpha_x^L(n_{od}), 0)$. Similarly, let $\alpha_x^H(n_{od})$ be the smallest solution to $x(\alpha, n_{od}) = 1$ where $\alpha \in (0, +\infty)$. Define $\alpha^H \equiv \min(\alpha_x^H(n_{od}), 1)$. Note from (A.3) and (A.4) that for any $\alpha \in [\alpha_L, \alpha_H]$, there exists a threshold value $c(\alpha)$ defined by:

$$c(\alpha) \equiv \frac{(1 - b(\alpha, n_{od}))(g(\alpha, n_{od}) - 1)(r_d - q_d)}{g(\alpha, n_{od}) - b(\alpha, n_{od})}, \tag{A.5}$$

so that $x(\alpha, n_{od}) \leq y(\alpha, n_{od})$ if and only if $c \leq c(\alpha)$. Let

$$\hat{\alpha} \equiv \underset{\alpha \in [\alpha_L, \alpha_H]}{\arg\max}\; c(\alpha). \tag{A.6}$$

A pair $\{\alpha_d^*, \theta_d^*\} \in \{(\hat{\alpha}, \alpha_H) \times (x(\hat{\alpha}, n_{od}), 1)\}$ solving (A.1) and (A.2) exists if the following conditions are satisfied: (i) $x(\alpha_H, n_{od}) > y(\alpha_H, n_{od})$, (ii) $x(\hat{\alpha}, n_{od}) < y(\hat{\alpha}, n_{od})$, and (iii) $Q > \underline{Q} \equiv \frac{w}{(k^B - 1)(1 - (1-\pi)(1-z))}$. From (A.3) and (A.4), it follows that condition (i) is satisfied if $c > \underline{c}$, where

$$\underline{c} \equiv \begin{cases} \frac{(1 - b(1, n_{od}))(g(1, n_{od}) - 1)(r_d - q_d)}{g(1, n_{od}) - b(1, n_{od})} & \text{if } \alpha_H = 1, \\ 0 & \text{if } \alpha_H \in (0,1). \end{cases} \tag{A.7}$$

Similarly, condition (ii) is satisfied if $c < \overline{c}$, where

$$\overline{c} \equiv c(\hat{\alpha}) = \frac{(1 - b(\hat{\alpha}, n_{od}))(g(\hat{\alpha}, n_{od}) - 1)(r_d - q_d)}{g(\hat{\alpha}, n_{od}) - b(\hat{\alpha}, n_{od})}. \tag{A.8}$$

Condition (iii) must also be satisfied so that if the type B firm chooses to separate from the type G firm (with probability $(1 - \beta_d^*)$) by setting a different price p_B and selling $n_B = w/(k^B - 1)$ shares, there is a sufficient number of investors in the equity market to buy these n_B shares.

Hence, given n_{od} and a disclosure policy d, there exists for all $c \in [\underline{c}, \overline{c}]$ at least one pair $\{\alpha_d^*, \theta_d^*\} \in \{(\hat{\alpha}, \alpha_H) \times (x(\hat{\alpha}, n_{od}), 1)\}$ solving (A.1)–(A.2), and thus, a PPE with information verification exists. If there are multiple solutions to (A.1)–(A.2), choose the one with the highest value of α.

Consider now the choice of n_{od}. A type G firm will raise at most I, since additional funds can only be invested in projects with zero NPV. Hence, the payoff to the insiders of a type G firm from issuing n_{od} shares is given by:

$$W_d^G(n_{od}) = \frac{w}{w + n_d^*(n_{od})} n_d^*(n_{od}) p_d^*(n_{od}) k^G, \quad \text{for } p_d^* n_d^* \le I. \tag{A.9}$$

Solving (12) for p_d^* and substituting it into (A.9), this can be rewritten as:

$$W_d^G(n_{od}) = \frac{k^B - 1}{k^B} k^G I \frac{n_d^*(w + \hat{n}_d^*)}{\hat{n}_d^*(w + n_d^*)} = \frac{k^B - 1}{k^B} k^G I (1 + \psi), \tag{A.10}$$

where

$$\psi \equiv \frac{\pi \alpha_d^*(n_{od})(r_d - q_d) w}{\left(1 - \alpha_d^*(n_{od})\pi(1 - q_d) - (1 - \pi)(1 - z)\right)\left(w + n_d^*(n_{od})\right)}. \tag{A.11}$$

Using the fact that in the proof of Lemma 1 we will show that $\frac{\partial \alpha}{\partial n_{od}} \ge \frac{\hat{n}_d^*}{[\pi(1-q_d)(n_{od}^*)^2]} > 0$ (see (A.29)), by total differentiation of ψ with respect to n_{od} it follows that:

$$\frac{\partial \psi}{\partial n_{od}} \ge \frac{\pi(r_d - q_d) w}{\hat{n}_d^*(w + n_d^*)^2} \left[\frac{\hat{n}_d^*(w + n_d^*)}{n_{od}\pi(1 - q)} + \alpha_d^* \left(w + \frac{(1 - r)\hat{n}_d^*}{(1 - q)} \right) \right] > 0, \tag{A.12}$$

and W^G is strictly increasing in n_{od}, for $p_d^* n_d^* \le I$. Hence, n_{od} is equal to the minimum between the number of investors on the market, Q, and the number of shares necessary to raise I. Type B firm will mimic type G ones by offering for sale an identical number of shares. Note also that in a PPE, we have:

$$I_d^*(n_{od}) = p_d^*(n_{od}) n_d^*(n_{od}) = \frac{k^B - 1}{k^B} I \left[1 + \frac{n_d^*}{w} + \frac{\pi \alpha_d^*(r_d - q_d)}{1 - \alpha_d^* \pi(1 - q_d) - (1 - \pi)(1 - z)} \right]. \tag{A.13}$$

By total differentiation of $I_d^*(n_{od})$ with respect to n_{od}, we obtain:

$$\frac{\partial I_d^*(n_{od})}{\partial n_{od}} = \frac{(k^B - 1) I}{k^B} \left[\frac{n_d^*}{w n_{od}} + \frac{\partial \alpha_d^*}{\partial n_{od}} \pi \left(\frac{(r_d - q_d)}{\left(\frac{\hat{n}_d^*}{n_{od}}\right)^2} - \frac{(1 - r_d) n_{od}}{w} \right) \right]. \tag{A.14}$$

Since in the proof of Lemma 1 we will show that $\frac{\partial \alpha_d^*}{\partial n_{od}} > 0$, there is a critical value r_d^c such that the RHS of (A.14) is positive for $r_d > r_d^c$. Hence, for $r_d > r_d^c$, $I(n_{od})$ is strictly increasing in n_{od}. Defining the threshold value of $\overline{Q}$ such that $I(\overline{Q}) = I$, a type G firm can raise I if and only if $Q \ge \overline{Q}$.

Finally, if a type G firm chooses $d = \varphi$, it will pool with a type B firm and will sell n_φ shares at a price p_φ that solves:

$$p_\varphi n_\varphi = I, \text{ and } p_\varphi = \frac{\bar{k} I}{w + n_\varphi}, \tag{A.15}$$

where $\bar{k} = \omega k^G + (1 - \omega) k^B$. By solving (A.15) we find that $n_\varphi = \frac{w}{\bar{k}-1}$ and $p_\varphi = \frac{(\bar{k}-1)I}{w}$. Hence, the expected payoff to the insiders of a type G firm from setting $d = \varphi$ is given by:

$$W_\varphi^G = \frac{w}{w + n_\varphi} V^G = \frac{\bar{k} - 1}{\bar{k}} k^G I. \tag{A.16}$$

Consider now the insider's expected payoff (A.10) in the case of a PPE with the optimal disclosure $d^* \in \{h, m\}$. By direct comparison of (A.16) and (A.10), $\psi > 0$, the fact that W_d^G is independent of ω, and strict monotonicity of (A.16) in ω all together imply that there exists a threshold value $\hat{\omega}$ such that $W_\varphi^G < W_d^G$ if and only if $\omega < \hat{\omega}$. ■

Proof of Lemma 1. Consider the system of equations (A.1)–(A.2), which may be written as:

$$\overline{X} = \theta_d g(n_d) + (1-\theta_d) b(\hat{n}_d) - 1 = 0, \tag{A.17}$$
$$\overline{Y} = (1-\theta_d)(1 - b(\hat{n}_d))(r_d - q_d) - c = 0. \tag{A.18}$$

Note that now $g(n_d) \equiv \frac{n_d k^G}{(w+n_d)}, b(\hat{n}_d) \equiv \frac{\hat{n}_d k^B}{(w+\hat{n}_d)}$, with $g'(n_d) > 0$, and $b'(\hat{n}_d) > 0$. Further, n_d and $\hat{n}_d$ have been defined in (7), and $n_{od} = Q$ since $Q < \overline{Q}$. In the proof of this lemma, the following partial derivatives are helpful:

$$\begin{aligned}
\frac{\partial \overline{X}}{\partial \alpha_d} &= -\pi n_{od}\left[(1-r_d)\theta_d g'(n_d) + (1-q_d)(1-\theta_d)b'(\hat{n}_d)\right] < 0, \quad \frac{\partial \overline{X}}{\partial \theta_d} = g(n_d) - b(\hat{n}_d) > 0,\\
\frac{\partial \overline{X}}{\partial \pi} &= \left[-\alpha_d(1-r_d) + (1-z)\right]\theta_d g'(n_d) n_{od} + \left[-\alpha_d(1-q_d) + (1-z)\right](1-\theta_d)b'(\hat{n}_d)n_{od},\\
\frac{\partial \overline{X}}{\partial r_d} &= \pi\alpha_d\theta_d g'(n_d)n_{od} > 0, \quad \frac{\partial \overline{X}}{\partial q_d} = \pi\alpha_d(1-\theta_d)b'(\hat{n}_d)n_{od} > 0,\\
\frac{\partial \overline{X}}{\partial n_{od}} &= \left(1 - \alpha_d\pi(1-r_d) - (1-\pi)(1-z)\right)\theta_d g'(n_d)\\
&\quad + \left(1 - \alpha_d\pi(1-q_d) - (1-\pi)(1-z)\right)(1-\theta_d)b'(\hat{n}_d) > 0,\\
\frac{\partial \overline{X}}{\partial c} &= 0, \quad \frac{\partial \overline{X}}{\partial z} = \left(\theta_d g'(n_d) + (1-\theta_d)b'(\hat{n}_d)\right)(1-\pi)n_{od} > 0.
\end{aligned} \tag{A.19}$$

Similarly,

$$\begin{aligned}
\frac{\partial \overline{Y}}{\partial \alpha_d} &= \pi(1-q_d)(r_d-q_d)(1-\theta_d)b'(\hat{n}_d)n_{od} > 0, \quad \frac{\partial \overline{Y}}{\partial \theta_d} = -(1-b(\hat{n}_d))(r_d-q_d) < 0,\\
\frac{\partial \overline{Y}}{\partial \pi} &= \left[\alpha_d(1-q_d) - (1-z)\right](r_d-q_d)(1-\theta_d)b'(\hat{n}_d)n_{od} > 0,\\
\frac{\partial \overline{Y}}{\partial r_d} &= (1-\theta_d)(1-b(\hat{n}_d)) > 0, \quad \frac{\partial \overline{Y}}{\partial q_d} = -(1-\theta_d)\left[(1-b(\hat{n}_d)) + \alpha_d\pi(r_d-q_d)b'(\hat{n}_d)n_{od}\right] < 0,\\
\frac{\partial \overline{Y}}{\partial n_{od}} &= -\left(1 - \alpha_d\pi(1-q_d) - (1-\pi)(1-z)\right)(r_d-q_d)(1-\theta_d)b'(\hat{n}_d) < 0,\\
\frac{\partial \overline{Y}}{\partial c} &= -1, \quad \frac{\partial \overline{Y}}{\partial z} = -(1-\theta_d)(r_d-q_d)b'(\hat{n}_d)(1-\pi)n_{od} < 0.
\end{aligned} \tag{A.20}$$

To derive the desired comparative static results, note that, from the proof of Proposition 1, at an equilibrium pair (α_d^*, θ_d^*) we have that $\partial x/\partial\alpha > \partial y/\partial\alpha$. This implies that $\partial\overline{Y}/\partial\theta_d \cdot \partial\overline{X}/\partial\alpha_d > \partial\overline{Y}/\partial\alpha_d \cdot \partial\overline{X}/\partial\theta_d$. Hence, the Jacobian determinant J of the system of equations (A.17) and (A.18) is negative since:

$$\begin{aligned}
J &= \begin{vmatrix} \partial\overline{Y}/\partial\alpha_d & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial\alpha_d & \partial\overline{X}/\partial\theta_d \end{vmatrix} = \frac{\partial \overline{Y}}{\partial\alpha_d}\frac{\partial \overline{X}}{\partial\theta_d} - \frac{\partial \overline{Y}}{\partial\theta_d}\frac{\partial \overline{X}}{\partial\alpha_d} < 0,\\
&= \pi(1-q_d)(r_d-q_d)(1-\theta_d)b'(\hat{n}_d)n_{od}\left(g(n_d) - b(\hat{n}_d)\right)\\
&\quad - (1-b(\hat{n}_d))(r_d-q_d)\left((1-r_d)\theta_d g'(n_d) + (1-q_d)(1-\theta_d)b'(\hat{n}_d)\right)\pi n_{od} < 0,\\
&= (1-q_d)(r_d-q_d)\pi n_{od}\left[(1-\theta_d)b'(g-b) - (1-b)\left(\theta_d g'\frac{(1-r_d)}{(1-q_d)} + (1-\theta_d)b'\right)\right] < 0.
\end{aligned} \tag{A.21}$$

Further, $J < 0$ and $r_d > q_d$ together imply that

$$\begin{aligned}
&(1-\theta_d)b'(g-b) < (1-b)\left(\theta_d g' + (1-\theta_d)b'\right),\\
&\frac{1}{(1-q_d)(r_d-q_d)\pi n_{od}} < \frac{\left[(1-\theta_d)b'(g-b) - (1-b)\left(\theta_d g' + (1-\theta_d)b'\right)\right]}{J}.
\end{aligned} \tag{A.22}$$

Consider now the system of equations given in (A.17)–(A.18). From the implicit function theorem, it follows by applying Cramer's rule that:

$$\frac{\partial \alpha_d^*}{\partial c} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial c & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial c & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J} = \frac{\partial\overline{X}/\partial\theta_d}{J} < 0, \quad \frac{\partial \theta_d^*}{\partial c} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial \alpha_d & \partial\overline{Y}/\partial c \\ \partial\overline{X}/\partial \alpha_d & \partial\overline{X}/\partial c \end{vmatrix}}{J} = -\frac{\partial\overline{X}/\partial\alpha_d}{J} < 0, \tag{A.23}$$

$$\begin{aligned} \frac{\partial \alpha_d^*}{\partial r_d} &= -\frac{\begin{vmatrix} \partial\overline{Y}/\partial r_d & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial r_d & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J} = -\frac{(1-b)\left[(1-\theta_d)(g-b) + \theta_d \pi \alpha_d g' n_{od}(r_d - q_d)\right]}{J} > 0, \\ \frac{\partial \theta_d^*}{\partial r_d} &= -\frac{\begin{vmatrix} \partial\overline{Y}/\partial \alpha_d & \partial\overline{Y}/\partial r_d \\ \partial\overline{X}/\partial \alpha_d & \partial\overline{X}/\partial r_d \end{vmatrix}}{J} \\ &= -\frac{(1-\theta_d)\pi n_{od}\left[(1-q_d)(r_d-q_d)\pi n_{od}\theta_d\alpha_d g' b' + (1-b)\left((1-r_d)\theta_d g' + (1-q_d)(1-\theta_d)b'\right)\right]}{J} > 0, \end{aligned} \tag{A.24}$$

$$\frac{\partial \alpha_d^*}{\partial q_d} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial q_d & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial q_d & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J} = \frac{(1-\theta_d)\left((g-b)(1-b) + \alpha_d \pi (r_d - q_d)(g-1)b' n_{od}\right)}{J} < 0, \tag{A.25}$$

$$\begin{aligned} \frac{\partial \theta_d^*}{\partial q_d} &= -\frac{\begin{vmatrix} \partial\overline{Y}/\partial \alpha_d & \partial\overline{Y}/\partial q_d \\ \partial\overline{X}/\partial \alpha_d & \partial\overline{X}/\partial q_d \end{vmatrix}}{J}, \\ &= \left[(1-b)\left(\theta_d(1-r_d)g' + (1-\theta_d)(1-q_d)b'\right) + (1-r_d)(r_d-q_d)\pi n_{od}\alpha_d\theta_d g' b'\right]\frac{(1-\theta_d)\pi n_{od}}{J} < 0, \end{aligned} \tag{A.26}$$

$$\begin{aligned} \frac{\partial \alpha_d^*}{\partial \pi} &= -\frac{\begin{vmatrix} \partial\overline{Y}/\partial \pi & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial \pi & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J} \\ &= -\frac{\alpha_d}{\pi} + \frac{1-z}{J}\left[(1-\theta_d)b'(g-b) - (1-b)(\theta_d g' + (1-\theta_d)b')\right](r_d-q_d)n_{od} > \frac{1-z-\alpha_d(1-q_d)}{\pi(1-q_d)}, \end{aligned} \tag{A.27}$$

$$\frac{\partial \theta_d^*}{\partial \pi} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial \alpha_d & \partial\overline{Y}/\partial \pi \\ \partial\overline{X}/\partial \alpha_d & \partial\overline{X}/\partial \pi \end{vmatrix}}{J} = -\frac{(1-z)\theta_d(1-\theta_d)b'g'\left((r_d-q_d)n_{od}\right)^2\pi}{J} > 0. \tag{A.28}$$

In the proof of Proposition 1, we have used the following:

$$\begin{aligned} \frac{\partial \alpha_d^*}{\partial n_{od}} &= -\frac{\begin{vmatrix} \partial\overline{Y}/\partial n_{od} & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial n_{od} & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J}, \\ &= -\frac{\alpha_d}{n_{od}} + \frac{(1-(1-\pi)(1-z))(r_d-q_d)}{J}\left[(1-\theta_d)b'(g-b) - (1-b)(\theta_d g' + (1-\theta_d)b')\right] \\ &> \frac{1-\alpha_d\pi(1-q_d) - (1-\pi)(1-z)}{\pi(1-q_d)n_{od}} > 0, \end{aligned} \tag{A.29}$$

$$\frac{\partial\theta_d^*}{\partial n_{od}} = -\frac{\begin{vmatrix}\partial\overline{Y}/\partial\alpha_d & \partial\overline{Y}/\partial n_{od}\\ \partial\overline{X}/\partial\alpha_d & \partial\overline{X}/\partial n_{od}\end{vmatrix}}{J} = -\frac{\pi(r_d-q_d)^2(1-(1-\pi)(1-z))(1-\theta_d)\theta_d b' g' n_{od}}{J} > 0. \tag{A.30}$$

Finally,

$$\begin{aligned}\frac{\partial\alpha_d^*}{\partial z} &= -\frac{\begin{vmatrix}\partial\overline{Y}/\partial z & \partial\overline{Y}/\partial\theta_d\\ \partial\overline{X}/\partial z & \partial\overline{X}/\partial\theta_d\end{vmatrix}}{J} = -\frac{(r_d-q_d)(1-\pi)n_{od}\left[(1-b)(\theta_d g' + (1-\theta_d)b') - (1-\theta_d)b'(g-b)\right]}{J}\\ &> \frac{(1-\pi)}{\pi(1-q_d)} > 0.\end{aligned} \tag{A.31}$$

$$\frac{\partial\theta_d^*}{\partial z} = -\frac{\begin{vmatrix}\partial\overline{Y}/\partial\alpha_d & \partial\overline{Y}/\partial z\\ \partial\overline{X}/\partial\alpha_d & \partial\overline{X}/\partial z\end{vmatrix}}{J} = -\frac{1}{J}\pi(1-\pi)(n_{od}(r_d-q_d))^2\theta_d(1-\theta_d)g'b' > 0. \tag{A.32}$$

■

Proof of Proposition 2. From the definition of W_d^G given in (A.10), and properties (c) and (d) of Lemma 1, we will first verify that, when $n_{od} = Q$, the type G firm's expected payoff W_d^G in a PPE is strictly increasing in r_d and strictly decreasing in q_d. By totally differentiating ψ with respect to r_d, we obtain:

$$\frac{\partial\psi}{\partial r_d} = \frac{\pi w}{\left(\frac{\hat{n}_d}{n_{od}}(w+n_d)\right)^2}\left(\frac{\partial\alpha_d}{\partial r_d}(r_d-q_d)\left((1-(1-\pi)(1-z))(w+n_d) + \alpha_d\pi(1-r_d)\hat{n}_d\right) + \alpha_d\frac{\hat{n}_d}{n_{od}}(w+\hat{n}_d)\right) > 0, \tag{A.33}$$

since $\frac{\partial\alpha_d}{\partial r_d} > 0$ from (A.24). By totally differentiating ψ with respect to q_d, we obtain:

$$\frac{\partial\psi}{\partial q_d} = \frac{\pi w}{\left(\frac{\hat{n}_d}{n_{od}}(w+n_d)\right)^2}\left(\frac{\partial\alpha_d}{\partial q_d}(r_d-q_d)\left((1-(1-\pi)(1-z))(w+n_d) + \alpha_d\pi(1-r_d)\hat{n}_d\right) - \alpha_d\frac{n_d}{n_{od}}(w+n_d)\right) < 0, \tag{A.34}$$

since $\frac{\partial\alpha_d}{\partial q_d} < 0$ from (A.25). Therefore, along the indifference curve $W_d^G(r_d, q_d) = W$, the slope is given by: $\frac{\partial r_d}{\partial q_d} = -\frac{\frac{\partial\psi}{\partial q_d}}{\frac{\partial\psi}{\partial r_d}} > 0$. Thus, we showed that the marginal rate of substitution between (r_d, q_d) for a type G firm is strictly positive. Hence, given a pair (r_h, q_h), for all q_m there is a minimum value $\hat{r}_m(q_m, r_h, q_h)$ such that a type G firm prefers $d = m$ over $d = h$ if and only if $r_m > \hat{r}_m$. Finally, note that if the firm sets $d = l$, the disclosure is uninformative to institutional investors, since $r_l = q_l = 1$. Therefore, $\alpha_l^* = 0$ and $\beta_d^* = 1$. Hence $d = \varphi$ weakly dominates $d = l$. ■

Proof of Proposition 3. Let $d \in \{h, m\}$ be the type of disclosure preferred by the type G firm. Part (a) of the proposition follows from the proof of Proposition 1. From (A.10) and (A.16), it follows that $W_d^G \geq W_\varphi$ if and only if $\omega \leq \hat{\omega}$. After some algebraic simplifications, the threshold value $\hat{\omega}$ is given by:

$$\hat{\omega} = \frac{\psi k^B(k^B-1)}{(k^G-k^B)(1-\psi(k^B-1))}, \tag{A.35}$$

which is increasing in ψ.

From (A.31) in the proof of Lemma 1, we know that $\frac{\partial\alpha_d^*}{\partial z} > \frac{(1-\pi)}{\pi(1-q_d)} > 0$. By totally differentiating ψ given in (A.11) with respect to z, it follows that

$$\frac{\partial\psi}{\partial z} \geq \frac{(1-\pi)(r_d-q_d)}{(1-q_d)}\frac{w n_{od}}{\hat{n}_d(w+n_d)}\left[1 - \frac{\alpha_d(r_d-q_d)\pi n_{od}}{w + (1-\alpha_d\pi(1-r_d)-(1-\pi)(1-z))n_{od}}\right] > 0. \tag{A.36}$$

This means that W_d^G is strictly increasing in z while it is independent of ω. On the other hand, W_φ^G in strictly increasing in ω, but independent of z. This implies that the threshold value $\hat{\omega}$, at which $W_d^G = W_\varphi^G$, is increasing in z, which proves part (b). ■

Proof of Proposition 4. Let $\underline{c} < c < \overline{c}$ so that a PPE exists. Let $\theta_d^*(c, \pi, \omega, r_d, q_d, z)$ be the equilibrium value for θ_d. The corresponding equilibrium information risk $\sigma_d^2(\theta_d^*)$ given in (13) can be simplified as:

$$\sigma_d^2(\theta_d^*) = \theta_d^* \left(1 - \theta_d^*\right) \left(g(n_d^*) - b(\hat{n}_d^*)\right)^2. \tag{A.37}$$

By totally differentiating σ_d^2 given in (A.37) with respect to c (and noting that the partial derivatives $\frac{\partial \alpha_d}{\partial c}$ and $\frac{\partial \theta_d}{\partial c}$ are given in (A.23)), we obtain:

$$\frac{\partial \sigma_d^2}{\partial c} = \frac{(g-b)^2 \pi n_{od}}{-J} \left((1-r_d)\theta_d g' - (1-q_d)(1-\theta_d)b'\right) > 0. \tag{A.38}$$

Note that since $\frac{\partial \theta_d}{\partial c} < 0$ from (A.24), (A.4) implies that θ_d^* converges toward 1 (or a number close to 1 when $\underline{c} > 0$) as c approaches $\underline{c}$ from above. Therefore, the above partial derivative in (A.38) is positive for small c. One can also verify from (A.11) that $\frac{\partial \psi}{\partial c} < 0$, and therefore, that $\frac{\partial W_d^G}{\partial c} < 0$.

Let $\sigma_\varphi^2(\omega)$ be the extent of information risk in the case of no disclosure. It is given by:

$$\sigma_\varphi^2(\omega) = \omega(1-\omega)\left(\frac{k^G - k^B}{\omega k^G + (1-\omega)k^B}\right)^2. \tag{A.39}$$

One can verify that $\sigma_\varphi^2(\omega)$ takes its maximum value at $\omega^* = \frac{k^B}{k^G + k^B}$, and that is strictly increasing in ω for $\omega \in (0, \omega^*]$. We also know from (A.16) that W_φ^G is strictly increasing in ω.

Let the threshold $\underline{\omega}$ be defined as that value of ω at which $\sigma_\varphi^2(\underline{\omega}) = \sigma_d^2(\underline{c})$. For any $\omega \geq \underline{\omega}$, let the threshold $c_1(\omega)$ be defined as that value of c where $\sigma_d^2(c_1(\omega)) = \sigma_\varphi^2(\omega)$. Since $\frac{\partial \sigma_d^2}{\partial c} > 0$ from (A.38), this means that $\sigma_d^2(\theta_d^*(c)) < \sigma_\varphi^2(\omega)$ for any value of c where $\underline{c} < c < c_1(\omega)$, and $\sigma_d^2(\theta_d^*(c)) > \sigma_\varphi^2(\omega)$ for any value of c where $c_1(\omega) < c \leq \overline{c}$. Note also that $c_1(\omega)$ is increasing in ω since $\frac{\partial \sigma_\varphi^2(\omega)}{\partial \omega} > 0$ and $\frac{\partial \sigma_d^2}{\partial c} > 0$.

For any $\omega \geq \underline{\omega}$, also let the threshold $c_2(\omega)$ be defined as that value of c where $W_d^G(c_2(\omega)) = W_\varphi^G(\omega)$. Since $\frac{\partial W_d^G}{\partial c} < 0$, this implies that the type G firm will prefer the PPE with disclosure to the fully pooling equilibrium with no disclosure for any value of c where $\underline{c} < c < c_2(\omega)$. Note that $c_2(\omega)$ is decreasing in ω since $\frac{\partial W_\varphi^G(\omega)}{\partial \omega} > 0$ and $\frac{\partial W_d^G}{\partial c} < 0$.

Finally, note that $c_1(\underline{\omega}) = \underline{c}$ by definition. For a PPE with disclosure to be chosen by the type G firm over non-disclosure at all (for some $c \in (\underline{c}, \overline{c}]$), it must be the case that $c_2(\underline{\omega}) > \underline{c}$. Given that $c_1'(\omega) > 0$ and $c_2'(\omega) < 0$, the proof is concluded by defining the threshold $\overline{\omega}$ as that value of $\omega > \underline{\omega}$ at which $c_1(\overline{\omega}) = c_2(\overline{\omega})$. ■

Proof of Proposition 5. By totally differentiating σ_d^2 given in (A.37) with respect to z (and noting that the partial derivatives $\frac{\partial \alpha_d}{\partial z}$ and $\frac{\partial \theta_d}{\partial z}$ are given in (A.31) and (A.32)) respectively, we obtain:

$$\frac{\partial \sigma_d^2}{\partial z} = 2\theta_d(1-\theta_d)(r_d - q_d)^2(g-b)^2 g' b' \frac{\pi(1-\pi)n_{od}^2}{-J}\left(\theta_d - \frac{1}{2}\right) > 0, \tag{A.40}$$

for $0 < c < \tilde{c}$. Note that since $\frac{\partial \theta_d}{\partial c} < 0$ from (A.24), (A.4) implies that θ_d^* converges toward 1 (or a number close to 1 when $\underline{c} > 0$) as c approaches $\underline{c}$ from above. Therefore, there exists a threshold $\tilde{c}$ so that the above partial derivative in (A.40) is positive for any feasible value of z when c is sufficiently c; i.e., if $0 < c < \tilde{c}$.

Let $0 \leq c < \tilde{c}$ and let $\overline{z}_{co}$ be the maximum value of z below which a PPE with $\alpha_d < 1$ exists. Similarly, let $\underline{z}_{co}$ be the minimum value of z above which a PPE with $Q \geq \underline{Q}(z)$ exists. For each value of z in $[\underline{z}_{co}, \overline{z}_{co})$, let $\omega(z,c)$ be defined as that value of ω at which $\sigma_d^2(z,c) = \sigma_\varphi^2(\omega(z,c))$. Since $\frac{\partial \sigma_d^2}{\partial z} > 0$ from (A.40) and $\frac{\partial \sigma_\varphi^2}{\partial \omega} > 0$, it follows that $\frac{\partial \omega(z,c)}{\partial z} > 0$. Further, since $\frac{\partial \sigma_d^2}{\partial c} > 0$ from (A.38), it follows that $\frac{\partial \omega(z,c)}{\partial c} > 0$. Then, let $\overline{z}_c$ be the maximum value of $z \in [\underline{z}_{co}, \overline{z}_{co})$ at which $W_d^G(c,z) \geq W_\varphi^G(\omega(z,c))$, which can be equivalently restated as $\omega(z,c) \leq \hat{\omega}(z,c)$, where $\hat{\omega}(z,c)$ is given by (A.35). Similarly, let $\underline{z}_c$ be the minimum value of $z \in [\underline{z}_{co}, \overline{z}_{co})$ at which $\omega(z,c) \leq \hat{\omega}(z,c)$. Note that for any $z \in [\underline{z}_c, \overline{z}_c]$, $\omega(z,c)$ is increasing in c while $\hat{\omega}(z,c)$ is decreasing in c. Hence, we define $\hat{c} > 0$ as the threshold value of c at which the interval $[\underline{z}_c, \overline{z}_c]$ shrinks to a single point on the interval $[\underline{z}_{co}, \overline{z}_{co})$.

For each $c \in (0, \hat{c})$, let $\omega_0(c) \equiv \omega(\underline{z}_c, c)$ and $\omega_1(c) \equiv \omega(\overline{z}_c, c)$. Note that for each $c \in (0, \hat{c})$, $\omega(z, c)$ defines a continuous mapping (one-to-one and onto) from $[\underline{z}_c, \overline{z}_c]$ to $[\omega_0(c), \omega_1(c)]$. Therefore, by the intermediate value theorem, it follows that for any $\omega \in [\omega_0(c), \omega_1(c)]$, there exists a value $z_1(c, \omega) \in [\underline{z}_c, \overline{z}_c]$ such that $\omega(z_1(c, \omega), c) = \omega$. Since $\sigma_d^2(z_1, c) = \sigma_\varphi^2(\omega)$ and $\frac{\partial \sigma_d^2}{\partial z} > 0$, it follows that $\sigma_d^2(z, c) < \sigma_\varphi^2(\omega)$ for $z \in [\underline{z}_c, z_1)$ and $\sigma_d^2(z, c) > \sigma_\varphi^2(\omega)$ for $z \in (z_1, \overline{z}_c]$. ■

Proof of Proposition 6. Part (a) of the proposition follows from (A.38) in the proof of Proposition 4. Part (b) of the proposition follows from (A.40) in the proof of Proposition 5. By totally differentiating σ_d^2 given in (A.37) with respect to r_d (and noting that the partial derivatives $\frac{\partial \alpha_d}{\partial r_d}$ and $\frac{\partial \theta_d}{\partial r_d}$ are given in (A.24)), we obtain:

$$\begin{aligned}\frac{\partial \sigma_d^2}{\partial r_d} = & \frac{(1-\theta_d)\pi n_{od}(g-b)^2}{-J} \times \\ & \left((2\theta_d - 1)\theta_d \alpha_d g' b' \pi n_{od}(1-q_d)(r_d - q_d) - (1-b)\left(\theta_d(1-r_d)g' - (1-\theta_d)(1-q_d)b'\right)\right) < 0.\end{aligned} \tag{A.41}$$

Similarly, by totally differentiating σ_d^2 given in (A.37) with respect to q_d (and noting that the partial derivatives $\frac{\partial \alpha_d}{\partial q_d}$ and $\frac{\partial \theta_d}{\partial q_d}$ are given in (A.25) and (A.26) respectively), we obtain:

$$\begin{aligned}\frac{\partial \sigma_d^2}{\partial q_d} = & \frac{(1-\theta_d)\pi n_{od}(g-b)^2}{-J} \times \\ & \left(-(2\theta_d - 1)\theta_d \alpha_d g' b' \pi n_{od}(1-r_d)(r_d - q_d) + (1-b)\left(\theta_d(1-r_d)g' - (1-\theta_d)(1-q_d)b'\right)\right) > 0.\end{aligned} \tag{A.42}$$

Therefore, part (c) of the proposition follows from (A.41) and (A.42). ■

Proof of Proposition 7. Holding every other parameter constant, we showed in the proof of Proposition 2 that the firms' equilibrium choice between $d = h$ and $d = m$ depends only on a comparison between the pairs (r_h, q_h) and (r_m, q_m), and that the marginal rate of substitution between r_d and q_d along the indifference curve that keeps the type G firm's expected payoff W_d^G constant is positive. Similarly, in the proof of Proposition 6, we showed in equations (A.41) and (A.42) that $\frac{\partial \sigma_d^2}{\partial r_d} < 0$ and $\frac{\partial \sigma_d^2}{\partial q_d} > 0$. This means that the marginal rate of substitution between r_d and q_d along the indifference curve that keeps the information risk σ_d^2 subsequent to a disclosure d constant is also positive. Therefore, whether $\sigma_h^2 > \sigma_m^2$ or $\sigma_h^2 < \sigma_m^2$ depends on the particular realization of the pairs (r_h, q_h) and (r_m, q_m).

Given the assumption that the regulatory agency will forbid disclosure if and only if both types of disclosures (h and m) increase the information risk faced by uninformed investors relative to non-disclosure, the relevant thresholds for c and z given in the proofs of propositions 4 and 5 will be determined by the type of disclosure (h or m) that involves a smaller information risk. Let $\hat{d}$ denote the type of disclosure $d \in \{h, m\}$ that entails a smaller information risk in a PPE: i.e.,

$$\hat{d} = \arg\min_{d \in \{h,m\}} \sigma_d^2(\theta_d^*, \alpha_d^*, r_d, q_d, c, \pi, z, n_{od}). \tag{A.43}$$

Then, it follows from the proof of Proposition 4 that $c_1(\omega) = c_1(\omega, \hat{d})$, $\underline{\omega}_0 = \underline{\omega}(\hat{d})$, and $\overline{\omega}_0 = \overline{\omega}(\hat{d})$. Similarly, from the proof of Proposition 5, it follows that $\overline{z}_1(c, \omega) = z_1(c, \omega, \hat{d})$, $\tilde{\omega}_0(c) = \omega_0(c, \hat{d})$, $\tilde{\omega}_1(c) = \omega_1(c, \hat{d})$, and $\hat{c}_0 = \hat{c}(\hat{d})$. ■

Proof of Proposition 8. Consider the system of equations (A.1)–(A.2), which may now be rewritten as:

$$\overline{Y} \equiv (1-\theta_d)\left(1 - \left(1 + \mu\gamma^B \lambda_d^B\right) b(\hat{n}_d)\right)(r_d - q_d) - c = 0, \tag{A.44}$$

$$\overline{X} \equiv \theta_d\left(1 + \mu\gamma^G \lambda_d^G\right) g(n_d) + (1-\theta_d)\left(1 + \mu\gamma^B \lambda_d^B\right) b(\hat{n}_d) - 1 = 0, \tag{A.45}$$

where $g(n_d) \equiv \frac{n_d k^G}{(w+n_d)}$, $b(\hat{n}_d) \equiv \frac{\hat{n}_d k^B}{(w+\hat{n}_d)}$, with $g'(n_d) > 0$, $b'(\hat{n}_d) > 0$ and $n_{od} = Q$.

We first obtain:

$$\frac{\partial \overline{X}}{\partial \mu} = \theta_d g(n_d)\lambda_d^G \gamma^G + (1-\theta_d) b(\hat{n}_d)\lambda_d^B \gamma^B > 0, \quad \frac{\partial \overline{Y}}{\partial \mu} = -(1-\theta_d)(r_d - q_d) b(\hat{n}_d)\lambda_d^B \gamma^B < 0,$$
$$\frac{\partial \overline{X}}{\partial \theta_d} = (1+\mu\gamma^G \lambda d^G) g(n_d) - (1+\mu\gamma^B\lambda_d^B) b(\hat{n}_d) > 0, \quad \frac{\partial \overline{Y}}{\partial \theta_d} = -(1-(1+\mu\gamma^B\lambda_d^B)) b(\hat{n}_d)(r_d - q_d) < 0. \tag{A.46}$$

Following a procedure similar to the one adopted in the proof of Lemma 1, we then obtain:

$$\begin{aligned}\frac{\partial \alpha_d^*}{\partial \mu} &= -\frac{\begin{vmatrix} \partial\overline{Y}/\partial\mu & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial\mu & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J}, \\ &= -\frac{(r_d - q_d)}{J}\left[-(1-\theta_d) b\gamma^B\lambda_d^B \left((1+\mu\gamma^G\lambda_d^G) g - (1+\mu\gamma^B\lambda_d^B) b\right)\right] \\ &\quad - \frac{(r_d - q_d)}{J}\left[\left(\theta_d g \gamma^G \lambda_d^G + (1-\theta_d) b\gamma^B\lambda_d^B\right)\left(1 - \left(1+\mu\gamma^B\lambda_d^B\right) b\right)\right],\end{aligned} \tag{A.47}$$

where $J < 0$ is the Jacobian determinant of (A.44)–(A.45). By solving (18) for p_d and substituting into (15), we obtain the type G firm's expected payoff in a PPE as:

$$W_d^G = \frac{(k^B - 1)Ik^G}{k^B} \frac{n_d(w+\hat{n}_d)}{\hat{n}_d(w+n_d)} \frac{(w - \mu\gamma^G\lambda_d^G n_d)}{(w-\mu\gamma^B\lambda_d^B\hat{n}_d)} = \frac{(k^B - 1)Ik^G}{k^B}(1+\psi)\left(1 + \frac{\mu(\gamma^B\lambda_d^B\hat{n}_d - \gamma^G\lambda_d^G n_d)}{(w-\mu\gamma^B\lambda_d^B\hat{n}_d)}\right). \tag{A.48}$$

By totally differentiating W_d^G in (A.48) with respect to μ and noting that $\frac{\partial \alpha_d^*}{\partial \mu}$ is given in (A.47), one can verify that for given values of γ^B, λ_d^G and λ_d^B, there exists a threshold value $\hat{\gamma}_d^G$ so that $\frac{\partial W_d^G}{\partial \mu} < 0$ if $\gamma^G \in (\hat{\gamma}^G, \gamma^B)$. Hence, from a direct comparison of (A.48) and (A.16), it follows that if $\gamma^G > \hat{\gamma}_d^G$, there exists a threshold value $\overline{\mu}(\omega, d)$ such that $W_\varphi^G > W_d^G$ for all $\mu > \overline{\mu}$, and disclosure d is not optimal. ■

Proof of Proposition 9. The proof directly follows from the proof of Proposition 8. For given values of γ^B, λ_d^G and λ_d^B; if $\gamma^G \in (0, \hat{\gamma}^G]$, then $\frac{\partial W_d^G}{\partial \mu} > 0$. This implies that $\frac{\partial \hat{\omega}(d,\mu)}{\partial \mu} > 0$. For $d \in \{h, m\}$, the threshold value $\overline{\mu}_0(d)$ is defined by the maximum value of μ at which $\alpha_d^* = 1$. ■

Proof of Proposition 10. From the system of equations given in (A.44)–(A.45), we obtain:

$$\frac{\partial \overline{X}}{\partial \gamma^G} = \mu\lambda_d^G\theta_d g(n_d) > 0, \quad \frac{\partial \overline{Y}}{\partial \gamma^G} = 0, \tag{A.49}$$

$$\frac{\partial \overline{X}}{\partial \gamma^B} = \mu\lambda_d^B(1-\theta_d) b(\hat{n}_d) > 0, \quad \frac{\partial \overline{Y}}{\partial \gamma^B} = -\mu\lambda_d^B(1-\theta_d)(r_d - q_d) b(\hat{n}_d) < 0, \tag{A.50}$$

$$\frac{\partial \overline{X}}{\partial \alpha_d} = -\pi n_{od}\left((1-r_d)\theta_d(1+\mu\gamma^G\lambda_d^G) g' + (1-q_d)(1-\theta_d)(1+\mu\gamma^B\lambda_d^B) b'\right) < 0, \tag{A.51}$$

$$\frac{\partial \overline{Y}}{\partial \alpha_d} = \pi n_{od}(1-q_d)(r_d - q_d)(1-\theta_d)(1+\mu\gamma^B\lambda_d^B) b' > 0. \tag{A.52}$$

Following again a procedure similar to the one adopted in the proof of Lemma 1, we obtain:

$$\frac{\partial \alpha_d^*}{\partial \gamma^G} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial\gamma^G & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial\gamma^G & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J} = \frac{\frac{\partial \overline{X}}{\partial \gamma^G}\frac{\partial \overline{Y}}{\partial \theta_d}}{J} > 0, \quad \frac{\partial \theta_d^*}{\partial \gamma^G} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial\alpha_d & \partial\overline{Y}/\partial\gamma^G \\ \partial\overline{X}/\partial\alpha_d & \partial\overline{X}/\partial\gamma^G \end{vmatrix}}{J} = -\frac{\frac{\partial \overline{Y}}{\partial \alpha_d}\frac{\partial \overline{X}}{\partial \gamma^G}}{J} > 0, \tag{A.53}$$

$$\frac{\partial \alpha_d^*}{\partial \gamma^B} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial\gamma^B & \partial\overline{Y}/\partial\theta_d \\ \partial\overline{X}/\partial\gamma^B & \partial\overline{X}/\partial\theta_d \end{vmatrix}}{J} < 0, \quad \frac{\partial \theta_d^*}{\partial \gamma^B} = -\frac{\begin{vmatrix} \partial\overline{Y}/\partial\alpha_d & \partial\overline{Y}/\partial\gamma^B \\ \partial\overline{X}/\partial\alpha_d & \partial\overline{X}/\partial\gamma^B \end{vmatrix}}{J} < 0, \tag{A.54}$$

where $J < 0$ is the Jacobian determinant of (A.44)–(A.45). Hence, we showed that $\frac{\partial \alpha_d^*}{\partial \gamma^G} > 0$ and $\frac{\partial \alpha_d^*}{\partial \gamma^B} < 0$.

■