Public Trading and

Private Incentives

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Public Trading and Private Incentives [*]

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Abstract

This paper studies the link between public trading and the activity of a firm's large shareholder who can affect firm value. Public trading results in the formation of a stock price that is informative about the large shareholder's activity. This increases the latter's incentives to engage in value increasing activities. Indeed, if he has to liquidate part of his stake before the effect of his activity is publicly observed, a more informative price rewards him for his activity. Implications of this perspective are derived for the decision to go public and security design.

1

1 Introduction

We consider a firm with a large shareholder and otherwise dispersed shares, which are publicly traded. The blockholder is an *insider* in the sense that he can undertake actions that directly affect the firm's value. Moreover, the insider might not necessarily take all value increasing actions as at least some of them involve a private cost for him. In other words, there is a potential moral hazard problem. A number of different situations fit into this general framework. For example, the insider may be an entrepreneur who can allocate corporate resources to activities increasing firm value rather than generating private benefits for himself. Alternatively, the insider may be the close financier of an entrepreneurial firm, such as its main bank or venture capitalist, who can increase firm value at a cost by advising and monitoring the entrepreneur, or by directly contributing to operating decisions. The insider can also stand for an institutional investor (e.g., a pension fund) monitoring the management of a large publicly traded company. The paper's main premise is that public trading, as part of the price formation process, generates information not only about exogenous factors affecting firm value but also about the insider's activity. For instance, as a result of public trading, a firm's stock price will incorporate the market's evaluation of a close financier's monitoring.

We identify two sources of incentives for the insider to engage in activities that will increase firm value. The first one is his stake in the firm. Since the insider participates in a value increase in proportion of his equity stake, a larger stake increases his interest in seeing to the firm value being high. The view that large shareholders affect firm value is indeed widespread (Shleifer and Vishny (1997)). They alleviate the free-rider problem pervasive in firms with passive dispersed investors, unable or unwilling to affect the firm's operations, i.e., who are *outsiders*. A second and more indirect incentive effect is provided by the trading of the firm's stock. Indeed, the insider's activity accounts for the possibility that he will have to sell part or all of his stake before the impact of his value increasing effort is publicly observed. For instance, the firm's need to raise external funds might result in a dilution of the insider's stake. Alternatively, the insider might want to exploit investment opportunities outside the firm and fund them by liquidating part of his stake. We refer to this urge to sell as *liquidity shock*. Examine first the polar case in which the insider is certain to have to liquidate his stake. He will participate in a value increase brought about by his activity only in so far as it is reflected in the stock price. Conversely, if the stock price contains little information about his value

increasing activity, then he has little incentive to engage in such activities. By feeding more information into the stock price, public trading can thus increase the insider's incentive. Hence, although the dispersed shareholders' activity (i.e., their trading) is not aimed at affecting firm value, it can affect it indirectly.

This simple insight has several interesting implications and applications. First, it suggests that public trading can increase the incentives of large shareholders. This result itself has interesting interpretations in the different contexts mentioned above. For instance, an entrepreneur's allocation of corporate resources may be improved when his firm's stock is actively traded. In that respect, going public can have a disciplinary effect. Furthermore, the increase in firm value brought about by going public may sometimes be crucial for the entrepreneur to find it worthwhile to found the firm in the first place. Hence, entrepreneurship and firm creation may be enhanced by the existence of an active market for Initial Public Offering (IPOs). In a similar manner, the monitoring and advising incentives of a firm's close financier may be increased by the public trading of the firm's stock (or, more generally, by the expectation that the stock will eventually be traded following an IPO). This suggests that an active IPO market may be a key element for the development of a venture capital industry. These considerations may be important for the debate over the promotion of entrepreneurship and the financing of start-ups, a prominent issue, in particular on the European agenda. Finally, an institutional investor's incentive to monitor a firm's management may be increased by the information generated by the public trading of the firm's stock, i.e., by market monitoring. This perspective is in contrast with the view that market monitoring makes large shareholders redundant as monitors, i.e., that market and insider monitoring are substitutes. It is in even greater contrast (although not in contradiction as we later explain) with the concern that by making exit easier, market liquidity reduces a large stakeholder's incentive to monitor (Coffee (1991), Bhide (1993)).

Second, while price informativeness can enhance the incentive effect of the insider's stake, increasing price informativeness and the insider's stake can constitute conflicting objectives. The insider's stake is maximized under full ownership, which is incompatible with the public trading of the firm's stock. More generally, ownership concentration and stock price informativeness are likely not to be independent. This in turn suggests a theory of the going public decision. Firms whose insiders are more likely to face liquidity shocks (as defined above) are more likely to go public. Indeed, such insiders put a greater weight on the price at which they might have to sell their shares, and

3

hence their incentives rely more on price informativeness. In this view, going public is motivated by an informational rather than an immediate financial need. More precisely, the informational need may itself correspond to the likelihood of future financing needs: Firms that go public are more likely to undertake further sales of securities, be they public offerings or private placements.

Third, this insight can be extended (under some conditions) to the choice of securities. On the one hand, direct incentives are best provided to the insider by a stake the value of which is closely tied to firm value, i.e., a *value-sensitive* stake. For instance, better incentives may be provided by an equity stake than by a safe debt stake. On the other hand, if the trading of the firm's securities is to generate some information, their value should depend to some extent on that information, i.e., these securities should be *information-sensitive.* For instance, trading essentially safe corporate debt might not generate much information about the insider's activity. Hence, the optimal choice of securities (and maybe the optimal design of securities) might strike a balance between value-sensitivity of inside claims and information-sensitivity of outside claims. When the latter objective dominates, a pecking order for initial offerings can arise, in which firms issue publicly traded claims that are information-sensitive. This is in contrast to the standard pecking order hypothesis that firms issue preferably less information sensitive securities (Myers and Majluf (1984)). Note, however, that once the informational role of public trading is ensured, the same firms might revert to the standard pecking order. One interesting aspect of this incomplete theory of capital structure and security design is that it deals with the securities of both insiders and outsiders.

Among other extensions, we explore the possibility for the insider to engage in strategic trading, i.e., to sell or retain his shares in order to exploit some private information about the firm. Such a possibility is important in our context. Indeed, the gains from strategic trading depend on the degree of information asymmetry, which is itself affected by public trading. By reducing the level of information asymmetry, public trading might decrease the insider's reluctance to sell when he has positive information about the firm. This creates another channel through which public trading affect incentives. Two findings are particularly noteworthy. First, an increase in the price informativeness does not necessarily increase the unconditional probability of exit. This is due to the feedback effect on effort which affects the distribution of states. Second, even in the case in which the exit probability increases, effort increases.

Our paper is related to several strands of literature, one of which examines the po-

4

tential trade-off between liquidity and control. Bhide (1993) and Coffee (1991) propose that market liquidity reduces a large stakeholder's incentives to monitor by increasing the attractiveness of the exit option. Instead, modelling liquidity as the ability to trade hide one's trade, Kyle and Vila (1991), Kahn and Winton (1998) and Maug (1998) argue that it can foster the emergence of active investors in the first place. Indeed, the stock's liquidity allows them to acquire stakes secretly, and thus at favorable terms, and so capture some of the value increase they will bring about. To focus on our main point, we assume instead that the insider cannot trade secretly. In that respect, our analysis is closer to Bolton and von Thadden (1998a,b). Formally, our argument is similar to Diamond and Verrecchia (1982) and especially Holmström and Tirole (1993) in which the information generated by public trading is used to improve the incentive contracts of employed managers. In our paper, the insider's stake constitutes an incentive scheme, the power of which is endogenously affected by public trading. Notice, however, that in our model, it is key that trading generates information about the insider's activity, i.e., not only about exogenous noise. Closest to ours is Chiesa (1998)'s model of the complementarity between monitoring by a large shareholder and market trading. Studying the effect of public trading as a by-product of privatizations, Faure-Grimaud (1999) examines how the information it generates affects a regulator's ability to commit not to expropriate regulated firms. Subrahmanyam and Titman (1999) relate the decision to go public or remain private to the nature of the information to be generated about the firm. We discuss these and other related work later in the paper.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 relates market trading to an insider's incentives, the going-public decision, and security design. Section 4 presents some extensions. In particular, the main result is extended in a setting allowing for strategic trading by the insider. Section 5 concludes. Mathematical proofs are in the appendix.

2 The Model

2.1 The Framework

The model has four dates and no discounting. All agents are risk neutral. A fraction $(1 - \alpha)$ of an all-equity firm is held as a block by a large shareholder (henceforth the insider), the remaining α being held by dispersed shareholders (henceforth the outsiders).

At $t = 1$, the insider can influence the firm's operating decisions because he holds

5

sufficient control rights to be able to do so and enough return rights to be willing to do so.[1] The insider can exert an unobservable "effort" which increases the firm's value: if he incurs a private cost $c(e) = e^2/2$, the firm's value is $V = V^H$ with probability $(1 + e)/2$, and $V = V^L$ otherwise, with $\Delta_V \equiv V^H - V^L > 0$.[2] Hence, the firm's expected value (gross of the effort cost) is

$$\hat{V}(e) \equiv V^L + \frac{1 + e}{2} \Delta_V \tag{1}$$

and the (first-best) level of effort maximizing firm value net of the effort cost is $\Delta_V/2$.

At $t = 2$, the firm's value V realizes but is not publicly observed until $t = 4$. Unless the firm is privately held ($\alpha = 0$), trading occurs and yields a price in a simplified model à la Kyle (1985). We assume that the insider cannot trade anonymously.

- The aggregate demand of the liquidity traders is $d_L \in \{-d, +d\}$, with $d > 0$ and $\Pr[d_L = +d] = \Pr[d_L = -d] = 1/2$. The demand d_L should be interpreted as the deviation from the expected aggregate demand of liquidity traders, which is normalized to zero for simplicity. For instance, the model is consistent with liquidity traders always being net sellers. In general, the volatility of the demand originating from noise traders will depend on the fraction of shares held by outsiders, so that $d \equiv d(\alpha)$. We assume that a market for the firm's stock exists only if the firm is public, i.e., $d(0) = 0$, and that $d(\cdot)$ is continuous.

- A speculator S learns k, his cost of acquiring information, drawn from a known distribution on $(0, +\infty)$ with c.d.f. F.[3] By choosing to incur k, he immediately observes the realization of V. Otherwise, he remains uninformed. Based on his information, he then submits a demand d_S for the firm's stock.

- A competitive market maker observes the trade orders, $\{d_L, d_S\}$, but not the identity of the trader passing each order.[4] He then posts a price for the firm's stock

$$P_2 = \mathrm{E}\left[V \mid \{d_L, d_S\}\right] \tag{2}$$

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[1] See Burkart *et al.* (1997) for a model of the source and limits of a blockholder's effective control.

[2] This formulation implies that a higher effort not only increases the first moment of the profits' distribution but also decreases the second moment. Our results hold in the opposite case. We assume that the parameter values are such that the equilibrium level of effort is always in $(0, 1)$.

[3] Whether k is private information is irrelevant.

[4] In Kyle (1985), liquidity trade orders are drawn from a continuum and only the aggregate order is observed. In our simplified version, under the latter assumption, a Perfect Bayesian Equilibrium would fail to exist because liquidity trades are drawn from a discrete set.

At $t = 3$, the insider may be hit by a liquidity shock. For simplicity, he has to sell all his shares with probability λ. Otherwise, he may but need not do so. (Section 4.1 deals with partial sales). We rule out secret trading and strategic trading by assuming that the insider's trade and his liquidity shock itself are publicly observed. Note however that we do not need to specify whether the insider has any private information.[5] (Section 4.1 deals with strategic trading). Finally, we assume that the buyers have access to public information only so that the stake sells for

$$P_3 = P_2 \tag{3}$$

At $t = 4$, the firm's value is publicly observed and the shareholders receive their payment. The firm is then liquidated for a value normalized to zero.

2.2 Interpretation and Comments

We have kept the model general enough to leave it open to several interpretations. The insider may be an entrepreneur who has retained control of the firm following an Initial Public Offering (IPO) for a fraction α of its equity. Effort can represent any hard-to-contract investment by the entrepreneur (such as "entrepreneurship"). It can also refer to his choosing to use corporate resources to generate benefits for all shareholders rather than private benefits for himself (Burkart *et al.* (1998)). If the entrepreneur incurs a liquidity shock, he has to sell his stake in a SPO or a private placement. Another interpretation is that the insider is a close financier of an entrepreneurial firm such as its main bank or venture capitalist. In the latter case, the venture capitalist might have retained a block of shares after an IPO. Effort can stand for this financier's advising and monitoring the entrepreneur, or even its direct contribution to operating decisions. The insider can also stand for an institutional investor (e.g., a pension fund) monitoring the management of a large publicly traded company.[6]

Several interpretations of the liquidity shock fit our model. The shock may be specific to the insider, as in the case of an entrepreneur who has to sell out when retiring or transferring control to a more effective party (e.g., a larger firm that will better develop and market the firm's product). Of particular interest is the situation in which the insider has investment opportunities outside the firm which he wants to exploit by selling his stake. For instance, a venture capitalist may need to liquidate its stake in a firm to

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[5]To be precise, the insider has private information about his chosen level of effort but this is irrelevant at $t = 3$. See footnote 9.

[6]We use the term "insider" although such investors are usually referred to as "outside investors".

fund new ones. Alternatively, the shock may be specific to the firm, the operations of which might require some funding at a time when the insider is unable or unwilling to provide it. Raising outside finance results in a dilution of the insider's stake. While, for simplicity, our basic model considers the unrealistic case of an extreme dilution, i.e. down to zero, the main results extend directly to less extreme cases (see Section 4.1).

We assume throughout that the insider cannot trade anonymously. This is to focus on our main effect, and to emphasize the contrast with some of the literature on the liquidity-control trade-off. Our model could accommodate some (limited) secret trading. We also assume that potential buyers of the insider's shares at $t = 3$ have public information only (hence equation (3)). This might seem particularly restrictive given that in our model, the speculator has access to private information at $t = 2$. We rule out the possibility that he buys the shares at $t = 3$ for several reasons. First, we consider our trading model to be a reduced form for the functioning of a market that aggregates the information of numerous investors. That is, one should think of a model with multiple pieces of information, each being acquired by a different speculator and eventually being partly reflected into the stock price. In that case, without public trading, each speculator's information would be coarser than that resulting from trading. Second, the speculator may not have enough resources to buy the insider's entire stake. Moreover, given the nature of his information, he may be credit constrained. Third, the possibility of speculative profits may enhance the speculator's incentive to acquire information even if they can later participate in private sales.[7] Finally, this assumption is consistent with the use of a microstructure model where all trades are intermediated by market makers: we simply assume that this feature applies also to the insider.

2.3 Trading and Price Informativeness

We first solve for the equilibrium in the market for the firm's stock, which is assumed to exist only if the firm issues equity, i.e., $\alpha > 0$. The informativeness of the equilibrium stock price will depend on both the speculator's strategy and the realization of the random liquidity trades. The speculator's decision whether to become informed will itself depend on his ability to avoid that his trade fully reveal his information.

If the speculator is informed, he will submit $d_S = +d$ when $V = V^H$ and $d_S = -d$ when $V = V^L$. Indeed, any other order would be identified by the market maker as

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[7]In fact, allowing for public trading at $t = 2$ and private sales to informed investors at $t = 3$ can reinforce our results. Indeed, if public trading at $t = 2$ fosters information acquisition by a speculator to whom the insider can sell his stake at its fair price at $t = 3$, public trading enhances effort at $t = 1$.

originating from the speculator, thus revealing the latter's information and ruining his opportunity to realize a trading profit. Moreover, submitting $d_S = -d$ (resp. $d_S = +d$) when $V = V^H$ (resp. $V = V^L$) is a strictly dominated strategy. For a given trade d_S, two types of outcomes are possible. If $d_S = d_L$, which occurs with probability $\frac{1}{2}$, the market maker infers perfectly the direction of the speculator's trade, and sets a price that fully reflects his information. If instead $d_S = -d_L$, the market maker cannot determine the origin of each trade and sets the stock price at $P_2 = \hat{V}(e^a)$, where e^a is his anticipation of the insider's effort. The possible outcomes of the trading game are as follows.

		$V = V^L$	$V = V^H$
Proba $\frac{1}{2}$, $d_L = +d$	Demands (d_S, d_L)	$(-d, +d)$	$(+d, +d)$
	Stock Price P_2	$\hat{V}(e^a)$	V^H
Proba $\frac{1}{2}$, $d_L = -d$	Demands (d_S, d_L)	$(-d, -d)$	$(-d, +d)$
	Stock Price P_2	V^L	$\hat{V}(e^a)$

The speculator's expected profit from informed trading is thus:

$$\pi(e^a) = \frac{1}{2} \cdot \frac{(1 - e^a)}{2} \cdot d \cdot \left[\hat{V}(e^a) - V^L\right] + \frac{1}{2} \cdot \frac{(1 + e^a)}{2} \cdot d \cdot \left[V^H - \hat{V}(e^a)\right] \qquad (4)$$

If the speculator is not informed, he submits a demand $d_S = 0$.[8] Since $0 \notin \{-d, +d\}$, the market maker infers that the speculator is uninformed and sets the stock price at $\hat{V}(e^a)$. In that case, the speculator makes no informed trading profits.

The speculator will incur the cost k to observe V if he expects trading on this information to yield a profit $\pi \geq k$, which occurs with probability $F(\pi)$. Therefore, the probability that P_2 is informative, to which we refer as stock price informativeness is

$$p(e^a) = \frac{1}{2} F(\pi(e^a)) = \frac{1}{2} F\left(\frac{\left(1 - (e^a)^2\right)}{4} \cdot d \cdot \Delta_V\right) \qquad (5)$$

Lemma 1 *Other things equal, stock price informativeness p:*

(i) increases with the variance of liquidity trades, d, the information sensitivity of the firm's stock, Δ_V, and with shifts of F towards lower values of k in the sense of FOSD;

(ii) decreases with e^a, the insider's effort as anticipated by the other agents.

A larger d allows speculators to submit larger orders without being identified by the market maker, and hence the value of information is larger. For our purpose, however, it is sufficient that in the absence of liquidity trades or when the stock is riskless, the

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[8]To be precise, there is an infinity of equilibria, in which, when uninformed, S submits any $d_s \in \left(-\frac{d}{2}, +\frac{d}{2}\right)$ and is identified. All these equilibria yield the same payoff to all players.

speculator's profit goes to zero. Point (ii) results from our assumption that effort reduces the volatility of returns (see footnote 2), thus reducing the value of information.

Definition 1 *We call increase in the price informativeness function an upward shift of the function $p(\cdot)$, for a given α.*

In our model, the price informativeness function increases with the information sensitivity of the firm's stock, Δ_V, and the variance of liquidity trades *for a given α, $d(\alpha)$*, and following a shift of F towards lower values of k in the sense of FOSD. While the first effect is firm specific, we like to think of the second and third ones as capturing features of the stock market. For instance, a well develop stock market might generate more information, and hence, will correspond to an increase in price informativeness with respect to a less developed market.

3 Public Trading and Shareholder Intervention

We highlight that the insider's incentives are enhanced by a larger equity stake, but also by more informative stock prices. We derive implications for the decision to go public and, in a variation of the model, for the choice and design of securities.

3.1 Trading and the Insider's Incentives

This section relates the information generated by the firm's stock public trading to the insider's equilibrium effort level. Assume that the insider incurs a liquidity shock at $t = 3$ and thus has to liquidate his stake. Since the shock is observed, his trade has no informational content about the firm's value and thus occurs at the market price, i.e., $P_3 = P_2$. If the insider anticipates that this price will be fully informative with probability p^a, and otherwise equal to $\hat{V}^a$, his expected payoff is:

$$-c(e) + \frac{(1+e)}{2} \cdot (1-\alpha) \cdot \left[\lambda \cdot \left(p^a \cdot V^H + (1-p^a) \cdot \hat{V}^a\right) + (1-\lambda) \cdot V^H\right]$$
$$+\frac{(1-e)}{2} \cdot (1-\alpha) \cdot \left[\lambda \cdot \left(p^a \cdot V^L + (1-p^a) \cdot \hat{V}^a\right) + (1-\lambda) \cdot V^L\right] \tag{6}$$

Maximizing this payoff with respect to effort, we have:

$$e(p^a) = (1-\alpha)\left[1 - \lambda(1-p^a)\right]\frac{\Delta_V}{2} \tag{7}$$

Note that unless $\alpha = 0$ and $p^a = 1$ or $\lambda = 0$, the insider is bound to exert less than the first-best level of effort. Hence, any increase in effort would also increase firm value. More importantly, this expression underlines the dual source of incentives for the insider.

Lemma 2 *Other things equal, the insider's effort level e:*

(i) increases with $(1 - \alpha)$, his stake in the firm (direct effect);

(ii) increases with p^a, his anticipation of price informativeness (indirect effect).

Consider first the polar case in which there is no liquidity shock. If $\lambda = 0$, the insider's effort is $e = \frac{(1-\alpha)\Delta_V}{2}$. It is thus increasing in the insider's stake $(1 - \alpha)$ and in the productivity of his effort $\frac{\Delta_V}{2}$ but does not depend on the other parameters. That is, absent the possibility of a liquidity shock, the model boils down to a standard moral hazard problem, in which a larger stake leads the insider to internalize more of the positive effect of his effort. Things are different when the insider can be subject to liquidity shocks. When making his effort decision, the insider takes into account that he might have to sell his shares at $t = 3$, before the impact of his effort on firm value is publicly observed at $t = 4$. In the polar case in which the liquidity shock is certain, i.e., $\lambda = 1$, the insider's payoff depends only on the price his stake will fetch at $t = 3$. Hence, he will exert effort only in so far as this translates into a higher expected selling price, $P_3 = P_2$. If he anticipates the price to be uninformative about his effort (i.e., $p^a = 0$), he has no incentive to exert effort. Instead, a more informative price induces more effort as the insider's payoff is tied more closely to his effort. More generally, the insider has to sell his stake at an uninformative price with probability $\lambda(1 - p^a)$, which is the factor reducing his effort in equation (7).

We can now determine the equilibrium effort level e^* and price informativeness p^*, defined by $p^* = p(e^*)$, and $e^* = e(p^*)$.

Proposition 1 *The insider's equilibrium effort level e^**

(i) increases following an increase in the price informativeness function;

(ii) decreases with the probability of a liquidity shock, λ.

We have established that effort and price informativeness depend of each other (Lemma 1 and 2). Since the insider's effort increases with stock price informativeness, the equilibrium effort level is increased by an upward shift of $p(\cdot)$. Still, the insider exerts less effort than without the risk of a liquidity shock ($\lambda = 0$) because P_2 (and hence P_3) is only a noisy signal of the firm's value V. As the probability λ of a liquidity shock increases, the insider puts more weight on the liquidation price at $t = 3$ and less weight on the firm's value to be revealed only at $t = 4$, when choosing his effort level. Consequently, the equilibrium effort level decreases with λ.[9]

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[9]It is noteworthy that while the insider has private information about his actual level of effort, this is not what is driving the result. Because liquidity shocks are observable, the insider cannot make out

Proposition 1 has several interesting interpretations. First, consider an entrepreneur who can decide to use corporate resources to generate benefits for all shareholders or to extract private benefits. The result suggests that the resource allocation may be improved by the information generated through the active trading of the firm's stock. In that respect, going public can have a disciplinary effect.In our model, this disciplinary effect is not related to the firm facing more stringent disclosure requirements or being on the market for corporate control as a result of going public. Of course, these effects might complement ours. Furthermore, in some cases, the increase in firm value brought about by the information generation of public trading may be crucial for the venture's viability, i.e., for the entrepreneur to find it worthwhile to undertake it in the first place. Consequently, our result suggests that entrepreneurship may be enhanced by the existence of an active market for IPOs and small caps. This not only facilitates the entrepreneur's eventual exit and allows better risk-sharing [10], but also promotes efficient operating decisions.

Second, the active trading of an entrepreneurial firm's stock can enhance the incentives of its main bank or venture capitalist to engage in advising and monitoring the entrepreneur, or to be directly involved in operating decisions. To be precise, the expectation that the stock will eventually be traded is enough. This suggests for instance that an active IPO market may be key to the development of the venture capital industry. These considerations may be important for the debate over the promotion of entrepreneurship and the financing of start-ups, a prominent issue on the European agenda. In particular, the mostly American model of venture capital funding has attracted considerable attention in this context. Our theory formalizes the ideas that the existence of an active IPO market in which venture capital backed companies can be floated may be key not only to facilitate the eventual exit of the venture capitalist but also to give it incentives to increase value in earlier stages of its relation with the firm.[11]

Finally, an institutional investor's incentive to monitor the management of a large publicly traded company may be increased by the information generated by the public trading of the firm's stock, i.e., by market monitoring. This is in contrast with the view

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an information motivated trade for a liquidity trade. In other words, the result would be unchanged if the insider suffered from amnesia and forgot the level of effort just after having exerted it. In fact, in equilibrium, all agents correctly infer the insider's effort level and so there is no information asymmetry.

[10]In Chemmanur and Fulghieri (1999), compared to a private placement, going public allows for better risk sharing but results in the duplication of information acquisition costs by many investors. Note however that, in principle, risk-sharing in itself does not require that the firm's stock be publicly traded. Diversification could also be achieved in a private placement to a financial intermediary.

[11]See Black and Gilson (1998) and Jeng and Wells (1998).

that market and insider monitoring are substitutes. It is also interesting to compare this perspective to the concern that by making exit easier market liquidity reduces a large stakeholder's incentive to become involved in corporate governance (Coffee (1991), Bhide (1993)), which we do in Section 4.2.

3.2 The Decision to Go Public

Our analysis has implications for the choice of the firm's ownership structure. Admittedly, insiders can control the firm's ownership concentration only to a certain point. Indeed, once shares are publicly traded, blocks might form, dissolve or change hands.[12] Nevertheless, deliberate decisions also influence ownership concentration. For instance, the stake retained by insiders is to some extent a choice variable as is the very decision to go public.[13] In the following, we take the so-called "Founding Fathers" approach and assume that the firm's ownership concentration is decided once and for all initially.

At $t = 0$, the firm's initial owner designs its ownership structure by allocating the rights to the firm's cash flows to a large investor (e.g., himself) and dispersed investors, i.e., he chooses α to maximize total firm value. The choice of ownership structure will depend on its implications for effort by the insider and on the pricing of the issue. To simplify the latter question, we assume that all outside investors are identical at $t = 0$ but that one of them (not hit by a liquidity shock) becomes a speculator at $t = 2$.[14]

We can now determine the price for which the initial fraction $\alpha > 0$ is sold. Trading is a zero sum game: the liquidity traders' loss at $t = 2$ equals the speculator' informed trading profit. However, the speculator incurs the cost of acquiring information when doing so is profitable. Investors being ex-ante identical, they are willing to pay at $t = 0$ the expected payoff net of expected cost of acquiring information:

$$\alpha \hat{V}\left(e^*(\alpha)\right) - \int_0^{\pi^*(\alpha)} k \, dF(k) \tag{8}$$

where $e^*(\alpha)$ and $\pi^*(\alpha)$ are the equilibrium effort level and expected informed trading profits, which both depend on α.

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[12]Pagano and Roell (1998) argue that entrepreneurs perceive the loss of control over the ownership concentration and the identity of the firm's shareholders as one of the costs of going public.

[13]Brennan and Franks (1998) present evidence that in the United Kingdom, insiders use IPO underpricing to establish a dispersed ownership structure and so retain corporate control.

[14]Our paper does not focus on the pricing of IPOs. However, it is consistent with some IPO underpricing theories (see Ibbotson and Ritter (1995)). Our results would be unchanged if we introduced a rationale for IPO underpricing as long as the level of underpricing was independent of other parameters in the model. For instance, in Holmström and Tirole (1993), IPOs entail a discount that compensates future liquidity traders for their future trading with informed traders, at unfavorable terms. Taking this additional cost of going public into account would not affect our results qualitatively.

Proposition 2 *There exists a threshold λ^* such that:*

(i) for $\lambda \geq \lambda^*$, firm value is maximized when a fraction of shares are publicly traded ($\alpha > 0$) and the insider retains some shares ($\alpha < 1$);

(ii) for $\lambda \leq \lambda^*$, firm value is maximized when no shares are publicly traded ($\alpha = 0$).

This result illustrates a trade-off between two sources of incentives for the insider to increase firm value. On the one hand, other things equal, a larger stake (i.e., a lower α) provides the insider with incentives for effort. On the other hand, given that the insider might have to liquidate his stake, the liquidation price's sensitivity to his effort also affects his effort decision (Proposition 1). The optimal ownership structure balances these two effects which are antagonistic in so far as a fully concentrated ownership (i.e., the absence of public trading) might correspond to little information being public.[15] When λ is small, the second concern is less relevant and a relatively concentrated ownership is optimal. When λ is large, the incentive benefits of price informativeness dominate and so some public trading is optimal.[16]

Corollary 1 *Firms that have gone public are more likely to undertake further private or public sales of equity.*

Firms that find it optimal to go public are those whose insiders are more likely to have to liquidate or reduce their holdings in the near future (i.e., with λ large). An implication of our theory is that IPOs are preludes to further equity sales, be they public transactions such as Seasoned Equity Offerings (SEOs) or private placements. That is, firms will float a limited amount of shares ($\alpha < 1$) in IPOs, even though they are likely to sell more equity in the near future.[17] In fact, it is precisely in order to return to the market in good conditions that issuers will split their issues, a behavior documented in Jegadeesh *et al.* (1990) and Welch (1996). It is also the case that venture capitalists do not usually liquidate their stake at the IPO stage (Lerner (1994)). In that sense too, IPOs are a prelude to further equity sales.

Our argument is related to the so-called "Good-Taste-in-the-Mouth" theory suggesting that issuers underprice IPOs as part of a signal of their prospects in order to attract a

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[15]Note that we do not assume that price informativeness increases with the quantity of shares floated $(1 - \alpha)$ and stock price informativeness. All that matters is that for some $\alpha > 0$, trading reveals information that would not be available if the firm were privately held (i.e., with $\alpha = 0$).

[16]In a more general model, λ might depend on the insider's block size. For example, if the insider invests a smaller fraction of his wealth in the firm, he might be able to meet his liquidity needs by liquidating other assets.

[17]Actually, our theory is also consistent with IPOs being the prelude to debt issues. See section 3.3.

more favorable price in subsequent equity sales. In our theory, the arrival of information about the firm's value is due to the very fact of going public, not the IPO price.[18] In Zingales (1995) firms also go public to affect the terms of future sales. More specifically, going public allows to use the free-rider behavior of dispersed shareholders as a bargaining tool to extract a greater surplus in future sales of corporate control in an imperfectly competitive market. Our model does not deal with control transfers per se, although it can be applied to such events (see Faure-Grimaud and Gromb (1999)). Moreover, we assume that sales take place in a competitive market and so there is no surplus to be extracted. The dispersion of shares yields a more accurate rather than a higher price.

3.3 Inside vs. Outside Security Design

Our theory has implications for the choice between different securities and for security design. The securities held by an insider will influence his incentive to exert effort. At the same time, those traded by outsiders will induce more or less information generation. We explore these issues by extending our model to allow for securities other than equity. The model is as before except for the following.

- At $t = 4$, the insider and outsiders' claims pay $R_I(V)$ and $R_O(V)$ respectively, with $R_I(V) + R_O(V) = V$ for $V = V^L, V^H$. We impose that claims be non-decreasing in firm value, $\Delta_{R_I} \equiv R_I(V^H) - R_I(V^L) \geq 0$ and $\Delta_{R_O} \equiv R_O(V^H) - R_O(V^L) \geq 0$.[19]

- At $t = 2$, trading takes place unless there are no outside claims, i.e., unless $R_O(V^L) = R_O(V^H) = 0$.

Proceeding as in the all-equity case yields the equivalent of equations (5) and (7).

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[18]For "Good-Taste-in-the-Mouth" theories, see Ibbotson and Ritter (1995)'s survey and the references therein. Ellingsen and Rydqvist (1998) make a similar point in an adverse selection context. They also study the implications for IPO underpricing.

[19]Usually (e.g. in Innes (1990)), the restriction to non-decreasing claims is motivated as follows. With $R(V^H) < R(V^L)$, and after the realization V^L, the entrepreneur could inflate the cash flow to V^H, e.g., by borrowing secretly, and so reduce his repayment from R^L to R^H. (Strictly speaking, this does not preclude such securities from being issued. Simply, investors will not consider them at face value. They will equate them to an equivalent security with non-decreasing repayments.) Here the problem is different. This may be best illustrated in the following example. Suppose that the firm has safe debt traded. In our model, this yields an uninformative price. The informativeness of prices might be increased if the firm issued several outside securities, here the two Arrow-Debreu securities corresponding to states V^L and V^H. The payoff of the two securities add up to that of safe debt but each of them is information sensitive. Since the insider's payoff is the same as if safe debt had been issued, the above moral hazard is not an issue. Admittedly, if both claims are traded, this might affect liquidity trading because small investors can combine them to synthesize the safe claim.

Lemma 3

(i) *The outside security's price informativeness is* $p(e^a) = \frac{1}{2} F\left(\frac{(1-(e^a)^2)}{4} \cdot d \cdot \Delta_{R_O}\right)$

(ii) *The insider's effort is* $e(p^a) = \frac{\Delta_{R_I}}{2}\left[(1-\lambda) + \lambda \cdot p^a\right].$

Note that $p(e^a)$ increases with Δ_{R_O}, the information-sensitivity of the outside claims. For instance, safe debt, which corresponds to $\Delta_{R_O} = 0$, does not allow for informed trading profits because its value is insensitive to information. Instead, a more information-sensitive security makes private information more valuable for the speculator.

Again, we take the standard "Founding Fathers" perspective by assuming that the firm's capital structure is decided once and for all initially (in stage $t = 0$).[20]

Proposition 3 *There exists a threshold λ^* such that:*

(i) *for $\lambda \geq \lambda^*$, firm value is maximized with some information-sensitive outside claims (with $\Delta_{R_O} > 0$) and some value-sensitive inside claims (with $\Delta_{R_I} > 0$);*

(ii) *for $\lambda \leq \lambda^*$, firm value is maximized with no outside claims or, equivalently, with information-insensitive outside claims ($\Delta_{R_O} = 0$).*

Consider the polar case in which the insider is not subject to any risk of a liquidity shock ($\lambda = 0$). The insider's equilibrium effort level $e^* = \frac{\Delta_{R_I}}{2}$ increases with the direct incentives provided by the value-sensitivity of his claims, Δ_{R_I}. With some risk of a liquidity shock, however, the insider's incentives also increases with the price's informativeness about his effort because he might have to liquidate early. Other things equal, information collection by the speculator is fostered by a greater information-sensitivity of the traded security, i.e., by a larger Δ_{R_O}. Other things equal, the informativeness of the traded security's price increases with this security's information-sensitivity. However, under our assumptions, a more effort-sensitive claim for the insider means a less information-sensitive security for the outsiders because $\Delta_{R_I} + \Delta_{R_O} = \Delta_V$. In other words, there is only so much sensitivity to be divided up between inside and outside claims. The optimal design of the firm's securities consists thus in striking the right balance. When a liquidity shock is unlikely, price informativeness is less important than direct incentives. Instead, as a shock becomes more likely, price informativeness becomes more important and so the optimal design moves towards more information-sensitive outside claims at the cost of reducing the effort-sensitivity of the insider's claim.

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[20]In Zwiebel (1996) and Novaes and Zingales (1997), it is chosen by a self-interested manager.

Interestingly, in the latter case, a pecking order for initial offerings can arise in which, contrary to the standard pecking order hypothesis (Myers and Majluf (1984)), firms issue preferably information sensitive securities. It is noteworthy that this "reversed" pecking order, if it arises, holds for issues of publicly traded securities. Moreover, it is likely to hold for initial offers only. Indeed, once the informational role of public trading is ensured, the firm might revert to the standard pecking order for its subsequent sales of securities, whether they are public issues or private placements.

To be sure, our theory is only sketchy and, in many ways, less than robust. Most notably, we allow only for only one outside security. Moreover, the possibility that derivatives be traded could reduce the volume of securities that the firm needs to issue to generate information. Nevertheless, we believe it worthwhile to point out a perspective that, in our view, differs in important ways from most of the security design literature in that it considers the design of securities held by outsiders.[21] Building on Jensen and Meckling (1976), and in response to Modigliani and Miller's irrelevance theorem, this literature emphasizes that security design affects operating decisions. In particular, in a standard moral hazard situation, it has been argued that insiders should hold securities that are as sensitive as possible to the component of the firm's value affected by their decisions. In such a situation, firm value is higher when debt rather than equity is issued to outside investors because the insider's retained claim, i.e., levered equity, is more sensitive to his effort and so acts as a better incentive scheme.[22] Notice however that in such models, and in contrast to ours, the allocation and the design of outside claims is irrelevant. For instance, if one assumes that the funds are raised from multiple creditors, the design of the claim that each of them owns is irrelevant as long as they add up to the complement of levered equity. In other words, the Modigliani-Miller theorem applies to outside claims. In our model, this irrelevance is broken because trading affects firm value and is influenced by the design of traded securities. That is, although outsiders cannot affect operating decisions directly, the securities they hold and trade do so indirectly.

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[21]In Boot and Thakor (1992), the trading of information sensitive securities reduces the costs of adverse selection. While they focus on the design of multiple publicly traded securities, we deal with the design of both an inside (non-traded) security and a single traded security. For instance, if the firm's financing needs can be met with safe debt, this will be optimal in their framework but not necessarily in ours. In that respect, Fulghieri and Lukin (1998) is closer to our analysis, although in an adverse selection setting. In Berkovitch and Israel (1995) and Dewatripont and Tirole (1994), security design can turn outsiders into insiders when desirable, while in our model, the outsiders never affect operations.

[22]Jensen and Meckling (1976) show that issuing debt dominates issuing equity in a standard moral hazard context. Innes (1990) extends their result to show that debt dominates all other securities.

4 Extensions

This section develops extensions of the basic model. For clarity, we return to the case of an all-equity firm.

4.1 Partial Sales

We have assumed so far that in the case of a liquidity shock, the insider needs to sell his entire stake. In this section, we show that our main result extends directly to the case of partial sales. Indeed, in many cases of practical interest, the insider might only have to sell a fraction of his stake as illustrated by the following examples corresponding to interpretations of the liquidity shock that we put forward in Section 2.2.

Example 1: Insider liquidity shock. The liquidity shock may correspond to a need that is specific to the insider. For example, the insider can discover an investment opportunity outside the firm which he needs to finance by selling some, but not necessarily all, of his shares. Assume that when hit by a shock, the insider needs to raise a fixed amount K, with $K \leq (1 - \alpha)V^L$ so that it is able to do so irrespective of the selling price. The insider raises K by selling a fraction $\frac{K}{(1-\alpha)P_3}$ of his block. Note that this fraction depends on the selling price P_3.

Example 2: Corporate funding need. An alternative interpretation of the liquidity shock is that it is the firm that needs to raise new funds to finance its operations. Assume that the firm needs to raise K, with $K \leq V^L$ so it can always do so. Hence, the firm needs to issue new shares representing a fraction $\frac{K}{P_3}$ of the equity. Consequently, the insider's stake is also reduced by the same fraction. Again, note that this fraction varies with the selling price.

We now develop a general extension of the model in which the insider might have to liquidate only a fraction of his block, possibly depending on the selling price. Suppose that the insider anticipates that this price will be fully informative with probability p^a, and otherwise equal to $\hat{V}^a$, and let β^L, β^H and β denote the fraction of his stake that he needs to sell when the selling price is V^L, V^H, and $\hat{V}^a$ respectively.

Lemma 4 *The insider's effort is* $e(p^a) = (1 - \alpha)\left[1 - \beta\lambda(1 - p^a)\right]\dfrac{\Delta_V}{2}$.

As before, effort equals the productivity of effort $\frac{\Delta_V}{2}$ times $(1 - \alpha)\left[1 - \beta\lambda(1 - p^a)\right]$, which is the expected fraction of shares that the insider will either retain until $t = 4$ or sell at $t = 3$ at a price reflecting his effort. Indeed, the price is uninformative with

probability $(1 - p^a)$, in which case the insider has to sells a fraction β of his stake with probability λ.

Notice that the insider's effort choice is independent of the fractions liquidated when the price is informative, β^L and β^H. This is because the insider's payoff is then independent of the fraction liquidated. Indeed, the insider is indifferent between selling a share at $t = 3$ for $P_3 = V$, and retaining it until $t = 4$ at which stage it is worth V.

More importantly, the expression of $e(p^a)$ is the same as equation (7), in which λ has been replaced with $\beta\lambda$. Since $p(e^a)$ is unchanged (i.e., remains as in equation (5)), Proposition 1 can be extended to the case of partial sales. Extending Proposition 2 is also possible but more tricky because the fraction β will generally depend on the insider's block size, as illustrated in Example 1. The same remark holds regarding Proposition 3 with the added issue that the fraction β will generally depend on the firm's capital structure. For instance, in Example 2, the firm might issue equity only, debt only, or maintain its debt-equity ratio, which all correspond to different values of β.

4.2 Exit Decision under Asymmetric Information

So far, we have considered the insider's exit as essentially exogenous.[23] In general, however, exit is likely to be a decision. In this section, we explore the possibility for the insider to engage in strategic trading, i.e., to sell or retain his shares in order to exploit private information about the firm. Such a possibility is important in our context. Indeed, the gains from strategic trading depend on the degree of information asymmetry, which is itself affected by public trading. Hence public trading might affect the insider's incentive to liquidate his stake, which creates another channel through which public trading affect incentives. To conduct this analysis, we need to amend our basic model. First, exit should be a decision by the insider. Second, this decision should be taken under some information asymmetry. Regarding the latter feature, we assume the following.

Assumption 1: *At $t = 2$, the insider observes the realization of V.*

Recall however that the basic model does not specify whether the insider has private information. The possibility of profitable strategic trading based on information was prevented by two features. First, the insider incurring a liquidity shock or not was assumed to be public information. Hence, the insider could not make out a sale motivated

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[23]Note however that our model did not assume that the insider has to retain his stake when he is not hit by a liquidity shock.

by negative private information for one motivated by a liquidity shock. Second, when hit by a liquidity shock, the insider was assumed to have to sell his stake irrespective of the liquidation price. Hence, he could not strategically retain his stake when judging the liquidation price to be too low. We consider two extensions of the model, in each of which one of the two assumptions above is relaxed.

4.2.1 Unobserved Liquidity Shock

Assumption 2: *Whether the insider incurs a shock is not publicly observed at $t = 3$.*

At $t = 4$, buyers of the insider's shares need not know whether his selling is motivated by a liquidity shock, or by negative information. Suppose that the insider anticipates that P_3 will be fully informative with probability p^a, and otherwise equal to $\hat{V}^a > V^L$.

Lemma 5 *The insider's effort is*

$$e(p^a, \hat{V}^a) = (1 - \alpha) \left([1 - \lambda(1 - p^a)] \frac{\Delta_V}{2} - (1 - \lambda)(1 - p^a) \frac{\hat{V}^a - V^L}{2} \right) \qquad (9)$$

Compared to equation (7), the additional term is due to the insider anticipating that when he observes $V = V^L$ and the price is uninformative, he will be able to sell for $\hat{V}^a$ shares worth V^L even absent a liquidity shock. The expression of $p(e^a)$ is unchanged (i.e., remains as in equation (5)). It is then possible to determine the equilibrium effort level e^* and price informativeness p^*, defined by $p^* = p(e^*)$, $e^* = e(p^*, \hat{V}^*)$ and $\hat{V}^* = \hat{V}(e^*)$. Extending Proposition 1 is not totally straightforward for two reasons. First, $\hat{V}^a$ affects the insider's choice of effort. Second, the additional term is decreasing in λ. Nevertheless, it can be shown that Proposition 1 still holds (see Appendix E).

4.2.2 Exit as a Decision

In this section, we relax the assumption that when hit by a liquidity shock, the insider has to sell irrespective of the liquidation price. In particular, the insider can decide to retain his stake when the selling price is too low. That is, when $V = V^H$, the insider trades off the benefits that he derives from exiting against the cost of selling at a discount. To analyze this trade-off, we need to model explicitly the benefits of exit.

Assumption 2': *At $t = 3$, there are no liquidity shocks but the insider uncovers an alternative investment project outside the firm with an exogenous return $(1 + \rho)$, with ρ drawn in $(0, +\infty)$ from a known distribution. He can then decide to liquidate*

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*his stake and invest the proceeds in this alternative project. The insider's decision
to sell and the nature of the alternative (i.e., the value of ρ) are publicly observed.*[24]

Now, when taking the decision to sell or retain his stake, the insider knows the true
firm value $V = V^\sigma$, with $\sigma \in \{L, H\}$. The insider values his stake at $(1 - \alpha)V^\sigma$, while
liquidating a fraction $(1 - \alpha)$ of shares at price P_3 to exploit the outside opportunity
yields $(1 + \rho)(1 - \alpha)P_3$. Hence, the insider chooses to liquidate if and only if

$$\rho P_3 + [P_3 - V^\sigma] > 0 \tag{10}$$

The first term captures the attractiveness of the outside investment opportunity. The
second term is the difference between the stake's liquidation price and its actual value. A
positive difference corresponds to overpricing and makes exit more attractive. Conversely,
a negative difference corresponds to underpricing and makes exit less attractive.[25]

If P_2 is informative, then $P_3 = P_2 = V^\sigma$ and the insider sells at $t = 3$. The case
of an uninformative price P_2 is more involved because the insider's decision to sell or
retain his stake can be informative about firm value. Consequently, the liquidation price
P_3 will depend on (the market's beliefs about) the insider's strategy. Although multiple
equilibria can arise, they all share the same following property. If P_2 is uninformative,
the insider's stake is underpriced when $V = V^H$ and weakly overpriced when $V = V^L$.
The insider is thus at least as eager to sell when $V = V^L$ as when $V = V^H$. This implies
that the liquidation price P_3 cannot exceed P_2, i.e., a sale cannot be a good news about
firm value. Hence, an uninformative P_2 makes the insider more reluctant to exit when
$V = V^H$. This is a manifestation of the lemon's problem. To simplify the discussion, for
the values of ρ for which multiple equilibria exist, we (somewhat arbitrarily) select the
equilibria in which exit is most likely.

Lemma 6

(*i*) *Under an informative price P_2, the insider exits in both states;*

(*ii*) *Under an uninformative price P_2,*

- *the insider exits when $V = V^L$;*
- *the insider exits when $V = V^H$ if and only if $\rho > \bar{\rho}(P_2) \equiv \frac{V^H - P_2}{P_2}$.*

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[24]We assume that he cannot wait to liquidate his stake Note that we also maintain the assumption
that the insider has to sell all or none of his shares. In particular, the insider cannot use the fraction
of shares that he sells as a signal. We analyze the latter case in Appendix H and find our results to be
robust.

[25]The basic model is nested into this one. Exogenous liquidity shocks are equivalent to the investment
opportunity being sufficiently valuable (i.e., ρ large enough) to warrant liquidation irrespective of P_3.

This gives the impact of an increase in p and P_2 on the exit probability in both states. When $V = V^L$, condition (10) is satisfied for any $P_3 \geq V^L$ and so the insider exits irrespective of whether P_2 was informative or not. Consequently, the exit probability is unaffected by an increase in p. When $V = V^H$, following an uninformative P_2, the insider chooses whether to retain his stake or sell it at a discount, a trade-off which would not arise with an informative price. Thus, a greater price informativeness p or a higher selling price P_2 alleviate the lemon's problem and therefore encourages exit.

Corollary 2 *Other things equal, following an increase in p or P_2:*

    (i)   the exit probability when $V = V^H$ increases strictly;

    (ii)   the exit probability when $V = V^L$ is unchanged.

An increase in the price informativeness function leads to an increase in effort. Indeed, a higher p alleviates the lemon's problem faced by the insider when $V = V^H$, making this state more attractive. Conversely, informative prices reduce the insider's ability to sell overpriced shares when $V = V^L$, making this state less attractive. Both effects encourage effort. The effect on the unconditional exit probability is two-fold. First, the probability of exit is (weakly) increased in each state. Second, as effort goes up $V = V^H$ is more likely, which reduces the probability of exit as exit is less likely when $V = V^H$ than when $V = V^L$. The combined effect is ambiguous.

Proposition 4 *Following an increase in the price informativeness function,*

    (i) the unconditional exit probability can either increase or decrease;

    (ii) the insider's equilibrium level of effort increases.

Two particularly noteworthy features can be related to the liquidity-control trade-off literature. Following an increase in the price informativeness function, the block is more liquid in the following sense. When $V = V^H$, selling is less likely to involve a discount (i.e., p^* increases), and when it does, the discount is smaller. In that respect, an increase in the price informativeness corresponds to an increase in the liquidity of insider's stake. One may be concerned that this will result in exit being more frequent, and eventually in reduced incentives for the insider. However, the proposition shows that although an increase in the price informativeness makes exit more likely in all states (Corollary 2), this does not necessarily imply an increase in the unconditional probability of exit. Again, this is due to the feedback effect on effort an increase of which makes it more likely that states in which the block is less liquid are reached. Moreover, remarkably enough, effort increases even in the case in which the exit probability increases.

5 Conclusion

This paper proposes that the information generated by public trading can enhance a large shareholder's incentives to undertake value increasing activities which are privately costly. This information makes the liquidation value of the insider's stake more sensitive to his activity, which improves his incentives. This insight has a number of applications to entrepreneurship, for the financing and monitoring of start-ups, and for institutional investors' activism. Additionally, although going public reduces the insider's stake, it may ultimately increase his incentives when liquidation is more likely, or more substantial. Similarly, when firms chose their capital structure, they might issue publicly traded securities that are information-sensitive for their trading to generate information. Thus a reversed pecking order might arise for initial offerings.

The paper has abstracted from a number of interesting issues. For instance, in the section on IPOs and security design, the market mechanism has been implicitly assumed to generate unique information. While this might not seem unreasonable, some foundation for this assumption would be useful. Second, we have not considered alternative ways in which the insider can deal with liquidity shocks. The insider might be able to take actions that affect the likelihood and the extent of liquidity shocks (i.e., the parameters λ and β in our model) such as tilting the firm's operations to ensure that most financing needs be met with internal funds. Another possibility is to ensure that insiders are institutions designed to have low λ and β. Such institutions may be particularly important when the market for IPOs and small caps is less developed. Conversely, the existence of such institutions may reduce the need to develop such markets. Finally, we have not considered the firm's fate following the insider's exit. When this is taken into account, whether exit results in the dispersion of the insider's block, or in its transfer to a new large shareholder may become relevant. We hope to have provided a framework that will prove useful to address these and other issues.

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A Proof of Proposition 1

The equilibrium is determined by the intersection of $p(e)$ which is decreasing, and $e(p)$ which is increasing. A change in parameters that induces an upward shift of one of $p(\cdot)$ or $e(\cdot)$, and a weakly upward shift of the other results in higher values of e^*. Increasing d or shifting F towards lower values of k in the sense of FOSD shifts $p(\cdot)$ upwards without affecting $e(\cdot)$. Increasing Δ_V shifts both $p(\cdot)$ and $e(\cdot)$ upwards. Decreasing λ shifts $e(\cdot)$ upwards without affecting $p(\cdot)$.

B Proof of Proposition 2

Let $e^*(\lambda, \alpha)$ and $\pi^*(\lambda, \alpha)$ denote the equilibrium effort and speculator expected profit. The value of the firm at $t = 0$ is the sum of the block's value (obtained from equations (6) and (7)) and the value of dispersed shares (obtained from equation (8)).

$$\hat{V}(e^*(\lambda, \alpha)) - c(e^*(\lambda, \alpha)) - \int_0^{\pi^*(\lambda, \alpha)} k dF(k) = g(e^*(\lambda, \alpha)) - \int_0^{\pi^*(\lambda, \alpha)} k dF(k) \qquad (11)$$

where $g(\cdot) \equiv \hat{V}(\cdot) - c(\cdot)$ and $g'' < 0$ and $g' > 0$ over $[0, \Delta_V/2]$. Assume that for some λ_1, V_0 is not maximized for $\alpha = 0$, i.e. there exists $\alpha_1 > 0$ such that

$$g(e^*(\lambda_1, \alpha_1)) - g(e^*(\lambda_1, 0)) > \int_0^{\pi^*(\lambda_1, \alpha_1)} k dF(k) \qquad (12)$$

The proof consists in showing that for $\lambda_2 > \lambda_1$, firm value is not maximized for $\alpha = 0$. We have $e^*(\lambda_1, \alpha_1) > e^*(\lambda_2, \alpha_1)$ (Proposition 1(ii)), which implies $\pi^*(\lambda_1, \alpha_1) < \pi^*(\lambda_2, \alpha_1)$. Hence, given that $\pi^*(\lambda_1, 0) = \pi^*(\lambda_2, 0) = 0$, the continuity of $\pi(\cdot)$ implies the existence of $\alpha_2 \in (0, \alpha_1)$ such that $\pi^*(\lambda_1, \alpha_1) = \pi^*(\lambda_2, \alpha_2)$, which implies $p^*(\lambda_1, \alpha_1) = p^*(\lambda_2, \alpha_2)$. Equation (7) implies

$$e^*(\lambda, \alpha) - e^*(\lambda, 0) = (1 - \alpha)\frac{\Delta_V}{2} \cdot \lambda \cdot p^*(\lambda, \alpha) \qquad (13)$$

which, given that $p^*(\lambda_1, \alpha_1) = p^*(\lambda_2, \alpha_2)$, $\alpha_2 < \alpha_1$ and $\lambda_2 > \lambda_1$, implies

$$e^*(\lambda_2, \alpha_2) - e^*(\lambda_2, 0) > e^*(\lambda_1, \alpha_1) - e^*(\lambda_1, 0) \qquad (14)$$

Noticing that g is concave and $g'(e^*(\lambda, \alpha)) > 0$, i.e., effort is strictly less than the optimal level (unless $\lambda = \alpha = 0$), and that $e^*(\lambda_2, 0) < e^*(\lambda_1, 0)$ (Proposition 1(ii)), we have

$$g(e^*(\lambda_2, \alpha_2)) - g(e^*(\lambda_2, 0)) \;\; > \;\; g(e^*(\lambda_1, \alpha_1)) - g(e^*(\lambda_1, 0)) \qquad (15)$$

$$> \int_0^{\pi^*(\lambda_1,\alpha_1)} k\,dF(k) \text{ by equation (12)} \tag{16}$$

$$> \int_0^{\pi^*(\lambda_2,\alpha_2)} k\,dF(k) \text{ because } \pi^*(\lambda_2,\alpha_2) = \pi^*(\lambda_1,\alpha_1) \tag{17}$$

We now show that a sufficient condition for $\lambda^* < 1$ is the assumption that for all e, $\pi(.,\alpha) \equiv \frac{1-e^2}{2} d(\alpha)\Delta_V$ is continuous in α and $\pi(.,0) = 0$. Notice that then there exists η, ν such that $\forall e$, if $\alpha < \nu$, then $\pi(e,\alpha) < \eta$. Consider now the case of an insider with $\lambda = 1$ and with an arbitrarily small fraction $\alpha \leq \varepsilon$ of the shares traded. We want to show that:

$$g(e^*(1,\alpha)) - g(e^*(1,0)) > \int_0^{\pi^*(1,\alpha)} k\,dF(k) \tag{18}$$

which is equivalent to:

$$\frac{e^*(1,\alpha)}{2}[\Delta_V - e^*(1,\alpha)] > \pi^*(1,\alpha)F(\pi^*(1,\alpha)) - \int_0^{\pi^*(1,\alpha)} F(k)\,dk \tag{19}$$

from $e^*(1,\varepsilon) = (1-\varepsilon)\frac{F(\pi^*(1,\varepsilon))}{2}\Delta_V$, a sufficient condition is

$$\frac{\Delta_V^2}{4}\left[1 - (1-\varepsilon)\frac{F(\pi^*(1,\varepsilon))}{2}\right] > \pi^*(1,\varepsilon) \tag{20}$$

which is true because $\frac{\Delta_V^2}{4} > 0$.

C Proof of Proposition 3

Analogous to the proof of Proposition 2 with firm value being

$$\hat{V}(e^*(\Delta_{R_I})) - c(e^*(\Delta_{R_I})) - \int_0^{\pi^*(\Delta_{R_O})} k\,dF(k) \tag{21}$$

D Proof of Lemma 4

Let V^σ, with $\sigma \in \{L, H\}$, denote the firm's true value. Under an informative price, i.e., $P_3 = V^\sigma$, the insider's expected payoff is

$$\lambda\left[(1-\alpha)(1-\beta^\sigma)V^\sigma + (1-\alpha)\beta^\sigma V^\sigma\right] + (1-\lambda)(1-\alpha)V^\sigma = (1-\alpha)V^\sigma \tag{22}$$

while under an uninformative price, i.e., $P_3 = \hat{V}^a$, his expected payoff is

$$\lambda\left[(1-\alpha)(1-\beta)V^\sigma + (1-\alpha)\beta\hat{V}^a\right] + (1-\lambda)(1-\alpha)V^\sigma = (1-\alpha)\left[(1-\lambda\beta)V^\sigma + \lambda\beta\hat{V}^a\right] \tag{23}$$

Given that he anticipates the price to be informative with probability p^a, his expected payoff conditional on V^σ being the true value is

$$(1 - \alpha) \left[V^\sigma - \lambda\beta(1 - p^a)(V^\sigma - \hat{V}^a) \right] \tag{24}$$

Overall, the insider chooses e to maximize

$$-c(e) + \frac{1 + e}{2}(1 - \alpha) \left[V^H - \lambda\beta(1 - p^a)(V^H - \hat{V}^a) \right] \tag{25}$$
$$+ \frac{1 - e}{2}(1 - \alpha) \left[V^L - \lambda\beta(1 - p^a)(V^L - \hat{V}^a) \right]$$

Taking the FOC completes the proof.

E Proof of Lemma 5 and Proposition 1 with Unobserved Liquidity Shocks

Because $\hat{V}^a > V^L$, the insider anticipates that he will exit when $V = V^L$ even absent a liquidity shock. Hence, he chooses e to maximize:

$$-c(e) + \frac{1 + e}{2}(1 - \alpha) \left[V^H - \lambda(1 - p^a)(V^H - \hat{V}^a) \right] \tag{26}$$
$$+ \frac{1 - e}{2}(1 - \alpha) \left[V^L - \lambda\beta(1 - p^a)(V^L - \hat{V}^a) - (1 - \lambda)\beta(1 - p^a)(V^L - \hat{V}^a) \right]$$

Taking the FOC proves the lemma. To prove Proposition 1, consider the equilibrium as defined by $p^* = p(e^*)$, $e^* = e(p^*, \hat{V}^*)$ and $\hat{V}^* = V^L + \frac{1 + e^*}{2}\Delta_V$. In other words, the equilibrium is defined by the intersection of $p(e)$ defined by equation (5) and of $e(p)$ defined as the solution to the equation

$$e(p^a) = (1 - \alpha) \left([1 - \lambda(1 - p^a)] \frac{\Delta_V}{2} - (1 - \lambda)(1 - p^a)\frac{\hat{V}(e(p^a)) - V^L}{2} \right) \tag{27}$$
$$= (1 - \alpha) \left([1 - \lambda(1 - p^a)] - (1 - \lambda)(1 - p^a) \left(\frac{1 + e(p^a)}{2} \right) \right) \frac{\Delta_V}{2} \tag{28}$$

which is equation (9) where $\hat{V}^a$ was replaced with $\hat{V}(e(p^a))$. To prove Proposition 1(i) as in Appendix A, one needs to show that $e(p)$ is increasing which it is. Indeed,

$$e'(p^a) = (1 - \alpha) \left(\lambda\frac{\Delta_V}{2} + (1 - \lambda) \left(\frac{1 + e(p^a)}{2} \right) - (1 - \lambda)(1 - p^a)\frac{e'(p^a)}{2} \right) \frac{\Delta_V}{2} \tag{29}$$

so that

$$e'(p^a) = \frac{\lambda\frac{\Delta_V}{2} + (1 - \lambda) \left(\frac{1 + e(p^a)}{2} \right)}{\frac{1}{(1 - \alpha)\frac{\Delta_V}{2}} + (1 - \lambda)(1 - p^a)\frac{\Delta_V}{4}} > 0 \tag{30}$$

29

We now prove Proposition 1(*ii*). In equilibrium,

$$e^* = (1-\alpha)\left(\left[1-\lambda(1-p^*)\right]-(1-\lambda)(1-p^*)\left(\frac{1+e^*}{2}\right)\right)\frac{\Delta_V}{2} \qquad (31)$$

Given that $\dfrac{\partial p^*}{\partial e^*} < 0$, taking the derivative with respect to λ implies (after rearrangement):

$$\frac{\partial e^*}{\partial \lambda} = \frac{-(1-p^*)\left(\dfrac{1-e^*}{2}\right)}{\dfrac{1}{(1-\alpha)\frac{\Delta_V}{2}} - \lambda\left(\dfrac{\partial p^*}{\partial e^*}\right) - (1-\lambda)\left(\dfrac{\partial p^*}{\partial e^*}\right)\left(\dfrac{1+e^*}{2}\right) + (1-\lambda)(1-p^*)\dfrac{1}{2}} < 0 \quad (32)$$

F   Proof of Lemma 6

Let $x(\sigma, \rho)$ (resp. $y(\sigma, \rho)$) denote the probability that the insider sells his stake at $t = 3$ given σ and ρ when the stock price at $t = 2$ is informative (resp. uninformative). We know $x(\sigma, \rho) = 1$ because $\rho > 0$. We also know that $y(L, \rho) \geq y(H, \rho)$. Moreover, if $y(H, \rho) \in (0, 1)$ then $y(L, \rho) = 1$ because if condition (10) holds (even weakly) for $\sigma = H$, it does strictly for $\sigma = L$. In equilibrium, the price at which the insider can sell his stake when P_2 is uninformative is:

$$P_3(\rho) = V^L + \frac{\left(\frac{1+e}{2}\right) \cdot y(H, \rho)}{\left(\frac{1+e}{2}\right) \cdot y(H, \rho) + \left(\frac{1-e}{2}\right)}\Delta_V \qquad (33)$$

When $y(H, \rho)$ increases from 0 to 1, $P_3(\rho)$ increases from V^L to P_2. Consequently, for $\rho < \frac{V^H - V^L}{V^L}$ (resp. $\rho > \frac{V^H - P_2}{P_2}$) condition (10) is never (resp. always) satisfied for $\sigma = H$ in equilibrium. There remains to determine $y(H, \rho)$ for $\rho \in [\frac{V^H - P_2}{P_2}, \frac{V^H - V^L}{V^L}]$. For each value of ρ, three Perfect Bayesian Equilibria co-exist, with three corresponding values of $y(H, \rho)$, and sustained by different investor beliefs following a sale.

Pooling equilibrium: If $y(H, \rho) = 1$ then $P_3(\rho) = P_2$. This is indeed an equilibrium as condition (10) holds for $\sigma = H$ and $P_3 = \hat{V}$, when $\rho \geq \frac{V^H - P_2}{P_2}$. This is the equilibrium we arbitrarily select.

Fully separating equilibrium: If $y(H, \rho) = 0$ then $P_3(\rho) = V^L$. This is indeed an equilibrium as condition (10) is violated for $\sigma = H$ and $P_3 = V^L$, when $\rho \leq \frac{V^H - V^L}{V^L}$.

Semi-separating equilibrium: In such an equilibrium, condition (10) holds with equality for $\sigma = H$. This determines a price $P_3(\rho)$ given by

$$\rho \cdot P_3(\rho) + (P_3(\rho) - V^H) = 0 \qquad \text{or} \qquad P_3(\rho) = \frac{V^H}{1+\rho} \qquad (34)$$

This in turn determines a unique value for $y(H, \rho)$ given

$$V^L + \frac{\left(\frac{1+e}{2}\right) \cdot y(H, \rho)}{\left(\frac{1+e}{2}\right) \cdot y(H, \rho) + \left(\frac{1-e}{2}\right)} \Delta_V = P_3(\rho) \qquad \text{or} \qquad y(H, \rho) = \frac{\left(\Delta_V - \frac{\rho V^H}{1+\rho}\right)}{\frac{\rho V^H}{1+\rho}} \left(\frac{1-e}{1+e}\right)$$

$$(35)$$

G   Proof of Proposition 4

Anticipating p^a and $\hat{V}^a$, the insider anticipates that he will exit if and only if the price is informative or $\rho(\hat{V}^a) > \frac{V^H - \hat{V}^a}{\hat{V}^a}$ and thus chooses e to maximize

$$-c(e) + p^a (1 - \alpha) \hat{V}(e)(1 + \mathrm{E}\,[\rho]) \qquad (36)$$
$$+ (1 - p^a)(1 - \alpha) \left\{ \int_0^{\bar{\rho}(\hat{V}^a)} \left[\frac{1+e}{2} V^H + \frac{1-e}{2} V^L (1 + \rho) \right] dG(\rho) + \int_{\bar{\rho}(\hat{V}^a)}^{+\infty} \hat{V}^a (1 + \rho) dG(\rho) \right\}$$

where G is the c.d.f. of ρ's distribution. Hence,

$$\begin{aligned} e(p^a) &= p^a (1 - \alpha) \frac{\Delta_V}{2} (1 + \mathrm{E}\,[\rho]) \\ &\quad + (1 - p^a)(1 - \alpha) \frac{1}{2} G(\bar{\rho}(\hat{V}^a)) \left(V^H - V^L \left(1 + \mathrm{E}\left[\rho \mid \rho \leq \bar{\rho}(\hat{V}^a) \right] \right) \right) \quad (37) \end{aligned}$$

which is increasing in p^a because

$$\begin{aligned} e'(p^a) &= (1 - \alpha) \frac{\Delta_V}{2} (1 + \mathrm{E}\,[\rho]) - (1 - \alpha) \frac{1}{2} G(\bar{\rho}(\hat{V}^a)) \left(V^H - V^L (1 + \mathrm{E}\left[\rho \mid \rho \leq \bar{\rho}(\hat{V}^a) \right]) \right) \quad (38) \\ &= (1 - \alpha) \frac{\Delta_V}{2} \left[(1 + \mathrm{E}\,[\rho]) - G(\bar{\rho}(\hat{V}^a)) \left(1 - \frac{V^L}{\Delta_V} \mathrm{E}\left[\rho \mid \rho \leq \bar{\rho}(\hat{V}^a) \right] \right) \right] \quad (39) \\ &> (1 - \alpha) \frac{\Delta_V}{2} \left[(1 + \mathrm{E}\,[\rho]) - G(\bar{\rho}(\hat{V}^a)) \right] > 0 \quad (40) \end{aligned}$$

Recall that the equilibrium is determined by the intersection of $p(e)$ which is decreasing, and $e(p)$ which is increasing. A increase in the price informativeness function induces a weakly upward shift of $e(\cdot)$, and thus results in higher values of both e^* and p^*.

This has no effect on exit when $V = V^L$ because $x(L, \rho) = y(L, \rho) = 1$ for all ρ. When $V = V^H$, however, exit is more likely for two reasons. First, the increase in e^* increases $\bar{\rho}(e^*)$: when the price is uninformative, the insider exits for more values of ρ. Second, the insider is also more likely to exit for $\rho < \bar{\rho}(e^*)$.

An increase of the price informativeness function has an ambiguous effect on the equilibrium unconditional exit probability

$$1 - (1 - p^*) \frac{1 + e^*}{2} G(\bar{\rho}(e^*)) \qquad (41)$$

H Signalling

We consider the possibility that the insider uses partial liquidation as a signal. Indeed, retaining shares is costly because $\rho > 0$, and is clearly more so when $V = V^L$ than when $V = V^H$. In a fully separating equilibrium in which the insider sells $\beta^L = 1$ if $V = V^L$ and $\beta^H < 1$ if $V = V^H$, the following incentive compatibility conditions must hold:

$$\text{When } V = V^H: \quad (1+\rho)\beta^H V^H + (1-\beta^H)V^H \geq (1+\rho)V^L \tag{42}$$

$$\text{When } V = V^L: \quad (1+\rho)V^L \geq (1+\rho)\beta^H V^H + (1-\beta^H)V^L \tag{43}$$

Hence, there exist an equilibrium for all $\beta^H \in [\frac{(1+\rho)V^L - V^H}{\rho V^H}, \frac{\rho V^L}{(1+\rho)V^H - V^L}]$. There is also a continuum of pooling equilibria, in which the insider sells a fraction β irrespective of V. As is standard in such signaling games, only the "best" separating equilibrium survives the Cho-Kreps intuitive criterion, i.e., $\beta^H = \frac{\rho V^L}{(1+\rho)V^H - V^L}$. Note that this fraction increases with ρ, as a better outside option increases the cost of retaining shares, and hence the cost of the signal, making it easier to separate. We have:

Proposition 5 *Following an increase in the price informativeness function,*
  (i) the insider's equilibrium level of effort increases;
  (ii) the average fraction liquidated by the insider can either increase or decrease.

The insider's expected payoff is then:

$$-c(e) + p^a(1-\alpha)\hat{V}(e)\left(1 + \mathrm{E}\left[\rho\right]\right) + (1 - p^a)(1-\alpha) \tag{44}$$
$$\left[\left(\frac{1+e}{2}\right)\int_0^{+\infty}\left[(1+\rho)\beta^H(\rho)V^H + (1 - \beta^H(\rho))V^H\right]dG(\rho) + \frac{1-e}{2}V^L\left(1 + \mathrm{E}[\rho]\right)\right]$$

Proceeding as before, effort can be shown to increase with p^a. Hence, $p(e^a)$ remaining as in equation (5), point (i) is proved. Moreover, price informativeness has two antagonistic effect on the average fraction liquidated by the insider, $\mathrm{E}[\beta] = \Pr\left[V = V^L\right] + \left(1 - (1 - p^*)\cdot\left(1 - \mathrm{E}\left[\beta^H\right]\right)\right)\Pr\left[V = V^H\right]$. On the one hand, p^* increases leading the insider to liquidate more shares conditional on $V = V^H$ because $\mathrm{E}\left[\beta^H\right] < 1$. On the other hand, the increased effort increases $\Pr\left[V = V^H\right]$ which reduces the overall probability of exit because $\mathrm{E}\left[\beta^H\right] < 1$. The overall effect can be shown to be ambiguous.