Public Trading and Private Incentives

Antoine Faure-Grimaud
London School of Economics, FMG, and CEPR London

Denis Gromb
London Business School, and CEPR London

This article 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 are derived for the decision to go public, capital structure, and security design.

We consider a firm with a large shareholder and otherwise dispersed shares, which are publicly traded. The block holder is an *insider* in the sense that he can undertake actions that directly affect the firm's value. Moreover, the insider might not take all value-increasing actions, as at least some of them involve a private cost for him. In other words, there is an incentive problem. The article'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 how a controlling shareholder allocates corporate resources.

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 to his equity stake, a larger stake increases the benefit to him from 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, that is, outsiders.

We are grateful for helpful discussions with Lucian Bebchuk, Patrick Bolton, Laurent Germain, Dirk Hackbarth, Arvind Krishnamurthy, Jean-Charles Rochet, Jean Tirole, and Raman Uppal and for comments from Mike Fishman (the editor), two anonymous referees, and seminar participants at Berkeley, Besançon, Chicago, Duke, Exeter, the Financial Markets Group's conference on "Market Liquidity," Gersenzee, Harvard, HEC, INSEAD, London Business School, LSE, MIT, Montreal, Northwestern University, Oxford, Princeton, Stanford, Stockholm, Tilburg, Toulouse, UBC, and University of Maryland. All remaining errors are our own. An earlier version was circulated under the title "Trading, Voice and Exit over the Firm's Life Cycle." Address correspondence to Antoine Faure-Grimaud, Department of Accounting and Finance and FMG, London School of Economics and CEPR, Houghton Street, London WC2A 2AE, UK. E-mail: A.Faure-Grimaud@lse.ac.uk.

The Review of Financial Studies Vol. 17, No. 4
doi:10.1093/rfs/hhh002 Advance Access publication April 2, 2004

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 actions 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. First, it suggests that public trading can increase the incentives of large shareholders. 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 offerings (IPOs).

The active monitoring and advising incentives of a firm's close financier may also be increased by 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.

In a similar manner, an institutional investor's incentive to oversee firm's management may be increased by the information generated by public trading of the firm's stock, that is, by market monitoring. This perspective is in contrast with the view that market monitoring makes large shareholders redundant as monitors, that is, 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), Bhidé (1993)].

A second type of implication is that 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 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 whose value is closely tied to firm value, that is, a *value-sensitive* stake. For instance, better incentives may be provided by equity than by a safe debt claim. On the other hand, if the trading of the firm's securities is to generate some information, their value should depend at least to some extent on that information, that is, 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)]. One interesting aspect of this theory of capital structure and security design is that it deals with the securities of both insiders and outsiders.

We also explore the possibility for the insider to engage in strategic trading, that is, 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 affects 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 article is related to several strands of literature.

One of these examines the potential trade-off between liquidity and control. Coffee (1991) and Bhidé (1993) propose that market liquidity reduces a large stakeholder's incentives to monitor by increasing the attractiveness of the exit option. Instead, modeling liquidity as the ability to hide one's trade, Kyle and Vila (1991), Kahn and Winton (1998), Maug (1998), and Noe (2002) argue that it can foster the emergence of active investors in the first place. Indeed, the stock's liquidity allows active investors 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).

The idea that stock price information matters to insiders is also in Fishman and Hagerty (1989). Absent incentive issues, they show that a firm may want to increase stock price efficiency by disclosing information. A more informative stock price allows firms to reap more of the benefits of efficient investment decisions. In our model, increasing stock price informativeness requires floating some shares, which has an incentive cost.

Formally, part of our argument is similar to Diamond and Verrecchia (1982), and especially Holmström and Tirole (1993), where the information generated by public trading is used to improve the incentive contracts of employed managers. In our article, 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, that is not only about exogenous noise.

Close to ours is Aghion, Bolton, and Tirole's (2004) analysis of the design of exit options for active monitors. In both our models, the insider's exit reduces his incentives, and this effect is mitigated by information. Moreover, the incentives of the insider and of the potential information producers (i.e., speculators) are considered jointly. Our articles differ in several respects. First, we model explicitly information production as arising from public trading of the firm's securities. This underlies our analysis of the going-public decision. Second, we consider the possibility for the insider's exit decision to convey information about firm value, which affects incentives. The main difference, however, is Aghion, Bolton, and Tirole's focus on the design of exit options. They assume that the exit decision itself can be contracted upon initially, and characterize the optimal arrangement. Instead, we do not consider contracts governing exit directly.

Studying the effect of public trading as a by-product of privatization, Faure-Grimaud (2002) examines how stock price information 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 article.

The article proceeds as follows. Section 1 presents the model. Section 2 relates market trading to an insider's incentives and studies the going-public decision. It also analyzes the role of security design. Section 3 extends the main result in a setting allowing for strategic trading by the insider. Section 4 concludes. Proofs are in the appendix.

1. The Model

1.1 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 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 is realized but is not publicly observed until $t = 4$. Unless the firm is privately held ($\alpha = 0$), trading occurs between liquidity traders, a speculator and a market maker, and a price is formed in a simplified model à la Kyle (1985). We assume that the insider cannot trade anonymously.

- The aggregate demand of the liquidity traders is $d_L \in \{-d, 0\}$, with $d > 0$ and $\Pr[d_L = 0] = \Pr[d_L = -d] = 1/2$. In general, the volatility

[1] See Burkart, Gromb, and Panunzi (1997) for a model of the source and limits of a block holder's effective control.

[2] This formulation implies that a higher effort not only increases the first moment of the value's distribution, but also decreases its second moment. Without our restriction, effort would first increase and then decrease the variance of value so that there would still be a parameter region where our results hold. We also assume throughout that the parameter values are such that the equilibrium level of effort is always in (0,1).

of the demand originating from liquidity 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, that is, $d(0) = 0$, and that $d(\alpha) > 0$, $\forall \alpha > 0$. We also assume that $d(\alpha)$ is continuous over [0,1], differentiable in the neighborhood of $\alpha = 0$ and $d(0) > 0$, and $(\alpha) > 0$.

- The speculator S can acquire information at a cost k. This cost is drawn from a known distribution on $(0, +\infty)$ with c.d.f. F, density $f(\cdot) > 0$, and publicly observed before S decides whether to become informed.[3] By choosing to incur k, the speculator observes the realization of V immediately (at $t = 2$). 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

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

At $t = 3$, the insider may be hit by a liquidity shock. For simplicity, he has to sell all his shares with probability λ. Allowing partial sales does not affect the results [Faure-Grimaud and Gromb (2000)]. Otherwise he may, but need not do so. We rule out secret trading by assuming that the insider's trade is always observable. For now, we also assume that his liquidity shock itself is publicly observed. We do not need to specify here whether the insider has any private information.[5] Section 3 deals with strategic trading, when market participants do not know the insider's motive for trading. Finally, we assume that the buyers have access to only public information, 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.

[3] The assumption that k is publicly observed is only needed when liquidity trade orders can be zero in equilibrium. When no trade occurs, the market maker needs to infer whether it is because S is not informed and stays out of the market or because S is informed and decides not to trade. If liquidity traders always trade some shares, this ambiguity is resolved and whether k is observable is irrelevant [see Faure-Grimaud and Gromb (2000)].

[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 separating perfect bayesian equilibrium would fail to exist because liquidity trades are drawn from a discrete set.

[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.

1.2 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 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, Gromb, and Panunzi (1998)]. If the entrepreneur incurs a liquidity shock, he has to sell his stake in a secondary public offering (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.

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 that he wants to exploit by selling his stake. For instance, a venture capitalist may need to liquidate its stake in a firm to 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. For simplicity, we analyze the case of an extreme dilution, that is, down to zero, but our results extend directly to less extreme cases in which the liquidity shock results in the insider selling a smaller fraction of his stake. This encompasses the case of a firm issuing equity [Faure-Grimaud and Gromb (2000)].

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 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 of the insider 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 he can later participate in private sales.[6] 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.

1.3 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, that is, $\alpha > 0$. The informativeness of the stock price in equilibrium 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 reveals fully his information.

If the speculator is informed, he will submit $d_S = 0$ when $V = V^H$ and $d_S = -d$ when $V = V^L$. Indeed, any other order would be identified by the market maker as originating from the speculator, thus revealing the latter's information and ruining his opportunity to realize a trading profit. Moreover, submitting $d_S = -d$ ($d_S = 0$) when $V = V^H$ ($V = V^L$) 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 $d_S \neq d_L$, then 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:

		$V = V^L$	$V = V^H$
Pr $\frac{1}{2}$, $d_L = 0$	Demands (d_S, d_L)	$(-d, 0)$	$(0, 0)$
	Stock price P_2	$\hat{V}(e^a)$	V^H
Pr $\frac{1}{2}$, $d_L = -d$	Demands (d_S, d_L)	$(-d, -d)$	$(0, -d)$
	Stock price P_2	V^L	$\hat{V}(e^a)$

[6] 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 $t = 1$.

The speculator's expected profit from informed trading is thus

$$\pi(e^a) = \frac{1}{2} \cdot \frac{(1 - e^a)}{2} \cdot d \cdot [\hat{V}(e^a) - V^L]. \tag{4}$$

If the speculator is not informed, he submits a demand $d_S = 0$.[7]

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, which we refer to as stock price informativeness is

$$p(e^a) = \frac{1}{2} F(\pi(e^a)) = \frac{1}{2} F\left(\frac{(1 - (e^a)^2)}{8} \cdot d \cdot \Delta_V\right). \tag{5}$$

Lemma 1. *Taking e^a as exogenous, 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 in F toward lower values of k in the sense of FOSD*;

(*ii*) *decreases with e^a.*

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 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 an increase in the price informativeness function an upward shift of the function $p(\cdot)$, for given α and Δ_V.*

In our model, the price informativeness function increases with the variance of liquidity trades *for a given α*, $d(\alpha)$, and following a shift of F toward lower values of k in the sense of FOSD. We think of these as capturing features of the stock market. For instance, a more developed financial market may have greater liquidity (larger values of $d(\alpha)$) and more numerous, specialized, and sophisticated speculators (lower values of k). In both interpretations, a well-developed stock market might generate more information, and hence will correspond to an increase in price informativeness relative to a less developed market.[8]

[7] To be precise, there is an infinity of equilibria in which, when uninformed, S submits any d_S and is identified. All these equilibria yield the same payoff to all players, and generate the same information.

[8] As a caveat, note that in our comparison, public information is kept constant across markets. This is clearly unappealing. For instance, more developed markets may have stricter disclosure rules, making private information more scarce and the costs of acquiring it greater rather than lower. Therefore our interpretation of more developed financial markets as corresponding to lower values of k assumes that the effect of public information does not dominate the "cost effect." Two remarks may be noteworthy

2. Public Trading and Shareholder Intervention

In this section we highlight that the insider's incentives are enhanced by a larger equity stake, and also by more informative stock prices. We then derive implications for the decision to go public and, in a variation of the model, for the size of the block that maximizes incentives.

2.1 Trading and the insider's incentives

This section relates the information generated by public trading of the firm's stock 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, that is, $P_3 = P_2$. 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

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

Maximizing this payoff with respect to effort, we have

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

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 an increase in effort would also increase firm value. More importantly, this expression underlines the dual source of incentives for the insider.

Lemma 2. *Taking p^a as exogenous, the insider's effort level e*

- (*i*) *increases with* $(1-\alpha)$, *his stake in the firm* (*direct effect*);
- (*ii*) *increases with* p^a (*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

however. First, some of the greater public information in more developed markets may stem from the very activity of speculators (e.g., as opposed to regulation). Second, a change leading to more public information might also lower the cost of acquiring private information. Indeed, suppose that an improvement in regulation makes public some information that would otherwise be private. This amounts to reducing the cost of acquiring that information down to zero. It seems logical that it should also affect the cost of acquiring those pieces of information that remain private. For instance, speculators might be able to combine more reliable earnings annoucements with other information to better determine the value of the firm.

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 deciding on the level of effort, 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 to the extent 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*) *increases with the information sensitivity of the firm's stock*, Δ_V;
- (*iii*) *decreases with the probability of a liquidity shock*, λ.

We have established that effort and price informativeness depend on 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 in the absence 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]

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 resource allocation may be improved by the information generated through the active trading of the firm's stock. In that respect, going public

[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 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.

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.

In some cases, the increase in firm value brought about by the information generated from public trading may be crucial for the venture's viability, that is, 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, but also promotes efficient operating decisions.[10]

Second, the active trading of an entrepreneurial firm's stock can enhance the incentives of its main financier, like a venture capitalist, to engage in advising and overseeing 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 idea that the existence of an active IPO market in which venture capital-backed companies can be floated may be key not only to facilitating the eventual exit of the venture capitalist, but also to giving incentives to increase value in earlier stages of its relation with the firm [see Black and Gilson (1998) and Jeng and Wells (2000)].

Finally, an institutional investor's incentive to oversee the management of a large publicly traded company may be increased by the information generated by the public trading of the firm's stock, that is, by market monitoring. This is in contrast to the view that market monitoring and insider activism 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), Bhidé (1993)], which we do in Section 3.

2.2 The decision to go public

Our analysis has implications for the choice of ownership structure. Admittedly, insiders can control the firm's ownership concentration only

[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.

to a certain extent. Indeed, once shares are publicly traded, blocks might form, dissolve, or change hands.[11] 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.[12] 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 (i.e., chooses α) to maximize the firm's initial value, that is, all proceeds from allocating shares to a large shareholder (e.g., himself) and dispersed investors. The value to a large shareholder of a block $(1 - \alpha)$ of shares is $(1-\alpha)\hat{V}(e^*(\alpha)) - c(e^*(\alpha))$. Turning now to dispersed shareholders, the initial price per share P_0 they are willing to pay will generally depend on α. Therefore α is chosen to maximize the initial firm value defined as

$$(1-\alpha)\hat{V}(e^*(\alpha)) - c(e^*(\alpha)) + \alpha P_0(\alpha). \tag{8}$$

Three factors affect the decision to go public. The first two factors correspond to the two sources of incentives for the insider identified in Lemma 2. On the one hand, other things being equal, a larger stake (i.e., a smaller α) motivates the insider to exert more 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. These effects are antagonistic in so far as a fully concentrated ownership (i.e., the absence of public trading) might correspond to little information being public. The third factor is the revenue from the IPO.

Several assumptions can be made about the initial share price function $P_0(\cdot)$ or, more precisely, about the initial discount $[\hat{V}(e^*(\alpha)) - P_0(\alpha)]$. In what follows, we adopt a particular theory thereof. Before that, however, we establish that when liquidity shocks are important, the discount cannot possibly always swamp the benefits of more informative prices—the insider would *give* shares away.

Proposition 2. *Even if $P_0(\cdot) = 0$, for λ and Δ_V large enough, firm value is maximized when some shares are publicly traded* ($\alpha > 0$) *and the insider retains some shares* ($\alpha < 1$).

To take an extreme case, assume that a liquidity shock is certain ($\lambda = 1$). If the insider remains the firm's sole owner, he will exert no effort. In other words, his large stake has no direct incentive effect. To motivate

[11] 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.

[12] Brennan and Franks (1997) present evidence that in the United Kingdom, insiders use IPO under pricing to establish a dispersed ownership structure and so retain corporate control.

the insider, stock price informativeness is necessary. Therefore, if effort is sufficiently desirable, going public is optimal even if this means giving shares away for free.

We now adopt a particular model of IPO pricing [see Holmström and Tirole (1993)]. At $t = 0$, shares are sold in the IPO to investors who anticipate that they might lose money at $t = 2$ when trading against a more informed speculator. This expected loss is compensated by a decrease in P_0 sufficient to ensure that future liquidity traders break even overall.[13] Since the liquidity traders' expected losses equal the speculator's expected gain (gross of the information acquisition costs), $\pi F(\pi)$, we have

$$P_0(\alpha) = \hat{V}(e^*(\alpha)) - \frac{1}{\alpha}\pi(e^*(\alpha))F(\pi(e^*(\alpha))). \tag{9}$$

Proposition 3. *For $P_0(\cdot)$ as in Equation* (9), *a threshold $\lambda^* \in (0, 1)$ exists such that*

(*i*) *for $\lambda \geq \lambda^*$, firm value is maximized when some 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* ($\alpha = 0$).

The optimal ownership structure balances the two incentive effects. When λ is small, the second concern is less relevant and private ownership is optimal. When λ is large, some public trading is optimal as price informativeness becomes key to providing incentives.[14]

Corollary 1. *Firms that have gone public are more likely to undertake further private or public sales of equity.*[15]

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

[13] As shown in Proposition 2's proof, our results hold for as long as the total discount $\alpha[\hat{V}(e^*(\alpha)) - P_0(\alpha)]$ increases with the speculator's expected profit $\pi(e^*(\alpha))$. See Faure-Grimaud and Gromb (2000) for an alternative theory satisfying this condition. More generally, we only need that the total discount does not decrease too fast with firm value.

[14] Note that we do not assume price informativeness to increase with the float $(1 - \alpha)$. 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 $\alpha = 0$). However, this approach prevents us from deriving an optimal α^*. In the appendix, we propose a version of our model in which the optimal float can be derived.

[15] An offering of primary shares would amount to a *partial* liquidation of the insider's stake. However, as mentioned before, our analysis can easily be extended to partial liquidations, and therefore also applies to offerings of primary shares [Faure-Grimaud and Gromb (2000)].

equity in the near future.[16] 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, Weinstein and Welch (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 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.[17] In Zingales (1995) firms also go public to affect the terms of future sales. More specifically, going public allows initial owner 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 [see also Burkart, Gromb and Panunzi (1999)]. Our model does not deal with control transfers per se, although it can be applied to such events. 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.

Consider now the attractiveness of going public as a function of the market's informational properties.

Proposition 4. *For* $P_0(\alpha)$ *as in Equation* (9), *more firms go public following an increase in the price informativeness function*, *that is*, λ^* *decreases.*

Following an increase in the price informativeness function, the value of a privately held firm (i.e., with $\alpha = 0$) remains unchanged. Therefore, when considering whether to go public, the initial owner realizes that by doing so he can get the same bang in terms of indirect incentive effect for a lower buck in terms of direct incentive effect. Therefore going public becomes more attractive and more firms find it optimal to follow that route.

This has implications for entrepreneurship. Consider an entrepreneur's incentives to start a firm in the first place, assuming that he must incur a fixed setup cost to do so. In that case, he will start the firm only if its initial value exceeds the setup cost.

Corollary 2. *An increase in the price informativeness function leads to more firms being started.*

Some ventures may be worth undertaking only if incentive problems are sufficiently alleviated. Therefore more firms will be created in economies

[16] Actually, our theory is also consistent with IPOs being the prelude to debt issues. See Section 2.3.

[17] For "good-taste-in-the-mouth" theories, see Chemmamur (1993) and Ibbotson and Ritter's (1995) 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.

with stock markets offering greater stock price informativeness. The impact of stock price informativeness on entrepreneurship will be stronger for activities that involve more severe incentive problems. For instance, access to a relatively informationally efficient stock market may be key to the development of industries with many intangible assets, little collateral, a large role of human capital, etc.

Our model also suggests a complementarity between entrepreneurship and stock price informativeness. This can be illustrated by introducing the possibility that at the same time entrepreneurs decide to fund firms, future speculators can invest to push the distribution of information cost $F(\cdot)$ toward lower values of k. If this investment is costly, they will do so only if they anticipate relatively high levels of entrepreneurship. Similarly incentives to entrepreneurship are increased if entrepreneurs expect speculators to undertake this investment. This can give rise to multiple equilibria.

2.3 Implications for capital structure and security design

Our analysis has implications for capital structure choices and more generally for security design. These can be explored by extending our main model to allow for securities other than equity.

Consider for instance the possibility that the insider issues risk-free bonds, that is, with total face value $K \leq V^L$. As before, these bonds are sold initially to investors who are potential future liquidity traders. At $t = 1$, the aggregate demand of the liquidity traders for these bonds is $d_{\mathrm{L}} \in \{-d, 0\}$ with $\Pr[d_L = 0] = \Pr[d_L = -d] = 1/2$. As before, d can depend on K.

The value of the firm is independent of K. Consider the effect of K on the three factors affecting the value of the firm. First, the insider's direct incentive effect is unaffected by K. Indeed, this effect depends on the wedge between his payoffs in both states of the world, $(V^H - K)$ and $(V^L - K)$, which is independent of K. Second, the indirect incentive effect is also unaffected by K. The bonds being risk free, their value at $t = 2$ is certain, equal to K. Therefore there is no opportunity for profitable informed trading, and no information is revealed. Third, the total discount at which the issue is sold is independent of K. Indeed, since initial investors anticipate no loss from trading against informed investors, the bonds sell at no discount at $t = 0$. Since firm value is independent of K, in particular it is the same as for $K = 0$, that is, when the insider retains full ownership of the firm's cash flows (the case $\alpha = 0$ in the previous analysis).

Corollary 3. *Insiders with a probability of liquidity shock $\lambda \geq \lambda^*$ prefer to go public by issuing shares rather than risk-free bonds.*

The trade-off governing the choice between issuing risk-free bonds and equity is the same as that governing the going-public decision. Issuing risk-free bonds minimizes indirect incentives (as bond prices are not informative), but minimizes the discount (liquidity traders do not lose out to more informed traders) and maximizes the insider's direct incentives (the insider is residual claimant). How does this generalize when we allow for other claims? In general, 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 acquisition and revelation. A similar trade-off will also be present in a more general model of security design if one assumes "monotonic" claims, that is, outside securities the value of which increases with V.[18] Under this assumption, increasing the "information sensitivity" of the outside claims (i.e., the difference between what outsiders get if $V = V^H$ and if $V = V^L$) needs to increase the outsiders' payoff in the good state and/or to decrease their payoff in the bad state. Consequently the insider's payoff, which equals the realized return minus the payoff to outsiders, is reduced in the good state and/or increase in the bad state. An increase of the information sensitivity of the outside claims fosters information collection by speculators and increases the likelihood that the insider liquidates his stake at its true value: an indirect positive impact on incentives. However, an increase in this information sensitivity comes at the cost of decreasing the sensitivity of the insider's stake to the final returns V, a negative direct effect. There is only so much sensitivity to be divided up between inside and outside claims. The optimal design of the firm's securities thus consists of 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 toward more information-sensitive outside claims at the cost of reducing the effort sensitivity of the insider's claim. In our binary model, there is not a unique optimal claim, but the previous corollary already identifies conditions where the best outside claim is information sensitive.

Interestingly, 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

[18] Usually [e.g., in Innes (1990)], the restriction to nondecreasing claims is motivated as follows. Consider a claim paying $R(V)$ when firm value is V. With $R(V^H) < R(V^L)$, and after the realization V^L, the entrepreneur could inflate the cash flow to V^H, for example, by borrowing secretly, and so reduce his repayment from $R(V^L)$ to $R(V^H)$. (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 nondecreasing repayments.) Here the problem is different. This may be best illustrated in the following example. Instead of safe debt with face value $K \leq V^L$, suppose that the insider issues two Arrow-Debreu securities, one paying K only when $V = V^L$ and zero otherwise, the other paying K when $V = V^H$ and zero otherwise. The payoff of the two securities add up to that of safe debt, but each of them is information sensitive. Their public trading could reveal some information. Since the insider's net payoff is the same as if safe debt had been issued, $(V - K)$, the insider has no incentives ex post to inflate cash flows. Admittedly, if both claims are traded, this might affect liquidity trading because small investors can combine them to synthesize the safe claim.

noteworthy that this "reversed" pecking order would hold for issues of publicly traded securities only. Moreover, it would likely 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.

While our theory is only sketchy, it takes a perspective that contrasts with much of the literature on incentives and security design. Building on Jensen and Meckling (1976), this literature argues that in a standard moral hazard situation, insiders should issue debt so as to retain a claim (here, levered equity) that is as sensitive as possible to the component of the firm's value affected by their decisions.[19] Note however, that in such models the design and allocation of outside claims is irrelevant. For instance, with multiple creditors, the claim that each of them owns is irrelevant as long as they add up to debt. In other words, the Modigliani-Miller theorem applies to outside claims. Our model considers outside claims explicitly.[20] The irrelevance is broken because trading affects firm value and is influenced by the design of publicly traded securities. That is, although outsiders cannot affect operating decisions directly, the securities they hold and trade do so indirectly.

3. Exit as a Signal

So far we have considered the insider's exit as essentially exogenous.[21] 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, that is, 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 affects incentives. To conduct this analysis,

[19] 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.

[20] In Boot and Thakor (1993), 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 (nontraded) 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 (2001) 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. In a repeated game context where management can be dismissed by outsiders, Fluck (1998) shows that outside equity with infinite maturity is optimal [see also Myers (2000)]. In our model, the outsiders never affect operations.

[21] 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.

we return to the basic model of Section 1 that we amend in two ways. 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 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 now relax this second assumption by allowing the insider to 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.*[22] *He can then decide to liquidate 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.*[23]

Now, when making 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

$$\rho > \frac{V^\sigma - P_3}{P_3}. \tag{10}$$

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

[22] Among others, Wang (1994) proposes a model of liquidity shocks similar to ours.

[23] 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 I and find our results to be robust.

and makes exit more attractive. Conversely, a negative difference corresponds to underpricing and makes exit less attractive.[24]

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 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, that is, a sale cannot be 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 lemons 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 3.

(*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 $\rho > \bar{\rho}(P_2) \equiv \frac{V^H - P_2}{P_2}$.*

This gives the impact of an increase in p and P_2 on the exit probability in both states. When $V = V^L$, Equation (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 that would not arise with an informative price. Thus a greater price informativeness p or a higher selling price P_2 alleviates the lemons problem and therefore encourages exit.

Corollary 4. *Other things being 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 lemons 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

[24] 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.

when $V = V^L$, making this state less attractive. Both effects encourage effort. The effect on the unconditional exit probability is twofold. 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 5. *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 the 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 4), 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.

4. Conclusion

This article 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. In addition, 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 choose their capital structure, they might issue publicly traded securities that are information sensitive for their trading to generate information. Thus a reverse pecking order might arise for initial offerings.

The article has abstracted from a number of interesting issues. The basic effect of speculative monitoring on incentives may have implications for the allocation of effort by insiders across several activities. Suppose for instance that the firm has two projects. If speculators find it more profitable to trade on information about project 1, stock prices may end up being informative only about project 1. If so, the insider has an incentive to allocate his effort to project 1, especially if a liquidity shock is likely. This can give rise to some form of myopia, in that an insider with a short horizon (high liquidity needs) will exert more effort in projects about which speculators are more likely to become informed [as in Paul (1992)]. This could also have implications for project selection, possibly leading to some form of managerial conservatism. Security design may be used to circumvent this effect (e.g., issuing a tracking stock for project 2). This may have implications for internal capital markets efficiency [as in Goel, Nanda, and Narayanan (2004)].

Another possible extension would be to consider alternative ways of generating information. For instance, 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. Also, 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 (the parameters λ and ρ in our model), such as tilting the firm's operations to ensure that most financing needs are met with internal funds. Another possibility is to ensure that insiders are institutions designed to have low λ. 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.

Appendix 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 $F(\cdot)$ toward lower values of k in the sense of FOSD shifts $p(\cdot)$ upward without affecting $e(\cdot)$. Increasing Δ_V shifts both $p(\cdot)$ and $e(\cdot)$ upward. Decreasing λ shifts $e(\cdot)$ upward without affecting $p(\cdot)$.

Appendix B: Proof of Proposition 2

Let $e^*(\lambda, \alpha)$ and $\pi^*(\lambda, \alpha)$ denote the equilibrium effort and speculator expected profit. We show that for $\lambda = 1$ and Δ_V large enough, firm value is *not* maximized for $\alpha = 0$.

For $P_0(\alpha) = 0$, the gain in initial firm value from issuing α rather than remaining private is $\Psi(\lambda,\alpha) \equiv (1-\alpha)\hat{V}(e^*(\lambda,\alpha)) - c(e^*(\lambda,\alpha)) - \left[V_L + \frac{\Delta_V}{2}\right]$.

We now show that there exists $\alpha > 0$ for which $\Psi(1, \alpha) > 0$,

$$\frac{d\Psi(1,\alpha)}{d\alpha} = -\hat{V}(e^*(1,\alpha)) + \left[(1-\alpha)\frac{d\hat{V}(e^*(1,\alpha))}{de} - c'(e^*(1,\alpha))\right]\frac{de^*(1,\alpha)}{d\alpha}.$$

Using the first-order condition for effort choice,

$$\frac{d\Psi(1,\alpha)}{d\alpha} = -\hat{V}(e^*(1,\alpha)) + \left[(1-\alpha)\frac{\Delta_V}{2}(1-p^*(1,\alpha))\right]\frac{de^*(1,\alpha)}{d\alpha}.$$

We show that this derivative is positive when α goes to zero. Indeed, we have

$$\lim_{\alpha\to 0}\frac{d\Psi(1,\alpha)}{d\alpha} = -\left[V_L + \frac{\Delta_V}{2}\right] + \left[\frac{\Delta_V}{2}\right]\lim_{\alpha\to 0}\frac{de^*(1,\alpha)}{d\alpha}.$$

Differentiating Equations (5) and (7), we have

$$\frac{de^*(1,\alpha)}{d\alpha} = \left[-p^*(1,\alpha) + (1-\alpha)\frac{dp^*(1,\alpha)}{d\alpha}\right]\frac{\Delta_V}{2}$$

$$\frac{dp^*(1,\alpha)}{d\alpha} = \frac{\Delta_V}{2} f\left(\frac{(1-(e^*(1,\alpha))^2)}{8} d(\alpha)\Delta_V\right)\left[\begin{array}{l}\frac{dd(\alpha)}{d\alpha}\frac{(1-(e^*(1,\alpha))^2)}{8}\\ -\frac{e^*(1,\alpha)}{4}d(\alpha)\frac{de^*(1,\alpha)}{d\alpha}\end{array}\right]$$

When α goes to zero, $p^*(1, \alpha)$ necessarily goes to zero as $d(0) = 0$. Given that $p^*(1, \alpha) \geq 0$, $\lim_{\alpha\to 0}\frac{dp^*(1,\alpha)}{d\alpha} \geq 0$ and necessarily $\lim_{\alpha\to 0}\frac{de^*(1,\alpha)}{d\alpha} \geq 0$. Unless $\lim_{\alpha\to 0}\frac{de^*(1,\alpha)}{d\alpha} = +\infty$ (and if so, necessarily $\lim_{\alpha\to 0}\frac{d\Psi(1,\alpha)}{d\alpha} \geq 0$ and the claim is proven), we have

$$\lim_{\alpha\to 0}\frac{de^*(1,\alpha)}{d\alpha} = \lim_{\alpha\to 0}\frac{dp^*(1,\alpha)}{d\alpha}\frac{\Delta_V}{2}$$

$$\lim_{\alpha\to 0}\frac{dp^*(1,\alpha)}{d\alpha} = \frac{\Delta_V}{2}f(0)\left[\lim_{\alpha\to 0}\frac{dd(\alpha)}{d\alpha}\frac{1}{8}\right]$$

and so

$$\lim_{\alpha\to 0}\frac{d\Psi(1,\alpha)}{d\alpha} = -\left[V_L + \frac{\Delta_V}{2}\right] + \frac{\Delta_V^3}{64}f(0)\lim_{\alpha\to 0}\frac{dd(\alpha)}{d\alpha}.$$

Necessarily $\lim_{\alpha\to 0}\frac{dd(\alpha)}{d\alpha} > 0$, as $d'(0) > 0$. Therefore $\lim_{\alpha\to 0}\frac{d\Psi(1,\alpha)}{d\alpha}$ is increasing in $\frac{\Delta_V}{2}$ for $\frac{\Delta_V}{2}$ large enough. Thus there exists $\frac{\Delta_V}{2}$ for which $\lim_{\alpha\to 0}\frac{d\Psi(1,\alpha)}{d\alpha} > 0$. Consequently, at least for α small enough, $\Psi(1, \alpha) > 0$, which means that when $\lambda = 1$, firm value is *not* maximized for $\alpha = 0$.

Finally, notice that $\alpha = 1$ results in the insider choosing no effort so that $\Psi(1, 1) = 0$, while we have just shown that there exists α for which $\Psi(1, \alpha) > 0$.

Appendix C: Proof of Proposition 3

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 (9)]:

$$\hat{V}(e^*(\lambda,\alpha)) - c(e^*(\lambda,\alpha)) - \pi^*(\lambda,\alpha)F(\pi^*(\lambda,\alpha)) = g(e^*(\lambda,\alpha)) - \pi^*(\lambda,\alpha)F(\pi^*(\lambda,\alpha)), \quad (11)$$

where $g(\cdot) \equiv \hat{V}(\cdot) - c(\cdot)$ and $g'' < 0$ and $g' > 0$ over $[0, \Delta_V/2)$.

We first check that going public is optimal when $\lambda = 1$. We have to check that there exists $\alpha > 0$ such that

$$g(e^*(1,\alpha)) - g(e^*(1,0)) > \pi^*(1,\alpha)F(\pi^*(1,\alpha)). \quad (12)$$

From the continuity of $\pi(.,\alpha) \equiv \frac{1-e^2}{2}d(\alpha)\Delta_V$ for all e and $\pi(.,0) = 0$, there exists η, ν such that $\forall e$, if $\alpha < \nu$, then $\pi(e,\alpha) < \eta$. Consider now the case of an insider with $\lambda = 1$ who decides to float an arbitrarily small fraction $\alpha \leq \varepsilon$ of the shares traded. The previous condition is equivalent to

$$\frac{e^*(1,\alpha)}{2}[\Delta_V - e^*(1,\alpha)] > \pi^*(1,\alpha)F(\pi^*(1,\alpha)). \quad (13)$$

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

$$(1-\varepsilon)\frac{\Delta_V^2}{4}\left[1-(1-\varepsilon)\frac{F(\pi^*(1,\varepsilon))}{2}\right] > \pi^*(1,\varepsilon) \quad (14)$$

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

We now establish the existence of a unique threshold λ^*. Assume that for some λ_1, initial firm value is not maximized for $\alpha = 0$, that is, there exists $\alpha_1 > 0$ such that

$$g(e^*(\lambda_1,\alpha_1)) - g(e^*(\lambda_1,0)) > \pi^*(\lambda_1,\alpha_1)F(\pi^*(\lambda_1,\alpha_1)). \quad (15)$$

The proof consists of 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 (*iii*)), which implies $\pi^*(\lambda_1, \alpha_1) < \pi^*(\lambda_2, \alpha_1)$. Hence, given that $\pi^*(\lambda_2, 0) = 0$, the continuity of $\pi(\cdot)$ implies the existence of $\alpha_2 \in (0, \alpha_1)$ such that $\pi^*(\lambda_1, \alpha_1) = \pi^*(\lambda_2, \alpha_2)$. Equation (7) implies

$$e^*(\lambda,\alpha) - e^*(\lambda,0) = (1-\alpha)\frac{\Delta_V}{2}\lambda p^*(\lambda,\alpha) - \alpha\frac{\Delta_V}{2}(1-\lambda), \quad (16)$$

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

$$e^*(\lambda_2,\alpha_2) - e^*(\lambda_2,0) > e^*(\lambda_1,\alpha_1) - e^*(\lambda_1,0). \quad (17)$$

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

$$g(e^*(\lambda_2,\alpha_2)) - g(e^*(\lambda_2,0)) > g(e^*(\lambda_1,\alpha_1)) - g(e^*(\lambda_1,0)) \quad (18)$$

$$> \pi^*(\lambda_1,\alpha_1)F(\pi^*(\lambda_1,\alpha_1)) \text{ by Equation (15)} \quad (19)$$

$$> \pi^*(\lambda_2,\alpha_2)F(\pi^*(\lambda_2,\alpha_2)) \text{ as } \pi^*(\lambda_2,\alpha_2) = \pi^*(\lambda_1,\alpha_1). \quad (20)$$

Note that the proof also holds if we replace $\pi^*(\lambda, \alpha)\, F(\pi^*(\lambda, \alpha))$ with any increasing function $h(\pi^*(\lambda, \alpha))$ in Equation (11). Therefore our result goes through for any $P_0(\cdot)$ of the form $P_0(\alpha) = \hat{V}(e^*(\lambda,\alpha)) - \frac{1}{\alpha}h(\pi^*(\lambda,\alpha))$.

Appendix D: Proof of Proposition 4 and Corollary 2

Consider the effect of a shift of $F(\cdot)$ toward lower values of k in the sense of FOSD, from $F_1(\cdot)$ to $F_2(\cdot)$. (The proof for an increase in $d(\cdot)$ is similar.)

For α and $F(\cdot)$, let $e^*(F, \alpha)$, $\pi^*(F, \alpha)$, $p^*(F, \alpha)$, and $V_0(F, \alpha)$ denote the equilibrium effort, speculator expected profit, price informativeness, and initial firm value, respectively. We show that when F shifts from F_1 to F_2, $\max_{\alpha>0}[V_0(F, \alpha) - V_0(F, 0)]$ increases weakly for all values of λ and strictly for some values of λ. This first result implies Proposition 4. We also show that $\max_{\alpha\geq 0} V_0(F, \alpha)$ increases weakly for all values of λ and strictly for some values of λ, which proves Corollary 2. Remarking that $V_0(F, 0)$ is unchanged by the shift of F and that Proposition 3 implies that for some λ large enough $\max_{\alpha\geq 0} V_0(F, \alpha) = \max_{\alpha>0} V_0(F, \alpha)$, both results amount to $\max_{\alpha>0} V_0(F, \alpha)$ increasing strictly following the shift of F which we now show.

For any $\alpha_1 > 0$,

$$\pi^*(\alpha_1, F_1) < \pi^*(\alpha_1, F_2),$$

which implies

$$\pi^*(\alpha_1, F_1)F_1(\pi^*(\alpha_1, F_1)) < \pi^*(\alpha_1, F_2)F_2(\pi^*(\alpha_1, F_2)).$$

Because

$$\pi^*(0, F_2)F_2(\pi^*(0, F_2)) = 0,$$

by continuity, there exists $\alpha_2 < \alpha_1$ such that

$$\pi^*(\alpha_1, F_1)F_1(\pi^*(\alpha_1, F_1)) = \pi^*(\alpha_2, F_2)F_2(\pi^*(\alpha_2, F_2)). \tag{21}$$

Since $F_1(\cdot) < F_2(\cdot)$, the only way this equality can hold is if $\pi^*(\alpha_1, F_1) > \pi^*(\alpha_2, F_2)$ and $F_1(\pi^*(\alpha_1, F_1)) < F_2(\pi^*(\alpha_2, F_2))$. This implies $p^*(\alpha_1, F_1) < p^*(\alpha_2, F_2)$, which in turn implies

$$e^*(\alpha_1, F_1) < e^*(\alpha_2, F_2).$$

Both effort levels being below first best, they belong to the interval $[0, \Delta_V/2)$ over which g is increasing. Therefore

$$g(e^*(\alpha_1, F_1)) < g(e^*(\alpha_2, F_2)). \tag{22}$$

For $\alpha > 0$ and $F(\cdot)$, the initial firm value is

$$V_0(\alpha, F) = g(e^*(\alpha, F)) - \pi^*(\alpha, F)F(\pi^*(\alpha, F)). \tag{23}$$

Equations (21) and (22) imply $V_0(\alpha_1, F_1) < V_0(\alpha_2, F_2)$. Therefore

$$\max_{\alpha>0} V_0(\alpha, F_1) < \max_{\alpha>0} V_0(\alpha, F_2),$$

which completes the proof. Note that the proof would also hold for any initial price such that $\alpha[\hat{V}(e^*(\alpha)) - P_0(\alpha)]$ is an increasing function of $\pi^*(\alpha)$.

Appendix E: Proof of Corollary 3

The value of the firm to the insider when $\Delta_{R_o} = 0$ is the same as in the case of a privately held firm. Proposition 3 has established that for $\lambda \geq \lambda^*$, the insider prefers issuing some shares to remaining private. This result also implies that the insider prefers to issue outside securities with $\Delta_{R_o} = \alpha^*\Delta_V$ to $\Delta_{R_o} = 0$.

Appendix F: A Model of the Optimal Float

In this section we specialize our model to derive the optimal float, that is, the fraction of shares α^* maximizing the firm's initial value. To obtain closed-form solutions, we specify the link between the float and the stock's liquidity (i.e., $d(\alpha)$) as well as the distribution of information acquisition costs (i.e., $F(\cdot)$). Moreover, our continuous effort choice model yields third-degree equations. To avoid these we adopt a discrete effort choice formulation.

- At $t = 0$, a continuum of mass one of ex ante identical consumers allocate their wealth between the firm's shares issued in an IPO (i.e., a fraction α) and a risk-free asset with exogenous return equal to one.
- At $t = 1$, the insider chooses $e \in \{0, e_H\}$ with $c(0) = 0$ and $c(e_H) = c$.
- At $t = 2$, a fraction of consumers learn that they have to consume immediately and liquidate their investments. The other consumers wait until $t = 4$. The fraction of early consumers is equiprobably zero or d.
- The speculator's cost of acquiring information is uniformly distributed on $[0, K]$.

We now solve for the optimal float, assuming that inducing the insider to exert e_H with certainty is optimal. At $t = 2$, early consumers liquidate their shares, and their aggregate demand for the firm's shares is equiprobably zero or $-d(\alpha) = -d \times \alpha$. The insider chooses $e = e_H$ if and only if

$$\frac{e_H}{2}(1-\alpha)(\lambda p^a + (1-\lambda))\Delta_V \geq c.$$

The corresponding probability that the stock price is informative is

$$p^a = \frac{(1-e_H^2)}{16K} d\alpha\Delta_V. \tag{24}$$

These conditions can be rewritten as

$$h(\alpha) \equiv (1-\alpha)\left(\lambda \frac{(1-e_H^2)}{16K} d\alpha\Delta_V + (1-\lambda)\right) - \frac{2c}{e_H\Delta_V} \geq 0. \tag{25}$$

It is easily shown that the maximum of $h(\alpha)$ is reached for $\hat{\alpha} = \frac{1}{2} - \frac{(1-\lambda)}{\lambda\frac{(1-e_H^2)}{8K} d\Delta_V}$. Because shares sell at a discount, the float α^* maximizing the initial firm value is the smallest such that the Equation (25) holds. Therefore it solves $h(\alpha) = 0$. To streamline the analysis, we focus on parameter values yielding an interior solution for α^*, that is, such that $\hat{\alpha} \in (0, 1)$, $h(0) < 0$, and $h(\hat{\alpha})$. In that case, α^* is the smallest root of the equation $h(\alpha) = 0$.

Lemma 4. *The float maximizing the firm's initial value is*

$$\alpha^* = \hat{\alpha} - \sqrt{\hat{\alpha}^2 - \frac{1-\lambda-\frac{2c}{e_H\Delta_V}}{\lambda\frac{(1-e_H^2)}{8K} d\Delta_V}}, \quad \textit{where } \hat{\alpha} = \frac{1}{2} - \frac{(1-\lambda)}{\lambda\frac{(1-e_H^2)}{8K} d\Delta_V}.$$

It is easily checked that α^* increases with λ: as the likelihood of a liquidity shock increases, a larger float is optimal as it generates more price informativeness.

Appendix G: Proof of Lemma 3

Let $x(\sigma, \rho)$ ($y(\sigma, \rho)$) 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 (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 Equation (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

$$P_3(\rho) = V^L + \frac{\left(\frac{1+e}{2}\right)\cdot y(H,\rho)}{\left(\frac{1+e}{2}\right)\cdot y(H,\rho) + \left(\frac{1-e}{2}\right)}\Delta_V. \tag{26}$$

When $y(H, \rho)$ increases from zero to one, $P_3(\rho)$ increases from V^L to P_2. Consequently, for $\rho < \frac{V^H - V^L}{V^L}\left(\rho > \frac{V^H - P_2}{P_2}\right)$, Equation (10) is never (always) satisfied for $\sigma = H$ in equilibrium. There remains to determine $y(H, \rho)$ for $\rho \in \left[\frac{V^H - P_2}{P_2}, \frac{V^H - V^L}{V^L}\right]$. For each value of ρ, three perfect bayesian equilibria coexist, 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 Equation (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 Equation (10) is violated for $\sigma = H$ and $P_3 = V^L$, when $\rho \leq \frac{V^H - V^L}{V^L}$.

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

$$\rho \cdot P_3(\rho) + (P_3(\rho) - V^H) = 0 \quad \text{or} \quad P_3(\rho) = \frac{V^H}{1+\rho}. \tag{27}$$

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

$$V^L + \frac{\left(\frac{1+e}{2}\right) \cdot y(H,\rho)}{\left(\frac{1+e}{2}\right) \cdot y(H,\rho) + \left(\frac{1-e}{2}\right)} \Delta_V = P_3(\rho) \quad \text{or} \quad y(H,\rho) = \frac{\left(\Delta_V - \frac{\rho V^H}{1+\rho}\right)}{\frac{\rho V^H}{1+\rho}} \left(\frac{1-e}{1+e}\right). \tag{28}$$

Appendix H: Proof of Proposition 5

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

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

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

$$e(p^a) = p^a(1-\alpha)\frac{\Delta_V}{2}(1 + \mathrm{E}[\rho])$$
$$+ (1-p^a)(1-\alpha)\frac{1}{2} G(\bar{\rho}(\hat{V}^a))(V^H - V^L(1 + \mathrm{E}[\rho|\rho \leq \bar{\rho}(\hat{V}^a)])),$$

which is increasing in p^a because

$$e'(p^a) = (1-\alpha)\frac{\Delta_V}{2}(1 + \mathrm{E}[\rho]) - (1-\alpha)\frac{1}{2} G(\bar{\rho}(\hat{V}^a))(V^H - V^L(1 + \mathrm{E}[\rho|\rho \leq \bar{\rho}(\hat{V}^a)]))$$
$$= (1-\alpha)\frac{\Delta_V}{2}\left[(1 + \mathrm{E}[\rho]) - G(\bar{\rho}(\hat{V}^a))\left(1 - \frac{V^L}{\Delta_V}\mathrm{E}[\rho|\rho \leq \bar{\rho}(\hat{V}^a)]\right)\right] \tag{30}$$

$$> (1-\alpha)\frac{\Delta_V}{2}[(1 + \mathrm{E}[\rho]) - G(\bar{\rho}(\hat{V}^a))] > 0. \tag{31}$$

Recall that the equilibrium is determined by the intersection of $p(e)$, which is decreasing, and $e(p)$, which is increasing. An 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,

$$1-(1-p^*)\frac{1+e^*}{2}G(\bar{\rho}(e^*)). \tag{32}$$

Appendix I: Signaling

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 a fraction $\beta^L = 1$ if $V = V^L$ and $\beta^H < 1$ if $V = V^H$, the following incentive compatibility conditions must hold:

$$(1+\rho)\beta^H V^H + (1-\beta^H)V^H \geq (1+\rho)V^L \tag{33}$$

$$(1+\rho)V^L \geq (1+\rho)\beta^H V^H + (1-\beta^H)V^L. \tag{34}$$

Hence there exists an equilibrium for all $\beta^H \in \left[\frac{(1+\rho)V^L - V^H}{\rho V^H}, \frac{\rho V^L}{(1+\rho)V^H - V^L}\right]$. 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, that is, $\beta^H = \frac{\rho V^L}{(1+\rho)V^H - V^L}$. 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 6. *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

$$\begin{aligned} &-c(e) + p^a(1-\alpha)\hat{V}(e)(1+\mathrm{E}[\rho]) + (1-p^a)(1-\alpha) \\ &\times \left[\left(\frac{1+e}{2}\right)\int_0^{+\infty}[(1+\rho)\beta^H(\rho)V^H + (1-\beta^H(\rho))V^H]dG(\rho) + \frac{1-e}{2}V^L(1+\mathrm{E}[\rho])\right]. \end{aligned} \tag{35}$$

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 effects on the average fraction liquidated by the insider, $\mathrm{E}[\beta] = \Pr[V = V^L] + (1-(1-p^*)\cdot(1-\mathrm{E}[\beta^H]))\Pr[V = V^H]$. On the one hand, p^* increases leading the insider to liquidate more shares conditional on $V = V^H$ because $\mathrm{E}[\beta^H] < 1$. On the other hand, the increased effort increases $\Pr[V = V^H]$, which reduces the overall probability of exit because $\mathrm{E}[\beta^H] < 1$. The overall effect can be shown to be ambiguous.

References

Aghion, P., P. Bolton, and J. Tirole, 2004, "Exit Options in Corporate Finance: Liquidity versus Incentives," forthcoming in Review of Finance.

Berkovitch, E., and R. Israel, 1995, "The Design of Internal Control and Capital Structure," *Review of Financial Studies*, 9, 209–240.

Bhidé, A., 1993, "The Hidden Costs of Stock Market Liquidity," *Journal of Financial Economics*, 34, 31–51.

Black, B. S., and R. J. Gilson, 1998, "Venture Capital and the Structure of Capital Markets: Banks versus Stock Markets," *Journal of Financial Economics*, 47, 243–277.

Bolton, P., and E.-L. von Thadden, 1998a, "Blocks, Liquidity, and Corporate Control," *Journal of Finance*, 53, 1–25.

Bolton, P., and E.-L. von Thadden, 1998b, "Liquidity and Control: A Dynamic Theory of Corporate Ownership Structure," *Journal of Institutional and Theoretical Economics*, 154, 177–211.

Boot, A., and A. Thakor, 1993, "Security Design," *Journal of Finance*, 48, 1349–1378.

Brennan, M., and J. Franks, 1997, "Underpricing, Ownership and Control in IPOs of Equity Securities in the UK," *Journal of Financial Economics*, 45, 391–414.

Burkart, M., D. Gromb, and F. Panunzi, 1997, "Large Shareholders, Monitoring and the Value of the Firm," *Quarterly Journal of Economics*, 113, 693–728.

Burkart, M., D. Gromb, and F. Panunzi, 1998, "Why Higher Takeover Premia Protect Minority Shareholders," *Journal of Political Economy*, 106, 172–204.

Burkart, M., D. Gromb, and F. Panunzi, 1999, "Agency Conflicts in Public and Privately Negotiated Transfers of Corporate Control," *Journal of Finance*, 55, 647–677.

Chemmanur, T. J., 1993, "The Pricing of Initial Public Offerings: A Dynamic Model with Information Production," *Journal of Finance*, 48, 285–304.

Chemmanur, T. J., and P. Fulghieri, 1999, "A Theory of the Going Public Decision," *Review of Financial Studies*, 12, 249–279.

Coffee, J., 1991, "Liquidity versus Control: The Institutional Investor as Corporate Monitor," *Columbia Law Review*, 91, 1277–1368.

Dewatripont, M., and J. Tirole, 1994, "A Theory of Debt and Equity: Diversity of Securities and Manager-Shareholder Congruence," *Quarterly Journal of Economics*, 109, 1027–1054.

Diamond, D. W., and R. E. Verrecchia, 1982, "Optimal Managerial Contracts and Equilibrium Security Prices," *Journal of Finance*, 37, 275–287.

Ellingsen, T., and K. Rydqvist, 1998, "The Stock Market as a Screening Device and the Decision to Go Public," mimeo, Stockholm School of Economics.

Faure-Grimaud, A., 2002, "Using Stock Price Information to Regulate Firms," *Review of Economic Studies*, 69, 169–190.

Faure-Grimaud, A., and D. Gromb, 2000, "Public Trading and Private Incentives," Discussion paper, *Financial Markets Group*.

Fishman, M. J., and K. M. Hagerty, 1989, "Disclosure Decisions by Firms and the Competition for Price Efficiency," *Journal of Finance*, 44, 633–646.

Fluck, Z., 1998, "Optimal Financial Contracting: Debt vs. Outside Equity," *Review of Financial Studies*, 11, 383–418.

Fulghieri, P., and D. Lukin, 2001, "Information Production, Dilution Costs, and Optimal Security Design," *Journal of Financial Economics*, 61, 3–42.

Goel, A., V. Nanda, and M. P. Narayanan, 2004, "Career Concerns and Resource Allocation in Conglomerates," *Review of Financial Studies*, 17, 99–128.

Holmström, B., and J. Tirole, 1993, "Market Liquidity and Performance Monitoring," *Journal of Political Economy*, 101, 678–709.

Ibbotson, R. G., and J. R. Ritter, 1995, "Initial Public Offerings," in R. Jarrow, V. Maksimovic, and W. Ziemba (eds.), *Handbooks in Operations Research and Management Science*, vol. 9, North-Holland, Amsterdam.

Innes, R., 1990, "Limited Liability and Incentive Contracting with Ex-Ante Action Choices," *Journal of Economic Theory*, 52, 45–67.

Jegadeesh, N., M. Weinstein, and I. Welch, 1990, "An Empirical Investigation of IPO Returns and Subsequent Equity Offerings," *Journal of Financial Economics*, 34, 153–176.

Jeng, L. A., and P. C. Wells, 2000, "The Determinants of Venture Capital Funding: Evidence Across Countries," *Journal of Corporate Finance*, 6, 241–289.

Jensen, M. C., and W. Meckling, 1976, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," *Journal of Financial Economics*, 3, 305–360.

Kahn, C., and A. Winton, 1998, "Ownership Structure, Speculation and Shareholder Intervention," *Journal of Finance*, 53, 99–129.

Kyle, A. S., 1985, "Continuous Auctions and Insider Trading," *Econometrica*, 53, 1315–1335.

Kyle, A. S., and J.-L. Vila, 1991, "Noise Trading and Takeovers," *Rand Journal of Economics*, 22, 54–71.

Lerner, J., 1994, "Venture Capitalists and the Decision to Go Public," *Journal of Financial Economics*, 35, 293–316.

Maug, E. 1998, "Large Shareholders as Monitors: Is There a Trade-off between Liquidity and Control," *Journal of Finance*, 53, 65–98.

Myers, S. C., 2000, "Outside Equity," *Journal of Finance*, 55, 1005–1037.

Myers, S. C., and N. Majluf, 1984,"Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have," *Journal of Financial Economics*, 13, 187–221.

Noe, T. H., 2002, "Investor Activism and Financial Market Structure," *Review of Financial Studies*, 15, 289–318.

Pagano, M., and A. Roell, 1998, "The Choice of Stock Ownership Structure: Agency Costs, Monitoring and the Decision to Go Public," *Quarterly Journal of Economics*, 113, 187–225.

Paul, J. M., 1992, "On the Efficiency of Stock Based Compensation," *Review of Financial Studies*, 5, 471–502.

Rajan, R., and L. Zingales, 1995, "What Do We Know About Capital Structure," *Journal of Finance*, 50, 1421–1460.

Shleifer, A., and R. W. Vishny, 1997, "A Survey of Corporate Governance," *Journal of Finance*, 52, 737–783.

Subrahmanyam, A., and S. Titman, 1999, "The Going Public Decision and the Development of Financial Markets," *Journal of Finance*, 54, 1045–1082.

Wang, J., 1994, "A Model of Competitive Stock Trading Volume," *Journal of Political Economy*, 102, 127–168.

Welch, I., 1996, "Equity Offerings Following the IPO: Theory and Evidence," *Journal of Corporate Finance*, 2, 227–259.

Zingales, L. 1995, "Insider Ownership and the Decision to Go Public," *Review of Economic Studies*, 62, 425–448.