Post-IPO Governance:

Venture Capitalists' Role in Strategic Decisions*

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Abstract

One important role of corporate governance is to ensure that strategic decisions are made in the interest of the shareholders. This paper explores whether and how this can be achieved in start-up firms by the venture capitalist retaining a post-IPO equity stake. Our setting is a firm whose future prospects are uncertain and strategic choices remain to be made. The payoff to entrepreneur and shareholders will be asymmetric across the different strategies, leading to the agency problem of suboptimal exercise of options. We derive VC's optimal post-IPO stake under symmetric information and show that this mechanism can alleviate the agency issue. Specifically, VC should only retain a stake for firms with poor prospects and exit fully otherwise. Under asymmetric information, however, VC's of the firms with good prospects have no other way to signal to the public than to retain the stake until the information is revealed. Conversely, VCs may fully exit firms with poor prospects, leading to adverse selection. Finally, although very large equity positions held by the entrepreneur can eliminate the conflict of interest, initial wealth constraints would prevent such situations. When the entrepreneur holds equity stakes insufficient to eliminate agency problem the agency problem may be exacerbated under asymmetric information.

NOTE: All proofs are omitted from this early draft.

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1. Introduction:

A large fraction of the value of early stage firms comes from the options inherent in them. In order to realize this value managers must exert effort to keep these real options alive and then optimally exercise them. Unlike financial options that involve legally binding contracts, real options often arise out of implicit opportunities for management flexibility. The absence of formal contracts and the presence of agency problems can, however, lead to suboptimal option exercise decisions.[1] Consequently, the form of governance plays a vital role in the shareholders' ability to capture the option value.

Nowhere is this issue more pronounced than in firms that go public with impending key strategic options exercise decisions. The agency problems are exacerbated in cases where entrepreneurs are still functioning as managers.[2] How then can shareholders ensure that entrepreneurs continue to exert sufficient effort in nurturing the options and make the option exercise decisions that are in the interest of the shareholders? Prior to going public, venture capitalists hold most of the equity, act as monitors, and discipline the entrepreneurs. If entrepreneurs act in their self-interest in violation of the shareholders' interest, then the VC can replace them. In contrast, after IPO, future prospects of the firm will be substantially uncertain and intangible asset values not verifiable by public investors, thus creating asymmetries in information

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[1] See Dixit and Pindyck (1994) and Amram and Kulatilaka (1999) for reviews of the real options literature. The agency problem arising from incomplete contracting is rarely mentioned but never included in real options valuation models. Although several mechanisms (e.g., choice of capital structure, outside board members, corporate charters, and merger and acquisitions) are available to enforce governance, the focus of the literature is on managerial effort rather than option exercise decisions. See Shleifer and Vishny (1997) and Zingales (2001) for reviews of the literature on corporate governance.

between insiders and prospective public investors. Even if information is available, their diffused shareholding will prevent public investors from exerting the necessary governance control to ensure that the real options exercise decisions will be made in their best interest.[3]

This seems to suggest that firms with significant options should not go public. But this will impose several costs to VCs by mal-diversification of their holdings and inability to devote efforts to more profitable ventures. Furthermore, the potential threat of expropriation by VCs may dissuade entrepreneurs from exerting sufficient effort.[4] In practice we see many such early stage firms go public prior to the exercise of key real options.[5] How is management discipline ensured in such cases? It is perhaps why we observe VCs retaining a significant stake in the post-IPO firm, often with a lock-up provision that further constrains post-IPO exit.

We propose a descriptively rich model that can explain partial exit by VCs. We explain the IPO decision and the amount of the stake to be sold to the public by jointly taking on asymmetric information, agency, and governance for real-options decisions.[6] This task can lead to fairly dense layers of assumptions — we make judicious

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[2] In the rest of the paper we will refer to these entrepreneur-managers as entrepreneurs.

[3] The literature on considers cases where blockholders may act in concert or in conflict with small public shareholders. See Burkart, Gromb, and Panunzi (1997) (2000) and Holderss (2003). In this paper we make explicit the VCs private costs and benefits that differentiate them from other investors. The key conflict occurs between entrepreneurs on the one hand and public investors and venture capitalist on the other.

[4] Myers (2000) seeks to explain why firms with asymmetric information choose to make an IPO. Consider a date after which the entrepreneur faces significant risk of expropriation by *VC* whose equity ownership confers concomitant governance power. In this scenario the entrepreneur will not contribute his effort to the firm even though it may be very valuable for the firm. This benefit from eliminating the expropriation threat by having *VC* sell her stake in the firm offsets the cost of selling at a date with asymmetric information. Myers's model that explains the *VC*'s exit, however, is inconsistent with the potential payoffs arising from strong governance and empirical evidence of considerable stake retained by venture capitalists.

[5] See for example, Megginson and Weiss (1991) and Lerner (2000).

simplifications, which we argue preserve the key features as well as the model's ability to inform about real-world issues.[7]

We also discuss manager's efforts. In fact, one of our results shows that too large a stake in the firm imposes strong governance but may have a negative impact on manager's effort. Nevertheless, it may be optimal to retain governance rights due to the presence of real options.

The setting discussed in our paper addresses a rich set of problems. Corporate real options can arise in many guises but all involve firms having the flexibility to make future strategic choices. For instance, imagine a firm that is developing a product around a technology that was developed by the entrepreneur. As business conditions change and technology standards evolve over time, it may be more appropriate for the firm to switch into a different technology. Doing so would be in the best interest of the shareholders, but to the extent that the entrepreneur's personal payoffs are misaligned (both financial benefits and non-pecuniary benefits stemming from his emotional attachments or reputation gained by commercializing his technology) with the firm value, he may resist such a change. In such situations the governance structure of the firm will play a crucial role in ensuring that the firm makes the correct decision in exercising the technology choice option. Other such real options may involve choices between marketing strategies, growth strategies (fast vs. slow organic), management teams (entrepreneur's friends & family vs. professional managers), and production strategies (e.g., location).

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[6] Gompers and Lerner (1999) note the importance of these characteristics in their book on venture capital financing.

[7] Our focus on the equity decision (what mix of equity financing) ignores the possibilities of more comprehensive capital structure choice. We discuss some suggestions for extending our model along this direction.

Although we are not aware of any systematic empirical studies, the business press provides ample examples of firms tussling with governance conflicts when making such strategic choices.

The key point driving these conflicts is the presence of agency problems where the payoffs to entrepreneur and shareholder will be asymmetric across the different strategies. A case that is trivial, yet highlights this asymmetry, arises when one strategy calls for abandoning the business and liquidating the assets against the alternative strategy that calls for keeping the firm as a going concern.[8] Although abandonment is in the best interest of the shareholders, entrepreneurs would be inclined to choose to continue operations in order to reap various private benefits -- e.g. his reputation, satisfaction of seeing his technology commercialized, his stature within the firm and his social or business network.[9]

In order to understand the intuition behind our paper, we stylize the facts. There are three key players -- entrepreneur (E, referred to in the third person as "he"), venture capitalist (VC, referred to in the third person as "she"), and public investors (P, referred to in the third person as "they"). Each player is assumed to maximize the present value of his or her own wealth. At Time 0, E providing his expertise and a VC providing financial capital organizes the firm.[10] Operating in an environment characterized by tremendous uncertainty, entrepreneurs, who are frequently constrained by their personally wealth and business skills, seek outside funding to develop their ideas and

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[8] Such situations often arise in declining industries, orphaned technology standards, or failed business models.

[9] Even popular movies such as "Wall Street" and "Other People's Money" have dramatized such situations.

prototypes, and other intangible assets whose value is hard to verify and is opaque to outsiders. Much of his input is wrapped in his human capital.

During the early gestation period the performance of the firm remains opaque to outsiders. The firm may not produce any tangible goods or services during this phase and has few sales, if any, let alone profits. Much of the value is in the form of real options that must be identified, nurtured and exercised in response to subtle signals that require intimate knowledge, that is privy only to informed insiders of the firm. The VC specializes in funding start-ups because of her unique evaluation skills along with her specialization in management and governance capabilities for new firms. The VC goes behind the corporate veil of the startup firm and de facto partners in the management of the firm. She participates in identifying and selecting projects and retains direct control over important investment decisions during the early phases by staged financing and later on indirectly by owning a governance stake in equity.[11]

At Time 1, once the firm chooses its projects (acquires its real options), some of the superior skills of VC are no longer needed. She then looks for ways to exit the firm and move her funds and skills to a firm that is in its startup phase where her skills are most needed. At this point the VC looks to sell some or part of her equity to outside investors who provide money and expects only to earn a fair rate of return on their investment. Although some information regarding the firm can be credibly revealed to the public, much of the firm's assets are still wrapped up in intangible real options and

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[10] Although the literature has considered the use of various performance-based bonus schemes and equity-based compensation to remedy the agency problem, most of these features are not feasible for early stage firms where the entrepreneur is wealth constrained.

[11] Gompers and Lerner (1999) provide useful and detailed discussion of the issues surrounding financing of start-ups by venture capitalists.

can not be verified by outsiders. Credibly communicating the value of the firm to outside investors unfamiliar with the intimate details of the firm remains a problem.

At Time 2, the uncertainty regarding the firms future outcomes is largely resolved and firm has an option to choose between two strategic choices: A (continue) and B (switch). The choice between the two strategies will be based on the particular realization of the economy at Time 2. At Time 1, the state of the Time 2 economy is uncertain. Between Times 1 and 2 the E's efforts continue to be essential in keeping the option alive. The agency problem arises from the fact that E receives greater private benefits under strategy A under all states of the economy.[12] Hence, if E continues to be a decision-making manager, he will choose strategy A even when the state of the economy suggests that the firm should switch to strategy B for the greater benefits of all shareholders.

We allow the VC to hold a post-IPO equity stake that can credibly signal to the public investors about the private information and minimizes the Lemon's problem in the valuation of the IPO. The stake should be large enough to discipline E to make the real options exercise choices that maximize firm value but not be so large that the entrepreneur will hold up his effort due to the threat of expropriation. The signaling and governance benefits due to the VC retaining a post-IPO stake must be offset against the cost of foregone outside opportunities where the VC's superior skills can be more profitably deployed. Hence we find that a partial exit by the VC can be optimal.

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[12] We assume that the payoff to strategy B is state independent. Entrepreneur may capture rents for his special skills, for instance in the form of vesting stock options or founders shares. He may also receive many intangible and often non-pecuniary benefits. For instance, many entrepreneurs develop an emotional attachment to their technology or business idea and will be reluctant to make rational choices. In other cases, entrepreneurs reputation can hinge on the continuation of strategy A.

Our model produces several important results. First, we show that the agency issue cannot always be solved through a contractual design. (In fact, we argue that most real start up situations are such that it cannot be solved contractually.) The contractual solution calls for E's payoff to be based entirely on equity. But wealth constraints and the presence of large private benefits prevent such solutions. Second, we study the cost-benefit tradeoff faced by VC and show that she would either exit fully or retain a certain amount that can be greater than the minimum required to exert. The VC keeps higher than required amount such that his improved expected payoff from the shares (by switching to Strategy B) justifies the expected cost of firing E.

We also study how VC's decision may vary across firms with different prospects. The prospects (and firm types) differ in their probability of achieving a good outcome at Time 2. In the case of where the outside public and insiders have symmetric information about this probability, we obtain a threshold probability below which the VC retains a fixed amount and exit fully otherwise. When uncertainty increases, the same firm may switch from complete exit to retaining a stake. In the case of asymmetric information, there can be a separating equilibrium or pooling. Under separating equilibrium, there is a probability threshold below which VC will exit fully. Since firms with low prospects get to free ride on good firms, asymmetric information leads to adverse selection.

The rest of the paper is organized as follows. In the next section we introduce a formal model and arrive at a simplified version that is able to capture the essential elements of our problem. In sections 3 we solve for the post-IPO stake under symmetric information assumptions and examine the impact of increasing uncertainty. In section 4

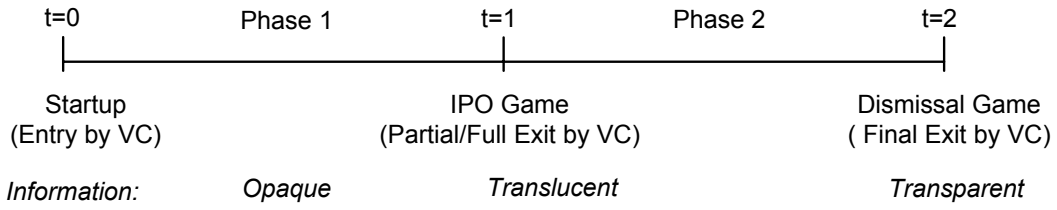
we consider the asymmetric information case and obtain pooling and separating equilibria. Finally, we provide some extensions and offer concluding remarks.

2. Model

The focus of our paper is around the initial public offering (IPO) when the venture capitalist considers exiting the venture by selling its stake to the public investors. The venture capitalist is trading off the costs and benefits of exerting governance by retaining a significant stake in the firm after IPO. The main benefits of retaining governance rights come from preventing suboptimal exercise of options in the firm. The costs of doing so include the opportunity cost of funds, monitoring costs, and the cost of exerting governance rights (i.e. firing the entrepreneur) when necessary.

There are three time points in our model. Figure 1 depicts the timeline.

Figure 1: Timeline



The three players in our model, the entrepreneur E, the venture capitalist VC, and public investors P, make contributions to the equity value of the firm across different dates and phases (summarized in Table 1). The detailed structure is then discussed.

Table 1

	Phase 1	t=1	Phase 2	t=2	After t=2
Entrepreneur, E	++	++	++	–	–
Venture Capitalist, VC	++	+	+	+	0
Public Investors, P	–	+	0	+	0

Notation: "++" = very significant value if participant; "+" = useful value; "0" = no value; "–" = cost.[13]

Time 0: Firm Starts

At time 0, an entrepreneur (*E*) combines with a venture capitalist (*VC*) to start the firm. We assume that the financial investment required to develop the business exceeds *E*'s financial resources and VC's fund is dispensable.

Contracts between *E* and *VC* are usually detailed and complex.[14] For our purposes, we assume that the contract specifies the sharing of the equity ownership of the firm – E gets *a* fraction of the equity and VC gets (1-*a*), and a wage to be paid to E, R_w, after t=2 as long as he stays in the firm as a decision maker.[15] In the model developed next, we assume that *E*'s initial equity stake is zero. Later in the paper, we discuss the impact of equity ownership by *E* and show that as long as *E* has limited financial resources to start the firm and derives significant private benefits from one strategy rather than another, the problem identified in the simplified model persists.

Phase 1

During Phase 1, the period between t=0 and t=1, *E* contributes resources such as concepts and intellectual property, while *VC* contributes her expertise in managing and governing startups. Through her involvement in the operations of the firm (including

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[13] The table is incomplete in at least two important ways: (a) the private costs to the players from staying on with the firm or from being removed from the firm are not accounted for; and (b) the spillover costs from VC's continuance after time 1 on E's well-being are ignored. Therefore, it would be incorrect to conclude from the above table that VC should definitely be retained till at least time 2 (or that E must be fired at t=2).

[14] For a detailed model of the start-up negotiations, see Gompers and Lerner (1999) and Myers (2000). For empirical studies of actual contracts between entrepreneurs and venture capitalists, see Kaplan and Strömberg (2003).

[15] See Myers (2000) for motivational details related to the economic rents available to the entrepreneur who continues as decision maker after an IPO.

being active on the Board of Directors), *VC* acquires capabilities to monitor the firm and its entrepreneur-manager.

Time 1: IPO Game

By time 1, some of the uncertainty surrounding the firm's prospects is resolved. The firm's assets and prospects become less opaque for outsiders (i.e., the firm has become translucent). However, the success of the business still requires continued effort by the entrepreneur in Phase 2.

At this point, VC has incentive to to exit the firm and move her funds and skills to a firm that is still in its startup phase where her skills are most needed. The marginal value of continued contributions by *VC* significantly diminishes. Given outside opportunities where *VC* can realize significant value from her participation (which must be joint with capital), she would like to cash-out to release funds.[16]

VC's urgency of reallocation is parameterized by a conversion factor, ρ, that equalizes her payoffs at time 2 from capital freed at time 1, i.e.,

$$\rho = \frac{V_1}{V_2} = \frac{\text{capital freed and reinvested in alternative opportunies at t} = 1}{\text{value of the freed and reinvested capital at t} = 2}.$$

One can think of ρ as *VC*'s private rate of time discounting as of time 1 that differs from that of the market. Additionally, ρ captures any mal-diversification by *VC* that leads to her risk premium from maintaining a stake in the risky firm to be higher than that of a well-diversified public investor.

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[16] Another motive for an IPO at time 1, which typically results in a very small stake sold to the public, is for marketing and for engaging in mergers/acquisitions employing equity exchanges. For this motive, the main goal is to have an external valuation of the firm that is as high as possible. If the main difficulty is asymmetric information and not expropriation risk, this is achieved by selling a very small stake. We don't explicitly model this possible driver for an IPO though it can be somewhat explored by considering ρ close to 1 and introducing a value drop at v=1.

Given $\rho \leq 1$, time 1 could be a useful juncture to sell some or all of *VC*'s equity to outside public investors (*P*).[17] In other words, the firm evaluates an initial public offering (IPO) at time 1. Formally, *VC* announces the fraction of the firms equity to be offered to the public, *p* (including possibly zero, i.e., no IPO).[18] Since she owns (1-*a*) fraction of the equity prior to the announcement, her remainder position is $v = 1 - a - p$, and she receives the entire proceeds from the public offering. $v = 0$ means that *VC* exits completely at time 1. If $v>0$, *VC* will sell her remainder equity stake at time 2. Since the firm is not transparent at time 1 and/or governance problems remain, *P*'s valuation at time 1 of the firm's equity (P_1) may differ from the intrinsic value known to the insiders (*E* and *VC*), and will depend on the announced *v*, which complication is fundamental to our explorations.

Phase 2

During Phase 2 (between time 1 and 2), assuming the firm has survived time 1, *E* exerts effort which is indispensable for the firm, and the disutility of this effort to *E* is denoted by *e*. *VC*'s active participation in this phase is at most that of monitoring which costs $m \geq 0$. In Phase 2, new information about the firm's prospects at t=2 becomes available to *E* and *VC* (or investors who choose to be monitors at extra costs).

During Phase 2, *E* and *VC* learn that with probability *q* the state of the world will be favorable for the firm t=2, and unfavorable with probability 1- *q* (the implications of the state of the world will be discussed shortly).

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[17] Though an IPO may occur at time 1 even if $\rho = 1$ because of the need to possibly mitigate the threat of expropriation to the manager — see Myers (2000) and discussion below.

[18] In general, we should recognize the cost of filing for IPO which has a fixed component that introduces a discontinuity at $v = 1$.

For simplicity, we assume that *E* and *VC* have the above information at the beginning of Phase 2, i.e. t=1. In the case of symmetric information, the public investors have the same information as *E* and *VC* at t=1. In the case of asymmetric information, the public investors know everything *E* and *VC* know except the value of q; instead, they only know the distribution of q.

Time 2: Strategic Decision and Dismissal Game

The state of the world is revealed and observable to everyone at t=2. A favorable state means that the firm is worth *H* while an unfavorable state means the firm is only worth *L*, provided that the firm continues to follow its current strategy (call it Strategy A).

The firm also has an alternative strategy, Strategy B, the return to which is independent of the state of the world. Choosing Strategy B will yield a value of *S* with certainty.

We assume that if the decision is made optimally (in the interests of the shareholders), Strategy A should be chosen under the favorable state and Strategy B when the state is unfavorable, i.e. $H > S > L$.

However, E derives extra private benefits R_p from following Strategy A, in addition to his equity stake and wage, but derive no such benefits from Strategy B. Thus, *E* may choose Strategy A even in the unfavorable state.

To ensure that the decision be made optimally in the unfavorable state, shareholders have to remove *E* from the firm first. *E* can be dismissed by the shareholders if together they control an equity position that equals or exceeds g ($g \in (0,1)$ is the minimum stake for effective governance that depends on statutory and institutional

characteristics and could be different from a simple majority [50%] stake). Assume that E gets a severance package, R_s, at the cost of the firm if fired. However, such equity-holders have to incur a private deadweight cost D to execute the dismissal.[19]

Because of their diffused ownership, public investors are unlikely to incur the costs of organizing to vote as a block (free rider problem). Hence, P does not pose a credible dismissal threat to E. However, if VC retains a governance interest, she may replace E at time 2, bearing the cost D herself, with a professional manager. The new manager requires a wage that we assume to be equal R_w., but does not derive any private benefits from any strategy.

Recognizing this threat of dismissal and consequent loss of R_p, E may quit the firm at time 1. Myers (2000) motivate VC's exit at time 1 via an IPO to mitigate the threat of dismissal. Our results significantly go beyond Myers in this area. While VC's post-IPO stakes should not be too high to discourage E from participating, they serve as a governance mechanism to prevent suboptimal exercise of real options. If E is retained, he continues to be the decision maker and derives private benefits R_p from the strategy he chooses. Although R_p is not a direct expense to the firm, retaining E under Strategy A may have a cost C ($C \geq 0$) to the firm.[20] $L \geq C$ is necessary for the firm's value to remain non-negative. Therefore, we have

Assumption 1: $H > S > L \geq C \geq 0$.

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[19] One way to understand D, the private deadweight cost that VC must incur if she dismisses E, is to consider the cost of building a solid enough case to defend against a charge of wrongful dismissal by E. This cost arises, for instance, due to the challenge for the monitor to make verifiable the privately known information about values at time 2. For VC, D also includes reputation considerations for future relations with other entrepreneurs.

[20] For instance, C may arise from inefficiencies in E's management style.

3. IPO Decisions by VC under Symmetric Information

The optimal equity to offer to the public at time 1 depends on what all the players do at time 1 and time 2 as a function of the offered equity. As is typical in such problems, we start from the end and fold the tree backwards.

Dismissal Game at Time 2 and the Agency Problem

By time 2, the firm's value relevant for the real options decision is known to insiders (*E* and *VC*). Each player in the game only seeks to maximize his/her own value. Consider the case when *VC*'s share of equity is greater than the minimum threshold that is needed to exert governance control (i.e., $v>g$) and that *VC* has expended *m* to monitor the firm during phase 2. In this case *VC* can decide whether to keep or dismiss *E* after accounting for her cost of dismissal, *D*. If *E* is retained, then *E* makes the decision of whether to continue with Strategy A or to switch to Strategy B based on his payoffs. If *E* is dismissed, then *VC* makes the strategic decision by maximizing the value to her (which will be the equity value accruing to her fraction *v*).

Figure 2 illustrates the dismissal game at t=2 between *E* and *VC* under both states of the world. Panel (a) of Figure 2 presents the general model. Note that at each player's each decision node, the impacts of R_w on the payoffs are common across the alternatives and thus can be normalized to zero. We further simplify the model by assuming $a=0$ and $R_s=0$ (see Panel (b) of Figure 2). We will discuss the impact of E's equity share ($a>0$) later. From now on, we use the simplified model in Figure 2(b) for our discussions unless otherwise noted.

Figure 2
(a) General Model

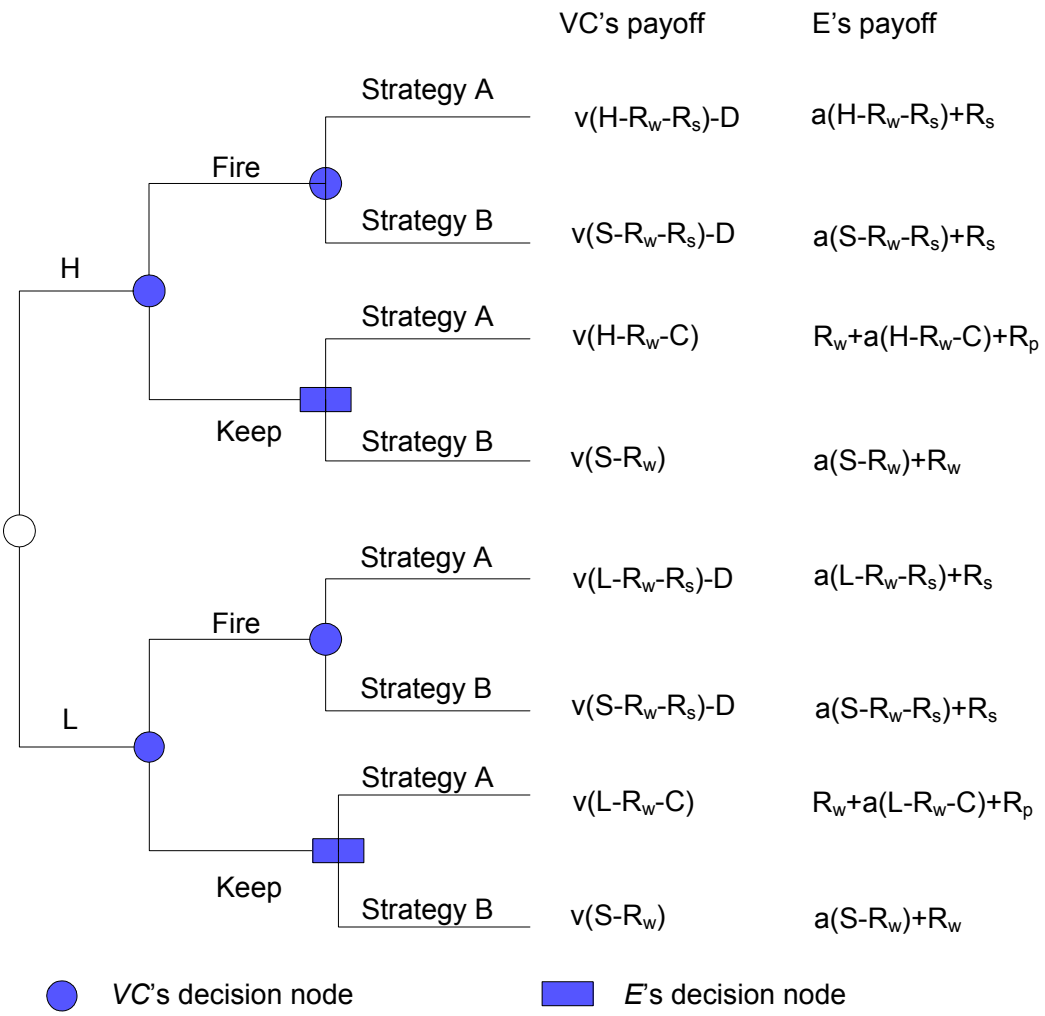
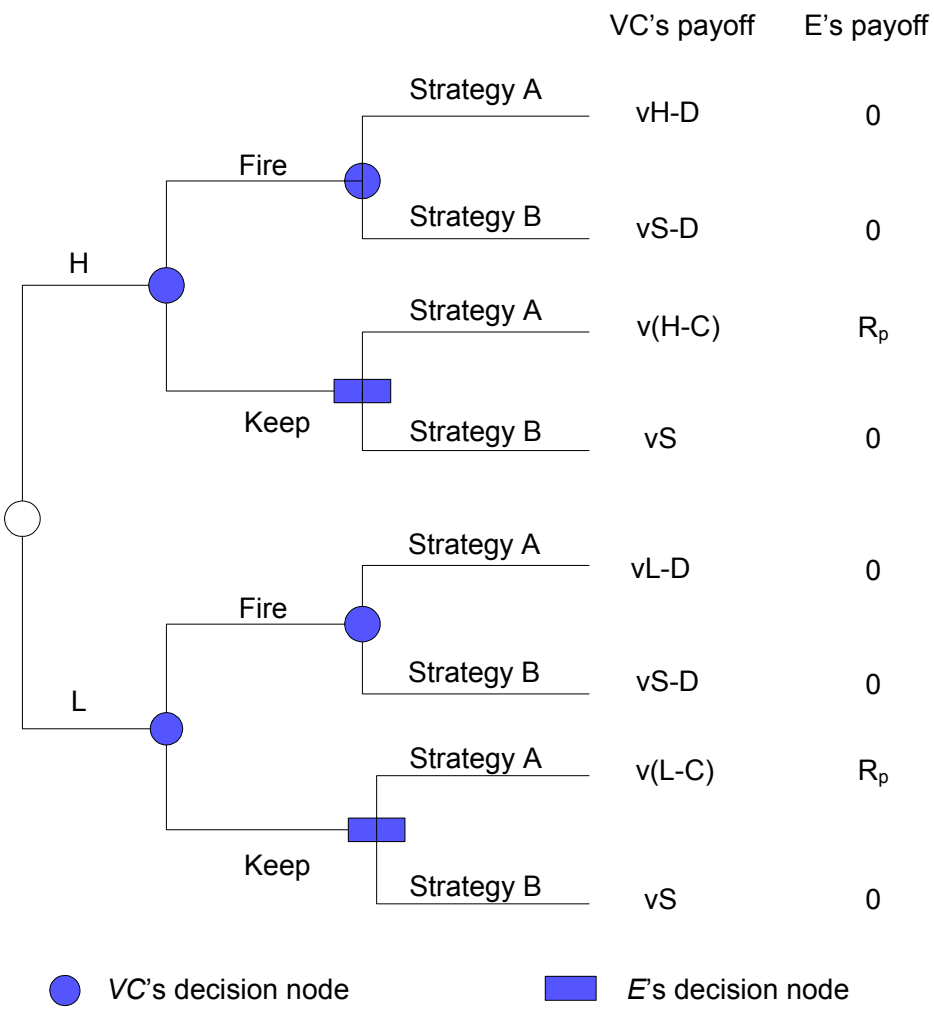


Figure 2
(b) Simplified Model
R_w is normalized to 0. Assume a=0, R_s=0



Consider the case in the favorable state (i.e. *H* occurs. For conciseness, we will call it the *H*-state) and *VC* decides to keep *E*. Then *E* will choose to continue with Strategy A and earn R_p. *VC* would get $v(H-C)$, her pro-rated portion of the firm's equity value. If instead, *VC* dismisses *E*, she will also choose to continue with Strategy A, earning $vH-D$. Note that the cost of dismissing *E* is borne only by *VC*. Similar logic

applies to the case of the unfavorable state. *VC*'s payoffs at time 2 are summarized in Table 2.

Table 2		
Action Regarding E	Realization of the State of the World	
	H	L
Dismiss E	$vH - D$	$vS - D$
Keep E	$v(H - C)$	$v(L - C)$

Note that *VC* will decide to keep the entrepreneur in the *H*-state if $v(H - C) \geq vH - D$, or $v \leq \frac{D}{C} \equiv h'$.[21] Since admissible values are $0 \leq v \leq 1$, let $h \equiv \min(1, h')$ denote the equity-fraction threshold above which *E* will be dismissed if the *H*-state is realized in phase 2. When *D* is small and *C* is large, h' is low and can be lower than 1. The intuition is that when the cost of firing *E* is low and the cost saving from firing him is high, VC has incentive to fire *E* in any state even with lower post-IPO stakes.

In the *L*-state, *VC* will dismiss *E* in order to pursue Strategy B if $vS - D \geq v(L - C)$, i.e. $v \geq \frac{D}{S + C - L} \equiv l'$. From Assumption 1, we know that $l' > 0$. Recall that we define *g* as the minimum stake for effective governance (i.e. being able to dismiss *E*). It must be noted that l' might be different from *g*, and in particular, higher than *g*. The reason lies in that the benefits of firing E in the L-state – getting *S* instead of $L - C$, are shared by all equity holders while the cost of firing E is borne purely by VC. Therefore, VC must have enough stakes in the firm for executing governance rights to be worthwhile. This means that to impose governance VC must not only have the ability to

do so, but also be incentivized to do so. Formally, we denote the minimum equity fraction for effective governance action as: $\max(g, l') \equiv l$.

In absence of *g*, or when $l = l'$, VC's optimal decisions at t=2 are given by:

i) Always keep *E* when $v < l'$;

ii) Keep *E* in *H*-state and fire *E* in *L*-state when $l' \le v < h$; and

iii) If h <1, then always fire *E* when $v \ge h$.

Next we examine the situation when $l = \max(g, l')$ and $h = \min(1, h')$. Since $g \in (0,1)$ and by Assumption 1 $l' < h'$, of all possible situations, $l \ge h$ occurs when $l' < h' \le g$ and $1 \le l' < h'$. Under the former condition, E will always be kept as long as $v < l'$ but always fired when $v \ge l'$; in the latter case, E will always be kept for any $v \in [0,1)$. We assume in what follows that $l < h$. This implies that $S + C - L > D$.

Under the assumption that $l < h$, VC's time-2 decisions are given by:

i) Always keep *E* when $v < l$;

ii) Keep *E* in *H*-state and fire *E* in *L*-state when $l \le v < h$; and

iii) If h <1, then always fire *E* when $v \ge h$.

We now formally discuss the agency issue in the setup. When the L-state occurs, it is optimal to switch to Strategy B. However, if E is the decision maker, he will choose to continue with Strategy A due to his private benefits. This is the agency cost to the firm. Under the H-state, again, E will choose Strategy A; however, we assume that this choice is in line with the shareholders' interests, i.e. $H - C > S$, and does not constitute an agency problem. Therefore, we introduce Assumption 2:

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[21] For technical convenience, we assume that E is dismissed if *VC* is indifferent between dismissing him and keeping him.

Assumption 2: $H > S + C > D + L$.

IPO Game at Time 1

Continuing the backward solving approach, we examine *E*'s problem at time 1.[22] *E*, who moves after *VC,* chooses whether to exert effort at cost *e* in phase 2. If he exerts effort, his payoffs are:

$qR_p + (1-q)R_p - e = R_p - e$ if $v < l$;

$qR_p + (1-q)0 - e = qR_p - e$ if $l \le v < h$;

$q0 + (1-q)0 - e = -e$ if $v \ge h$.

Recollect that *h* is the *VC*'s fractional ownership level at and above which she will always fire *E* at time 2. If $qR_p - e > 0$, which we assume to be true, *E* will exert effort for all $v < h$, but not for any $v \ge h$. But if *E* does not work in phase 2, the firm becomes valueless in our setup. Therefore, to incentivize *E* to provide his effort indispensable for the firm, *VC* should never hold a higher fraction of the firm than *h*.

The other player moving after *VC* at time 1 is *P* who establishes a fair value of the firm's equity, P_1, conditional on public information including the announced *v*. Since discounting for time and risk is eliminated by choice of normalization, the fair P_1 for us is *P*'s expectation of the firm's value at time 2, say P_2.

VC moves first at time 1 and announces the equity fraction she will sell to the public, *p* (= 1 – *v*). If *p*<1, she also commits to monitor in phase 2 at a private cost to her of *m*.[23] *VC* realizes proceeds of $(1-v)P_1$ at time 1 (less *m* if *v*>0) and expects to realize

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[22] Since the decisions of *P* and *E* are separable at time 1 in our model, we can study them in any order.
[23] In principle, she could choose to not incur *m* even if she retained some stake. But recall that *m* might be near zero (or even negative) because she realizes spillover benefits to her activities with other startups. Several venture capitalists inform us that such spillovers are quite important in early-IPO cases. For our

proceeds from sale of her remainder stake at time 2 less dismissal costs if any. Let P_{21} denote *VC*'s expectation of the public value of equity at time 2 if she retains a stake below *l*, and P_{22} denote *VC*'s expectation when her retained stake satisfies $l \le v < h$. *VC*'s value function at time 1 is then:

$$u(v) = \begin{cases} P_1(0) & \text{if } v = 0 \\ (1-v)P_1(v) - m + \rho v P_{21} & \text{if } 0 < v < l \\ (1-v)P_1(v) - m + \rho v P_{22} - \rho(1-q)D & \text{if } l \le v < h \\ 0 & \text{if } v \ge h \end{cases} \qquad (1)$$

The dependence of P_1 on the fraction retained by *VC* is explicitly noted via the braces attached to P_1. The optimal fraction that *VC* should retain in firm is then: $v^* = \arg\max u(v)$.

It is straightforward to compute P_{21} and P_{22}:

$$P_{21} = q(H-C) + (1-q)(L-C) = q(H-L) + L - C$$

$$P_{22} = q(H-C) + (1-q)S = q(H-C-S) + S.$$

Intuitively, the value P_{22} represents the value of the firm when it is expected that the real options in the firm will be exercised optimally. The value P_{21} represents the expected value of the firm when no effective corporate governance exists to ensure the optimal exercise of real options in the firm, leading to an agency problem which is due to *E*'s misaligned objectives with the firm's strategies. As a benchmark, we define $\delta = P_{22} - P_{21} = (1-q)(S + C - L)$. The magnitude of δ indicates the severity of the agency problem. Obviously, the agency cost is higher for low *q* – probability of getting an H-state, and for high (*S*+*C*-*L*) - net value of adopting the alternative strategy,.

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purposes, introducing *m* suffices while modeling a choice situation about it appears to offer little insight. We can assume that other shareholders may incur a cost *M* to become monitors. M>>*m* allowed us to

The value of $P_1(v)$ is more challenging to determine. It depends critically upon the information specification of what *P* knows relative to *VC*. In this section, we assume symmetric information between *P* and *VC*. When *P* and *VC* know all the parameters,

$$P_1(v) = \begin{cases} P_{21} & \text{if } 0 \le v < l \\ P_{22} & \text{if } l \le v < h \\ 0 & \text{if } v \ge h \end{cases}$$

As long as either $\rho < 1$ or $m > 0$, the strategy to hold any fraction in the interval of (0, *l*) is strongly dominated by the strategy of exiting fully (*v* = 0). When $\rho = 1$ and $m = 0$, exiting fully (*v* = 0) weakly dominates retaining a fraction $v \in (0, l)$. Under the assumption that weakly dominated strategies are never played, VC will not choose any $v \in (0, l)$.

When $l \le v < h$, it can be easily seen that it is optimal for the *VC* to hold no more than *l* fraction of the firm. Therefore, *VC*'s optimal post-IPO stake in the firm is either *v*=0 (exits completely) or *v*=*l* (retains a minimum effective governance stake), depending on the parameters. This case slightly generalizes Myers (2000) in that we find that *VC* may not exit completely if there is a significant value from his comparative advantage of governance (because of monitoring, rather than screening ideas).

We have:

$$u(v = 0) = q(H - L) + L - C \qquad (2)$$

and

$$u(v = l) = q[(1 - l + \rho l)(H - C - S) + \rho D] + (1 - l + \rho l)S - \rho D - m \quad (3)$$

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conveniently address the comparative advantage of *VC* as a monitor relative to outside monitors.

It is noted that $u(v=0)$ equals to the value of the firm without governance (in terms of real options). We also note that $u(v=l)$ is lower than the first-best case (P_{22}) when the real options will always be exercised optimally due to the costs of imposing governance represented by parameters *D*, *m*, and ρ. We are interested in when *VC* has incentive to impose governance, and thus improving upon the case of no governance. In particular, we are interested in how *VC*'s decision may vary with different prospects, i.e. different *q* values. We also call the *q* value of a firm its type.

Consider *VC*'s expected payoffs for both choices of post-IPO stake (0 and *l*) as functions of *q* and denote these payoffs as $u_0(q)$ and $u_l(q)$ respectively. Both functions are linear in *q*. It can be proved that under Assumptions 1 and 2, the slope of $u_0(q)$ is greater than that of $u_l(q)$. Therefore, unless the intercept of $u_l(q)$ is higher than that of $u_0(q)$, VC has no incentive to retain governance rights in the firm to alleviate the agency problem.

Lemma 1: When $L - C + \rho D + m \geq (1 - l + \rho l)S$, VC chooses *v*=0 for any $q \in (0,1)$.

The shapes of $u_0(q)$ and $u_l(q)$ also suggest that if *VC* chooses to impose governance for some firms, it must be firms with relatively low *q* values, i.e. when the *L*-state is more likely to occur. We introduce the following definition.

Lemma 2: $q^* \in [0,1]$, if exists, is a threshold level of *q* such that *VC* chooses *v*=*l* for any $q < q^*$ and *v*=0 for $q > q^*$. VC is indifferent between *v*=0 and *v*=*l* when $q = q^*$.

Recall that the agency problem is more severe for low values of *q*. Therefore, under symmetric information VC's post-IPO stakes can alleviate the agency problem in

firms where it is more serious while VCs choose not to deal with the agency issue in mild cases.

From (2) and (3), we get:

Lemma 3: When q^* exists, it is given by:

$$q^* = 1 - \frac{(1-\rho)(H-C)l + m}{S(1-l+\rho l) + C - L - \rho D - (1-\rho)(H-C)l}.$$

Next, we present a sufficient condition for which such a threshold level exists and *VC*'s post-IPO stake may alleviate the agency problem for firms with prospects worse than the threshold type.

Lemma 4: When $g \le l' < 1 - \frac{(1-\rho)(L-C)+m}{S-\rho(L-C)}$, there exists a unique positive q^* as given by Lemma 3.

When the conditions in Lemma 4 are satisfied, the agency problem in firms with q lower than the threshold level will be alleviated. We also get the following corollary of Lemma 4.

Corollary 1: When $g \le l'$, $m = 0$ and $\rho = 1$, i.e. the *VC* retains l fraction of the firm for any $q \in (0,1)$.

Intuitively, as long as the monitoring cost is negligible, and there is no opportunity cost for the funds locked up in the firm, since we assume that the benefits of executing governance exceeds the cost of firing E, $S-(L-C) > D$, *VC* is always willing to retain a significant stake in post-IPO firms to impose governance.

Proposition 1 summarizes the above results.

Proposition 1: When q^* exists, the agency problem in firms with $q < q^*$ is alleviated.

Lastly, we examine the impact of uncertainty of the firm's prospects on *VC*'s IPO decision. We look at how *VC*'s IPO decision may change when states of the world are more uncertain while the expected payoff from following Strategy A remains the same. For simplicity, we assume that $L = C = 0$. Under this assumption, a mean- preserving spread implies that $\mu = qH = constant$ while $\sigma^2 = q(1-q)H^2$ increases. This involves an increase in H and a decrease in q.

It can be proved that when q^* exists, it decreases in H. This means that when the payoff in the favorable state is even greater, the threshold level of q above which VC exits fully is lowered. However, under the mean-preserving spread, the firm's q value is also lower. Which effect dominates the other? Furthermore, does high uncertainty induce regime change?

Proposition 2: Suppose $L = C = 0$. More uncertainty makes the VC who was indifferent between retaining l fraction of the firm and exiting fully will now choose to retain l fraction of the firm.

Proposition 2 implies that when uncertainty increases, the decrease in the threshold level of q is always smaller in magnitude than the decrease in the probability of the favorable state occurring. As a benchmark, a comparison between P_{21} and P_{22} (assuming $L = C = 0$) under the mean-preserving spread shows that the agency problem is more severe under higher uncertainty. Proposition 2 suggests that in face of changing uncertainty, *VC*'s propensity to impose governance moves in the right direction and the regime may change.

4. IPO Decisions by VC under Asymmetric Information

We discuss asymmetric information regarding q. We use the notion of Perfect Bayesian Equilibrium (PBE) in defining equilibrium.

Assume that at t=1 *VC* and *E* know the exact value of q while public investors only know that q values of firms are distributed on an interval $\left[\underline{q}, \bar{q}\right]$ with a density function of $f(q)$. We also define $q_m \equiv \int_{\underline{q}}^{\bar{q}} q f(q) dq$.

Assumption 3: For any $q \in \left[\underline{q}, \bar{q}\right]$, $f(q) > 0$ and for any $q_x \in \left[\underline{q}, \bar{q}\right]$, $\Pr(q = q_x) = 0$.

The second condition in Assumption 3 ensures that no particular type of firms can change the belief of the public investors about the overall behaviors of firms.

To determine VC's decisions at t=1, we need to construct $u(v)$ under asymmetric information. Recall that:

$$u(v) = \begin{cases} P_1(0) & \text{if } v = 0 \\ (1-v)P_1(v) - m + \rho v P_{21} & \text{if } 0 < v < l \\ (1-v)P_1(v) - m + \rho v P_{22} - \rho(1-q)D & \text{if } l \le v < h \\ 0 & \text{if } v \ge h \end{cases}$$

Since all information and outcomes are revealed at t=2, *VC*'s expectation, taken at t=1, of *P*'s evaluations of the value of the firm at t=2, P_{21} and P_{22}, remain unchanged under asymmetric information. This is because the value of the firm to be realized at t=2 depends only on the true type of the firm and the governance structure, and it is not influenced by any information asymmetry at time 1. This implies that under asymmetric information, retaining post-IPO stakes in a firm may not only impose governance, but also serve as a signal for VC (informed) to communicate information to the public (uninformed).

What has changed is the value of $P_1(v)$, which depends on the beliefs held by *P* regarding the behaviors of VC's at time 1. At time 1, the fraction of the equity stake retained by VC at IPO is the only signal observable to *P*. Therefore, *VC*s of different types (*q* values) of firms may choose different fractions of the equity to retain, *v*, for signaling purpose.

Since *P* only observes *v*, they group firms according to *VC*'s choices of *v*. When *P* observes a *v*, they form a belief about the portion in the population of firms choosing this level of *v*, and about the average level of *q* given these firms have chosen *v*. Denote the believed conditional mean of *q* for the firms with a particular *v* level by q_v (for example, q_0 denotes the conditional mean of *q* for firms with *v*=0). VC's payoffs for different choices of *v* are then given by:

$$u(v=0) = q_0 H + (1-q_0)L - C$$

$$u(v|v \in (0,l)) = (1-v)[q_v H + (1-q_v)L - C] - m + \rho v[qH + (1-q)L - C]$$

$$u(v|v \in [l,h)) = (1-v)[q_v (H-C) + (1-q_v)S] - m + \rho v[q(H-C) + (1-q)S] - \rho(1-q)D$$

It can be proved that in equilibrium, no VCs choose any level of *v* other than 0 and *l*.

Lemma 5: In a PBE under asymmetric information, VCs of all firms choose to either exit fully, $v = 0$, or retain the minimum stake for effective governance, $v = l$.

Lemma 5 suggests that even though VCs can choose any post-IPO fraction of equity from the whole interval of [0, *h*), in equilibrium, they only choose two possible values. Therefore, the post-IPO stake retained by VC in a firm is not a perfect signal of the firm's future prospects.

Based on Lemma 5, we denote the portion of firms with $v = 0$ in the population by θ, and therefore the portion of firms with $v = l$ is 1-θ. When θ=1, it is a pooling equilibrium where all firms have $v = 0$; when θ=0, it is the other pooling equilibrium where all firms have $v = l$; when $0<\theta< 1$, it is a separating equilibrium where both $v = 0$ and $v = l$ can be observed. Since all equilibria are PBE, we know that $\theta q_0 + (1-\theta)q_l = q_m$.

Proposition 3 describes the separating equilibrium, if it occurs given the parameters.

Proposition 3: When a separating equilibrium occurs, under Assumption 3, there exists a unique, positive q^{**} given by:

$$q^{**} = \frac{q_0(H-L)+L-C+m+\rho D-(1-l+\rho l)S-(1-l)q_l(H-C-S)}{\rho[l(H-C-S)+D]}$$

where $q_0 = E(q|q < q^{**})$ and $q_l = E(q|q > q^{**})$,

such that VC chooses v=0 for any $q < q^{**}$ and v=l for $q > q^{**}$. VC is indifferent between v=0 and v=l when $q = q^{**}$.

The result presented in Proposition 3 is surprising. In Lemma 2, we show that under symmetric information, it is optimal for VCs to retain governance rights in firms with lower q and to exit fully when q is high. In addition, VC's decision under symmetric information alleviates the agency cost when this cost is very high. Under asymmetric information, however, VC's decisions are the exact opposite: she retains stakes in firms with high q, i.e. where the agency cost is relatively low, while exits fully from firms where the agency problem is severe and governance is most needed. It shows that asymmetric information has led to adverse selection!

The intuition for this suboptimal result is that under asymmetric information, the VCs are more concerned about communicating the correct information to the public than the governance of the firms. For any shares offered to the public at time 1, P can only evaluate based on their beliefs regarding the collective behavior of each group of firms (in our model, there are two groups in equilibrium: firms where VCs exit fully and those where VCs retain post-IPO stakes). Besides, any particular type of firm (a particular q value) cannot change the beliefs held by the public. On the contrary, the value of shares offered at time 2 reflects the true prospects of each firm: the better the prospects (higher q), the higher the value of the shares.[24] Therefore, good firms (higher q) have incentive to retain more post-IPO stakes for signaling purpose even though the agency problem is not significant. However, the firms are not holding on to any fraction of the firm higher than l due to the opportunity cost of locking up funds (see the proof of Lemma 5).

Proposition 4 specifies the two pooling equilibria.

Proposition 4:

a) VCs of all firms choose $v = 0$ when:

$$q_m(H-L) \geq \bar{q}\left[(1-l+\rho l)(H-C-S)+\rho D\right]+(1-l+\rho l)S+C-L-\rho D-m$$

b) VCs of all firms choose $v = l$ when:

$$q_m(H-L) \leq \underline{q}\left[(1-l+\rho l)(H-C-S)+\rho D\right]+(1-l+\rho l)S+C-L-\rho D-m$$

[24] These results are consistent with the theoretical results empirical findings in Brau, Lambson, and McQueen (2004) that shorter lockup periods being associated with firms with lower asymmetries. Their model, however, considers the tradeoff of signaling benefits against the costs of mimicking good firms.

5. Extensions

We now discuss the impact of equity ownership by *E*. Can the contract between the venture capitalist and the entrepreneur be designed to eliminate or mitigate the agency cost and the adverse selection problem identified?

With the wage paid to E normalized to zero, Table 3 summarizes the payoffs to E at his time-2 decision nodes when he holds fraction '*a*' of the equity that he can cash out after time 2.

Table 3		
Strategic Decision	Realization of the State of the World	
	H	*L*
Strategy A	$a(H-C)+R_p$	$a(L-C)+R_p$
Strategy B	aS	aS

By Assumption 2, E will choose Strategy A in the *H*-state. In the *L*-state, E's decision rule is: choose Strategy A if $a < \frac{R_p}{S+C-L}$ and B if $a > \frac{R_p}{S+C-L}$. The agency problem discussed above involves choosing Strategy A in the *L*-state. Therefore, the problem may be solved if *E*'s equity share in the firm is sufficiently high – specifically, it must exceed the threshold level given by $\frac{R_p}{S+C-L}$.[25] However, first and foremost, the reason that VC was brought in is due to the financial constraints of E and E's contribution to the firm may not be sufficient to justify a claim higher than the threshold given above to prevent the agency problem. Second, for sufficiently high value of R_p and low net value of adopting the alternative strategy, *S*+*C*-*L*, the threshold for E's ownership given

[25] In the extreme case, VC can sell the firm to E.

by $\frac{R_p}{S+C-L}$ may be higher than 1! In such situations, no contract between the venture capitalist and the entrepreneur can eliminate the agency problem discussed in this paper. This occurs when the entrepreneur has strong personal preference for a specific strategy and/or derives significant private benefits from it, and these personal payoffs to E exceed the net value of adopting the alternative strategy. Third, the contract between E and VC is signed at time 0. At this early stage, it would be difficult to form expectations about these parameters (R_p, S, C, and L), which may render the contracting solution infeasible or extremely difficult.

When contracting cannot eliminate the agency problem, how does ownership by the entrepreneur impact the agency problem? It can be proved that E's ownership of the firm exacerbates the agency problem under both symmetric and asymmetric information, though the sources for the increased agency costs differ under the two types of information structures.

Proposition 5: When $0 < a < \min\left(1, \frac{R_p}{S+C-L}\right)$, VCs choose to impose governance in fewer cases (firms) under asymmetric information, leading to higher agency costs than cases when $a = 0$.

Intuitively, under asymmetric information, when the entrepreneur's ownership is not high enough to prevent the agency problem, his ownership will leave the VC with a smaller fraction of the firm and thus the VC has less incentive to ensure governance.

6. Concluding Remarks

This paper explored the use of insider equity held by VCs as a mechanism to mitigate the agency problems that may arise in the exercise of valuable corporate real options. Although our setting is a start up firm around its IPO decision, the results can be broadly interpreted in terms of the block-holder literature. The problem arises when managers and shareholders have payoff asymmetries that lead the parties to prefer different strategic choices. We show how appropriate block holdings by inside investors can be used to ensure shareholder wealth-maximizing decisions.

We also show that optimal equity stake under symmetric information is for the VC to hold an equity stake for firms with poor prospects and exit fully, otherwise. Under asymmetric information, however, VC's of the firms with good prospects have no other way to signal to the public than to retain the stake until the information is revealed. Conversely, VCs may fully exit firms with poor prospects, leading to adverse selection.

Finally, we relax consider the use of a contractual solution to the agency problem by allowing the entrepreneur to hold equity stakes in the firm. We find that, although very large equity positions held by the entrepreneur can eliminate the conflict of interest, initial wealth constraints would prevent such situations. When the entrepreneur holds equity stakes insufficient to eliminate agency problem the agency problem is exacerbated.

These results help explain some empirical phenomena and suggest several empirically testable hypotheses. Our results are consistent with the observation that sometimes VCs exit fully at IPOs, while other times they retain a significant post-IPO stake.

Our models suggest that in industries with well-understood business models,[26] VCs would tend to exit firms that have high up-side potential but retain a substantial stake to exert governance for firms with poor prospects. In contrast, for firms undertaking new business models (with more asymmetric information) will exhibit adverse selection -- VC's will exit firms with poor prospects where their governance discipline is need but retain stakes in firms with good prospects to signal their value to public investors.

[26] We expect that firms with well-understood business models will be more transparent to outside investors and, thus, have less severe information asymmetries.

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