Venture Capital Meets Contract Theory: Risky Claims or Formal Control? *

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February 26, 2013

Abstract

This paper develops a theory of the joint allocation of control and cash-flow rights in venture capital (VC) deals. When the need for VC advice and support calls for a high-powered outside claim, the entrepreneur should optimally retain control in order to avoid undue interference. Hence, I predict that more high-powered claims should be associated with fewer control rights. This challenges the idea that control should always be attached to equity-like claims, and is in line with contractual terms used in venture capital, in corporate venturing and in partnerships between biotech start-ups and large corporations. The paper also rationalizes evidence that venture capital contracts include contingencies triggering both a reduction in VC control and the automatic conversion of VC's preferred stock into common.

Keywords: Control Rights, Cash-Flow Rights, Security Design, Venture Capital.
JEL Classification: G24, G32

*I am grateful to Jean Tirole, Sudipto Bhattacharya, Mike Burkart, Giovanni Cespa, Josh Lerner, Holger Müller, Giovanna Nicodano, Fausto Panunzi, Patrick Rey, Rune Stenbacka, Per Strömberg, Lucy White and an anonymous referee for their very constructive comments and suggestions. I also thank seminar participants at the CEPR meeting on The Firm and its Stakeholders (Courmayeur), the 2001 European Summer Symposium in Financial Markets (Gerzensee), the Institut d'Anàlisi Econòmica (Barcelona), Universitat Pompeu Fabra, Università di Brescia, CSEF University of Salerno, University of Turin, and Ente Einaudi (Rome). Address for correspondence: Giacinta Cestone, Cass Business School, 106 Bunhill Row, London, ECY1 8TZ, UK. E-mail: Giacinta.Cestone.1@city.ac.uk

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1 Introduction

In the last decade empirical studies of venture capital finance have highlighted that in VC deals control rights are allocated independently of cash-flow rights, through separate and distinct contractual covenants (see Kaplan and Strömberg 2003 and 2004, or Cumming and Johan 2007 and 2009). This suggests that the rights held by VC investors cannot be described by the standard array of securities defined in corporate finance textbooks. One notable example is the widespread use in VC deals of several classes of common stock to which very different voting, board and liquidation rights are attached. This paper develops a financial contracting model to investigate the joint allocation of control and cash flow rights attained through contractual covenants in VC deals.[1]

Control and cash-flow rights seem to follow a joint pattern in venture capital contracts, which suggests they are strongly interrelated. In their extensive study of venture capital agreements, Kaplan and Strömberg (2003) find that while VCs usually take preferred stock in the firms they fund, other covenants attribute to VCs' preferred stock substantial control rights. Conversely, in many corporate venturing deals and in partnerships between biotech start-ups and big drug companies, the investor takes a majority equity stake in the start-up, but few or no seats on the board of directors. This evidence is striking, in that - contrary to common wisdom - *more equity-like claims seem to be associated with weaker control rights.* Existing financial contracting models do not offer an explanation for this fact. Trying to fill this gap, my paper addresses two questions on the optimal form of venture capital contracts: might it be desirable to assign substantial control rights to more debt-like claims such as preferred stock, and fewer control rights to more equity-like claims? If so, when are VCs more likely to take common stock with less than proportional voting and board rights?

The paper studies the optimal contracting problem of an early start-up seeking venture capital finance in a setting where two non-contractible efforts – entrepreneurial effort and VC advice – are crucial for the start-up's success. At the seed stage, the entrepreneur must exert effort in researching the different projects available (*EN initiative*); the VC may also learn the relevant information through costly monitoring. After information gathering takes

[1]Hellmann (1998, 2006) and Dessí (2004) also take an optimal contracting approach to study the joint allocation of control and cash flow rights in VC deals, yet they focus on different issues (see my literature discussion). Hellmann (1998) has been the first to point out that "the separation of control rights from financial structure is important since for any given financial structure it is always possible to allocate control rights independently. If control resides with the board of directors, then the contract between the VC and the EN may directly determine the board structure. And if control emanates from holding the majority of the voting stock, then voting power can be attached to any financial instrument."

place, a project is selected by the party in control. At a later stage, the venture capitalist may provide professional advice in formulating the firm's strategy, introduce the firm to potential customers and suppliers, and help recruit key employees (*VC support*).

In modeling the VC role, I account for the fundamental difference between *VC support* and *VC interference* highlighted in recent empirical work.[2] To significantly interfere in the firm's project selection, the venture capitalist needs formal control rights. Conversely, the VC can provide support and advice even when the founding entrepreneur controls the firm. Based on this premise, the following trade-off is analyzed. To induce costly VC support, one would like to sell the venture capitalist a high-powered claim. However - if the VC is granted formal control over project selection - a high-powered claim also induces excessive VC interference, which in turn kills entrepreneurial initiative.[3] In other words, when the venture capitalist's monetary payoff is very sensitive to the firm's performance, the cost of her formal control in terms of entrepreneurial initiative may become too high. This trade-off formalizes a typical entrepreneurial attitude towards venture capitalists. On the one hand, entrepreneurs want VC investors to support their firms with professional advice and business connections; on the other hand, entrepreneurs are unhappy and demotivated when VCs exercise too much control on their firms.

The paper investigates how an appropriate design of financial claims and control rights may enable entrepreneurs to induce VC support (the bright side of venture capital) while limiting VC interference (the dark side of venture capital). Intuitively, when the need for costly support calls for very high-powered VC incentives, the entrepreneur should retain control, thus avoiding investor interference. This implies that when VC support is particularly costly, the venture capitalist holds a class of common stock with no formal control attached, whereas the entrepreneur holds preferred stock and retains most control rights. When instead VC support is not very costly, the VC holds preferred stock but is given formal control.

The results in the paper challenge the textbook assumption that common stock should

[2] Hellmann and Puri (2002), Kaplan and Strömberg (2004), and Cumming and Johan (2007) identify two different roles for venture capitalists. A supporting role, which is welcome by firm founders, whereby the VC contributes to the venture by helping hire key personnel or providing advice on R&D, strategy and product development. And a controlling (or "adversarial") role, whereby the VC may forcefully replace the founder with an outside CEO, or impose other decisions that conflict with the founder's preferences. The evidence in these papers suggests that VC support and interference respond to different contractual mechanisms and thus do not necessarily go hand in hand. Kaplan and Strömberg (2004) find for instance that VC interference is related to VC board control, while VC support is related to VC equity ownership.

[3] In the spirit of Aghion and Tirole (1997), it is the venture capitalist's *real* control over project selection ("interference") that discourages entrepreneurial initiative.

always be associated with more control rights than preferred stock, and are in line with the use – in real-world VC contracts – of covenants attaching substantial control to preferred stock. My findings also rationalize the evidence that corporate VCs, who suffer from potential conflicts of interest with their portfolio firms and thus need high-powered incentives, hold common stock with little control attached. An extension of the model also provides an explanation for the inclusion in VC deals of contingencies that trigger both a reduction in the investor's control rights *and* the (automatic) conversion of her preferred stock into common stock (see Gompers 1999 and Kaplan and Strömberg 2003).

The model presented combines two incentive problems that have been studied separately in the literature, one which focuses on the non-contractible VC's advice and support, and a second one which focuses on the costs of investor overmonitoring. The advising/supporting role of venture capitalists has been explored in a series of papers including Schmidt (2003), Casamatta (2003), Repullo and Suarez (2004), Inderst and Müller (2004) and Renucci (2006). These models focus on the optimal allocation of cash flow rights in venture capital, but do not endogenize control allocation.

The dark sides of investor monitoring have been unveiled in two related papers. Burkart, Gromb and Panunzi (1997) show that shareholder monitoring and interference may kill entrepreneurial initiative, thus reducing firm value. In Pagano and Röell (1998), excess monitoring occurs as large shareholders do not internalize the entrepreneur's private benefits. In both papers, ownership concentration inevitably leads to undue investor interference, as large equity stakes are assumed to come with formal control. Therefore, dispersed ownership is called for to dilute the monitoring incentives of large shareholders. My model allows for both types of overmonitoring costs, but endogenizes the allocation of control; hence, high-powered investor claims induce overmonitoring only when associated with formal control rights. By combining the overmonitoring problem with the need to incentivize non-contractible VC support, I show that the *joint* design of control and cash flow rights can take care of both sides of the coin – spurring the investor's support while limiting her interference.

My paper is also related to early financial contracting models, where control and cash flow rights were obtained for the first time from an optimization problem. In the costly state verification models of Townsend (1979), Diamond (1984) and Gale and Hellwig (1985) the optimal contract allocates to the investor a flat claim and the right to intervene (that is, to audit the firm) if the payment is not made – a standard debt contract. In these papers, the type of control associated with a flat claim consists of the right to intervene in low income states; conversely, my paper shows that in VC environments the right to select the firm's strategy in normal times can be attached to a flat claim.

Other papers have studied the joint design of control and cash flow rights in venture capital.[4] In Hellmann (1998) a specific control right, the right to appoint the CEO, is relinquished to the venture capitalist to give her incentives to engage in an executive search, while cash-flow rights take care of entrepreneurial incentives. In Dessí (2005), control over the liquidation decision as well as cash-flow rights are designed so as to induce VC's monitoring and efficient continuation decisions, while also taking care of the potential for collusion between the VC and the entrepreneur at the expense of outside investors. Hellmann (2006) studies the allocation of control on the exit decision (IPO versus acquisition). These papers focus on aspects of the venture's life where it is vital for the VC to hold superior control rights. I add to this literature by pointing out that control and interference in other stages of a venture can instead be detrimental to firm value. This allows me to provide a rationale for those deals where the VC does not seek much control despite buying a high-powered claim in the company.[5] Schindele (2003) also trades off VC monitoring and VC advice in an optimal contracting model and yields a similar prediction that high-powered claims and monitoring/interference may be negatively correlated. However, in contrast to my theory the main driving force in her model is the assumption that advice is spurred by high-powered financial claims while monitoring is best induced by a debt-like claim.

The paper proceeds as follows. Section 2 describes the model. Section 3 studies the benchmark case where VC support is contractible, revisiting the trade off between monitoring and entrepreneurial initiative. In section 4, VC support is assumed to be non-contractible, and the optimal control and cash-flow right allocation is solved for. In Section 5, I discuss the robustness of my results, and draw an extension of the model to allow for a contingent allocation of control and cash-flow rights. The paper's empirical predictions and the relation with existing evidence are discussed in section 6. Section 7 concludes. The Appendix collects most of the proofs.

[4]This strand of literature owes to Dewatripont and Tirole (1994) the idea that control and cash-flow rights are interrelated. In that model, the optimal capital structure allows for multiple claim-holders with contingent control rights: debt-holders (who prefer manager-unfriendly actions) should have control after bad performance, and equity-holders (whose preferences are more aligned with the manager's) should have control after good performance. This helps rationalize the observed correlation between control and cash-flow rights within standard securities (i.e., debt and equity) used by traditional corporations, but not the hybrid securities devised in more innovative venture capital arrangements.

[5]Other papers analyzing the allocation of control rights between entrepreneurs and venture capitalists obtain predictions that contrast with mine. Chan, Siegel and Thakor (1990) predict that VCs should bear all cash-flow risk when in control, while in Kirilenko (2001) the VC demands control rights that are disproportionately large compared to the size of her equity.

2 The model

An entrepreneur has an innovative investment project that requires a fixed initial investment I. The investment is risky and generates a verifiable random outcome $\tilde{R}$. $\tilde{R}$ takes the value $R^L \in (0, I)$ in case of failure and the value $R^H = R^L + \Delta R$ (with $\Delta R > 0$) in case of success. The entrepreneur (EN) has no money, hence he has to raise funds from a venture capitalist (VC). Pure financiers can as well contribute to the initial investment I. Investors behave competitively in the market for funds. All agents in the model are risk-neutral, and the riskless interest rate is normalized to zero.

Projects

At date 0, when external financing is raised and the investment made, the entrepreneurial idea is still vague (for instance, there may be alternative discoveries or patents to pursue).[6] The start-up faces $N + 1$ a priori identical projects, $k \in \{0, 1, 2, \ldots, N\}$. All projects may fail or succeed, but they differ in their probability of success and the non-verifiable private cost they entail upon the entrepreneur. The status-quo project (project 0) is known: it succeeds with probability $q \in \{0, p\}$ and imposes a private cost $\gamma > 0$ on the entrepreneur. The payoffs attached to the N other projects are *not* known by the parties unless further investigation is carried out. However, all players know the following facts from date 0. First, $(N - 2)$ projects are worse than project 0 for both VC and EN, and at least one of them is a "disastrous project" inflicting a huge non-monetary loss (eg, in terms of reputation) on both. Second, there exist two projects, indexed $N - 1$ and N, that have probabilities of success and private costs to EN equal to:

$N-1$	N
$q+\tau, 0$	q, γ

with probability λ, or:

$N-1$	N
$q+\tau, \gamma$	$q, 0$

with probability $1 - \lambda$, where $q + \tau \in (0, 1)$ and $\lambda \in (0, 1)$. At $t = 0$, Nature determines whether project $N-1$ or project N impose the private cost γ on the entrepreneur.[7] However,

[6] This pattern is quite common in the biotech sector: when a biotech start-up is financed, it is typically still unknown which therapeutic products it will pursue and in which order. Only at a subsequent stage, the management of clinical trials determines which of several therapeutic uses of a drug will seek regulatory approval (see Lerner and Merges, 1998).

[7] In section 3.1, I show that as long as EN's monetary incentives are not too high-powered, the entrepreneur

as stated above, a party cannot observe the payoffs attached to different projects unless successful information gathering has been carried out. I assume:

$$\tau\Delta R > \gamma, \tag{A.1}$$

implying that $N-1$ is the first best project.

Information Gathering

At $t=1$, after the investment cost has been paid, the entrepreneur exerts a non-verifiable effort $e \in [0,1]$ to learn the project payoffs. At a private cost $e^2/2$ he learns the payoff of all candidate projects with probability e. This effort could be interpreted as additional research pursued to come up with a well-defined product; hence, I will refer to it as entrepreneurial initiative. Simultaneously, the venture capitalist exerts a non-verifiable effort $E \in [0,1]$ at a cost $E^2/2$ to monitor the entrepreneur's research activity. I assume the following monitoring technology: the VC can only become informed if the entrepreneur is; if the entrepreneur learns the project payoffs, the VC also learns them with probability E, and does not learn with probability $(1-E)$.

Project Selection

At $t=2$, a project must be selected. Although the project choice is observable by informed parties, it is not verifiable, hence compensation schemes based on project selection are not feasible. The initial contract must then allocate the formal authority to choose a project to either the entrepreneur or the venture capitalist.[8] Under *EN control*, the entrepreneur has the formal right to select a project. Under *VC control*, the VC has the formal right to select a project; however, the entrepreneur can make a project proposal $j_{en} \in \{0,1,2,\ldots,N\}$: after hearing the proposal, the VC can rubber-stamp it ($j_{vc}=j_{en}$), or choose a different project ($j_{vc} \in \{0,1,2,\ldots,N\} \setminus j_{en}$). I assume that control rights cannot be renegotiated. The robustness of results to renegotiation is discussed in section 5.1.

VC's Late Stage Moral Hazard

At $t=3$, when the selected project is implemented, support and advice from the VC are needed.[9] If VC advice and support are provided, $q=p$; project k's probability of success is

prefers project N to project $N-1$ whenever the latter imposes the private cost γ on him, which happens with probability $(1-\lambda)$. To the extent that the venture capitalist always prefers the efficient project $N-1$, Nature's move determines whether EN and VC's preferences over projects are aligned or not. λ then measures the *congruence of interests* between EN and VC (see Aghion and Tirole, 1997).

[8] Remark 2 in section 4 discusses the more general case where a probabilistic control allocation is allowed for.

[9] The assumption that the VC provides support after basic research has been carried out is *not* crucial to

then $p + \tau_k > 0$, where $\tau_k \in \{0, \tau\}$. If VC advice/support is not provided, $q = 0$: project k's probability of success is then τ_k.[10] The VC's advising effort is unverifiable and prone to moral hazard: when the venture capitalist does not exert any effort, she enjoys a private benefit $c \in (0, p\Delta R)$. I assume:

$$R^L + \tau\Delta R - I + c < 0 < R^L + p\Delta R - I - \gamma. \tag{A.2}$$

The left hand side inequality in A.2 implies that the start-up is not worth funding unless the VC provides advice at $t = 3$; the right hand side inequality implies that when the VC provides advice, even the status-quo project (project 0) generates a positive surplus.

Timing

The timing assumed here is suited to the companies I am trying to model, namely R&D start-ups (such as biotech firms) that are still far from bringing a product to the market. It is summarized in the following figure:

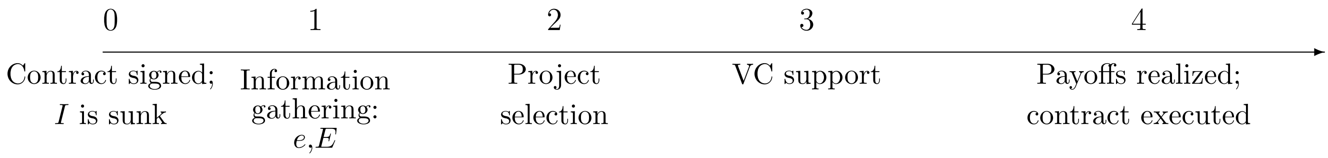

Figure 1: Time line

Contracts

As projects cannot be described and contracted upon ex ante, the contract must allocate to either EN or VC the formal control over project selection. At $t = 0$ the entrepreneur makes a take-it-or-leave-it contract offer to the venture capitalist (and possibly to pure financiers) specifying the parties' cash-flow rights and control-rights. Due to the non-verifiability of projects, cash-flow rights can be contingent on the final outcome, but not

the paper's results. Indeed, even if the timing was reversed the basic trade-off between VC support and VC interference would still be there. Whether VCs provide more support at an earlier or later stage is largely an empirical question on which the evidence is mixed. See for instance Sapienza (1992) and Kaplan and Strömberg (2004).

[10]Note that the venture capitalist's effort *directly* increases the profitability of a project. This assumption is meant to capture her role as an advisor, in contrast to the monitoring role à la Holmström and Tirole (1997).

on the project choice. Therefore, the contract specifies the parties' payoffs in case of failure (R_i^L, $i = en, vc, out$) and success (R_i^H, $i = en, vc, out$), where the subscripts *en*, *vc*, *out* denote respectively the entrepreneur, the VC, and the pure financiers. Entrepreneurs and investors are protected by limited liability: only the project outcome can be shared.

The VC's and EN's incentives depend on the riskiness of their financial claims, which I define as:

$$\delta_{vc} \equiv R_{vc}^H - R_{vc}^L$$

and

$$\delta_{en} \equiv R_{en}^H - R_{en}^L.$$

I also define:

$$\delta_I \equiv \delta_{vc} + \delta_{out},$$

and

$$R_I^L \equiv R_{vc}^L + R_{out}^L.$$

The First Best benchmark

As a benchmark, it is useful to consider the case where all efforts are observable, and any information collected after $t = 1$ is hard, so that control allocation is not an issue. In this case, project $N-1$ is adopted whenever it is identified; furthermore, the VC always provides advice to the firm. Monitoring is redundant (hence $E^{FB} = 0$), while entrepreneurial initiative maximizes the net social surplus generated by the investment:

$$R^L + p\Delta R - \gamma - I + e(\tau\Delta R + \lambda\gamma) - \frac{e^2}{2}$$

The first best level of initiative is:

$$e^{FB} = \tau\Delta R + \lambda\gamma,$$

that I assume to be smaller than 1. I also assume that the surplus is positive in the first best:

$$V^{FB} \equiv R^L + p\Delta R - \gamma - I + \frac{(\tau\Delta R + \lambda\gamma)^2}{2} > 0.$$

As implied by the Modigliani and Miller theorem, in this scenario it is irrelevant whether the initial investment is funded solely by the VC or pure financiers also participate in the financing. The shape of cash-flow rights is also irrelevant.

The following section focuses on the second benchmark case where VC support is contractible but information gathering efforts are not and information is soft, and studies how control and cash flow rights affect VC and EN's incentives at the information gathering stage. This allows to revisit the basic trade off between VC monitoring and EN initiative (Burkart, Gromb and Panunzi, 1997) in a setting where formal control allocation is endogenous.

3 The Benchmark: Contractible VC Support

To study the optimal control and cash flow right allocation when VC support is contractible, I proceed in the following way. First, I establish under which conditions control allocation actually matters; to this aim, I show that different cash flow right allocations can induce congruent or dissonant preferences over projects, depending on how high-powered the entrepreneur's claim is. Secondly, I derive the optimal cash flow right allocation under, respectively, EN control and VC control. Finally, I compare the social surplus generated under the two arrangements to determine the optimal allocation of control.

3.1 Project selection and monetary incentives

As the entrepreneur responds to monetary incentives, the shape of his claim determines which project he would select or propose when informed about project payoffs. This implies that control allocation matters or not, depending on whether the EN's financial claim is relatively low or high-powered.[11] If $\tau\delta_{en} \geq \gamma$, the entrepreneur prefers the project generating the largest monetary benefits (project $N-1$) even when this entails a private cost γ. In this case, high-powered monetary incentives are perfectly aligning EN's preferences over projects with VC's preferences, making control allocation irrelevant. Conversely, if $\tau\delta_{en} < \gamma$, the entrepreneur prefers project N to project $N-1$ whenever the former involves no private cost γ and the latter does. Hence, EN and VC have *dissonant preferences* over projects with probability $(1-\lambda)$; the degree of dissonance is increasing in the distance $\gamma - \tau\delta_{en}$ and is thus endogenous in the model.

[11] This is in contrast to Aghion and Tirole (1997), where the agent is infinitely averse to risk and thus does not respond to monetary incentives.

The following Lemma shows that the "control irrelevance" case can be ruled out whenever the initial investment cost is sufficiently large.

Lemma 1 *There exists a threshold I_1 such that control allocation matters if the initial investment is relatively large ($I > I_1$). Conversely, the parties' preferences are congruent and control allocation is irrelevant if I is small ($I \leq I_1$).*

Proof. See the Appendix. ■

The intuition behind the lemma is simple. If the firm's financing needs are sufficiently large, a significant part of the outcome from the investment must be pledged to the investors to satisfy their participation constraints. This limits the extent to which the contract can provide the entrepreneur with high-powered monetary incentives, and in turn implies that the entrepreneur's preferences over projects cannot be aligned with the VC's. Hence, control allocation matters. In the rest of the paper, I rule out the less interesting "control irrelevance" case by assuming that $I > I_1$.

3.2 Cash flow rights under EN control

When the entrepreneur has formal control, at $t = 2$ he selects his favorite project provided he is informed about payoffs.[12] If uninformed, the entrepreneur sticks with the status-quo project – the existence of disastrous projects makes it suboptimal to make an uninformed choice. Note that as the VC can only be informed if the EN is, an uninformed entrepreneur can never rely on the VC's project proposal.

At $t = 1$ the entrepreneur and the VC simultaneously choose their effort levels so as to maximize their respective utilities. Under EN control, entrepreneurial initiative e and VC monitoring E are determined by the following incentive compatibility constraints:

$$e \in \arg\max_{e} R_{en}^{L} + p\delta_{en} + e\lambda\tau\delta_{en} - (1-e)\gamma - \frac{e^2}{2},$$
$$E \in \arg\max_{E} R_{vc}^{L} + p\delta_{vc} + e\lambda\tau\delta_{vc} - \frac{E^2}{2}.$$

Equilibrium efforts at stage 1 under EN control are then:

$$\begin{aligned} e^{EN} &\equiv \lambda\tau\delta_{en} + \gamma \\ E^{EN} &= 0, \end{aligned}$$

[12]Owing to the non-verifiability of project choice, no contract may ensure that an informed entrepreneur always chooses the efficient project. However, an informed entrepreneur optimally selects project $N-1$ when this entails no private cost γ.

where $e^{EN} < \lambda\tau\Delta R + \gamma$, $\forall \delta_{en} < \Delta R$.

The financial contract maximizes the expected utility of the entrepreneur, subject to the VC's participation constraint

$$R^L_{vc} + p\delta_{vc} + e\lambda\tau\delta_{vc} \geq I_{vc}, \qquad (IR1_{vc})$$

and the pure financiers' participation constraint

$$R^L_{out} + p\delta_{out} + e\lambda\tau\delta_{out} \geq I_{out}. \qquad (IR1_{out})$$

It is immediate that both participation constraints are binding at the optimum, and the entrepreneur appropriates all the net social surplus:

$$V^{EN}(e) = R^L + p\Delta R - \gamma - I + e[\lambda\tau\Delta R + \gamma] - \frac{e^2}{2}. \qquad (1)$$

The optimal cash flow right allocation thus solves the program:

$$\max_{e, R^L_i, \delta_i, I_i} V^{EN}(e)$$

s.t.

$$e = \lambda\tau\delta_{en} + \gamma$$
$$(IR1_{vc}), (IR1_{out}),$$
$$R^L_i \geq 0 \text{ and, } R^L_i + \delta_i \geq 0,$$

where $i = en, vc, out$; the last two inequalities ensure limited liability holds.

Note that as $\delta_{en} = \Delta R - \delta_I$, riskier VC and pure financier claims (i.e. a larger δ_I) come at the expense of EN's monetary incentives, thus jeopardizing entrepreneurial initiative and the surplus generated by the firm. This implies that the optimal cash flow allocation under EN control minimizes the combined riskiness of investors' claims δ_I, subject to investors' participation constraints. Moreover, to the extent that monitoring is zero regardless of δ_{vc}, the VC and the pure financiers' shares of the investment outcome and their respective contribution to the investment cost are not uniquely determined. These facts are formally laid out in the following proposition.

Proposition 1 *Define δ^{EN}_I as the smallest root of the equation*

$$R^L + p\delta_I + (\lambda\tau(\Delta R - \delta_I) + \gamma)\,\lambda\tau\delta_I = I. \qquad (2)$$

Then, when VC advice is contractible, under EN formal control it is uniquely optimal to set $R^L_{en} = 0$ and $\delta_{en} = \Delta R - \delta^{EN}_I$. This can be implemented by any combination of VC funding and pure financier funding that satisfies $R^L_{vc} + R^L_{out} = R^L$, $\delta_{vc} + \delta_{out} = \delta^{EN}_I$, $I_{vc} + I_{out} = I$.

Proof. See the Appendix. ■

3.3 Cash flow rights under VC control

Monitoring and initiative under VC control

Under VC formal control, information gathering can lead to three outcomes at $t = 2$. With probability $(1 - e)$ both parties are uninformed; in this case, the VC adopts the status-quo project, as this dominates making an uninformed choice. With probability eE, both VC and EN observe the project payoffs; in this case, the VC selects the efficient project ($j_{vc} = N - 1$) irrespective of what is EN's proposal j_{en}.[13] Finally, with probability $e(1-E)$, EN is informed but VC is not. The entrepreneur thus makes a project proposal $j_{en} \neq 0$ to the VC, and the VC infers that (i) EN is informed (ii) the project proposed is $N - 1$ with probability λ and project N with probability $1 - \lambda$. Formally, the VC's beliefs about the payoffs of proposed project are as follows: $Pr(j_{en} = N - 1/j_{en} \neq 0) = \lambda$; $Pr(j_{en} = N/j_{en} \neq 0) = 1 - \lambda$. It follows that for an uninformed VC rubber-stamping EN's proposal ($j_{vc} = j_{en} \neq 0$) strictly dominates sticking to the status quo. Therefore, the informed EN enjoys *real* control in spite of VC having formal control – in line with previous papers, formal control turns into *real* control only when the controlling party is informed.[14]

At the information gathering stage ($t = 1$), the entrepreneur and the VC simultaneously choose their effort levels so as to maximize their respective utility functions. e and E are then determined by the following incentive compatibility constraints:

$$e \in \arg\max_{e} R^L_{en} + p\delta_{en} + e\lambda\tau\delta_{en} + eE(1-\lambda)\tau\delta_{en} - eE(1-\lambda)\gamma - (1-e)\gamma - \frac{e^2}{2},$$

$$E \in \arg\max_{E} R^L_{vc} + p\delta_{vc} + e\lambda\tau\delta_{vc} + eE(1-\lambda)\tau\delta_{vc} - \frac{E^2}{2}.$$

The first order conditions of the incentive compatibility constraints define the reaction functions in information gathering for EN and VC:

$$e^{VC}(E) = (\lambda\tau\delta_{en} + \gamma) - (\gamma - \tau\delta_{en})(1-\lambda)E$$

$$E^{VC}(e) = (1-\lambda)\tau\delta_{vc}e.$$

[13] Thus, $j_{vc} = j_{en}$ if and only if $j_{en} = N - 1$, which holds true when $N - 1$ imposes no private cost γ on EN. Therefore, the selected project coincides with EN's proposal or not depending on Nature's move at $t = 0$.

[14] See for instance Aghion and Tirole (1997) as well as Dessein (2002).

The entrepreneur's initiative (e) is spurred by the prospect of having real control. Monitoring (E), and thus increased interference by the venture capitalist, can only inhibit such initiative, hence $e^{VC}(E)$ is downward sloping; quite intuitively, this effect is increasing in the *degree of dissonance* $((\gamma - \tau\delta_{en})(1-\lambda))$.[15] The VC's reaction function $E^{VC}(e)$ is instead upward sloping: as the VC can only become informed when the entrepreneur is, her incentives to monitor are boosted by EN's information gathering.

Combining the parties' first order conditions, and assuming interior solutions, one obtains the equilibrium levels of initiative and monitoring under VC control as functions of δ_{en} and δ_{vc}:

$$e^{VC}(\delta_{en}, \delta_{vc}) = \frac{\lambda\tau\delta_{en} + \gamma}{1 + (\gamma - \tau\delta_{en})(1-\lambda)^2\tau\delta_{vc}} \tag{3a}$$

$$E^{VC}(\delta_{en}, \delta_{vc}) = \frac{(\lambda\tau\delta_{en} + \gamma)(1-\lambda)\tau\delta_{vc}}{1 + (\gamma - \tau\delta_{en})(1-\lambda)^2\tau\delta_{vc}}. \tag{3b}$$

It can be easily checked that $\partial E^{VC}/\partial\delta_{vc} > 0$, $\partial e^{VC}/\partial\delta_{vc} < 0$. Increasing the riskiness of the VC's claim makes the VC more eager to monitor and interfere in the project selection process. This reduces the entrepreneur's incentives for information acquisition.[16]

Optimal cash flow rights

When the VC enjoys formal control over project selection, the investment generates a surplus given by

$$V^{VC}(e, E) = R^L + p\Delta R - \gamma - I + e(\lambda\tau\Delta R + \gamma) + eE(1-\lambda)(\tau\Delta R - \gamma) - \frac{(e)^2}{2} - \frac{(E)^2}{2}. \tag{4}$$

The optimal cash-flow right allocation then solves the following program

$$\max_{e,E,R_i^L,\delta_i,I_i} V^{VC}(e, E)$$

[15] The project selection decision in my model may be interpreted more broadly as "fine-tuning the firm's course of action". Imposing a given direction to the R&D process, forbidding scientific publications related to the start-up's R&D, replacing the original founder with a more suited outside CEO are examples where VC interference may create value ex post, but generate conflict and demotivate the founding entrepreneur ex ante.

[16] This is a straightforward extension of Burkart, Gromb and Panunzi's (1997) result that initiative is inhibited when *voting* equity is concentrated in the hands of a large shareholder. However, in my setting – where the degree of dissonance between EN and VC's preferences is endogenous – the effect of δ_{vc} on initiative is magnified whenever a higher δ_{vc} also increases the entrepreneur's distaste for VC interference.

s.t.

$$R^L_{vc} + p\delta_{vc} + e[\lambda + E(1-\lambda)]\tau\delta_{vc} - \frac{E^2}{2} \geq I_{vc} \qquad (IR2_{vc})$$

$$R^L_{out} + p\delta_{out} + e[\lambda + E(1-\lambda)]\tau\delta_{out} \geq I_{out} \qquad (IR2_{out})$$

$$E = \tau(1-\lambda)\delta_{vc}e$$

$$e = [\lambda\tau\delta_{en} + \gamma] - (\gamma - \tau\delta_{en})(1-\lambda)E$$

$$R^L_i \geq 0 \text{ and, } R^L_i + \delta_i \geq 0,$$

where $i = en, vc, out$; the last two inequalities ensure limited liability holds.

To solve for the optimal cash flow allocation when the VC has formal control, I study how the shape of the VC's claim affects the surplus. Similarly to Burkart, Gromb and Panunzi (1998), the effect of a more high-powered VC claim on the surplus depends on the interplay between VC monitoring and EN initiative. To see this, it is useful to study $V^{VC}(E)$, where e has been replaced in equation (**??**) with the best reply $e^{VC}(E)$. The effect of VC monitoring on firm value can then be decomposed in the following way:

$$\frac{dV^{VC}}{dE} = \frac{\partial V^{VC}}{\partial E} + \frac{\partial V^{VC}}{\partial e}\frac{de}{dE}. \qquad (5)$$

The first term represents the *control effect*. Under VC control, increased monitoring benefits the venture in that the VC exerts real control and imposes the first best project more often. However, costly monitoring imposes private costs on the EN; therefore, the control effect is positive only provided $e(1-\lambda)(\tau\Delta R - \gamma) > E$, i.e. E is not too high. The second term represents the *initiative effect*. This effect is always negative: increased monitoring discourages the EN's information-gathering effort ($de/dE < 0$), which in turn reduces the surplus, as $\partial V^{VC}/\partial e > 0$.

When the VC has high-powered incentives, both the initiative *and* the control effect are negative. *Overmonitoring* then occurs due to the combined effect of two forces. Monitoring kills entrepreneurial initiative, as in Burkart, Gromb and Panunzi (1997); furthermore, excess costly monitoring is ex-post inefficient as in Pagano and Röell (1998). This logic lies behind the following result:

Lemma 2 *V^{VC} is concave in E, and $(dV^{VC}/dE) < 0$ whenever $\delta_{vc} \geq \Delta R - \gamma/\tau$.*

Proof. See the Appendix. ■

The following Proposition shows that to optimally tackle the overmonitoring problem, when the VC is granted control over project selection passive financiers must be involved in funding the project. This allows to mitigate the power of the VC's incentives and avoid excess monitoring and interference. In this respect, pure (passive) financiers play the same role as in Burkart, Gromb and Panunzi (1997).

Proposition 2 *The optimal cash flow right allocation under VC control is such that* $\delta_{en} < \gamma/\tau$, $\delta_{vc} < \Delta R - \gamma/\tau$, *and* $\delta_{out} > 0$. *Hence, pure financiers are involved in the financing of the venture:* $I_{out} > 0$.

Proof. See the Appendix. ■

3.4 Optimal control allocation when VC support is contractible

We have shown that the optimal allocation of cash flow rights changes depending on whether the formal control over project selection remains with the VC or the entrepreneur. With entrepreneurial control, initiative is solely determined by the power of EN's monetary incentives, that in turn are limited by the need to generate enough income for investors to break even. With VC control, entrepreneurial initiative, besides responding to the entrepreneur's monetary incentives, is also affected by the extent of VC monitoring: monitoring kills initiative. However, in the benchmark case where VC support is contractible, it is always possible to dilute the power of VC's incentives for monitoring by involving passive financiers as budget breakers. This suggests that VC control can do at least as well as EN control, as the following proposition shows.

Proposition 3 ***Optimal contract when VC support is contractible*** – *When VC support is contractible, it is always optimal for the entrepreneur to relinquish formal control to the VC, have pure financiers co-finance the venture* ($I_{out} > 0$)*, and sell the VC a relatively safe financial claim in the start-up* ($\delta_{vc} < \Delta R - \frac{\gamma}{\tau}$).

Proof. See the Appendix. ■

Following Hart (1995), the optimal allocation of authority and cash flow rights in a venture trades off ex-ante incentives with ex-post efficiency. In my model, ex-post efficiency calls for VC control in that the VC always chooses the first best project, while the entrepreneur may choose a suboptimal project when in control. On the other hand, under VC control the entrepreneur's incentives to gather information are reduced when a riskier VC claim magnifies the venture capitalists's interference. The solution is then to allocate *formal* control rights to the venture capitalist while limiting the riskiness of her financial claim and thus the extent of her *real* control.

4 Optimal contract when VC support is not contractible

This section studies the optimal control and cash flow right allocation when VC support cannot be contracted upon. The financial contract must be designed so as to cope with the multiple moral hazard problems faced by the start-up at different stages of its life. At $t = 1$, the main issue is to induce the EN and the VC to exert the optimal amount of initiative and monitoring before a project is selected. Monitoring allows a controlling VC to interfere in the company's life, imposing that the efficient project is chosen at $t = 2$; however, VC interference discourages entrepreneurial initiative. At $t = 3$, when the selected project must be implemented, VC support and advice become crucial. The optimal venture capital deal must then induce VC support while avoiding VC excess interference.

4.1 VC moral hazard at the implementation stage

As in much of the literature on venture capital finance, I assume that the VC plays an active role in determining a start-up's success. It is a well documented fact that venture capitalists are actively engaged in managing the firms they fund.[17] Venture capitalists help recruit key personnel, advise the entrepreneur on strategic decisions, provide introductions to potential customers and suppliers. I define all these activities as *VC support*; c is the private benefit enjoyed by the VC when *not* providing support. An alternative interpretation for VC's moral hazard is the following. The venture capitalist may cannibalize the project, for instance by stealing the entrepreneurial idea and using it in a competing venture. In this case, she gains a non-transferable benefit c but reduces the firm's probability of success by an amount p. The fear of idea expropriation is indeed a relevant concern for innovative entrepreneurs.[18]

In order that the venture capitalist supports the start-up at the project implementation stage, the cash flow splitting rule must satisfy the following incentive compatibility constraint:

[17]See for instance Gorman and Sahlman (1989), Sahlman (1990), Hellmann and Puri (2002) and Cumming and Johan (2007).

[18]The risk of value-destroying actions is perceived as very strong in the venture capital world (see also the discussion in section 6). For instance, here is Silver's (1984) advice to new entrepreneurs approaching a corporation's venture capital arm: "beware of corporate officers disguised as venture capitalists! Many are the corporations who attempt to kill new companies whose products may become competitive." Hellmann (2002) trades off this cost with the benefits of corporate venture capital financing. In Ueda (2004), the dark side of venture capital is the threat that the investor duplicates the project when intellectual property rights are weak. Finally, in Cestone and White (2003) a financial contract is designed so as to commit the investor not to fund a competing firm.

$$\delta_{vc} \geq \frac{c}{p}. \qquad (IC_{vc})$$

I assume that c is sizeable when compared with the scale of the project, so that the pledgeable income compatible with (IC_{vc}) is strictly larger than the investment cost I:

$$R^L + \left(p + (\lambda\tau\Delta R - \lambda\tau\frac{c}{p} + \gamma)\lambda\tau\right)\left(\frac{c}{p}\right) > I. \qquad (A.3)$$

Assumption **??** has two implications. First, together with $I > I_1$ it implies that $c/p > \Delta R - \gamma/\tau$; this in turn implies (lemma **??**) that the need to incentivize VC support also generates excess monitoring and interference when the VC has formal control over the project selection. Secondly, **??** implies that when the contract is subject to (IC_{vc}), passive investors are not needed as budget breakers: even if they are involved in the financing, they are not granted a risky claim. This is formalized in the following lemma:

Lemma 3 *When VC support is not contractible, optimal cash flow rights under both EN and VC control are such that* $\delta_{out} = 0$ *and* $\delta_{en} = \Delta R - \delta_{vc}$.

Proof. See the Appendix. ∎

4.2 Optimal control and cash-flow rights when VC support is not contractible

In order to determine the optimal financial contract I analyze first how the allocation of cash flow rights affects the firm surplus under, respectively, EN control and VC control.

We know that the project choice at $t = 2$ and information gathering efforts at $t = 1$ are determined as in section 3's benchmark. It is useful to emphasize that increasing the riskiness of the VC's claim may have a twofold detrimental effect on entrepreneurial initiative. First, as $\delta_{en} = \Delta R - \delta_{vc}$, a riskier VC claim comes at the expense of EN's *monetary incentives*: ceteris paribus, a less high-powered claim provides the entrepreneur with less incentives for costly information acquisition. This is a natural effect in a double-sided moral hazard setting, and an effect that takes place under both EN and VC control. Secondly, a riskier claim makes the VC more eager to monitor and interfere in the project selection process, further reducing the entrepreneur's incentives for information acquisition.[19] This second effect only takes place under VC control, which immediately implies that: $de^{VC}/d\delta_{vc} < de^{EN}/d\delta_{vc} < 0$.

[19] This is a straightforward extension of Burkart, Gromb and Panunzi's (1997) result that initiative is inhibited when *voting* equity is concentrated in the hands of a large shareholder. However, in my setting – where the degree of dissonance between EN and VC's preferences is endogenous – the effect of δ_{vc} on initiative

The firm surplus under EN control is given by equation (**??**), with $e = \lambda\tau(\Delta R - \delta_{vc}) + \gamma$, implying that V^{EN} is strictly decreasing in δ_{vc}. The firm surplus under VC control is instead given by equation (**??**), with efforts e and E defined as in (**??**) and (**??**). To the extent that $\delta_{vc} \geq c/p > \Delta R - \gamma/\tau$, it follows from lemma **??** that $(dV^{VC}/dE) < 0$, hence $(dV^{VC}/d\delta_{vc}) < 0$. This result is summarized in the following lemma.

Lemma 4 *The surplus generated by the venture under both EN and VC control is a decreasing function of δ_{vc} for all $\delta_{vc} \in [c/p, \Delta R]$.*

Lemma 4 implies that under either control allocation, optimal cash flow rights make (IC_{vc}) binding: $\delta_{vc} = c/p$. The following proposition establishes an important result that will allow to compare the two formal control allocations for different levels of c.

Proposition 4 *There exists a threshold $\widehat{\delta} \in \left(\Delta R - \frac{\gamma}{\tau}, \Delta R\right]$ such that $V^{VC}(\delta_{vc}) > V^{EN}(\delta_{vc})$ if and only if $\delta_{vc} \in \left(\Delta R - \frac{\gamma}{\tau}, \widehat{\delta}\right)$.*

Proof. See the Appendix. ■

We know that (IC_{vc}) binds under both EN and VC control, to the extent that V^{EN} and V^{VC} are strictly decreasing in δ_{vc}. It follows immediately from proposition **??** that for any $c \geq \widehat{c} \equiv \widehat{\delta}p$, EN control does better than VC control. This is because when c is large the cost of VC control in terms of over-monitoring and loss of entrepreneurial initiative becomes too high, hence the more high-powered VC claim must be associated with entrepreneurial control. This result is summarized in the following proposition.

Proposition 5 – ***Risky Claims or Formal Control ?*** – *When the cost of VC support is large, it is optimal to grant formal control to EN: there exists a threshold value $\widehat{c} \in (0; p\Delta R)$ such that the financial contract maximizing the value of the venture is:*

- *if $c < \widehat{c}$: VC has formal control, and $\delta^*_{vc} = \frac{c}{p}$*
- *if $c \geq \widehat{c}$: EN has formal control and $\delta^*_{vc} = \frac{c}{p}$.*

Figure 2 graphically illustrates proposition **??**. It displays the functions $V^{VC}(\delta_{vc})$ and $V^{EN}(\delta_{vc})$ for the following values of the parameters: $\Delta R = 1$, $\tau = 0.5$, $p = 0.5$, $\lambda = 0.5$, $\gamma = 0.3$. Accordingly, the power of VC's claim, δ_{vc}, varies between 0.4 and 1. The intersection of

is magnified with respect to their model, to the extent that a higher δ_{vc} also increases the entrepreneur's distaste for VC interference.

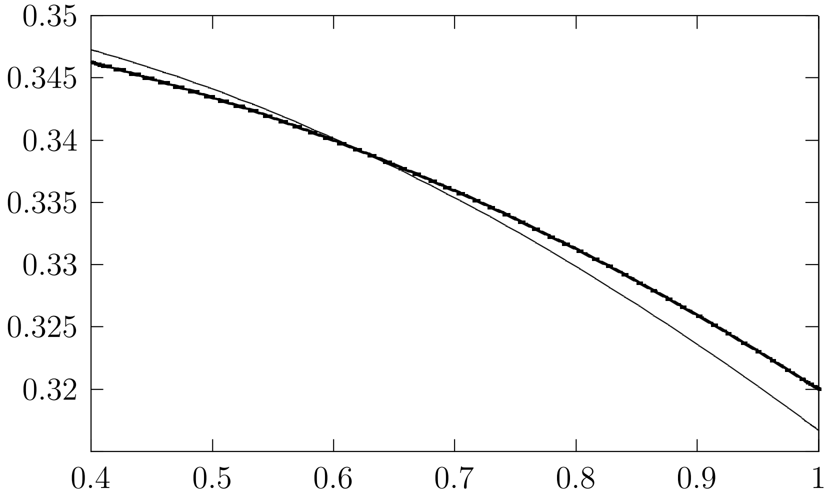

Figure 2: Plot of $V^{VC}(\delta_{vc})$ and $V^{EN}(\delta_{vc})$. The thick (thin) curve displays $V^{EN}(\delta_{vc})$ ($V^{VC}(\delta_{vc})$).

the two curves defines the threshold $\widehat{\delta}$, which takes here the value 0.6218. When $\delta_{vc} > 0.6218$ ($c > \widehat{c} \cong 0.31$), entrepreneurial control does better than VC's control. It is interesting to see how the threshold $\widehat{\delta}$, and thus $\widehat{c}$, change when larger values of γ are selected, implying (i) smaller efficiency benefits of VC monitoring and (ii) a larger degree of dissonance between the parties' preferences (hence a larger impact of VC control on initiative). Indeed, one would expect that ceteris paribus a larger γ makes EN control more likely to dominate VC control. In line with this intuition, lower values of the threshold $\widehat{\delta}$ correspond to larger values of γ. For instance, for parameter values $\Delta R = 1$, $\tau = 0.5$, $p = 0.5$, $\lambda = 0.5$, $\gamma = 0.4$ one finds $\widehat{\delta} \cong 0.35$.

Remark 1 – Continuous VC support – In an online Appendix I study how cash flow rights are optimally combined with control rights in the more general case where VC support is a continuous variable. In this case, under both EN and VC control the over-monitoring costs of selling the VC a more high-powered claim must be traded off against the benefit of increased VC support. Intuitively, due to the initiative effect, under VC control the optimal level of δ_{vc} is smaller than under EN control. This confirms the prediction that safer (riskier) VC claims should be associated with VC (EN) control.

Remark 2 – Stochastic control allocation – Proposition **??** derives the optimal contract by restricting attention to deterministic allocations of control, and shows that EN control is optimal when the need to give high-powered incentives to the VC induces excessive monitoring and interference in the project selection stage. One may wonder whether a less extreme result would obtain allowing for a probabilistic allocation of control.[20] If the initial contract states that VC will enjoy control over project selection with probability $x \in [0, 1]$, x could be reduced below 1 when c is large, thus reducing excessive interference without sacrificing completely the efficiency benefits of VC control by switching to full EN control (i.e. $x = 0$). One would then conjecture that in the optimum contract smaller levels of x would correspond to larger values of c. Although it can be easily shown that initiative (monitoring) is a decreasing (increasing) function of x, it is difficult to obtain analytical results on the optimal level of x and its comparative statics with respect to c. However, turning to numerical simulations, I find that interior solutions for x are never optimal for the range of parameter values that I have considered: in all simulation results $x = 0$ (i.e. full EN control) is optimal whenever $c > \widehat{c}$. This would suggest that the benefit of preserving entrepreneurial initiative is particularly strong and thus always dominates the efficiency benefit of VC control, leading to a corner solution for x.

4.3 Security design

The optimal contracts derived in the previous section consisted of a cash-flow splitting rule $\left\{\delta_{vc}, R^L_{vc}\right\}$ and a formal control allocation. Here I illustrate how those contracts can be implemented through financial instruments commonly observed in venture capital deals.

4.3.1 Case 1: c "large"

When $c \geq \widehat{c}$, the optimal contract allocates control to EN and gives VC a relatively risky claim: $\delta_{vc} = c/p$ and $R^L_{vc} = I - \left[p + e^{EN}\lambda\tau\right] c/p$, with $e^{EN} = \lambda\tau(\Delta R - c/p) + \gamma$. The entrepreneur's payoffs are: $R^L_{en} = R^L - R^L_{vc} > 0$ and $R^H_{en} = R^L_{en} + (\Delta R - c/p)$. As VC grabs a large part of the upside ΔR, her payment in the low state must be reduced so as to ensure that EN appropriates all the surplus from the venture. These cash-flow rights can be implemented by giving *common stock to VC and preferred stock to the entrepreneur.* Let r be the minimum revenue to be paid to preferred stock-holders, and $(1 - \alpha)$ the fraction of preferred stock held by EN. α is the fraction of common stock issued to VC. Preferred stock to EN has a role in that - by promising a minimum dividend to EN - ensures that a VC

[20] A different question is how a probabilistic allocation of control can be implemented by real life contracts. See Tirole (2006), on how different mechanisms, including the design of incentives to exert real authority, can be viewed as a way to provide a more continuous allocation of control in a contractual relationship.

holding common stock is not paid much in the low state. Obviously, this is the case if and only if $r > (1-\alpha)R^L$ (i.e., $R^L_{vc} = R^L - r < \alpha R^L$), otherwise preferred and common stock do not differ *de facto*. To implement the optimal contract, it is sufficient to set:

$$r = R^L - R^L_{vc} \qquad \text{and} \qquad \alpha R^H = R^L_{vc} + \frac{c}{p}$$

which implies $\alpha = \left(R^L_{vc} + c/p\right)/R^H$. The pair $\{r, \alpha\}$ satisfies the condition $r > (1-\alpha)\, R^L$ whenever c is sufficiently large:

$$I - \left[p + e^{EN}\lambda\tau\right]\frac{c}{p} < \frac{R^L}{\Delta R}\frac{c}{p}.$$

4.3.2 Case 2: c "small"

When $c < \widehat{c}$, the optimal contract gives VC formal control over the venture and a relatively safe financial claim: $\delta_{vc} = c/p$ and $R^L_{vc} = I - \left[p + e^{VC}\lambda\tau + e^{VC}E^{VC}(1-\lambda)\tau\right]c/p$, with $e^{VC} = e^{VC}(c/p)$ and $E^{VC} = E^{VC}(c/p)$. As VC captures a small part of the upside ΔR, she must receive an adequate compensation in case of failure in order that she is willing to fund the firm. This can be done by giving *preferred stock to VC and common stock to the entrepreneur.*[21] Let r be the minimum revenue to be paid to preferred stock and α VC's equity share. This contract implements the optimal cash-flow rights if it satisfies:

$$r = R^L_{vc} \qquad \text{and} \qquad \alpha R^H = R^L_{vc} + \frac{c}{p}.$$

This pair represents indeed preferred stock provided $\alpha R^L < r$, that is if c is sufficiently small:

$$I - \left[p + e^{VC}\lambda\tau + e^{VC}E^{VC}(1-\lambda)\tau\right]\frac{c}{p} > \frac{R^L}{\Delta R}\frac{c}{p}.$$

[21] Here I am arguing that an appropriate use of common stock and preferred stock may implement the optimal cash-flow rights. Note however that the same cash-flow splitting rule can be achieved by selling a combination of standard debt and equity to the VC. Multiple security design interpretations of the optimal contract are standard when the distribution of returns has a two-point support (a feature shared by many models of VC contracting). Yet in venture capital deals, preferred stock, rather than a debt-equity mix, seems to be the most common financial instrument used to give a party a debt-like claim.

5 Robustness and Extensions

5.1 Option contracts

The model so far has not allowed for option contracts in the spirit of Schmidt (2003). Yet, a contract awarding the venture capitalist the right to buy control at a predetermined price K after the information gathering stage might do better than outright EN control or VC control. First, the prospect of receiving the transfer price K would encourage the entrepreneur to exert initiative, to the extent that control has value only if the project payoffs have been discovered initially. Second, the option to buy control from the entrepreneur would encourage the VC to exert monitoring, to the extent that control only has value if the VC is informed.[22] In this section I allow for option contracts of this kind, and show that the paper's central result can be generalized. In fact, I find that the optimal contract grants the EN formal control, with the provision that control can be bought by the VC at a predetermined price after the information gathering stage. However, the transfer price to be paid to buy control is strictly larger when the VC is sold a riskier claim – *more equity-like claims are associated with "less control"*.

Note that control has no value to the VC unless two conditions hold: (i) the VC is informed about project payoffs; (ii) project payoffs are such that preferences are dissonant. The price K satisfies:

$$0 \leq K \leq \tau\delta_{vc}.$$

When $K = \tau\delta_{vc}$, the option to buy control is not in the money; this case corresponds to outright EN control. When $K = 0$, the VC reclaims (and exercises) control whenever she is informed and project payoffs are such that preferences are dissonant; this case corresponds to outright VC control. One would expect a less extreme allocation of control to dominate both outright EN and VC control, and a larger transfer price to be associated with a riskier VC claim. The intuition is simple. Increasing K makes control more costly to buy for the VC. This in turn boosts entrepreneurial information gathering incentives at $t = 1$, while reducing the VC's incentives for monitoring. Setting a higher transfer price is then a tool to compensate for excess monitoring and suboptimal EN initiative when the need for costly advice calls for a high-powered VC claim. This is formalized in proposition **??**.

Proposition 6 *When VC advice is non contractible, formal control is initially allocated to the entrepreneur and the VC is granted an option to buy control at a price* $K^* \in (0, \tau\delta_{vc})$*.*

[22] I am grateful to an anonymous Referee for providing these insights.

The optimal exercise price K^* is strictly increasing in the riskiness of the VC's claim δ_{vc}.

Proof. See the Appendix. ∎

5.2 Renegotiation of control rights

So far I have ruled out that control rights can be renegotiated after $t = 1$; this is equivalent to assuming that the entrepreneur enjoys all the bargaining power when control rights are renegotiated. This hypothesis simplifies the analysis by ensuring that independently of δ_{vc}, monitoring never occurs under EN control. I now discuss the robustness of my main predictions to a more even allocation of bargaining power when control rights are renegotiated.[23]

Consider the case of EN control and suppose both parties have become informed about project payoffs. Whenever preferences are not congruent, the EN will accept to select the efficient project in exchange for a monetary transfer T that compensates him for any loss due to the dissonant project choice:

$$T \geq \gamma - \tau\left(\Delta R - \delta_{vc}\right).$$

Of course, the VC will be ready to pay a transfer $T \leq \tau\delta_{vc}$. As $\tau\Delta R - \gamma > 0$, there are gains from trade to be shared and renegotiation occurs. Anticipating this, the VC may have an incentive to monitor (and thus enjoys some real control) even when formal control rights are allocated to the EN initially.[24] Interestingly, the parties' best replies in information gathering under EN control are now both upward sloped provided $T \in (\gamma - \tau\Delta R + \tau\delta_{vc}, \tau\delta_{vc})$:

$$E^{EN}(e) = (1-\lambda)(\tau\delta_{vc} - T)e$$
$$e^{EN}(E) = [\lambda\tau(\Delta R - \delta_{vc}) + \gamma] + (1-\lambda)\left(\tau\Delta R - \tau\delta_{vc} - \gamma + T\right)E.$$

Under EN control the entrepreneur has *more* incentives to gather information when the VC exerts more monitoring, to the extent that only when both parties are informed EN is in a position to grab the transfer T out of renegotiation. Hence, while under VC control monitoring kills entrepreneurial initiative, under EN control monitoring spurs initiative. Intuitively, this should not undermine (and rather reinforce) the paper's central prediction

[23] Note that no renegotiation of control rights occurs under VC control. Hence, the results on how monitoring, initiative and firm value respond to the design of cash flow rights under VC control are unchanged.

[24] In earlier models on formal versus real authority (see e.g., Aghion and Tirole 1997) the principal never enjoys any real control when formal control is allocated to the agent. This is because in these models the agent only cares about private benefits and thus cannot be brought to renegotiate control rights.

that high-powered VC incentives are more likely to be associated with EN control than with VC control.

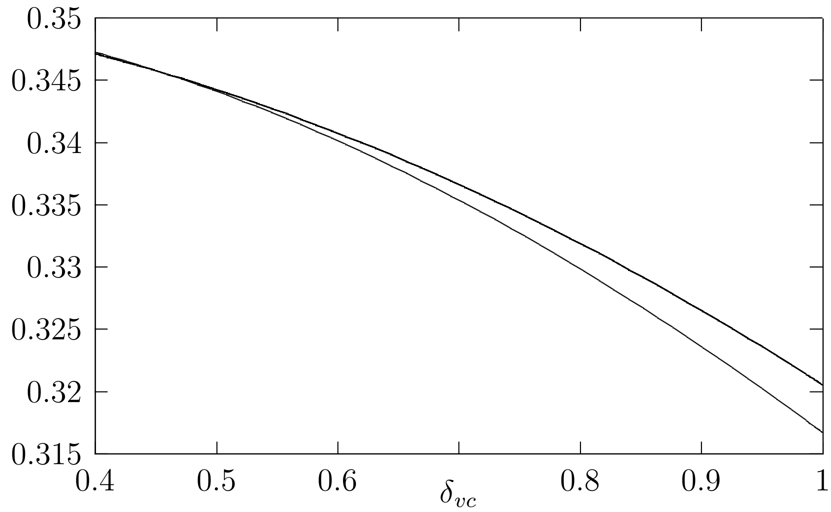

Figure 3: Plot of $V^{VC}(\delta_{vc})$ and $V^{EN}(\delta_{vc})$ when gains from renegotiating control rights are equally split. The thick (thin) curve displays $V^{EN}(\delta_{vc})$ ($V^{VC}(\delta_{vc})$).

When $T \in (\gamma - \tau\Delta R + \tau\delta_{vc}, \tau\delta_{vc})$ analytical results are difficult to obtain, therefore I turn to numerical simulations, focusing on the case where the gains from renegotiating control rights are equally split between the parties. I here discuss in particular the results obtained for the following parameter values: $\Delta R = 1$, $\tau = 0.5$, $p = 0.5$, $\lambda = 0.5$, $\gamma = 0.3$. In line with the basic model, in the interval $\delta_{vc} \in [\Delta R - \gamma/\tau, \Delta R]$ the function $e^{VC}(\delta_{vc})$ takes smaller values and is steeper than $e^{EN}(\delta_{vc})$. I analyze how choosing increasing levels of δ_{vc} in $[\Delta R - \gamma/\tau, \Delta R]$ affects the value of the venture under VC control and under EN control, and compare V^{VC} and V^{EN} for different levels of δ_{vc}. Figure 3 displays $V^{VC}(\delta_{vc})$ (thin curve) and $V^{EN}(\delta_{vc})$ (thick curve). By inspection, $V^{VC}(0.4) = 0.3473 > 0.3471 = V^{EN}(0.4)$. The two curves intersect at $\widehat{\delta} = 0.459087$, the threshold above which EN control dominates VC control. The simulations have been extended to encompass the following changes in parameter values: $\gamma \in \{0.25, 0.35, 0.4, 0.45\}$ and $\lambda \in (0.3, 0.4, 0.6, 0.7)$.[25] The results obtained are qualitatively similar to the main findings in the paper: in all simulations VC control dominates EN control (EN control dominates VC control) at low (high) levels

[25] To the extent that both the efficiency benefits of VC monitoring and the degree of dissonance between VC and EN's preferences vary dramatically with γ and λ, it is sensible to conjecture that the model implications are particularly sensitive to variations in these two parameters.

of δ_{vc}. Also, and in line with economic intuition, the threshold $\widehat{\delta}$ becomes smaller when larger levels of γ are set in the model. To conclude, my simulations validate the claim that the central prediction of the paper (i.e., high-powered VC incentives are more likely to be associated with EN control than with VC control) is robust to renegotiation.

5.3 Early profitability signals and contingent control

Venture capital deals make an extensive use of contingencies. Gompers (1999) and Kaplan and Strömberg (2003) report that cash-flow rights, control rights and disbursements of additional finance are made contingent upon observable measures of performance. Performance milestones are both financial (e.g. the attainment of a minimum level of short term earnings or net worth) and non-financial (patent approval, Federal Drug Administration approval for new drugs). Along the life of a start-up, the parties' rights typically evolve in the following way: at the initial stage of financing the VC usually enjoys control, but as early performance milestones are attained VC loses her superior voting, board and liquidation rights. Also, upon attainment of performance targets, the VC's preferred stock is converted into common stock. This contingent allocation of cash-flow and control rights can be rationalized in an extension of the basic model.

Assume that during the start-up's life *two* non-contractible actions must be taken in sequence. The first is the project selection; the second (the "interim action") represents all further decisions that may enhance profitability. Before each decision is made, both parties gather information on the payoffs attached to all alternative courses of action. The timing is as follows (see Figure 4). After the contract is signed, information gathering on project payoffs takes place ($t = 1$), and at $t = 2$ a project is chosen as in the basic model. Then, an early signal accrues about the profitability of the project adopted. The signal is verifiable. At $t = 3$, after the signal realization, the VC provides support to the start-up; simultaneously, both VC and EN gather information about the interim action. At $t = 4$ the interim action is selected. Finally, payoffs are realized. I define the period between the initial financing and the signal realization as the *seed stage*; the *start-up stage* takes place after the signal occurs and until the payoffs are realized.[26] I assume that VC support is a continuous variable as

[26] The British Venture Capital Association identifies four crucial stages in a company's development. At the *seed stage*, VC finance "allows a business idea to be developed, perhaps involving the production of a business plan, prototypes and additional research, prior to bringing a product to market..." The *start-up stage* is "to develop the company's products and fund their initial marketing." In a *further early stage* the company may "initiate commercial manufacturing and sales...but may not yet be generating profits." Finally, at the *expansion stage*, the VC may provide finance "to grow and expand an established company." (*A Guide*

in Remark 1. To simplify matters, I assume the entrepreneur is not responsive to monetary incentives.[27]

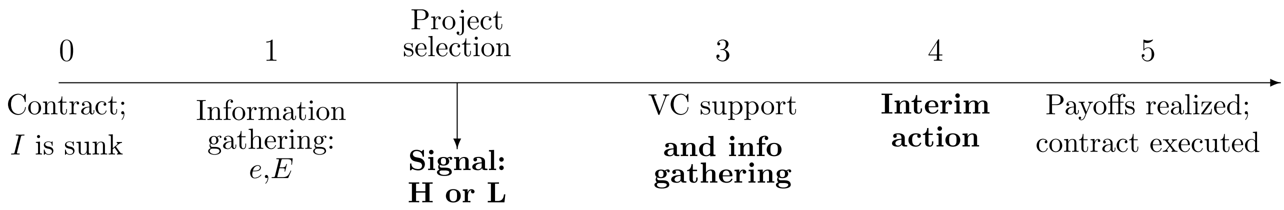

Figure 4: Time line

The initial contract must allocate *control rights over both actions*, as well as *cash-flow rights over the final profit.* Both the cash-flow rights and the formal control over the second action can be made contingent upon the verifiable signal of project profitability. At $t = 1$, incentives for information gathering and for project selection crucially depend on how control and cash-flow rights change upon attainment of a good (bad) signal.

The start-up stage

The paper's bottom line implies that the optimal claim to be held by the venture capitalist depends on who has formal control on the interim action. As argued in Remark 1, when VC advice/support is continuous, under EN control the VC should hold a risky claim that induces a high level of support. Under VC control, a trade off arises between VC support and VC interference, hence it is optimal to limit the riskiness of VC's claim. This implies that if control over the interim action is contingent upon the signal, cash-flow rights should be made contingent as well.

Define U_{en}^{EN} the entrepreneur's second-round utility when he has formal control on the second action, and U_{en}^{VC} the entrepreneur's second-round utility when the VC has formal control.

to Venture Capital, page 16-17). Usually, these early stages are followed by an exit stage where the firm is brought to the market through an IPO. For a complete description of the venture capital process, from investment to exit, see also Gompers and Lerner (1999). I do not explicitly model exit as this lies beyond the scope of the paper. Hence, my model cannot provide a theory for the use of contingencies like the outcome or the timing of an IPO. See Aghion, Bolton and Tirole (2004) for an optimal contracting model analyzing exit provisions in venture capital financing.

[27]One may reasonably assume that EN enjoys a large private benefit from running the firm, and thus is willing to start a venture even if he has to bear the costs of information gathering and of project implementation.

The seed stage

Project selection takes place at the seed stage and is not reversible at a later stage. The $N+1$ available projects have different probabilities of success $(pa+\tau_k)$ and private costs (γ_k) for the entrepreneur. Let me slightly generalize the basic model by assuming that one project $(N-2)$ has disastrous consequences for the firm $(\tau_{N-2}=-pa)$ but gives a private benefit b to the entrepreneur $(\gamma_{N-2}=-b)$. When project $(N-2)$ is available, EN's and VC's preferences over projects are never congruent, as EN invariably prefers project $(N-2)$ to any other project. Hence, VC should have formal control at the seed stage, as she always chooses the profit-enhancing project while EN never does.

There is a problem, though. If the VC has formal control over $t=2$ project selection, even if uninformed she never rubber stamps the entrepreneur's proposal. Indeed, if EN proposes a project, this must be his favorite one, namely, the value-destroying project $(N-2)$. As his proposal will never be accepted, EN has no incentive to gather information at $t=1$. To put it in other words, "the key to entrepreneurial real control (and initiative!) is congruence" (Tirole, 2000). If the EN's preferences are never congruent with the investor's objectives, his proposals are never rubber-stamped, which completely kills initiative as a result. To partially realign the EN's preferences over projects with investor objectives, a contingent control allocation at the start-up stage may be called for.

Assume that early performance variables realized after $t=2$ signal whether a value-destroying project was chosen: if $(N-2)$ is selected, a bad signal (L) accrues. If any other project is selected, signal L only accrues with probability $(1-\xi)$, while with probability $\xi>0$ a good signal (H) accrues. *A contract allocating start-up stage control to the entrepreneur if the signal is good, and to the venture capitalist if the signal is bad* can ensure that the EN - when informed - never proposes project $(N-2)$ at the seed stage.[28] This is the case if:

$$\xi U_{en}^{EN}+(1-\xi)U_{en}^{VC}\geq b+U_{en}^{VC}$$

or:

$$U_{en}^{EN}-U_{en}^{VC}\geq\frac{b}{\xi}$$

which holds whenever entrepreneurial benefits of control over the interim action are large enough relative to the benefits of control over project selection. By realigning EN's preferences with VC's, contingent start-up stage control allows to grant seed-stage control to the

[28] This "carrot-and-stick" view of contingent control is in line with Dewatripont and Tirole (1994), who argue that shifting control to tough investors after bad performance is a way to discipline managers when monetary incentives are costly to provide.

venture capitalist (as is efficient), and yet preserve entrepreneurial initiative at $t = 1$.

The contingent allocation of control and cash-flow rights delineated so far can be implemented in the following way. In the optimal contingent contract the venture capitalist holds superior control rights at the close of the financing and takes convertible preferred equity in the firm. When a good interim signal of profitability is observed, control is shifted back to the founding entrepreneur, and VC's preferred stock is converted into common. If a bad signal is observed, VC keeps control of the firm and her preferred stock is not converted.

6 Empirical predictions and evidence

In this paper I have shown that an innovative start up selling a venture capital investor a high-powered financial claim to spur costly support should limit the VC's control rights in the venture. This is because high-powered claims associated with control rights spur excessive VC interference, thus killing entrepreneurial initiative. I here discuss three main predictions that can be drawn from my theory and how they relate with existing empirical evidence.

First, my results challenge the textbook corporate finance assumption that riskier claims, such as common equity, should always be associated with more control rights. Indeed, my model predicts that when both entrepreneurial initiative *and* VC support are central to a company's success, very risky claims should be granted fewer control rights, while more control rights can be attached to relatively safe claims such as preferred equity. Recent empirical evidence seems to corroborate this claim. Relying on a large sample of VC funds in continental Europe, Cumming and Johan (2007) observe a negative correlation between VC control rights and the sensitivity of venture capitalists' financial claim to the company's performance ("VCs typically have fewer control rights with common equity, and more control rights when mixes of preferred and common are used.").

The paper's prediction that riskier claims should have less control attached rests on the importance of both EN initiative and VC advice in innovative ventures. While entrepreneurial initiative is also central in traditional corporate finance settings, the valuable support and advising services delivered by venture capitalists are not generally provided by other large shareholders. This explains why the hybrid financial claims (i.e., common stock with limited control attached) devised in venture capital contracts are not commonly observed in other corporate financial arrangements.[29]

[29] In other words, in more traditional settings entrepreneurs willing to preserve their own incentives by limiting large shareholder interference can opt for dispersed ownership, as in Burkart, Gromb and Panunzi (1997). Conversely, in VC environments entrepreneurs may not be eager to reduce their investor's monetary

A second prediction of the paper is that the combination of high-powered claims and weak control rights should be more common among investors who face a high opportunity cost in supporting the success of a portfolio company (i.e., VCs for which c is large). A widespread perception in the business community is that corporate venture funds display this feature to a larger extent than independent venture capitalists. Indeed, rather than supporting the portfolio company, corporate VCs may "cannibalize" its idea and let the information shared at various stages of the venture be exploited by the parent house (see Silver 1984 and Hellmann 2002). This explains why entrepreneurs often express concerns about confidentiality when dealing with corporate VCs. In line with my theory, many corporate venturing programs have adopted an "hands-off approach" to protect entrepreneurs. Gompers and Lerner (1999) document for instance that many corporate VCs do not take board seats in portfolio firms.[30]

Corporate VCs may also have a lower cost of monitoring the start up's research process, especially when due diligence and early monitoring are performed by scientists at the parent company who are particularly knowledgeable of the start up's research area. In my model, this would imply that – for given cash flow rights – corporate VCs have more tendency to interfere in the project selection. The contraposition between spurring VC support at a later stage and avoiding excess interference at the early stage is thus exacerbated, which strengthens my prediction that corporate VCs should be allocated less control rights than independent VCs.Of course, some corporate VCs may resort to other commitment devices to reduce the potential conflict with portfolio companies, which would reduce the need to limit their control rights. My theory suggests that *these* corporate VCs may be able to attach more control rights to their equity. One interesting case study is that of Lilly Ventures, the corporate VC arm of Eli Lilly (see Hamermesh et al. 2007). When performing due diligence on a biotech start-up called Protagonist in late 2005, Lilly Ventures signed a confidentiality and disclosure agreement "to reassure the company that any information shared in the due-diligence process would not be used to benefit Lilly." To this aim, the VC team even chose to

incentives, as this would reduce VC support/advice. Therefore, they may have to resort to a combination of risky claim and limited VC control.

[30]Gompers and Lerner (2000) also find that corporate venture investors pay higher valuations, hence taking smaller equity stakes than independent venture capitalists. This may be because corporate VCs include in their valuations the strategic benefits generated by the venture for the parent company (Hellmann, 2002), or compensate entrepreneurs ex ante for the larger risk of idea expropriation. As a typical corporate VC share is smaller, in order to motivate the VC to support the venture it is even more important to give her higher-powered incentives. This can be achieved by selling the VC common rather than preferred stock and avoiding granting the VC any downside protection.

hire external consultants, rather than Lilly scientists, to perform some parts of the scientific due-diligence process. More generally, Lilly Ventures' management emphasizes that it is well aware of entrepreneur's concerns about confidentiality and loss of control, hence it always tries to establish a "Chinese wall" between the portfolio company and Lilly when requesting to have any seats on the board.

Partnership deals between biotech start-ups and big drug companies are plagued by similar problems as in corporate VC deals. Leading drug firms may be helpful financiers when it comes to advising biotech research, or performing the costly stages of testing and manufacturing a newly discovered drug. However, a *controlling* corporate partner willing to keep an eye on new discoveries may be tempted to appropriate the good ones or destroy the ones that compete with its leading drugs. Apparently, scared by excess interference and the risk of cannibalization, biotech start-ups have traditionally been cautious when writing such "window-on-technology" deals.[31]

The third prediction that can be drawn from my paper is that in VC deals where control allocation is contingent on performance milestones, control rights and the riskiness of cash flow rights should be negatively correlated along the life of the venture. This is in line with the evidence (Gompers 1999, Kaplan and Strömberg 2003) that upon attainment of milestones VCs usually lose their superior control rights while their preferred stock is converted into common stock. In a significant number of cases, such conversion occurs automatically once the performance milestone is attained, and thus it is *not* just an option offered to the venture capitalist.[32] My theory offers a framework to explain why the venture capitalist should lose control exactly at the time when her preferred stock can (or must) be converted into common stock.[33] Within this framework, the need for *automatic conversion clauses* can also be rationalized, to the extent that the shift to entrepreneurial control (implying that

[31] As reported in *The Economist* (August 29th, 1992), "...when a big drug firm buys a controlling stake in a biotech firm, it is usually careful to let the firm's founders continue to run it."

[32] Automatic conversion occurs in 38% of the contracts in Gomper's sample. Conversion is contingent on profit or sales benchmarks, as well as on an initial public offering. See however Kaplan and Strömberg (2003), who argue that automatic conversion contingent on profits or sales is less common.

[33] Several papers have provided a rationale for the use of convertible securities. In a first set of papers, control allocation is neglected and convertibles only implement a contingent allocation of cash-flows (see for instance Green 1984, Biais and Casamatta 1999, Schmidt 2003, Cornelli and Yosha 2003). In other models, convertibles serve to allocate contingent control rights to the parties (see Berglöf 1994, Kalai and Zender 1997), however conversion of a debt-like claim into equity is always associated to an *increase* in control. Finally, Hellmann (2006) develops a theory to account for the use of convertible preferred equity *and* contingent control rights in venture capital. His theory focuses on control on the exit decision rather than on early project selection, and rationalizes the use of late contingencies (IPOs rather than earlier performance milestones), hence it can be viewed as complementary to my model.

suboptimal project choices will occur) can make the VC wary of converting her preferred equity into common in spite of a good interim performance signal accruing.[34] In this respect, my model also adds to the few financial contracting theories (to my knowledge, only Schmidt 2003 and Hellmann 2006) that offer an explanation for the use of automatic conversion clauses.

7 Concluding remarks

This paper contributes to the strand of literature that studies the optimal joint allocation of cash-flow rights and control rights between entrepreneurs and venture capitalists (see Hellmann 1998 and 2006, Schindele 2004 and Dessí 2005). In a model with sequential moral hazard, I show that when the need for costly VC advice and support calls for a high-powered outside claim, the entrepreneur should optimally retain control in order to preserve his incentives to engage in costly information acquisition.

My theory challenges the common idea that more equity-like claims (e.g. common stock) should always come with more control rights, as is the case in standard securities. In line with my results, venture capital contracts, corporate venturing deals, and sophisticated partnership deals between biotech start-ups and big drug companies often display a negative correlation between control rights and the riskiness of claims. My theory also explains the use - documented in Gompers (1999) and Kaplan and Strömberg (2003) - of contingent contracts where the investor's superior control rights are reduced and her preferred stock is automatically converted into common upon attainment of early performance milestones.

[34]By contrast, in most existing models conversion is ex post optimal for the venture capitalist once a good signal accrues. This is for instance the case in models where the conversion of preferred stock into common serves to signal good prospects to outside investors (see e.g., Dessí 2005).

References

[1] Aghion, P., P. Bolton and J. Tirole (2004), "Exit Options in Corporate Finance: Liquidity versus Incentives", *Review of Finance*, 8(3): 327-353.

[2] Aghion, P. and J. Tirole (1997), "Real and Formal Authority in Organizations", *Journal of Political Economy,* 105: 1-29.

[3] AssetAlternatives Inc. (2000), *The Corporate Venturing Directory & Yearbook*, Wellesley, Massachusetts, AssetAlternatives Inc.

[4] Berglöf, E. (1994), "A Control Theory of Venture Capital Finance", *Journal of Law, Economics and Organization*, 10: 247-267.

[5] British Venture Capital Association (1998), *A Guide to Venture Capital*, (available at: http://www.bvca.co.uk).

[6] Biais, B. and C. Casamatta (1999), "Optimal Leverage and Aggregate Investment", *Journal of Finance*, 54: 1291-1323.

[7] Burkart, M., D. Gromb and F. Panunzi (1997), "Large Shareholders, Monitoring, and the Value of the Firm", *Quarterly Journal of Economics*, 112: 693-728.

[8] Casamatta, C. (2003), "Financing and Advising: Optimal Financial Contracts with Venture Capitalists", *Journal of Finance*, 58: 2059-2086.

[9] Cestone, G. and L. White (2003), "Anti-Competitive Financial Contracting: The Design of Financial Claims", *Journal of Finance*, 58: 2109-2142.

[10] Chan, Y., D. Siegel, and A. Thakor (1990), "Learning, Corporate Control, and Performance Requirements in Venture Capital Contracts", *International Economic Review*, 31: 365-381.

[11] Cornelli, F. and O. Yosha (2003), "Stage Financing and the Role of Convertible Debt", *Review of Economic Studies*, 70: 1-32.

[12] Cumming, D.J. (2008), "Contracts and Exits in Venture Capital Finance", *Review of Financial Studies*, 21(5): 1947-1982.

[13] Cumming, D. and S. A. Johan (2007), "Adice and Monitoring in Venture Finance", *Financial Markets and Portfolio Management*, 21(1): 3-43.

[14] Cumming, D. and S. A. Johan (2009), *Venture Capital and Private Equity Contracting: An International Perspective*, Elsevier Science Academic Press.

[15] Dessein, W. (2002), "Authority and Communication in Organizations", *Review of Economic Studies*, 69: 811-838.

[16] Dessí, R. (2005), "Start-up Finance, Monitoring, and Collusion", *RAND Journal of Economics,* 36(2): 255-274.

[17] 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.

[18] Diamond, D. (1984), "Financial Intermediation and Delegated Monitoring", *Review of Economic Studies*, 51: 393-414.

[19] Gale, D. and M. Hellwig (1985), "Incentive-Compatible Debt Contracts", *Review of Economic Studies*, 52: 647-663.

[20] Gompers, P. (1999), "Ownership and Control in Entrepreneurial Firms: An Examination of Convertible Securities in Venture Capital Investments", Working Paper, Harvard Business School.

[21] Gompers, P. and J. Lerner (1999), *The Venture Capital Cycle*, Cambridge: MIT Press.

[22] Gorman, M. and W. Sahlman (1989), "What do Venture Capitalists Do?", *Journal of Business Venturing*, 4: 231-248.

[23] Green, R. (1984), "Investment Incentives, Debt, and Warrants", *Journal of Financial Economics*, 13: 115-136.

[24] Hamermesh, R.G., R. Laufer and D. Lane (2007), "Corporate Venture Capital at Eli Lilly", Harvard Business School Case 806-092.

[25] Hart, O. (1995), *Firms, Contracts and Financial Structure*, Oxford: Oxford University Press.

[26] Hellmann, T. (1998), "The Allocation of Control Rights in Venture Capital Contracts", *Rand Journal of Economics*, 29: 57-76.

[27] Hellmann, T. (2002), "A Theory of Strategic Venture Investing", *Journal of Financial Economics*, 64: 285-314.

[28] Hellmann, T. (2006), "IPOs, Acquisitions and the Use of Convertible Securities in Venture Capital", *Journal of Financial Economics*, 81(3): 649-679.

[29] Hellmann, T. and M. Puri (2002), "Venture Capital and the Professionalization of Start-Ups: Empirical Evidence", *Journal of Finance*, 57: 169-197.

[30] Holmström, B. and J. Tirole (1997), "Financial Intermediation, Loanable Funds and the Real Sector", *Quarterly Journal of Economics,* 112: 663-691.

[31] Inderst, R. and H. Müller (2004), "The Effect of Capital Market Characteristics on the Value of Start-Up Firms", *Journal of Financial Economics*, 72: 319-356.

[32] Kalai, A. and J. Zender (1997), "Bankruptcy, Warrants, and State-Contingent Changes in the Ownership of Control", *Journal of Financial Intermediation*, 6: 47-379.

[33] Kaplan, S. and P. Strömberg (2003), "Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts", *Review of Economic Studies*, 70: 281-315.

[34] Kaplan, S. and P. Strömberg (2004), "Characteristics, Contracts, and Actions: Evidence from Venture Capital Analyses", *Journal of Finance,* 59: 2177-2210.

[35] Kirilenko (2001), "Valuation and Control in Venture Finance", *Journal of Finance*, 56: 565-587.

[36] Lerner, J. and R.P. Merges (1998), "The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry", *Journal of Industrial Economics*, 46: 125-156.

[37] Pagano, M. and A. Röell (1998), "The Choice of Stock Ownership Structure: Agency Costs, Monitoring, and the Decision to Go Public", *Quarterly Journal of Economics*, 113: 187-225.

[38] Renucci, A. (2006), "Optimal Claims and Tightness of Relationships with a Value-Enhancing Investor", *mimeo*, GREMAQ, Université de Toulouse.

[39] Repullo, R. and J. Suarez (2004), "Venture Capital Finance: A Security Design Approach", *Review of Finance*, 8: 75-108.

[40] Sahlman, W. (1990), "The Structure and Governance of Venture Capital Organizations", *Journal of Financial Economics*, 27: 473-522.

[41] Sapienza, H. (1992), "When do Venture Capitalists Add value?", *Journal of Business Venturing*, 7: 9-27.

[42] Schindele, I. (2004), "Advice and Monitoring: Venture Financing With Multiple Tasks", *mimeo*, Norwegian School of Management.

[43] Schmidt, K.M. (2003), "Convertible Securities and Venture Capital Finance", *Journal of Finance*, 58: 1139-1166.

[44] Silver , A.D. (1984), *Who's Who in Venture Capital*, New York: Wiley and Sons.

[45] Tirole, J. (2000), "Corporate Governance", *Econometrica*, 69: 1-35.

[46] Tirole, J. (2006), *The Theory of Corporate Finance*, Princeton University Press.

[47] Townsend, R. (1979), "Optimal Contracts and Competitive Markets with Costly State Verification", *Journal of Economic Theory*, 21: 417-425.

[48] Ueda, M. (2004), "Banks versus Venture Capital: Project Evaluation, Screening and Expropriation", *Journal of Finance*, 59(2): 601-621.

8 Appendix

Proof of Lemma 1

The proof consists in showing that no contract specifying $\tau\delta_{en} \geq \gamma$ can satisfy investors' participation constraints if $I > I_1$.

Assume the VC investor accepts a contract stating cash flow rights: $R^L_{vc} = R^L$, $\delta_{vc} = \Delta R - \gamma/\tau$, $R^L_{en} = 0$, $\delta_{en} = \gamma/\tau$. Then, EN's and VC's preferences over projects are perfectly aligned, and control allocation is irrelevant: project $N-1$ is always selected at $t = 2$ irrespective of who holds formal control. At $t = 1$, the entrepreneur chooses effort e to maximize:

$$e\left(\tau\frac{\gamma}{\tau} + \lambda\gamma\right) - \frac{e^2}{2},$$

hence

$$e = \gamma(1+\lambda) < \lambda\tau\Delta R + \gamma,$$

and the income that can be credibly pledged to the investor at $t = 0$ is

$$R^L + (p + \gamma(1+\lambda)\tau)\left(\Delta R - \frac{\gamma}{\tau}\right).$$

Define

$$I_1 \equiv R^L + (p + \gamma(1+\lambda)\tau)\left(\Delta R - \frac{\gamma}{\tau}\right). \tag{6}$$

It is immediate that whenever $I > I_1$, a contract specifying cash flow rights $R^L_{vc} = R^L$, $\delta_{vc} = \Delta R - \gamma/\tau$ does not satisfy the VC investor's participation constraint. A fortiori, when $I > I_1$ no other contract setting $\delta_{en} \geq \gamma/\tau$ (and thus inducing congruent preferences) can satisfy the investor's participation constraint.

Proof of Proposition 1

Substituting $e = \lambda\tau(\Delta R - \delta_I) + \gamma$ in (**??**), and differentiating with respect to δ_I, one obtains:

$$\frac{dV^{EN}}{d\delta_I} = \frac{dV^{EN}}{de}\frac{de}{d\delta_I} = (\lambda\tau\Delta R + \gamma - e)(-\lambda\tau) = -\lambda^2\tau^2\delta_I < 0.$$

It follows that the optimal contract must minimize the combined riskiness of investors' claims, δ_I, subject to the investors' break-even constraint: the income pledged to investors equals the funds provided:

$$R_I^L + p\delta_I + (\lambda\tau(\Delta R - \delta_I) + \gamma)\,\lambda\tau\delta_I = I. \tag{7}$$

At the optimum $R_I^L = R^L$, hence $R_{en}^L = 0$. If not, it would be possible to increase R_I^L and reduce δ_I – thus increasing the surplus – while keeping (**??**) satisfied. Under the model assumptions, the pledgeable income under EN control:

$$PI^{EN} = R^L + p\delta_I + (\lambda\tau(\Delta R - \delta_I) + \gamma)\,\lambda\tau\delta_I,$$

is increasing in δ_I, $\forall\delta_I \in [0, \Delta R]$. It follows immediately that the optimal δ_I is the smallest root of equation (**??**).

Proof of Lemma 2

To simplify the notation, I define $X \equiv \tau\Delta R - \gamma$ and $e^* \equiv \lambda\tau\Delta R + \gamma$, hence:

$$V^{VC}(E) = R^L + p\Delta R - \gamma - I + e^* e^{VC}(E) + (1-\lambda)XEe^{VC}(E) - \frac{\left(e^{VC}(E)\right)^2}{2} - \frac{E^2}{2}.$$

Differentiating V^{VC} with respect to E, and using $de^{VC}/dE = -(1-\lambda)\,(\gamma - \tau(\Delta R - \delta_I))$:

$$\begin{aligned} \frac{dV^{VC}}{dE} &= \frac{\partial V^{VC}}{\partial E} + \frac{\partial V^{VC}}{\partial e}\frac{de^{VC}}{dE} \\ &= e^{VC}(E)(1-\lambda)X - E + \left(e^* + (1-\lambda)XE - e^{VC}(E)\right)\left(-\left(\gamma - \tau(\Delta R - \delta_I)\right)(1-\lambda)\right). \end{aligned} \tag{8}$$

Replacing into the above expression $e^{VC}(E) = e^{EN} - (1-\lambda)\,(\gamma - \tau(\Delta R - \delta_I))\,E$, one obtains:

$$\begin{aligned} \frac{dV^{VC}}{dE} &= e^{EN}(1-\lambda)X - (\gamma - \tau(\Delta R - \delta_I))\,(1-\lambda)^2 XE - E - (\gamma - \tau(\Delta R - \delta_I))\,(1-\lambda)e^* \\ &\quad - (\gamma - \tau(\Delta R - \delta_I))\,(1-\lambda)^2 XE + e^{EN}\,(\gamma - \tau(\Delta R - \delta_I))\,(1-\lambda) - (\gamma - \tau(\Delta R - \delta_I))^2\,(1-\lambda)^2 E. \end{aligned}$$

The second derivative is then:

$$\frac{d^2V^{VC}}{dE^2} = -2\,(\gamma - \tau(\Delta R - \delta_I))\,(1-\lambda)^2 X - ((\gamma - \tau(\Delta R - \delta_I)))^2\,(1-\lambda)^2 - 1 < 0.$$

Let us now study the sign of dV^{VC}/dE. We know that the initiative effect in (**??**) is always strictly negative. Using the best reply function $E^{VC} = e(1-\lambda)\tau\delta_{vc}$ to replace E into the control effect $\partial V^{VC}/\partial E = e(1-\lambda)(\tau\Delta R - \gamma) - E$, one obtains

$$\frac{\partial V^{VC}}{\partial E} = e(1-\lambda)(\tau\Delta R - \gamma - \tau\delta_{vc}) \leq 0, \forall\delta_{vc} \geq \Delta R - \frac{\gamma}{\tau}.$$

It follows that $dV^{VC}/dE < 0$, $\forall\delta_{vc} \in \left[\Delta R - \frac{\gamma}{\tau}, \Delta R\right]$.

Proof of Proposition 2

The proof is by contradiction, and involves two steps.

- *Step 1.* Define pledgeable income net of monitoring costs under VC control as:

$$PI^{VC}(\delta_{vc}, \delta_{en}, \delta_{out}) = R^L + p(\delta_{vc} + \delta_{out}) + e[\lambda + E(1-\lambda)]\tau(\delta_{vc} + \delta_{out}) - \frac{E^2}{2} \quad (9)$$

  where $e = e^{VC}(\delta_{vc}, \delta_{en})$ and $E = E^{VC}(\delta_{vc}, \delta_{en})$ as in equations (**??**) and (**??**). Suppose $\delta_{out} = I_{out} = 0$, hence $\delta_{vc} = \delta_I$ and $\delta_{en} = \Delta R - \delta_I$. Define $\hat{\delta}_I$ as the smaller root of the equation:

$$PI^{VC}(\delta_I, \Delta R - \delta_I, 0) = I. \quad (10)$$

  Note that $\hat{\delta}_I > \Delta R - \gamma/\tau$. This follows from two facts: (i) when $\delta_{out} = 0$, $\delta_{vc} = \Delta R - \gamma/\tau$, $\delta_{en} = \gamma/\tau$, it is $PI^{VC} < I_1 < I$ and (ii) PI^{VC} is strictly increasing in δ_I.

- *Step 2.* I now show that $\delta_{out} = I_{out} = 0$, $\delta_{vc} = \hat{\delta}_I > \Delta R - \gamma/\tau$ cannot be an optimum. Suppose the contract sets $\delta_{vc} > \Delta R - \gamma/\tau$: it is possible to reduce δ_{vc} and increase δ_{out} so as to keep δ_{en} constant, while keeping investors' break-even constraints satisfied. This will reduce monitoring E and, by Lemma **??**, it will increase the surplus V^{VC}. It follows that at the optimum it is $\delta_{out} > 0$ and $I_{out} > 0$: a pure financier must be involved in the deal.

Proof of Proposition 3

If VC support is contractible, VC control weakly dominates EN control: the surplus attained under EN formal control can always be replicated by granting the VC *formal* control attached to a flat claim, so that the VC never exercises any *real* control. Formally, setting $\delta_{vc} = 0$, $\delta_{out} = \delta_I$ under VC control, one gets $E^{VC} = 0$, $e^{VC} = e^{EN}$, and $V^{VC} = V^{EN}$. Indeed, it can be checked that VC control does *strictly* better than EN control whenever the efficiency gains from VC control ($\tau\Delta R - \gamma$) are large relative to the firm's financing needs (I). Then, the optimal contract allocates formal control to the VC, and provides her with incentives to exercise *some* monitoring and real control: $\delta_{vc} \in (0, \Delta R - \gamma/\tau)$.

Proof of Lemma 3

Assume $\delta_{out} > 0$. Assumption **??** and (IC_{vc}) imply that under both VC and EN control, pledgeable income is strictly larger than the investment cost I. It is then possible to reduce δ_{out} and increase δ_{en}, while keeping (IC_{vc}) and the investors' participation constraints satisfied. Under any control allocation, an increase in δ_{en} ceteris paribus increases firm surplus.

Proof of Proposition 4

To compare the value of the venture under VC and EN control for any given level of δ_{vc}, I study the function $H(\delta_{vc})$:

$$H(\delta_{vc}) \equiv V^{VC}(\delta_{vc}) - V^{EN}(\delta_{vc}).$$

$H(\delta_{vc})$ can be decomposed in the following way:

$$H(\delta_{vc}) = L(\delta_{vc}) + M(\delta_{vc}),$$

where:

$$L(\delta_{vc}) \equiv \left[e^{VC}(\lambda\tau\Delta R + \gamma) - \frac{(e^{VC})^2}{2}\right] - \left[e^{EN}(\lambda\tau\Delta R + \gamma) - \frac{(e^{EN})^2}{2}\right]$$

and

$$M(\delta_{vc}) \equiv e^{VC}E^{VC}(1-\lambda)(\tau\Delta R - \gamma) - \frac{(E^{VC})^2}{2}.$$

The proof is in three steps.

- *Step 1* – The function $L(\delta_{vc})$ captures the dark side of VC control as compared with EN control: entrepreneurial initiative under VC control is ceteris paribus lower than initiative under EN control:

  $$e^{VC} < e^{EN}, \ \forall \delta_{vc} > \Delta R - \frac{\gamma}{\tau}.$$

  This, together with $e^{EN} < \lambda\tau\Delta R + \gamma$, implies that $L(\delta_{vc}) < 0 \ \forall \delta_{vc} > \Delta R - \gamma/\tau$. Furthermore, $L(\Delta R - \gamma/\tau) = 0$, as $e^{VC} = e^{EN}$ when $\delta_{vc} = \Delta R - \gamma/\tau$. In fact, only when there is a discrepancy between the entrepreneur's preferred project and the VC's preferred project – as measured by the distance $\gamma - \tau(\Delta R - \delta_{vc})$ – a "control-kill-initiative effect" à la Burkart, Gromb and Panunzi (1997) shows up under VC control.

  Note also that the distance between e^{VC} and e^{EN} is increasing as δ_{vc} grows. Formally: $de^{VC}/d\delta_{vc} < de^{EN}/d\delta_{vc} < 0$. This in turn implies:

  $$\frac{dL}{d\delta_{vc}} = [(\lambda\tau\Delta R + \gamma) - e^{VC}]\frac{de^{VC}}{d\delta_{vc}} - [(\lambda\tau\Delta R + \gamma) - e^{EN}]\frac{de^{EN}}{d\delta_{vc}} < 0.$$

- *Step 2* – The function $M(\delta_{vc})$ represents the benefit of VC control net of monitoring costs. Using the best reply function $E^{VC} = \tau(1-\lambda)\delta_{vc}e^{VC}$, one can write:

  $$M(\delta_{vc}) = E^{VC}e^{VC}\left[(1-\lambda)(\tau\Delta R - \gamma) - \frac{\tau(1-\lambda)\delta_{vc}}{2}\right],$$

implying that $M(\delta_{vc}) \leq 0$ if $\delta_{vc} \geq 2(\Delta R - \gamma/\tau)$. Secondly, as VC and EN's preferences are dissonant when $\gamma > \tau(\Delta R - \delta_{vc})$, it is $\lim_{\delta_{vc} \to (\Delta R - \gamma/\tau)^+} M(\delta_{vc}) > 0$. Third, from lemma **??** we know that for all $\delta_{vc} \geq \Delta R - \gamma/\tau$, the net benefits of VC control are decreasing in E. This, together with $dE^{VC}/d\delta_{vc} > 0$, implies that

$$\frac{dM}{d\delta_{vc}} < 0 \quad \forall \delta_{vc} \geq \Delta R - \frac{\gamma}{\tau}.$$

- *Step 3* – From steps 1 and 2 it follows that: (i) $\lim_{\delta_{vc} \to (\Delta R - \gamma/\tau)^+} H(\delta_{vc}) > 0$; (ii) $H(\delta_{vc}) < 0$ at $\delta_{vc} = 2(\Delta R - \gamma/\tau)$; (iii) $dH/d\delta_{vc} < 0$, $\forall \delta_{vc} \geq \Delta R - \gamma/\tau$. As H is continuous, it follows that there exists a threshold value $\widehat{\delta} \in \left[\Delta R - \frac{\gamma}{\tau}, \Delta R\right]$ such that $V^{VC} > V^{EN}$ if and only if $\delta_{vc} \in \left(\Delta R - \gamma/\tau, \widehat{\delta}\right)$.

Proof of Proposition 6

When the VC holds an option to buy control at price K, the incentive compatibility constraints for information gathering are:

$$e \in \arg\max_{e} R_{en}^{L} + (p + e\lambda\tau)(\Delta R - \delta_{vc}) - (1-e)\gamma + eE(1-\lambda)\left(K + \tau(\Delta R - \delta_{vc}) - \gamma\right) - \frac{e^2}{2},$$

$$E \in \arg\max_{E} R_{vc}^{L} + (p + e\lambda\tau)\delta_{vc} + eE(1-\lambda)(\tau\delta_{vc} - K) - \frac{E^2}{2}.$$

Hence, the reaction functions in information gathering efforts are:

$$e^{O}(E) = (\lambda\tau(\Delta R - \delta_{vc}) + \gamma) + (1-\lambda)\left(K + \tau(\Delta R - \delta_{vc}) - \gamma\right)E$$

$$E^{O}(e) = (1-\lambda)\left(\tau\delta_{vc} - K\right)e.$$

Note that initiative is now increasing in monitoring if $K > \gamma - \tau(\Delta R - \delta_{vc})$, that is if the option exercise price more than compensates the entrepreneur for the loss of control; otherwise, e is decreasing in monitoring as under outright VC control, with higher levels of K alleviating the monitoring-kills-initiative effect. When instead $K = \gamma - \tau(\Delta R - \delta_{vc})$, initiative is independent of monitoring as in the outright EN control case, and $e^{O} = e^{EN}$. Equilibrium effort levels $e^{O}(K, \delta_{vc})$ and $E^{O}(K, \delta_{vc})$ can be derived from the above, and tedious calculations show that $\partial E^{O}/\partial K < 0$, $\partial E^{O}/\partial \delta_{vc} > 0$ and $\partial^2 E^{O}/\partial K \partial \delta_{vc} < 0$.

The contractual design problem boils down to choosing a transfer price K and a level of δ_{vc} that maximize the surplus

$$V = R^{L} + p\Delta R - \gamma - I + e(\lambda\tau\Delta R + \gamma) + eE(1-\lambda)(\tau\Delta R - \gamma) - \frac{(e)^2}{2} - \frac{(E)^2}{2}.$$

subject to the incentive compatibility constraint $\delta_{vc} \geq c/p$. Note that the effect of K on the surplus can be decomposed in the following way:

$$\frac{dV}{dK} = \left(\frac{\partial V}{\partial e}\frac{\partial e^O}{\partial E} + \frac{\partial V}{\partial E}\right)\left(\frac{\partial E^O}{\partial K}\right) + \frac{\partial V}{\partial e}\frac{\partial e^O}{\partial K}. \tag{11}$$

A larger exercise price reduces VC monitoring ($\partial E^O/\partial K < 0$), and this in turn has an *initiative effect* and a *control effect* on V. The last term in (**??**) represents instead the direct impact of the exercise price on initiative and value, and it is strictly positive provided $K < \tau\delta_{vc}$; at $K = \tau\delta_{vc}$ the option to buy control is never exercised, hence an increase in K does not spur initiative.

Replacing $e^O(E)$ in the initiative effect one obtains:

$$\frac{\partial V}{\partial e}\frac{\partial e^O}{\partial E} = (\lambda\tau\Delta R + \gamma - e + E(1-\lambda)(\tau\Delta R - \gamma))\frac{\partial e^O}{\partial E} = (\lambda\tau\delta_{vc} + (1-\lambda)E(\tau\delta_{vc} - K))\frac{\partial e^O}{\partial E},$$

that is positive if $\partial e^O/\partial E > 0$, that is iff $K \geq \gamma - \tau(\Delta R - \delta_{vc})$.

Replacing $E^O(e)$ in the control effect, one obtains

$$\frac{\partial V}{\partial E} = e(1-\lambda)\left(K + \tau\Delta R - \tau\delta_{vc} - \gamma\right),$$

that is positive iff $K \geq \gamma - \tau(\Delta R - \delta_{vc})$.

It follows from the above that V achieves its maximum at $K^* \in (\gamma - \tau(\Delta R - \delta_{vc}), \tau\delta_{vc})$. Moreover, from $\tau\Delta R > \gamma$ and $(c/p) > \Delta R - \gamma/\tau$ it follows that $\gamma - \tau(\Delta R - \delta_{vc}) \in (0, \tau\delta_{vc})$: therefore, neither outright VC control nor outright EN control is optimal.

Next, I show that K^* is increasing in δ_{vc}. We know that (**??**) is equal to zero at $K = K^*$. Using the implicit function theorem and the concavity of V, $dK^*/d\delta_{vc}$ can be signed by signing the mixed partial derivative:

$$\frac{\partial^2 V}{\partial K \partial \delta_{vc}} = \frac{\partial}{\partial E}\left(\frac{\partial V}{\partial e}\frac{\partial e}{\partial E} + \frac{\partial V}{\partial E}\right)\frac{\partial E}{\partial \delta_{vc}}\frac{\partial E}{\partial K} + \left(\frac{\partial V}{\partial e}\frac{\partial e}{\partial E} + \frac{\partial V}{\partial E}\right)\frac{\partial^2 E}{\partial K \partial \delta_{vc}} + \frac{\partial V}{\partial e}(1-\lambda)\frac{\partial E}{\partial \delta_{vc}}. \tag{12}$$

We know that $(\partial V/\partial e)(\partial e/\partial E) + \partial V/\partial E$ is positive at K^*, and by lemma **??** it is decreasing in E. Hence, $\partial^2 V/\partial K \partial \delta_{vc}$ is positive, implying that K^* is increasing in δ_{vc}.

Web appendix to the paper: Venture Capital Meets Contract Theory: Risky Claims or Formal Control?

February 26, 2013

This appendix contains supplementary material to the article "Venture Capital Meets Contract Theory: Risky Claims or Formal Control?"

Continuous VC support

I analyze here the more general case where VC support is a continuous variable: at $t = 3$ the VC exerts an unobservable advising effort $a \in [0, 1]$. Let $c_A(.)$ be the disutility of this effort and assume:

$$c_A(a) = \frac{a^2}{2}.$$

Any project k succeeds with probability $q_k(a)$, where

$$q_k(a) = ap + \tau_k,$$

and $\tau_k \in \{0; \tau\}$. I also assume that the surplus generated by the venture is negative unless a minimal level of advice $a_{\min}$ is provided:

$$a_{\min} \equiv p\left(\Delta R - \frac{\gamma}{\tau}\right),$$

hence VC incentives must be sufficiently high-powered: $\delta_{vc} \geq \Delta R - \gamma/\tau$. The venture capitalist's choice of effort at $t = 3$ is determined by the first order condition:

$$a = p\delta_{vc} \qquad (IC_{vc})$$

which implies that VC support is increasing in the riskiness of VC's claim δ_{vc}.

I now study the optimal design of the VC claim under EN control (δ_{vc}^{EN}) and under VC control (δ_{vc}^{VC}). Under EN control, the firm surplus is:

$$V^{EN} = R^L - \gamma - I + ap\Delta R + e^{EN}\left[\lambda\tau\Delta R + \gamma\right] - \frac{(e^{EN})^2}{2} - \frac{a^2}{2},$$

where $a = p\delta_{vc}$ and $e^{EN} = \lambda\tau(\Delta R - \delta_{vc}) + \gamma$. Differentiating with respect to δ_{vc} one obtains:

$$\frac{dV^{EN}}{d\delta_{vc}} = \frac{\partial V^{EN}}{\partial a}\frac{da}{d\delta_{vc}} + \frac{\partial V^{EN}}{\partial e}\frac{de^{EN}}{d\delta_{vc}}\ . \qquad (1)$$

The first term represents the *support effect*: a riskier claim benefits the start-up by increasing VC's incentives to provide support at stage 3. This effect is always positive as $\delta_{vc} \leq \Delta R$. The second term is negative: EN initiative is reduced if a more high-powered claim is sold to the VC (making the EN's claim less high-powered).

Under VC control, the sorplus is:

$$V^{VC} = R^L - \gamma - I + ap\Delta R + e^{VC}\left[\lambda\tau\Delta R + \gamma\right] + e^{VC}E^{VC}(1-\lambda)\left[\tau\Delta R - \gamma\right] - \frac{(e^{VC})^2}{2} - \frac{(E^{VC})^2}{2} - \frac{a^2}{2},$$

where $a = p\delta_{vc}$ and $e = e^{VC}(\delta_{vc})$, $E = E^{VC}(\delta_{vc})$ as defined in section 3.3 of the paper.

Differentiating with respect to δ_{vc}:

$$\frac{dV^{VC}}{d\delta_{vc}} = \underset{(+)}{\frac{\partial V^{VC}}{\partial a}\frac{da}{d\delta_{vc}}} + \underset{(-)}{\frac{\partial V^{VC}}{\partial e}\frac{de^{VC}}{d\delta_{vc}}} + \underset{(-)}{\frac{\partial V^{VC}}{\partial E}\frac{dE^{VC}}{d\delta_{vc}}}. \tag{2}$$

where the support effect (the first term) is to be traded-off against the *initiative effect* (the second term) and the *control effect* (the third term). The support effect is the same as in (**??**), while the initiative and control effect have been analyzed in the paper. We know that when $\delta_{vc} > \Delta R - \gamma/\tau$ the net benefits of monitoring are negative; furthermore:

$$\frac{\partial V^{VC}}{\partial e}\frac{de^{VC}}{d\delta_{vc}} < \frac{\partial V^{EN}}{\partial e}\frac{de^{EN}}{d\delta_{vc}} < 0.$$

It follows that VC's optimal claim is safer under VC control than under EN control: $\delta_{vc}^{VC} < \delta_{vc}^{EN}$.