Preferred Stock in Venture Capital Financing*

Filippo Ippolito

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Abstract

We develop a model in which cash-constrained entrepreneurs seek a venture capitalist (VC) to finance their firm. Costly monitoring is employed by VCs to reduce entrepreneurial moral hazard. When monitoring reveals poor performance, VCs want to punish the entrepreneur with liquidation. However, when assets are specific and liquidation would lead to a loss, VCs choose to renegotiate the terms of financing, rather than to liquidate. Renegotiation undermines the threat of liquidation. The use of preferred stock with automatic conversion, as is commonly observed in VC financing, significantly reduces the renegotiation problem. Preferred stock guarantees seniority to investors in a liquidation, while automatic conversion into common stock before an IPO reduces such seniority. Therefore, investors have the incentives to promote an IPO only when it is expected to do well and to liquidate otherwise. The model also explains the use of vesting clauses for the stock held by the entrepreneur.

JEL Classification: G21, G24, G32, G33

Keywords: venture capital, monitoring, liquidation, security design, preferred stock, vesting

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1 Introduction

Recent empirical research on venture capital has provided a wealth of information about financial contracting in newly established entrepreneurial ventures. A key feature of these contracts is that traditional securities, such as common stock and debt, are not commonly employed to finance a new venture. These securities are replaced by more sophisticated contracting practices which often employ some kind of preferred stock, a hybrid security which shares some of the features of debt and equity and allows for greater flexibility over the allocation of cash flows.

Preferred stock is typically characterized by a liquidation preference over common stock: that is, in the event of sale or liquidation of the company, the preferred stock gets paid ahead of the common stock. This means that the owners of preferred stock share in the profits of the firm in case of good performance, as if they were common stockholders, while retaining a higher degree of seniority in case of liquidation. Furthermore, preferred stock often allows for a convertibility clause which gives investors the option to take their returns either through liquidation or through a common equity position. In reality, the option to convert is often limited because conversion becomes mandatory (automatic) in the event of an initial public offering (IPO) of the company.[1]

When we simultaneously account for all the above features of preferred stock, it emerges that venture capitalists (VCs) are like debtholders in case of liquidation, because they are senior and their payoff is limited to the interests on the face value of the preferred stock; while in case of IPO the security of a VC turns into an equity stake which has no seniority, but gets the payoff of common stock, which is expectedly higher than that of debt.

To complete the picture of how venture capital firms are financed, one should mention that entrepreneurs typically hold shares which vest over time (time vesting) or when some value accretion event occurs, such as a public sale of the firm (performance vesting). Before vesting, the entrepreneur's shares give no cash flow - nor voting - rights. After vesting, the shares turn into common equity. Key to vesting is the concept of the entrepreneur earning her equity through value creation.

The main objective of this paper is to explain the peculiar nature of the

[1] Gompers (1997) and Kaplan and Strömberg (2003) provide evidence that in almost all financing rounds conversion automatically occurs before an IPO. See also Lerner, Hardymon, and Leamon (2005), p. 291.

financial contracts that we have just described. We question why VCs accept the automatic conversion of their claims in case of IPO; why VCs are senior in case of liquidation; and finally, why entrepreneurs hold equity shares that vest in case of a IPO and not otherwise. The answers that we provide are based on the idea that VCs and entrepreneurs stipulate contracts which aim at minimizing contractual costs in the presence of asymmetric information and renegotiation problems. Therefore, the above contractual features are the result of Second Best agreements between the involved parties.

The basic idea of the paper is that a contract with preferred stock and automatic conversion allows VCs to reduce a key commitment problem. VCs face a problem of entrepreneurial moral hazard when they finance a young firm with no capital. Entrepreneurs may take unobservable actions which are in their own best interests and not in that of the VC. Costly monitoring and forceful liquidation is employed by VCs to reduce the moral hazard of entrepreneurs. However, the monitoring cum liquidation mechanism does not always work. In fact, liquidation does not represents a credible threat when the firm's assets are specific and have low resale value. In this case, even if monitoring reveals low entrepreneurial effort, VCs prefer not to liquidate because liquidation entails a greater loss than continuation. In case of continuation, the firm is here assumed to undergo an IPO, through which the value of the firm becomes publicly observable.

VCs then face a commitment problem which is a result of a conflict between *ex ante* and *ex post* efficiency. From an *ex ante* point of view, liquidation is efficient because it promotes entrepreneurial effort and maximizes expected returns for a VC. From an *ex post* point of view, liquidation may be inefficient if assets are specific. In this case, VCs are tempted to renegotiate rather than liquidate. However, if they do so, they undermine the incentive mechanism based on liquidation.

What VCs need to overcome this impasse is a contract which commits them *ex ante* to take actions which may be potentially inefficient from an *ex post* perspective. Such contract would be optimal, in a Second Best sense, because it would maximize entrepreneurial incentives and, consequently, the VC's return on investment.

The first thing that we need to show is that debt and equity are unsuitable for this purpose. Consider first the case of debtholders. The simplest way to promote effort is to give entrepreneurs the entire residual claims on the cash generated by the firm. Entrepreneurs then hold equity and have an incentive to work hard because they will get a positive payoff only when the firm performs well (*relative-payoff incentive mechanism*). Plain debt has a major drawback: all the returns in the upside go to the entrepreneur whose only contribution was in "sweat capital".

Investors can strengthen the relative-payoff incentive mechanism by monitoring the entrepreneur. Investors threaten the entrepreneur with forceful liquidation if monitoring reveals low effort. However, this threat is empty when assets are firm specific because resale value is low and liquidation entails a loss for VCs. As a result, they keep the firm alive and take it to the IPO even if the entrepreneur is not exerting sufficient effort. The incentive mechanism of monitoring falls apart.

A similar argument applies to the use of common stock. If VCs hold common stock, the entrepreneur must hold some of this stock, otherwise she has no incentive to exert effort. Therefore, we have a capital structure in which the VC holds a majority equity stake and the entrepreneur is a minority shareholder. The entrepreneur is unwilling to exert optimal effort because she does not fully capture the returns of effort. Once again, monitoring might help incentivize the entrepreneur. However, as in the case of debt, VCs will impose liquidation only if it is *ex post* efficient. Any time assets are specific liquidation does not occur. This implies that in equilibrium entrepreneurial effort will be suboptimal.[2]

The commitment problem can only be resolved if in case of low effort VCs get less in an IPO than in liquidation. This condition can be achieved when VCs hold preferred stock which is senior in a liquidation and converts automatically into common stock in case of IPO. Furthermore, the entrepreneur must have shares which vest only in case of IPO. This contract is renegotiation-proof and promotes entrepreneurial effort. In case of liquidation investors have a right to claim the entire resale value of the assets. In case of IPO, conversion and vesting occur. These two contractual features imply that 1) due to conversion pre-IPO, VCs are no longer senior because they no longer hold preferred, but common stock; 2) because of vesting, the percentage of IPO proceeds that goes to the VCs is reduced.

The combined effect of conversion and vesting implies that VCs are "pe-

[2] As Gompers and Lerner (2001) notes there are also other reasons for not employing simple equity or debt contracts. If the firm raises equity from outside investors, the manager has an incentive to engage in wasteful expenditures (like lavish offices) because the manager may benefit disproportionately from these but does not bear their entire cost. Similarly, if the firm raises debt, the manager may increase risk to undesirable levels (Jensen and Meckling (1976))

nalized" for going into an IPO because they loose seniority and cash flow rights. Finding the optimal Second Best contract is then a matter of correctly determining the percentage of the entrepreneur's shares that vest. VCs need to make sure that it is convenient for them to promote an IPO only if monitoring reveals high effort. In this case, the potentially high returns of the IPO more than compensate the VCs for the loss of cash flow and seniority rights. In conclusion, a correctly specified contractual agreement in which conversion occurs and the entrepreneur's shares vest at the IPO ensures that VCs promote the IPO only when its expected profits are high and force liquidation in all other cases, also if assets are specific and liquidation leads to a partial loss.

The rest of the paper is structured as follows. Section 2 surveys the related literature. Section 3 outlines the basic structure of the model. Section 4 discusses the issue of financing a capital constrained entrepreneur in the case of symmetric information and derives the First Best contracting solution which represents a useful benchmark for the sections that follow. Section 5 illustrates the case of financing in the presence of entrepreneurial moral hazard under the assumption that investors are unable to monitor their investments. Section 6 examines the role of informed investors, such as VCs, and shows the advantages of monitoring and how this affects optimal contracting. Section 7 discusses the issue of seniority in a context in which the entrepreneur provides some of her own capital to the financing of the firm. Finally, Section 8 provides a summary of the main results.

2 Related Literature

A number of authors examine contracting issues in the venture capital industry and offer insightful explanations for why VCs employ complex financial contracts when dealing with under-capitalized young firms. This literature typically offers applications of more general results obtained by the research on security design with incomplete contracts (Aghion and Bolton (1992), Dewatripont and Tirole (1994), Fluck (1998), Grossmann and Hart (1982), Grossman and Hart (1986), Hart and Moore (1989), Townsend (1978)). Hellmann (1998) provides an explanation for the use of vesting which is alternative to the one presented here. Helmann examines the conflicts of interests in the transition to a professional management in a venture backed firm and shows that the main reason why entrepreneurs relinquish control and accept "vesting" of their equity stake is to preserve the VC's incentives to engage in a value-increasing search of a professional CEO. Cornelli and Yosha (2003) provide an explanation for the use of convertible securities. The two authors show that when the VC retains the option to abandon the project, the entrepreneur has an incentive to engage in window dressing and bias positively the short-term performance of the project, reducing the probability that it will be liquidated. An appropriately designed convertible security prevents such behavior because window dressing also increases the probability that the venture capitalist will exercise the conversion option becoming the owner of a substantial fraction of the project's equity. Casamatta (2003) primarily focuses on the explanation of how external financing arises endogenously in VC financing in a double moral hazard setting. However, the paper also examines the implementation of the contract between venture capitalists and entrepreneurs. Identifying common stock as a high powered incentive contract and preferred stock as relatively less powerful, Casamatta concludes that preferred stock should be held by VCs only when their financial contribution is particularly large. In this case VCs do not need strong incentives to exert effort in correctly advising the firm, because they already hold a large share of the firm. Our explanation for the use of preferred stock complements well that of Casamatta, because, though for different reasons, we also show that preferred stock is employed when the share held by the VC is large. Hellmann (2006) focuses on the distinction between exit through acquisition or IPO and provides an optimal contracting explanation for why the allocation of control rights differs under the two exit strategies. Helmann shows that conversion of preferred stock should be automatic only in case of an IPO and not in case of exit through acquisition. With such contingent allocation of cash flows, VCs have an incentive to exert effort and promote a positive performance of the firm. A paper which is closely related to the latter is Schmidt (2003) which develops a model to explain the use of convertible securities in VC. In a sequential moral hazard setting, Schmidt shows that these contracts are employed because they promote the efficient level of investment both by VCs and entrepreneurs. The VC invests only if she exercises her conversion rights and she converts only if the entrepreneur worked sufficiently hard, which in turn induces the entrepreneur to put in the efficient amount of effort. Our explanation for the use of preferred stock is close to that of Schimdt in the sense that we also stress the commitment effect of this kind of security. However, it differs substantially in that we focus on the commitment to liquidate, while Schimdt focuses on the commitment to exert effort on the side of VCs.

The difficulty of imposing a credible threat of liquidation has been previously examined by other authors who, building on the work on information in a moral hazard setting (Holmstrom (1979)), examine the problems of eliciting information from agents and imposing credible threats (Cremer (1995), Dewatripont (1988)). A model which combines the issue of commitment with security design is Repullo and Suarez (1998). These authors argue that informed lenders (banks) are unable to impose a credible threat of liquidation when liquidation values are small and informed lenders are the sole financiers. The conflict between preserving the credibility of the liquidation threat and compensating the lender provides a rationale for mixed finance: adding a passive uninformed lender (market) allows a reduction in the funds contributed by the informed lender and hence restores the credibility of the threat. Although our model touches upon the issue of commitment from a point of view which is similar to that of Repullo and Suarez, the solution that we provide here is radically different from theirs. Our model focuses directly on how informed lenders (VCs) are able to re-establish the credibility of their threat by properly allocating cash flow rights, even in a context in which they are the sole financiers. Therefore, in our explanation there is no need for mixed finance to make liquidation credible, in fact appropriate security design normally suffices.

The results of the model are robust to an extension which allows for repeated effort. If we introduced repeated effort and monitoring in the model (Admati and Pfleiderer (1988), Gompers (1995), Sahlman (1990) and the already cited Cornelli and Yosha (2003)) preferred stock would still identify the optimal Second Best contract. Moreover, we would find that preferred is employed alongside with stage financing, as it happens in the aforementioned papers. Stage financing strengthens the incentive effect of monitoring, while at the same time it reduces the risk born by the entrepreneur (Holmstrom (1982)).

3 The Basic Framework

We consider an economy populated by risk-neutral entrepreneurs that need 1$ to finance their firm. If financing occurs, the value of the firm is $\overline{V}$ if successful and $\underline{V} = \overline{V} - \Delta V < 1 < \overline{V}$ if unsuccessful. The firm's probability of success depends on entrepreneurial effort $e \in \{0, 1\}$ and this is equal to

π_0 if the entrepreneur makes no effort and to $\pi_1 = \pi_0 + \Delta\pi > \pi_0$ when the entrepreneur exerts effort. The cost of effort for an entrepreneur is $\psi(e) \in \{0, \psi\}$. We assume that

A1: Firms have negative net present value (NPV) when the entrepreneur exerts no effort:

$$\pi_0 \overline{V} + (1 - \pi_0) \underline{V} < 1. \tag{1}$$

The entrepreneurs are capital constrained and must finance externally the \$1 which their firm requires. Firm financing is provided by investors. There are various types of investors, which can be classified according to whether they have the ability to monitor their investment or not. We assume that

A2: Individual investors do not have the ability to monitor.

A3: *Venture capitalists* do have the ability to monitor.

We will generally refer to the former type of investor with the term "uninformed" and to the latter as "informed".

A *financial contract* $(\overline{r}, \underline{r})$ stipulates the payments to be made by an entrepreneur to an investor should her firm succeed or fail, respectively. The phases of a financial contract are illustrated in Figure 1. At time t_0, an investor makes a "take-it-or-leave-it" offer $\{(\overline{r}, \underline{r}), e\}$ to an entrepreneur which stipulates payments in case of firm success or failure and the required entrepreneurial effort. At time t_1, an entrepreneur determines the required level of effort. At time t_2, firm returns are realized and distributed according to the initial contract $(\overline{r}, r)$. It is useful to think of the realization at time t_2 as a private sale or an initial public offering.

Given a contract $(\overline{r}, \underline{r})$, an effort level e and a cost of effort $\psi(e)$, an entrepreneur's expected utility is

$$U(\bar{r}, \underline{r}, e) \equiv \pi(e)\left(\overline{V} - \bar{r}\right) + (1 - \pi(e))(\underline{V} - \underline{r}) - \psi(e), \tag{2}$$

where $\pi(e)$ is π_1 if an entrepreneur makes an effort and π_0 if he does not. The expected income of an investor is

$$I(\bar{r}, \underline{r}, e) \equiv \pi(e)\overline{r} + (1 - \pi(e))\underline{r} - 1. \tag{3}$$

If an entrepreneur does not run her firm, she gets zero, which is her reservation utility. Typically, an entrepreneur's effort decision will be unobservable, so that there is a moral hazard problem between her and investors. In the following section, we establish the first best effort decision in the case where effort is observable and contractible.

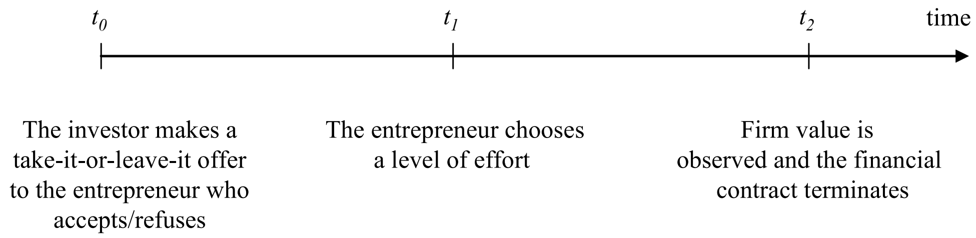

Figure 1: Timing of a Financial Contract

4 Observable Effort: a Benchmark

In this section, we derive the benchmark model when effort is observable and thus contractible. Under these conditions, an optimum contract between investors and an entrepreneur defines First Best (FB). We assume that contracts are enforceable without cost. An investor is willing to finance a firm only when her participation constraint is satisfied. The participation constraint of an investor requires

$$I\left(\bar{r}, \underline{r}, e\right) \geq 0. \qquad PC_I$$

We assume that entrepreneurs are protected by limited liability in every state of the world which implies that

$$\overline{V} \geq \overline{r} \qquad LLu$$

and

$$\underline{V} \geq \underline{r}. \qquad LLd$$

An entrepreneur is willing to participate in a firm only when her participation constraint is satisfied, i.e. her utility must be such that

$$U\left(\bar{r}, \underline{r}, 1\right) = \pi_1\left(\overline{V} - \bar{r}\right) + \left(1 - \pi_1\right)\left(\underline{V} - \underline{r}\right) - \psi \geq 0 \qquad PC_E$$

Investors seek to maximize their returns from the investment and do so by optimizing the contract that they write with the entrepreneur. As shown in the appendix, the degree of observability of effort gives investors a great deal of flexibility when choosing a contract. There are infinite contracts that maximize the returns to an investor. We can use the payoff function of each of these contracts to characterize the securities that are commonly observed. Two examples of optimum contracts follow:

Debt Financing + Equity to the Entrepreneur Consider a financial contract in which investors and entrepreneurs have the following payoffs

$$\text{investor: } \begin{matrix}\text{High}\\ \text{Low}\end{matrix} \begin{cases} \overline{r} = \overline{V} - \frac{\psi}{\pi_1} \\ \underline{r} = \underline{V} \end{cases} \quad \text{and entrepreneur: } \begin{matrix}\text{High}\\ \text{Low}\end{matrix} \begin{cases} \frac{\psi}{\pi_1} \\ 0 \end{cases}$$

Such a contract satisfies conditions PC_E, LLu and LLd. It is therefore accepted by the entrepreneur and achieves FB. The payoffs of this contract indicate that investors use debt to finance the firm; an investor's returns are "capped" in the high state and equal to the residual value of the firm in the low state. The entrepreneur gets zero in the low state and is rewarded in the high state. Her payoff function is that of an equity holder.

Equity Financing + Employee An alternative contract is one in which the payoffs to investors and entrepreneurs are as follows

$$\text{investor: } \begin{matrix}\text{High}\\ \text{Low}\end{matrix} \begin{cases} \overline{r} = \overline{V} - \psi \\ \underline{r} = \underline{V} - \psi \end{cases} \quad \text{and entrepreneur: } \begin{matrix}\text{High}\\ \text{Low}\end{matrix} \begin{cases} \psi \\ \psi \end{cases}$$

In this contract, an investor appropriates the entire returns of the firm in both states, minus the cost of effort (ψ). In this setting, the entrepreneur is an employee of the investor, whose payoff resembles that of an equity holder.

These results are illustrated in Figure 2. The straight downward sloping lines respectively represent the entrepreneur's and the investor's participation constraints, PC_E and PC_I. Both curves are downward sloping because $\bar{r}$ and $\underline{r}$ are regarded as substitutes by investors and entrepreneurs. More precisely, $\bar{r}$ and $\underline{r}$ are considered 'bads' by an entrepreneur and 'goods' by an investor. The utility of an entrepreneur increases as one moves southwest in the figure, while that of an investor increases towards the northeast. An entrepreneur's participation constraint is satisfied at all points below the line $U(\bar{r}, \underline{r}, 1) = 0$ (in the figure, this line is PC_E); while an investor's participation constraint is satisfied at all points above the line $I(\bar{r}, \underline{r}, 1) = 0$ (line PC_I). An optimum contract must lie on the entrepreneur's participation constraint and within the box $\underline{V}\overline{V}$. An investor is indifferent to all of the contracts on the segment AA' and will therefore choose one of these. Contract A' identifies the case of pure debt financing, while contract A'' identifies the case of equity financing. In the former case, the entrepreneur is simply paid the cost of effort ψ and can be seen as an employee. Optimally, an investor's expected profits equal $\pi_1\overline{V}+(1-\pi_1)\underline{V}-\psi-1$, which implies that at FB, investors entirely *internalize* the cost of managerial effort.

In summary, this section shows that a FB contract leaves the entrepreneur at her reservation utility and investors are indifferent about financing a firm with equity or debt. These results provide a restatement of the first proposition of Modigliani and Miller (1958) on the irrelevancy of a firm's capital structure.

5 Uninformed Investors (Moral Hazard)

The analysis becomes more complex if the effort of the entrepreneur cannot be ascertained with complete confidence. In this case, it may be difficult to write a contract governing the financing of the firm (Grossman and Hart (1986), Hart and Moore (1989)). Along these lines, in this section we consider the case of unobservable effort and examine to what extent the results of the previous section still hold. More precisely we assume that

A4: Effort e is only observable to the entrepreneur.

As a result of unobservability, effort is not contractible and entrepreneurial moral hazard arises. For the moment, we restrict our analysis to individual investors. We investigate how these investors maximize returns under moral hazard.

As a result of A4, effort cannot be explicitly included in a financial contract which takes the form $(\overline{r},\underline{r})$. Secondly, since by equation (1) investors prefer $e=1$, to induce effort, a contract must satisfy the following incentive constraint to the entrepreneur,

$$\pi_1\left(\overline{V}-\overline{r}\right)+(1-\pi_1)\left(\underline{V}-\underline{r}\right)-\psi\geq\pi_0\left(\overline{V}-\overline{r}\right)+(1-\pi_0)\left(\underline{V}-\underline{r}\right). \quad IC$$

The incentive constraint simplifies to

$$\overline{V}-\overline{r}\geq\underline{V}-\underline{r}+\frac{\psi}{\Delta\pi}. \tag{4}$$

When condition (4) is satisfied, entrepreneurs have the incentive to exert effort $e = 1$. This condition shows that an incentive compatible contract requires an entrepreneur's payoff to be larger in the high state than in the low state. From the perspective of an investor, profit maximization can be formally written as

$$\max_{0 \leq \bar{r} \leq \overline{V}, 0 \leq \underline{r} \leq \underline{V}} I(\bar{r}, \underline{r}, 1)$$

$$\text{subject to } IC \text{ and } PC_E.$$

The following Proposition provides the solution to this maximization which is illustrated in Figure 2.

Proposition 1 ***(Debt Financing)*** *When effort is not observable, constraints LLd and IC bind at the optimum. An investor receives the following payoffs,*

$$\bar{r}^{SB} = \overline{V} - \tfrac{\psi}{\Delta\pi},$$
$$\underline{r}^{SB} = \underline{V}.$$

The entrepreneur receives zero in the low state and $\frac{\psi}{\Delta\pi}$ *in the high state. Contract* $\left(\bar{r}^{SB}, \underline{r}^{SB}\right)$ *defines Second Best. The firm is entirely financed with debt.*

Proof. See Appendix. ■

The main finding of Proposition 1 is that debt represents the best type of security to finance an entrepreneurial firm in the presence of moral hazard. As in Jensen and Meckling (1976), we find that debt is used because it gives entrepreneurs the incentive to maximize effort. When investors hold debt, entrepreneurs are rewarded for generating profits. Any profit which is not used to pay interest goes to the entrepreneur. At the same time, if performance is poor and the firm does not generate profits, the entire value of the firm ($\underline{V}$) is used to pay off the face value of debt. In this case the entrepreneur is "punished" for not generating profits. Her payoff is zero. The difference between the payoff of an entrepreneur in the high and low states constitutes a *relative-payoff incentive mechanism*, which investors employ to motivate managers.

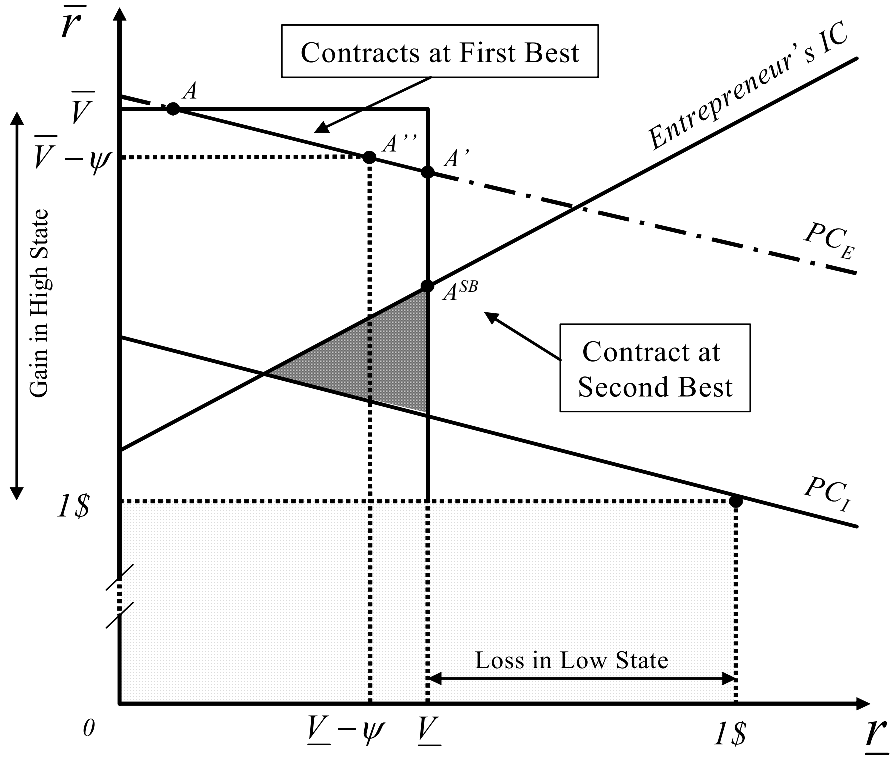

Figure 2: The diagram illustrates the financing problem of an entrepreneurial firm both when effort is observable (First Best) and when there is moral hazard (Second Best). 1$ represents the sum initially invested. The terms $\overline{r}$ and $\underline{r}$ represent the payoffs to an investor in the high and low states, respectively. Similarly, $\overline{V}$ and $\underline{V}$ indicate the returns of the investment in the two outcomes. FB is achieved by any contract that lies on the segment AA'. Contract A' identifies the case of pure debt financing, while A'' identifies the case of pure equity financing. At A'', the entrepreneur receives ψ with both outcomes. In the case of moral hazard (unobservability of entrepreneurial effort), incentive compatible contracts lie in the shaded triangular area, which is situated below IC and to the left of $\underline{V}$. A^{SB} defines the contract that maximizes profits at Second Best. The payoffs of A^{SB} imply that at Second Best the firm is entirely financed with debt.

5.1 The Financing Decision of Uninformed Investors

Define the net present value of a firm when $e = 1$ as

$$NPV_1 = \pi_1 \overline{V} + (1 - \pi_1) \underline{V} - 1.$$

At FB, a firm is financed only if its NPV_1 is greater than the cost of managerial effort, a condition that can be formally stated as $NPV_1 \geq \psi$. The financing decision of an uninformed investor at SB depends on the following inequality[3]

$$NPV_1 \geq \frac{\pi_1 \psi}{\Delta \pi} \tag{5}$$

The financing decision at SB is more stringent than at FB. This is due to the fact that $\pi_1 \psi / \Delta \pi \geq \psi$. At SB entrepreneurs receive a rent which is equal to the difference $\pi_1 \psi / \Delta \pi - \psi$. This rent is generated by the asymmetry in the information which is available to investors and entrepreneurs, respectively, at SB. On the contrary, there is no information rent at FB because the information structure is symmetric.

The cost of the information rent is born by investors. As a result of this rent, fewer firms are financed at SB than at FB. To prove this point, consider a firm for which

$$\psi \leq NPV_1 \leq \frac{\pi_1 \psi}{\Delta \pi}.$$

The NPV_1 of this firm is large enough to pay for managerial effort. It is thus efficient to finance the firm. Indeed, at FB this firm is financed because $NPV_1 \geq \psi$. However, at SB the firm is not financed, because $NPV_1 \leq \pi_1 \psi / \Delta \pi$. Examine the following numerical example. Suppose that $\psi = 0.1$, $\pi_1 = 0.7$ and $\pi_0 = 0.4$. At FB, a firm is financed when $NPV_1 \geq 10\%$. At SB a firm is financed only when $NPV_1 \geq 23.3\%$.

We conclude that information asymmetries generate implicit costs for an investor. Some firms are not financed even if they generate enough profits to reimburse the original investment and pay for entrepreneurial effort.

6 Informed Investors (Monitoring)

In this section, we examine the case of firm financing by informed investors. As stated in assumption A3, informed investors have the ability to monitor

[3]Condition (5) is obtained by inserting $\left(\underline{r}^{SB}, \overline{r}^{SB}\right)$ into the investor's participation constraint.

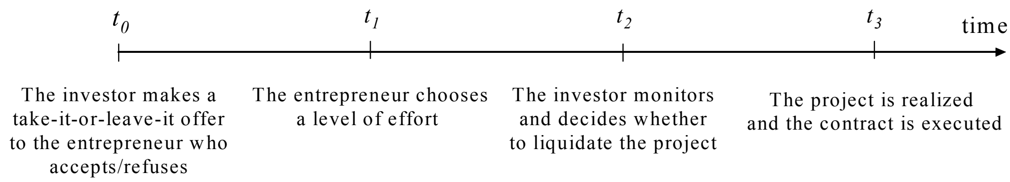

Figure 3: Timing of contracting with monitoring and liquidation

their investments. The cost of monitoring is c. Through monitoring, an investor acquires a signal $\tilde{\sigma}$ which depends on the entrepreneur's effort. We assume that

A5: $\tilde{\sigma}$ is observable by investors and entrepreneurs but it is not verifiable (and therefore, not contractible)

This signal belongs to the set $\Sigma = \{\sigma_0, \sigma_1\}$. The matrix below gives the probabilities of each signal σ_i for different levels of entrepreneurial effort

Signal/Effort	$e = 0$		$e = 1$
σ_1	$1 - p_0$	$<$	$1 - p_1$
σ_0	p_0	$>$	p_1

For simplicity, we set $p_0 = p$ and assume $p_1 = 0$ which implies that the monitoring technology may only generate Type I errors. We also assume that

A6: Firms can be liquidated before they reach completion.

A7: The liquidation value of a firm is $\alpha \leq 1\$$.

As shown in Figure 3, if liquidation occurs, it takes place at time t_2. As a result of assumption A7, liquidating a firm is costly for investors because the resale value of the assets is smaller than the original investment. The residual value $1 - \alpha$ represents the *dead-weight loss* of liquidation.

The timing of contracting with monitoring is represented in Figure 3. At time t_0, an investor makes a "take-it-or-leave-it" offer $(\overline{r}, \underline{r})$ to an entrepreneur. The offer stipulates the payments in the cases of firm success, failure and liquidation. At time t_1, the entrepreneur chooses the level of effort. At time t_2, monitoring takes place and liquidation might follow. The contract is executed at time t_3.

In equilibrium, only informed investors liquidate firms.[4] In case of liquidation, an entrepreneur receives a payoff which is not greater than zero. In fact, investors want to maximize the punishment effect of liquidation. Given limited liability, the maximum punishment that investors can impose to entrepreneurs for not exerting effort, is exactly zero payoff.[5] Therefore, an entrepreneur's incentive constraint changes from IC to the following condition,

$$\pi_1 \left(\overline{V} - \overline{r}\right) + (1 - \pi_1) \left(\underline{V} - \underline{r}\right) - \psi \geq (1 - p) \left[\pi_0 \left(\overline{V} - \overline{r}\right) + (1 - \pi_0) \left(\underline{V} - \underline{r}\right)\right] \quad ICm$$

This new incentive constraint underlines the effect that monitoring has on the incentives of an entrepreneur. To explain this point in more detail, observe that entrepreneurs dislike liquidation because it gives them a payoff equal to zero, and that liquidation occurs with probability p when $e = 0$ and with probability zero when $e = 1$. Therefore, the risk of liquidation reduces the incentives of an entrepreneur to choose $e = 0$. In fact, if she chose $e = 0$, she would be less likely to receive positive compensation. As a result, Condition ICm is easier to satisfy than IC. Furthermore, an increase in p makes condition ICm less stringent because, for a large p, the monitoring technology is more efficient.[6]

Thanks to the ability to monitor, informed investors are able to use more effective incentive mechanisms than uninformed investors. As we have shown in the previous section, uninformed investors rely uniquely on a relative-payoff incentive mechanism which gives managers the incentive to work hard by promising a reward for generating profits. Informed investors have at

[4] Uninformed investors do not acquire new information after a project has been launched. Therefore, they have no reason to liquidate a project at an interim stage.

[5] See Baron and Besanko (1984) for a discussion of the Maximum Punishment Principle.

[6] When investors have the ability to monitor, an entrepreneur's incentive constraint is represented by a straight line which crosses condition LLd at $\overline{V} - \frac{\psi}{\Delta \pi_p}$. The incentive constraint has positive slope if $p < \frac{\Delta \pi}{1 - \pi_0}$ and negative if $p > \frac{\Delta \pi}{1 - \pi_0}$. When $p = 1$, i.e., technology is perfectly efficient, the incentive and participation constraints are identical and effort is always observable. On the contrary, when $p = 0$, the monitoring technology is useless and condition ICm simplifies to IC, as effort was not observable.

their disposal another tool with which to provide incentives; this is called a *liquidation incentive mechanism.* This mechanism relies on punishing entrepreneurs with liquidation when managerial effort is signalled to be low (σ_0). When combined, the relative payoff and liquidation mechanisms prove to be an effective way to induce managerial effort. In fact, these two incentive mechanisms generate a "carrot and stick" effect. The relative-payoff mechanism gives entrepreneurs a carrot for generating high returns. At the same time, the liquidation mechanism provides a stick with which entrepreneurs are punished for not exerting enough effort.

The problem for an investor is that liquidation is not always an *ex post* efficient solution. Under certain circumstances, investors might be unwilling to liquidate a firm in which they have invested a lot of money. This reduces the role of liquidation in threatening inefficient managers. If renegotiation is likely, the threat of liquidation is not credible.

A contract is *renegotiation-proof* only if the following condition is satisfied[7]

$$\alpha \geq \pi_0 \overline{r} + (1 - \pi_0)\underline{r}. \qquad CC$$

Condition CC defines an investor's *commitment constraint.* This constraint ensures that an investor is better off liquidating the firm if σ_0 is observed. Asset specificity plays an important role here because it determines whether CC is a binding constraint or not. When assets have little value outside the firm (low α), it is difficult for an investor to credibly commit *ex-ante* that she will liquidate the investment *ex-post.* On the contrary, when assets are not firm specific (high α), they can be resold for a high value in case of liquidation and condition CC is easily satisfied.

We now show why conditions ICm and CC are important for profit maximization. To maximize profits investors choose a financial contract which maximizes returns and, at the same time, gives the entrepreneur an incentive to exert effort. This means that condition ICm must hold at the optimum. If such contract is to rely on the threat of liquidation, it must also satisfy condition CC. More formally, an investor's profit maximization can be written as

$$\max_{0 \leq \overline{r} \leq \overline{V}, 0 \leq \underline{r} \leq \underline{V}} I\left(\overline{r}, \underline{r}, 1\right)$$

$$\text{subject to } CC,\ ICm \text{ and } PC_E.$$

[7] See the appendix for a discussion on renegotiation proofness.

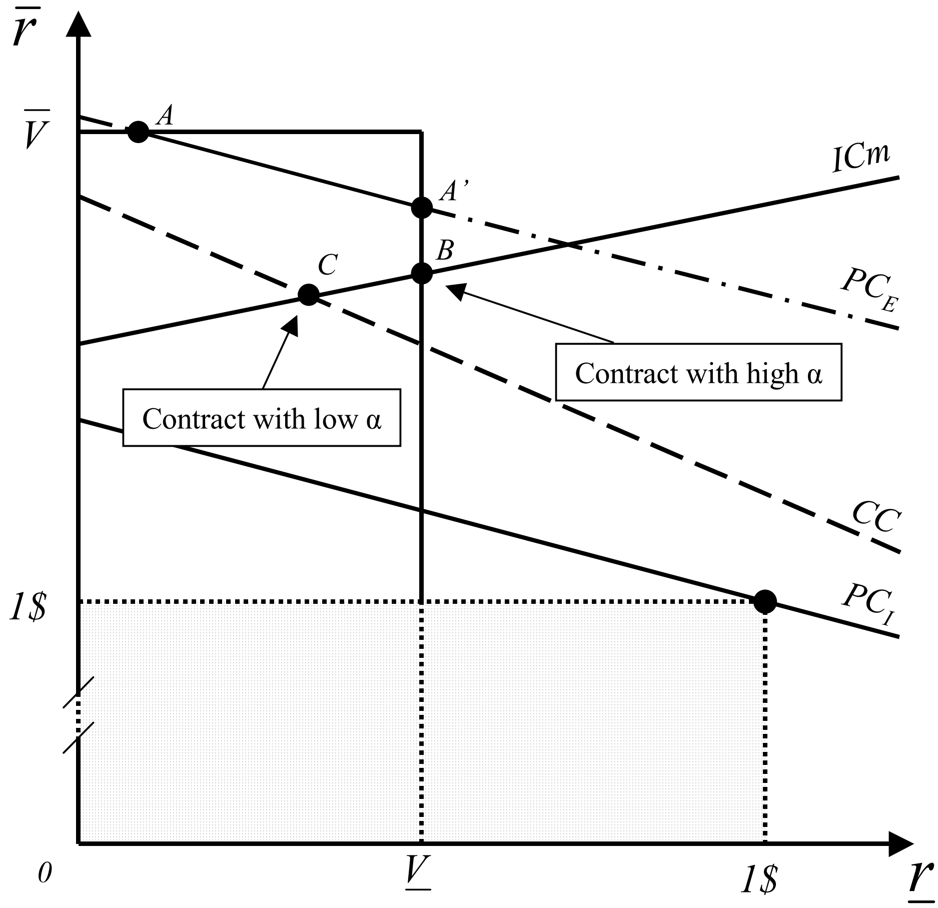

Figure 4: The diagram illustrates an investor's profit maximization when investments can be monitored. Feasible contracts must be in the box $\underline{V}\overline{V}$ and below conditions ICm and CC. When the efficiency of the monitoring technology increases (higher p) condition ICm becomes less stringent, thus moving upwards and becoming shallower. When assets are not firm-specific (high α), the optimum is identified by B. Financing takes place via a pure debt contract. When assets are firm-specific (low α), the optimum is in C and financing requires the use of preferred stock. In this case entrepreneurs hold equity which vests over time.

The following Proposition provides a solution to an investor's profit maximization and defines the type of security that informed investors employ to finance an entrepreneurial firm. Figure 4 provides an illustration.

Proposition 2 ***(Preferred Stock, Automatic Conversion and Vesting)*** *Let*

$$V_0 \equiv \pi_0 \left(\overline{V} - \frac{\psi}{\Delta \pi_p} \right) + (1 - \pi_0) \underline{V}$$

with $\Delta \pi_p = \pi_1 - (1 - p)\pi_0$. *Then, conditional upon monitoring, the optimal payoffs of an investor satisfy the following conditions:*

- *if* $\alpha \geq V_0$ *the payoffs are* $\overline{r} \leq \overline{V}$ *and* $\underline{r} = \underline{V}$*;*
- *if* $\alpha < V_0$ *the payoffs are* $\overline{r} < \overline{V}$ *and* $\underline{r} < \underline{V}$*.*

In case of liquidation, an investor receives α *and the entrepreneur gets zero.*

Proof. See Appendix. ■

Proposition 2 illustrates the relationship between asset specificity and the type of securities that investors hold. When assets are not firm specific (high α), the firm is financed via a simple debt contract in which monitoring occurs at the interim stage (contract B in the figure). As we have explained above, debt provides incentives to the entrepreneur to exert effort because it makes her residual claimant. At contract B entrepreneurs receive a smaller rent than at A^{SB} because monitoring attenuates the problem of moral hazard.

Proposition 2 shows that in case of specific assets (low α) the firm cannot be financed with a simple debt contract. A low α implies that debt holders are not guaranteed to recoup the face value of their investment in case of liquidation. To compensate for a lower liquidation value, debt holders could increase interest rates. However, by doing so they would distort the incentives to exert effort of the entrepreneur.

An alternative, viable strategy is for investors to design a contract such as the one in C. Contract C is optimal when $\alpha < V_0$ and can be interpreted as preferred stock combined with automatic conversion in case of sale and a vesting clause of the shares held by the entrepreneur. To clarify this interpretation, consider the following contract:

Contract with preferred stock, automatic conversion and vesting At time t_0 the VC finances the firm entirely with preferred stock which gives a preference in case of liquidation and automatically converts in case of sale/IPO. The entrepreneur has the right to a share of the firm in an IPO. More precisely, in case of sale of the firm, the preferred stock must be converted into $X\% \leq 100\%$ of the firm's common stock (automatic conversion). The entrepreneur receives the residual $1 - X$ of the firm's stock as a reward (vesting clause). In case of liquidation, the VC gets the entire resale value of the firm α.

The contract that we have just described generates the payoffs of contract C. The VC receives the entire value of the firm in case of liquidation and less than this value in case of continuation. The entrepreneur receives a share of the firm's equity only in case of continuation. In this contract, the payoffs are designed so to account for the renegotiation that may occur at time t_2.

This type of contract allows VCs to overcome the problem of commitment that exists when α is low. To explain this point, it is useful to return to condition CC. This condition says that if α is low, an investor is unwilling to liquidate the firm even when σ_0 has been observed. This implies that a low α undermines the credibility of liquidation as a punishment. Unfortunately, α is exogenously given and, as a result, it cannot be changed. However, the right-hand side of condition CC *can* be changed by the investors. In fact, the value on the right-hand side of the inequality depends on the contract that investors offer to the entrepreneur. This value represents the payoff that investors receive when σ_0 is observed and the firm is not liquidated, i.e. the payoff that investors expect to receive when $e = 0$.

Therefore, when α is low, the main task for an investor is to set up a contract which reduces the expected payoff from continuation. Investors need to set $\overline{r}$ and $\underline{r}$ in such a way that the payoff from continuation is greater than α only when σ_1 is observed, and not when σ_0 is observed. These payoffs imply that investors always choose to liquidate a firm when σ_0 is observed, but never do so when σ_1 is observed. The vesting clause plays a key role here. In fact, $\overline{r}$ and $\underline{r}$ are reduced by allocating some shares to the entrepreneur in case the firm is sold.

An implication of the proposition is that a larger number firms can be financed by informed investors than by uninformed ones. Informed investors are better off than uninformed investors only if they can extract a larger share of profits from the firm and, at the same time, ensure a high level of managerial effort. This condition can be formally written as $I\left(\overline{r}_C, \underline{r}_C, 1\right) \geq I\left(\overline{r}_{A^{SB}}, \underline{r}_{A^{SB}}, 1\right)$. Manipulating the inequality, we obtain

$$\underbrace{\frac{\psi\pi_1}{\Delta\pi} - \frac{\psi\pi_1}{\Delta\pi_p}}_{\text{expected reduction in moral hazard rents}} \geqslant c + \underbrace{(1-p)\left(V_0 - \alpha\right).}_{\text{cost of commitment}} \tag{6}$$

Condition (6) says that informed investors are better off than uninformed ones only if they reduce the information rents of a manager by a certain amount. This amount is equal to the sum of monitoring and commitment costs. The terms $\frac{\psi\pi_1}{\Delta\pi}$ and $\frac{\psi\pi_1}{\Delta\pi_p}$ are respectively what uninformed and informed investors give to entrepreneurs in the form of incentives for the provision of effort. Notice that $\frac{\psi\pi_1}{\Delta\pi} \geq \frac{\psi\pi_1}{\Delta\pi_p}$. The left hand side of condition (6) gives the amount of money that can be saved by informed investors on moral hazard rents. The right hand side of condition (6) represents the cost of monitoring. The term $(1-p)\left(V_0 - \alpha\right)$ refers to the cost of commitment (*bonding cost*), while c represents the cost of observing σ. The sum of these two terms determines the total cost of monitoring.

Taking into account these considerations, the financing decision of an informed investor requires that,

$$NPV_1 \geq \min\left[\frac{\pi_1\psi}{\Delta\pi}, \frac{\pi_1\psi}{\Delta\pi_p} + c + \left(V_0 - \alpha\right)(1-p)\right]. \tag{7}$$

Condition (7) is slacker than the analogous condition for uninformed investors. Intuitively, informed investors have the option to "behave" as uninformed investors, if monitoring is too costly. Earlier on we showed that due to information asymmetries some firms with positive NPV are not to be financed. In the light of condition (7), we conclude that this phenomenon is less relevant if investors have the ability to monitor their investments. Let us return to the numerical example of the previous section. Suppose that $\alpha > V_0$, $p = 0.5$ and $c = 0.01$. Then, condition (7) requires $NPV_1 \geq \min\left[0.233, 0.15\right] = 15\%$ rather than $NPV_1 \geq 23.3\%$, as would be the case for uninformed investors.

7 Seniority

In this section we provide an extension of the model to discuss seniority. We assume that entrepreneurs partly finance the firm with their own capital.

Under this new assumption, we examine the role of seniority and show that an optimal capital structure allocates senior claims to investors.

Suppose that the entrepreneur contributes with her own capital to the initial financing of the firm. This contribution is equal to $0 \leq \tau \leq 1$ per cent of 1\$. The residual amount $1-\tau$ is provided by a VC. We assume that in case of liquidation the VC receives $\beta\alpha$ of the resale value of the firm, while the entrepreneur gets $(1-\beta)\,\alpha$ with $0 \leq \beta \leq 1$. The term β represents the percentage of liquidated assets that goes to investors.

The inflow of capital provided by the entrepreneur attenuates the moral hazard problem described in the previous sections. More precisely, it affects the commitment costs of informed investors. When the entrepreneur contributes to the initial financing of the firm, the cost of commitment is

$$\text{new cost of commitment} = (V_0 - \alpha\beta - \tau)\,(1-p).$$

This cost is a decreasing function of τ and is equal to $(1-p)\,(V_0 - \alpha)$ when $\tau = 1$ and $\beta = 1$, i.e. when the entrepreneur does not provide any capital.[8] The capital contribution of the entrepreneur helps reduce the commitment cost of an investor only when the following condition holds

$$\tau \geq \alpha\,(1-\beta) \tag{8}$$

Condition (8) states that the contribution of the entrepreneur must be relatively sizeable in order to reduce the commitment cost of an investor. More precisely, the share of the assets that an entrepreneur has the right to claim in case of liquidation needs to be smaller then the capital that she has invested in the firm. The cost of commitment decreases only when in case of liquidation, the investors are relatively better off than the entrepreneur.

This result suggests that the seniority of an investor's claims plays an important role in the investment process. Intuitively, if investors hold senior claims, in case of liquidation they will be relatively better off than entrepreneurs. We now provide a formal explanation of this intuition.

Start by observing that β is greater when investors hold senior, rather than junior claims. When investors are senior, in case of liquidation, they receive $\alpha\beta = 1-\tau$ if $\alpha > 1-\tau$ and $\alpha\beta = \alpha$ otherwise. These cash flows are summarized by the following expression,

$$\beta_{Sen}\,(\tau) = \min\left[1, \frac{1-\tau}{\alpha}\right].$$

[8]See the appendix for a derivation of this result.

On the other hand, when investors are junior, they receive $\alpha\beta = \alpha - \tau$ if $\alpha > \tau$ and 0 otherwise. Therefore, their cash flows are described by the following function,

$$\beta_{Jun}(\tau) = \max\left[0, \frac{\alpha - \tau}{\alpha}\right].$$

As we have shown above, the greater the costs of commitment, the more stringent the financing decision of an investor becomes. This means that a firm is less likely to be financed if the cost of commitment is high. Therefore, investors and entrepreneurs are interested in minimizing the cost of commitment, in order to facilitate the investment process. This minimization entails a correct allocation of seniority and a precise definition of how much of the initial capital is provided by the entrepreneur, rather than from external sources. To minimize commitment costs, we must solve

$$\min_{\tau} \left(V_0 - \alpha\beta(\tau) - \tau\right)(1 - p).$$

subject to (8).

The following proposition provides the solution to the above constrained minimization.

Proposition 3 ***(Seniority)*** *The cost of commitment is minimized when investors are senior and entrepreneurs provide an amount of capital* $\tau = 1 - \alpha$.

Proof. See Appendix. ■

The Proposition contains two main results. First, in order to minimize the cost of commitment, investors hold claims that are more senior than those of the entrepreneur. This result is driven by the fact that senior claimants receive a larger share of the assets in case of liquidation. More formally, we observe that $\beta_{Sen}(\tau) \geq \beta_{Jun}(\tau)$. The capital provided by the entrepreneur acts as a form of insurance for investors. In case of liquidation, investors are protected by the capital contribution of the entrepreneur, which is effectively a "cash cushion" for investors. If the entrepreneurs' contribution is large ($\tau \geq 1 - \alpha$), investors are perfectly insured against a liquidation loss.[9]

[9] A rather different result is obtained by Rajan (1992) which shows that senior claims should be allocated to uninformed investors (debt holders) and not to informed investors (banks). The argument against giving priority to informed investors is that it limits their *ex post* bargaining power and the distortive effects that this may have on entrepreneurial incentives.

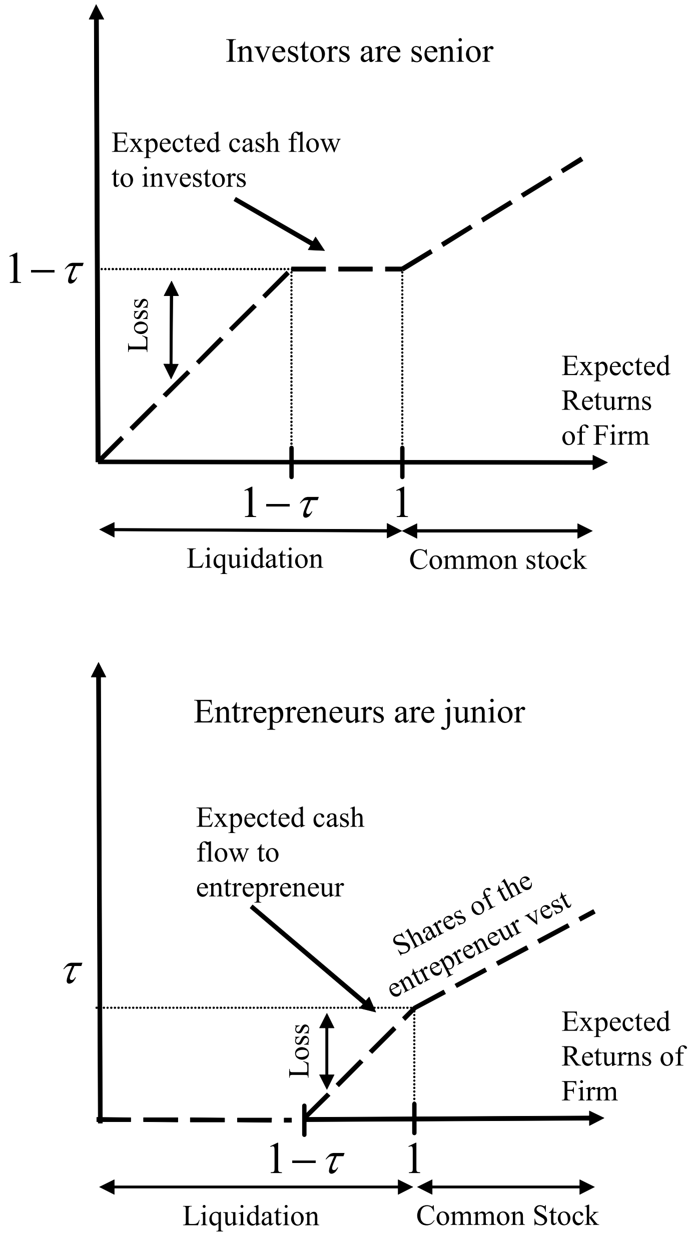

Figure 5: Summary of Cash Flows

The second result of the Proposition is that the optimal investment share of an entrepreneur decreases with α. This result suggests that when assets have little resale value, a firm should be largely financed by its own founders. On the other hand, it is easier to attract investors when the resale value of the assets is large.

Figure 5 provides a summary of the expected cash flows of investors and entrepreneurs for different expected firm returns. The expectations used here are conditional upon observing a signal σ. The top diagram illustrates the expected returns of investors when they hold convertible preferred stock. When σ_0 is observed, firms with low expected cash flows are liquidated. If the liquidation value of the firm is smaller than $1-\tau$, the investors claim the entire liquidation value of the assets and make a loss equal to $1-\tau-\alpha$. If the liquidation value of the firm is greater than $1-\tau$, the investors receive $1-\tau$, which is the value of their original investment. When σ_1 is observed, the convertible preferred stock is converted into common stock. In this case, the expected returns of investors increase with the expected returns of the firm.

The dashed line in the bottom diagram illustrates the expected returns of an entrepreneur that holds common stock with a vesting clause. In case of liquidation, if $\alpha \leq 1-\tau$ the entrepreneur receives zero. If $\alpha \geq 1-\tau$, and the firm is liquidated, the entrepreneur receives $\alpha - 1 + \tau$. If σ_1 is observed, the stock of the entrepreneur vests. In this case, the entrepreneur receives a share of the final value of the firm.

We conclude this section with a numerical example which illustrates the importance of a capital contribution by the entrepreneurs. Consider a firm that has an initial cost of 1 and has an expected return of 0.8 with $e = 0$. If the entrepreneur does not put into the firm any of her own capital, a renegotiation-proof contract can only be written if $\alpha \geq 0.8$. Suppose now that the entrepreneur contributes with a percentage of the initial capital which is equal to $\tau = 0.5$ and that she accepts a junior claim. In this case, it is easier to write renegotiation-proof contracts. For such a contract to be written, it suffices to have $\alpha \geq 0.5$. Therefore, the contribution of the entrepreneur creates more opportunities for investment. In fact those firms which have a positive NPV and $0.5 \leq \alpha \leq 0.8$ are financed only if the entrepreneur invests some of her own money.

7.1 Capital Structure and Asset Specificity

We are now able to provide a complete characterization of the capital structure of an entrepreneurial firm. The key variables that determine the capital structure are the NPV of a firm and the specificity of its assets. Additionally, the type of security that investors employ to finance the firm depends on these two variables. Furthermore, the capital contribution of the founders of the firm is determined endogenously with respect to NPV and α.

When NPV and α are both large, the firm represents a relatively safe investment for investors. In case of liquidation, investors are able to exit the investment without suffering significant losses. In such a case, we showed in Proposition 2 that a simple debt contract can be employed to finance the firm.

As NPV and α progressively decrease, VCs employ more sophisticated securities to finance the firm. We have shown above that in this scenario the use of preferred stock combined with a vesting clause and automatic conversion is advisable. A further decrease in α means that investors are willing to finance the firm only if the entrepreneur contributes with some of her own capital. Finally, if NPV and α are very low, the firm is not financed. Figure 6 summarizes these results.

8 Conclusions

We present an optimal contracting model to explain the widespread use of preferred stock in venture capital financing. We show that VCs face a commitment problem when they back firms with little capital and specific assets. VCs would want to employ liquidation as a threat to poorly performing entrepreneurs. However, if assets are specific and, thus, have little value outside the firm, VCs may be unable to force liquidation once the investment has been made.

Optimal security design must take into account the problem of commitment. We show that at Second Best VCs hold a position in common equity which enjoys preference in case of asset liquidation. At the same time, the entrepreneur is rewarded with shares of common equity which vests only in case the firm is sold. This financial structure closely resembles the ones that are typically employed in the VC industry. In most cases VCs finance young firms with preferred-stock, a hybrid security which offers strong rights in case

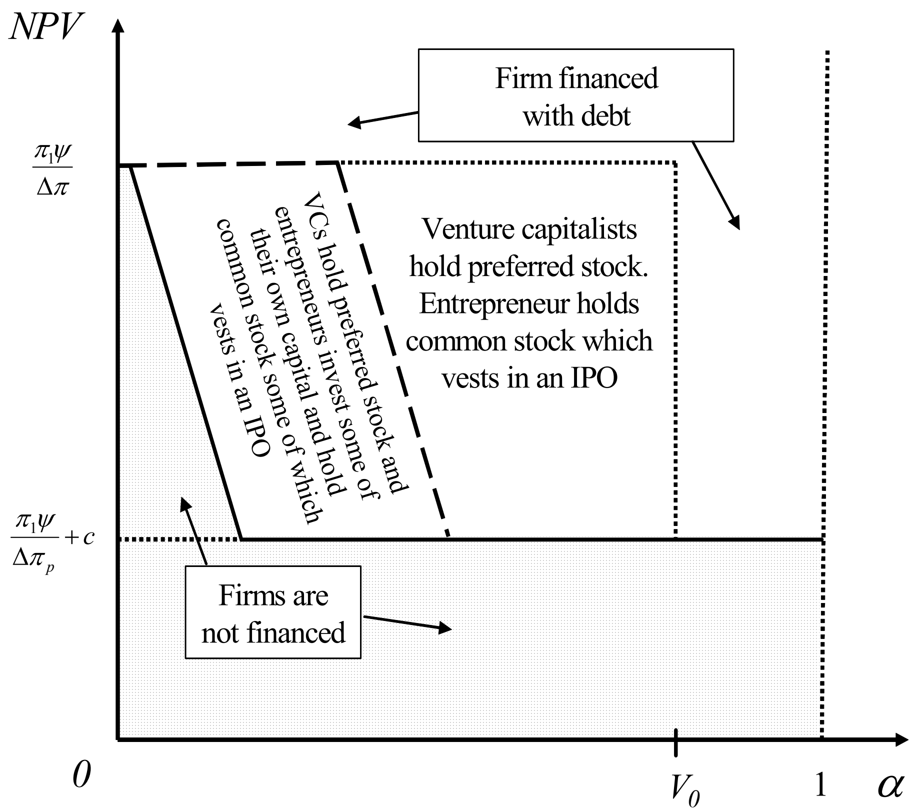

Figure 6: The diagram illustrates the conditions for firm financing for different values of NPV and α. A firm that has either high NPV or high α will be financed with a debt contract. Firms with low NPV and high α are financed by venture capitalists with preferred stock. Projects with low NPV and low α are financed only if there is a sizable contribution by the entrepreur. In this case, the entrepreneur holds common stock, some of which vests over time.

of liquidation and which automatically converts into common stock in case of IPO. Importantly, conversion of preferred into common stock implies a reduction of seniority for VCs. While with preferred stock VCs are senior to entrepreneurs, once conversion has taken place, entrepreneurs and VCs have the same level of seniority.

The loss of seniority is the core mechanism which ensures commitment. Conversion combined with vesting of the entrepreneur's stock determines a reduction of the percentage of profits that VCs can claim in case of IPO. This means that if the prospects of a firm are uncertain, VCs have a strong incentive to liquidate while they still hold preferred stock. In fact, with preferred stock they can benefit from strong liquidation rights. On the other hand, VCs have little incentive to promote an uncertain IPO, because the IPO process implies conversion into common stock – and the associated loss of priority – plus the shares of the entrepreneur vest; two effects which reduce the rights of a VC. Therefore, this financial structure ensures that VCs have an incentive to promote only potentially successful IPOs and liquidate all other firms.

The model bears precise empirical implications on how the financial structure of a young firm should change in relation to asset specificity. More precisely, we find that the use of preferred stock and vesting clauses should be particularly associated with firms that employ specific assets. In this regard, there is broad empirical evidence which shows that debt – in the form of mortgages, for example – is the security employed by banks to provide capital when there are valuable assets that can be used as collateral in case of default. On the contrary, preferred stock is employed by VCs which typically operate in poorly collateralized sectors. This evidence points in the direction of a positive correlation between the resale value of the assets and the choice of preferred stock over debt. However, there is scope for future empirical research to examine in more detail whether a precise correlation exists between preferred stock and asset specificity *within* the VC industry. Finally, the model shows that vesting should be particularly associated with firms that employ specific assets. More precisely, the percentage of cash flows that goes to the entrepreneur through the mechanism of vesting should increase when assets are specific.

9 Appendix 1

Derivation of a contract at First Best Notice first that a contract must satisfy constraints LLu, LLd and PC_E, otherwise it will not be accepted by the entrepreneur. To determine the profit maximizing contract, investors set $\bar{r}$, $\underline{r}$ and e. Observe that at the optimum the following holds: 1) $e = 1$ and 2) PC_E binds. The choice of e is dictated by our assumptions on the firm's returns. Equation (1) implies that a time t_0 contract must stipulate that $e = 1$, otherwise the firm has negative NPV. PC_E binds because the investors have full bargaining power and thus minimize costs by keeping the entrepreneur at her reservation utility. The above conditions ($e = 1$ and $PC_E = 0$) are necessarily satisfied at the optimum. However, they are not enough to identify a single optimum contract. In fact, there are infinite First Best contracts that investors can choose because, due to risk neutrality, any pair $(\bar{r}, \underline{r})$ which satisfies conditions PC_E, LLu and LLd defines an optimal contract. Each of these contracts entails different payoffs for entrepreneurs and investors.

Proof of Proposition (1) First show that the entrepreneur's incentive constraint is always more stringent than her participation constraint. To prove this point, it suffices to observe that the right hand side of condition IC is greater than zero when $\overline{r} \geq \overline{V}$ and $\underline{r} \geq \underline{V}$. PC_E can then be omitted. Cost minimization implies that IC binds at the optimum, thus yielding

$$\overline{r} = \Delta V + \underline{r} - \frac{\psi}{\Delta\pi}. \tag{9}$$

In order to minimize costs, an investor sets $\underline{r} = \underline{V}$. From equation (9) we then obtain $\overline{r} = \overline{V} - \frac{\psi}{\Delta\pi}$.

Discussion of Renegotiation Proofness In this section, we discuss the issue of renegotiation proofness. To do so, we need to analyze the sub-game that takes place when σ_0 is observed. This sub-game exists off the equilibrium path. Suppose that investors observe σ_0 at time t_2. Then, if the following condition holds

$$\pi_0\overline{V} + (1 - \pi_0)\underline{V} \leq \alpha. \tag{10}$$

renegotiation does not occur. In fact, the firm will be liquidated because liquidation is the efficient option. However, if condition (10) is not satisfied, renegotiation occurs. Given that, by assumption, investors have all the bargaining power, they will make a new take-it-or-leave-it offer to the entrepreneur. The bargaining process works as follows:

Entrepreneur	**Investor**	**Outcome**
0	$\pi_0\overline{V} + (1-\pi_0)\underline{V}$	not accepted (back to original contract)
$\varepsilon < \alpha$	$\pi_0\overline{V} + (1-\pi_0)\underline{V} - \varepsilon$	not accepted (back to original contract)
$\pi_0\overline{V} + (1-\pi_0)\underline{V} - \alpha$	α	accepted

The values in the first two columns represent the payoffs of entrepreneurs and investors in case of firm continuation. The bargaining process starts with the investor offering the entrepreneur zero in case of continuation. This offer is based on the idea that if the entrepreneur does not accept this contract, the firm will be liquidated, in which case she will receive a payoff of zero. This offer is not accepted by the entrepreneur because liquidation is not credible when condition (10) is not satisfied.

The second offer from the investor gives the entrepreneur $\varepsilon < \alpha$ in case of continuation. Again, this offer is not accepted because liquidation is not a credible threat.

Finally, the investor offers $\pi_0\overline{V} + (1-\pi_0)\underline{V} - \alpha$ to the entrepreneur. In this case, the investor gets α in case of continuation. This offer is accepted because liquidation is credible. In fact, the investor now gets α both in case of continuation and liquidation. Therefore, the investor is indifferent between the two options.

We conclude that investors can credibly commit to liquidation only if their payoff in case of continuation is not greater than that in case of liquidation. This implies that the continuation payoff must be not greater than α. From this reasoning, it follows that condition CC must be satisfied by a renegotiation-proof contract.

Proof of Proposition (2) We begin by showing that the entrepreneur's incentive constraint is always more stringent than her participation constraint. To prove this point, it suffices to observe that the right hand side of condition ICm is greater than zero when $\overline{r} \geq \overline{V}$ and $\underline{r} \geq \underline{V}$. PC_E can then be omitted. ICm and CC always cross and their intersection takes place at

$$\overline{r}' = \overline{V} - \frac{\psi}{\Delta\pi_p} + (V_0 - \alpha)\frac{p - \Delta\pi_p}{\Delta\pi},$$
$$\underline{r}' = \underline{V} - (V_0 - \alpha)\frac{\Delta\pi_p}{\Delta\pi}$$

with $V_0 \equiv \pi_0\left(\overline{V} - \frac{\psi}{\Delta\pi_p}\right) + (1-\pi_0)\underline{V}$ and $\Delta\pi_p \equiv \pi_1 - \pi_0(1-p)$. Conditions LLu and LLu are respectively satisfied when $\overline{r}' \leq \overline{V}$ and $\underline{r}' \leq \underline{V}$. Using the definitions of $\overline{r}'$ and $\underline{r}'$, we identify six possible cases:

1. if $p > \frac{\Delta\pi}{1-\pi_0}$ and $\alpha \leq V_0 - \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{p-\Delta\pi_p}$ then $\overline{r}' \geq \overline{V}$ and $\underline{r}' \leq \underline{V}$.

2. if $p > \frac{\Delta\pi}{1-\pi_0}$ and $V_0 - \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{p-\Delta\pi_p} \leq \alpha \leq V_0$ then $\overline{r}' \leq \overline{V}$ and $\underline{r}' \leq \underline{V}$;

3. if $p > \frac{\Delta\pi}{1-\pi_0}$ and $\alpha \geq V_0$ then $\overline{r}' \leq \overline{V}$ and $\underline{r}' \geq \underline{V}$;

4. if $p < \frac{\Delta\pi}{1-\pi_0}$ and $\alpha \leq V_0$ then $\overline{r}' \leq \overline{V}$ and $\underline{r}' \leq \underline{V}$;

5. if $p < \frac{\Delta\pi}{1-\pi_0}$ and $V_0 \leq \alpha \leq V_0 + \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{\Delta\pi_p - p}$ then $\overline{r}' \leq \overline{V}$ and $\underline{r}' \geq \underline{V}$;

6. if $p < \frac{\Delta\pi}{1-\pi_0}$ and $\alpha \geq V_0 + \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{\Delta\pi_p - p}$ then $\overline{r}' \geq \overline{V}$ and $\underline{r}' \geq \underline{V}$;

The following results can be obtained with a graphical analysis: in case 1, the only constraints that bind are CC and LLu and the optimum is $\overline{r}_D = \overline{V}$ and $\underline{r}_D = \frac{\alpha - \pi_0\overline{V}}{1-\pi_0}$. In cases 2 and 4 , CC and ICm are the only constraints that bind and the optimum is $\overline{r}_C = \overline{r}'$ and $\underline{r}_C = \underline{r}'$. In cases 3, 5 and 6, ICm and LLd are the only constraints that bind and the optimum is $\overline{r}_B = \overline{V} - \frac{\psi}{\Delta\pi_p}$ and $\underline{r}_B = \underline{V}$. Therefore, we conclude that when $\alpha \geq V_0$, the payoffs to an investor are such that $\overline{r} \leq \overline{V}$ and $\underline{r} = \underline{V}$. On the contrary, when $\alpha \leq V_0$, the payoffs are $\overline{r} \leq \overline{V}$ and $\underline{r} \leq \underline{V}$.

Proof that the Cost of Commitment Equals $(V_0 - \alpha\beta - \tau)(1-p)$ The incentive constraint of an entrepreneur is now given by the following condition,

$$\pi_1\left(\overline{V} - \bar{r}\right) + (1-\pi_1)\left(\underline{V} - \underline{r}\right) - \tau - \psi \geq (1-p)\left[\pi_0\left(\overline{V} - \bar{r}\right) + (1-\pi_0)\left(\underline{V} - \underline{r}\right) - \tau\right]. \quad (ICm')$$

and her participation constraint is,

$$\pi_1\left(\overline{V} - \bar{r}\right) + (1-\pi_1)\left(\underline{V} - \underline{r}\right) - \tau - \psi \geq 0.$$

The participation constraint is more stringent than the incentive constraint only if

$$\pi_0\left(\overline{V} - \bar{r}\right) + (1-\pi_0)\left(\underline{V} - \underline{r}\right) \leq \tau. \quad (11)$$

By assumption A1, we know that $\pi_0\overline{V} + (1-\pi_0)\underline{V} < 1$. Therefore, it is always possible to find a τ which is large enough for (11) to be satisfied. This implies that when entrepreneurs provide a large share of capital, First Best is achieved.

Consider instead the case when (11) is not satisfied. The incentive constraint of the entrepreneur binds, while her participation constraint is slack. In this case, First Best cannot be achieved. Indicate with $\left(\underline{i},\overline{i}\right)$ the returns of an entrepreneur respectively in the high and low state. The allocation of bargaining power to investors implies that $\pi(e)\,\overline{i}(1-\pi(e))\underline{i} = \tau$. A contract is renegotiation-proof only if the following condition is satisfied,

$$\alpha\beta \geq \pi_0\overline{r} + (1-\pi_0)\underline{r}. \qquad CC'$$

ICm' and CC' always cross and for any given $\overline{i}$ and $\underline{i}$ their intersection takes place at

$$\begin{aligned}\overline{r}'' &= \overline{V} - \overline{i} - \tfrac{\psi}{\Delta\pi_p} + \left(V_0' - \alpha\beta\right)\tfrac{p-\Delta\pi_p}{\Delta\pi},\\ \underline{r}'' &= \underline{V} - \underline{i} - \left(V_0' - \alpha\beta\right)\tfrac{\Delta\pi_p}{\Delta\pi}\end{aligned}$$

with $V_0' \equiv \pi_0\left(\overline{V} - \overline{i} - \frac{\psi}{\Delta\pi_p}\right) + (1-\pi_0)\left(\underline{V} - \underline{i}\right)$. Limited liability is satisfied when $\overline{r}'' \leq \overline{V} - \overline{i}$ and $\underline{r}'' \leq \underline{V} - \underline{i}$. Using the definitions of $\overline{r}''$ and $\underline{r}''$, we identify six possible cases:

1. if $p > \frac{\Delta\pi}{1-\pi_0}$ and $\alpha\beta \leq V_0' - \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{p-\Delta\pi_p}$ then $\overline{r}'' \geq \overline{V} - \overline{i}$ and $\underline{r}'' \leq \underline{V} - \underline{i}$.
2. if $p > \frac{\Delta\pi}{1-\pi_0}$ and $V_0' - \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{p-\Delta\pi_p} \leq \alpha\beta \leq V_0'$ then $\overline{r}'' \leq \overline{V} - \overline{i}$ and $\underline{r}'' \leq \underline{V} - \underline{i}$;
3. if $p > \frac{\Delta\pi}{1-\pi_0}$ and $\alpha\beta \geq V_0'$ then $\overline{r}'' \leq \overline{V} - \overline{i}$ and $\underline{r}'' \geq \underline{V} - \underline{i}$;
4. if $p < \frac{\Delta\pi}{1-\pi_0}$ and $\alpha\beta \leq V_0'$ then $\overline{r}'' \leq \overline{V} - \overline{i}$ and $\underline{r}'' \leq \underline{V} - \underline{i}$;
5. if $p < \frac{\Delta\pi}{1-\pi_0}$ and $V_0' \leq \alpha\beta \leq V_0' + \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{\Delta\pi_p - p}$ then $\overline{r}'' \leq \overline{V} - \overline{i}$ and $\underline{r}'' \geq \underline{V} - \underline{i}$;
6. if $p < \frac{\Delta\pi}{1-\pi_0}$ and $\alpha\beta \geq V_0' + \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{\Delta\pi_p - p}$ then $\overline{r}'' \geq \overline{V} - \overline{i}$ and $\underline{r}'' \geq \underline{V} - \underline{i}$;

In case 1, the constraints that bind are CC' and the limited liability in the high state. The optimum contract requires $\overline{r}_D' = \overline{V} - \overline{i}$ and $\underline{r}_D = \frac{\alpha\beta - \pi_0\left(\overline{V} - \overline{i}\right)}{1-\pi_0}$. In cases 2 and 4 , CC' and ICm' are the constraints that bind and the optimum is $\overline{r}_C = \overline{r}''$ and $\underline{r}_C = \underline{r}''$. In cases 3, 5 and 6, ICm' and the limited liability constraint in the low state are the only constraints that bind and the optimum is $\overline{r}'_B = \overline{V} - \overline{i} - \frac{\psi}{\Delta\pi_p}$and $\underline{r}'_B = \underline{V} - \underline{i}$.

The optimum contracts can then be summarized as follows:

- if $\alpha > \frac{V'_0}{\beta}$ the optimum contract is $\overline{r}'_B = \overline{V} - \overline{i} - \frac{\psi}{\Delta\pi_p}$ and $\underline{r}'_B = \underline{V} - \underline{i}$;
- if $p > \frac{\Delta\pi}{1-\pi_0}$ and $\frac{1}{\beta}\left(V'_0 - \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{p-\Delta\pi_p}\right) \leq \alpha \leq \frac{V'_0}{\beta}$ or if $p < \frac{\Delta\pi}{1-\pi_0}$ and $\alpha \leq \frac{V'_0}{\beta}$ the optimum contract is

$$\begin{array}{c}\overline{r}'_C = \overline{V} - \overline{i} - \frac{\psi}{\Delta\pi_p} + (V'_0 - \alpha\beta)\frac{p-\Delta\pi_p}{\Delta\pi} \\ \underline{r}'_C = \underline{V} - \underline{i} - (V'_0 - \alpha\beta)\frac{\Delta\pi_p}{\Delta\pi}\end{array}$$

- if $p > \frac{\Delta\pi}{1-\pi_0}$ and $\alpha \leq \frac{1}{\beta}\left(V'_0 - \frac{\psi}{\Delta\pi_p}\frac{\Delta\pi}{p-\Delta\pi_p}\right)$ the optimum contract is $\overline{r}_D = \overline{V} - \overline{i}$ and $\underline{r}_D = \frac{\alpha\beta-\pi_0\left(\overline{V}-\overline{i}\right)}{1-\pi_0}$.

At contract $\left(\overline{r}'_C, \underline{r}'_C\right)$, the ability to monitor an investment increases an investor's profits if $I\left(\overline{r}'_C, \underline{r}'_C\right) \geq I\left(\overline{r}_{A^{SB}}, \underline{r}_{A^{SB}}\right)$, a condition that can be written as

$$\frac{\psi\pi_1}{\Delta\pi} - \frac{\psi\pi_1}{\Delta\pi_p} \geqslant c + \underbrace{(V_0 - \alpha\beta - \tau)(1-p).}_{\text{cost of commitment with joint financing}}$$

Proof of Proposition 3 As illustrated in Figure (7), $\beta_{Sen}(\tau) \geq \beta_{Jun}(\tau)$, thus implying that informed investors must be senior to minimize commitment costs. If $\tau \leq 1-\alpha$, the objective function equals $(V_0 - \alpha - \tau)(1-p)$ and has a minimum in $\tau = 1-\alpha$. In this case $\beta = 1$ and condition (8) simplifies to $\tau \geq 0$ which is always satisfied. If $\tau \geq 1-\alpha$, the objective function equals $(V_0 - 1)(1-p)$ which is constant. In this case, condition (8) requires $\alpha \leq 1$ which is true by assumption. By comparing the two cases, we find that the optimum is in $\tau = 1-\alpha$.

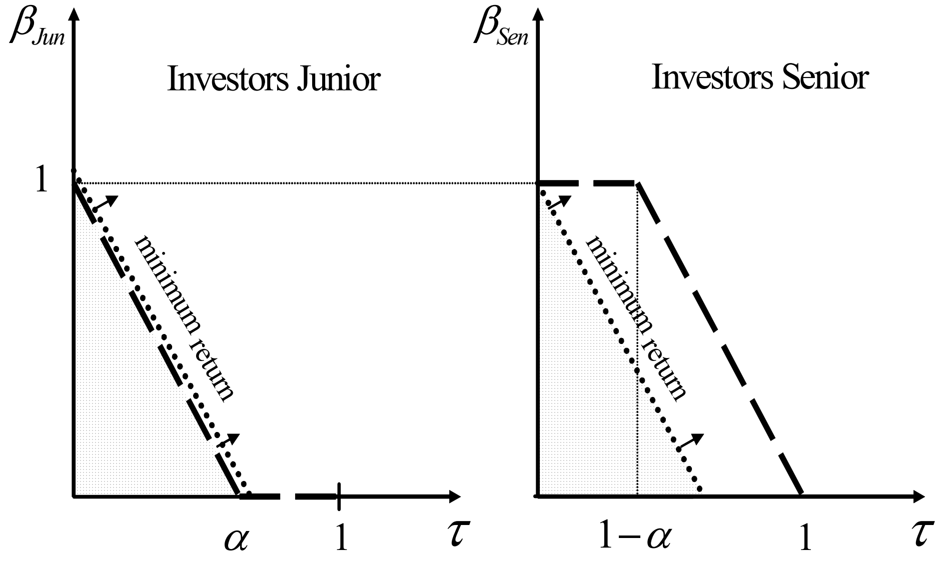

Figure 7: In both diagrams, the value on the vertical axis represents the share of liquidated assets that goes to investors. Condition (8) is satisfied only when β lies above the dotted line. In the left diagram, the dashed line represents $\beta_{Jun}(\tau)$. Investors receive a share which is between 1 and zero when $\tau \leq \alpha$. Their share of liquidated assets drops to zero when $\tau \geq \alpha$. In the right diagram, the dashed line represents $\beta_{Sen}(\tau)$. Investors receive a share of liquidated assets which is strictly greater than zero when $\tau < 1$. This means that their share is strictly positive as long as they provide some financing.

References

Admati, A. R., and P. Pfleiderer (1988): "A Theory of Intraday Patterns: Volume and Price Variability," *Review of Financial Studies*, 1(1), 3–40.

Aghion, P., and P. Bolton (1992): "An "Incomplete Contracts" Approach to Financial Contracting," *Review of Economic Studies*, 59, 473–94.

Baron, D., and D. Besanko (1984): "Regulation, Asymmetric Information, and Auditing," *RAND Journal of Economics*, 15(4), 447–470.

Casamatta, C. (2003): "Financing and Advising: Optimal Financial Contracts with Venture Capitalists," *Journal of Finance*, LVIII(5), 2059–2085.

Cornelli, F., and O. Yosha (2003): "Stage Financing and the Role of Convertible Securities," *Review of Economic Studies*, 70(1), 1 – 32.

Cremer, J. (1995): "Arm's Length Relationships," *The Quarterly Journal of Economics*, CX(2), 275–296.

Dewatripont, M. (1988): "Commitment Through Renegotiation-Proof Contracts with Third Parties," *Review of Economic Studies*, LV, 377–90.

Dewatripont, M., and J. Tirole (1994): "A Theory of Debt and Equity: Diversity of Securities and Manager-Shareholder Congruence," *Quarterly Journal of Economics*, 109(4), 1027–1054.

Fluck, Z. (1998): "Optimal Financial Contracting: Debt versus Outside Equity," *Review of Financial Studies*, 11(2), 383 – 418.

Gompers, P., and J. Lerner (2001): "The Venture Capital Revolution," *Journal of Economic Perspectives*, 15(2), 145–168.

Gompers, P. A. (1995): "Optimal Investment, Monitoring, and the Staging of Venture Capital," *Journal of Finance*, 50(5), 1461–1490.

——— (1997): "Ownership and Control in Entrepreneurial Firms: An Examination of Convertible Securities in Venture Capital Investments," mimeo.

Grossman, S. J., and O. D. Hart (1986): "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94, 691–719.

Grossmann, S., and O. Hart (1982): *Corporate Financial Structure and Managerial Incentives. In J. McCall (Ed.), The Economics of Information and Uncertainty*. University of Chicago Press, Chicago.

Hart, O., and J. Moore (1989): "Default and Renegotiation: A Dynamic Model of Debt," *Quarterly Journal of Economics*, 113(1), 1–41.

Hellmann, T. (1998): "The Allocation of Control Rights in Venture Capital Contracts," *RAND Journal of Economics*, 29(1), 57–76.

——— (2006): "IPOs, Acquisitions and the Use of Convertible Securities in Venture Capital," *Journal of Financial Economics*, 81(3), 649–679.

Holmstrom, B. (1979): "Moral Hazard and Observability," *Bell Journal of Economics*, X, 74–91.

Holmstrom, B. (1982): *Managerial Incentive Problems: A Dynamic Perspective*, in Essays in Economics and Management in Honor of Lars Wahlbeck, Helsinki: Swedish School of Economics.

Jensen, M., and W. Meckling (1976): "Theory of the Firm: Managerial Behaviour, Agency Costs and Capital Structure," *Journal of Financial Economics*, 3, 305–360.

Kaplan, S. N., and P. Strömberg (2003): "Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts," *Review of Economic Studies*, 70(2), 281–315.

Lerner, J., F. Hardymon, and A. Leamon (2005): *Venture Capital and Private Equity: A Casebook*. John Wiley and Sons, Inc.

Modigliani, F., and M. Miller (1958): "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review*, 48(3), 261–97.

Rajan, R. G. (1992): "Insiders and Outsiders: The Choice Between Informed and Arm's Length Debt," *Journal of Finance*, 47(4), 1367–1400.

Repullo, R., and J. Suarez (1998): "Monitoring, Liquidation, and Security Design," *Review of Financial Studies*, 11(1), 163 – 187.

Sahlman, W. (1990): "The Structure and Governance of Venture-Capital Organizations," *Journal of Financial Economics*, 27, 473–521.

Schmidt, K. M. (2003): "Convertible Securities and Venture Capital Finance," *Journal of Finance*, LVIII(3), 1139–1166.

Townsend, R. (1978): "Optimal Contracts and Competitive Markets with Costly State Verification," *Journal of Economic Theory*, 21, 265–93.