Staging of Venture Financing, Investor Opportunism, and Patent Law

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Abstract:

Stage financing provides a real option valuable when facing external uncertainty. However, it may also induce investor hold-up, if the property rights on an invention are not sufficiently protected. As a consequence, the entrepreneur might not work hard. Investor opportunism is less likely to occur, if investor's residual cash-flow-rights are contingent on verifiable "milestones" in the previous stage. Convertible preferred stock also provides high-powered incentives to the investor not to "steal the idea". The paper provides a new explanation for both types of contingent provisions that are quite common in the venture capital industry.

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1. Introduction

One salient feature of venture financing is the staging of capital infusions (Sahlman, 1990, Gompers and Lerner, 1999). Financing rounds are usually related to significant stages in the development process such as completion of design, production of a prototype, patent filing, or the introduction of a second product. There are two benefits of staging, both due to the *option to exit*. First, it is possible to stop the venture without losing too much money when it turns out that external factors become unfavorable, e.g. market demand does not increase as expected or competitors suddenly emerge. Second, the staging of capital allows the mitigation of opportunistic behavior by the entrepreneur (Gompers and Lerner, 1999, Neher, 1999). Since the entrepreneur usually provides few funds of her own she may be interested in continuation when the termination of a venture would be efficient, for instance, when she receives a private benefit from running a venture.

Staging of capital, however, may also induce *investor* hold-up due to weak intellectual property rights.[1] The investor may threaten to steal the idea and thus, can appropriate parts of the surplus through renegotiation. As a consequence, however,

[1] A new innovation may not qualify for a patent because it does not represent a significantly new contribution to existing knowledge. Still, it might be valuable. Sometimes, entrepreneurs may not patent the innovation for strategic reasons (keeping the innovation secret), see Anton and Yao (2004). Besen and Raskind (1991) discuss the limitations of trade secrets and no-compete agreements. Patents do not necessarily guarantee strong property rights. Sometimes patents are overturned in court (see Areeda and Kaplov (1998), sometimes the scope of the patent is narrow such that imitators find close substitutes without infringing the patent. Often, it does not pay to enforce the patent. Pfister (2000) finds that 45% of 2,046 French firms that have suffered from intellectual property rights infringement never react to it.

the entrepreneur may reduce her non-contractible effort level even it is not efficient to do so (*underinvestment*). Thus, stage financing comes up with a cost.

The hold-up-problem may be mitigated if the parties write a long-term contract which binds the investor, and where the investor's residual cash-flow-rights are contingent on the venture's revenue or non-monetary verifiable "milestones" in the previous stage. So far, such provisions have been considered as an instrument to mitigate *entrepreneurial* moral hazard (see Sahlman, 1990). Contingent cash flow rights are common in the venture capital industry (see Kaplan and Strömberg, 2003).

If the venture capitalist has high-powered incentives he might be less willing to steal the idea since this might considerably reduce the venture's return. High-powered incentives are given by common stock, debt-equity and especially, with convertible preferred stock. Kaplan and Strömberg (2003) state that convertible preferred stock is widely used in the U.S. venture capital industry.[2]

The impact of patent law is important. In the law and economics literature patent law is primarily seen as an instrument balancing the trade-off between setting incentives to innovate and the need to limit the monopoly power of patent holders (see Kitch, 1998, Cooter and Ulen, 2000). It, however, overlooks the fact that an entrepreneur's idea often only develops to a market product with the help of investors providing financial resources. Thus, I argue that there is an additional goal of patent law. Patent law potentially mitigates conflicts in the venture financing process thereby making innovations more likely.

Literature overview. This paper distinguishes itself from the venture capital literature in several ways. First, it shows that stage financing might induce *costs*,

[2] Similar findings are reported by Sahlman (1990).

whereas the literature stresses its benefits (see Sahlman, 1990, Gompers and Lerner, 1999). Second, it provides a new explanation for contingent cash-flow rights (see Berglöf, 1994, Schmidt, 2003). Third, it looks at investor moral hazard only, whereas the literature focuses mainly on opportunistic behavior by a wealth-constrained entrepreneur, e.g. Bergemann and Hege (1998) and Neher (1999).[3] There are some papers on double-sided moral hazard. However, investor opportunism in these papers is not driven by weak intellectual property rights and/or there is no focus on stage financing (see Hansmann and Kraakman, 1992, Aghion and Tirole, 1994, Repullo and Suarez, 1999, Schmidt, 2003, Casamatta, 2003). The papers by Berglund and Johansson (2000) and Ueda (2004) are the closest ones to our model.

Berglund and Johansson argue that an entrepreneur may develop the venture on her own in the early stages without any help from a venture capitalist since the entrepreneur's negotiation power is weak, for instance due to weak intellectual property rights. However, Berglund and Johansson do not explicitly model how this affects the choice of entrepreneurial effort. Second, they do not consider long-term contracts with contingent residual cash flow rights which are widely used in the venture capital industry. Ueda (2004) focuses on the question why some start-up firms raise funds from banks and others from venture capitalists. Venture capitalists are able to evaluate the project more accurately than banks and are more likely to overcome adverse selection. However, they can also threaten to steal the idea from the entrepreneur whereas banks cannot. Ueda's model explains why some

[3] For other models on venture financing not explicitly mentioned here, see Berglöf (1994), Aghion and Tirole (1994), Trester (1998), Bascha and Walz (2000) and Kirilenko (2001). Berglöf (1994) and Bascha and Walz (2000) investigate conflicts of interest when a venture capitalist wants to sell his stocks. Trester (1998) assumes that an investor cannot observe the venture's return. Kirilenko (2001) considers a setting where an investor cannot correctly assess either the venture's value or the control premium the entrepreneur demands for giving up the private benefits of control. This list is not exhaustive.

entrepreneurs seek for bank funds, however, it does not consider convertible debt or stage financing.

In what follows, we first present a model in section 2 showing how stage financing might induce the incumbent investor to extract rents due to weak intellectual property rights. If milestones are verifiable, a long-term contingent contract turns out to be efficient. Section 3 presents a model showing that convertible preferred stock mitigates investor opportunism if stealing is not verifiable. Section 4 shows the economics of patent law and provides a closer look at the requirements for patent protection. Section 5 serves as a conclusion.

2. Model 1: Stage financing and investor hold-up

2.1 Related literature

Let us take a closer look at some of the models analyzing stage financing. Hart and Moore (1994) and Neher (1999) assume that the venture yields no return without the entrepreneur's non-contractible human capital. Since the investor provides all the funds the entrepreneur may renegotiate the contract threatening to withdraw her human capital. In this scenario, stage financing is useful since at every stage, the human capital is embodied in the physical assets of the venture. The value of the venture's physical assets grows over time and serves, in a sense, as collateral for future investment rounds. In our paper, however, stage financing *allows* the inside investor to take advantage of weak intellectual property rights at the entrepreneur's cost. Hellmann (1998) shows that an entrepreneur may voluntarily agree on a provision to be dismissed in the case of failure. Such a provision reduces the costs of replacing the entrepreneur by a professional manager and, thus, makes the venture

capitalist more willing to finance the venture. Bergemann and Hege (1998) assume that neither the venture capitalist nor the entrepreneur can correctly assess the venture's prospects. Rather, the venture capitalist adjusts his beliefs conditional on the outcomes of the previous stages. The problem is that he cannot observe whether the entrepreneur has invested the funds efficiently or rather in order to maximize her individual utility. Thus, he may underrate the venture's prospects and terminate some ventures, although continuation may be efficient. In order to provide strong incentives to the entrepreneur and to prevent inefficient discontinuation the entrepreneur's fraction of cash flows should be larger in the early stages than in the advanced ones, since the investor then learns what underlies failure.

Finally, Admati and Pfleiderer (1994) look at syndicated investments where a well-informed lead-investor, such as a venture capitalist, can correctly assess the venture's prospects, and thus be able to decide whether continuation is efficient or not. However, co-investors lack some information. The lead-investor may be tempted to continue an inefficient venture if his fraction of the future cash flows exceeds his fraction of the additional investment. There is no conflict of interest when there is a fixed-fraction contract. Although Admati and Pfleiderer do not study hold-up by the lead-investor, they mention the possibility of it transpiring.[4]

2.2 The model

This section describes an economy where an entrepreneur can raise funds from different venture capitalists. All agents are risk neutral, and the risk-free interest rate

[4] Admati and Pfleiderer (1994), p. 389, argue that "the possibility exists that the insider venture capitalist can use his bargaining power to force the entrepreneur for a higher fraction of the firm."

is normalized to zero. The wealth-constrained entrepreneur E is endowed with an innovative project. It takes two periods to fully develop the innovation. There is an investment of *I/2* in the beginning of each period. The return in *t=2* is verifiable and random. In *t=1* there is no non-monetary outcome (e.g., a "milestone") and thus, a value to the innovation at this stage.[5] The milestone might not be verifiable, but the venture capitalist can observe it.

To keep the model simple, both value in t=1 and an (additional) return in t=2 amount to X or 0 $(X > I/2 > 0)$, with probability p and $(1-p)$, respectively. If there is zero outcome in *t=1*, there is also zero return in *t=2*. One can think of a scenario where an entrepreneur simply lacks sufficient skills to develop the innovation. In this case, stage financing provides an option to exit without losing too much money.

If the venture has succeeded at the first stage (value of X), the probability of receiving a return of $2X$ (an additional X) in stage 2 depends on the entrepreneur's non-verifiable effort level (e):

(1) $p = p(e)$ with $e = \{e_L, e_H\}$, $e_L = 0$ and $e_H > 0$ and

$$0 < p(e = e_L) = p_L < p(e = e_H) = p_H = p_L + \pi < 1.$$

For simplicity, e also denotes the cost of effort. The cost of low effort (e_L) is set to zero.[6] According to (1), there are three possible outcomes in *t=2*: either $2X$

[5] Usually, ventures lack monetary returns in the very early stages, but the venture's favorable prospects may be reflected by some progress in developing the idea (e.g., completion of a prototype) or in hiring skilled staff.

[6] For the sake of simplicity, we assume $p_L > 0$ even with $e_L = 0$. The probability of success may also depend on other factors than entrepreneurial effort, such as external factors or the entrepreneur's quality (skills) which we do not explicitly consider here. With $0 < e_L < e_H$, we obtain very similar qualitative results, the presentation becomes more complex, though.

(probability: $p \cdot p(e)$), or X (probability: $p \cdot (1 - p(e))$ or 0 (probability: $1 - p$). Expected return amounts to $p[1 + p(e)]X$ and exceeds the expected investment $(1 + p)I/2$.

With success after the first stage, success probability in $t=2$ increases if the entrepreneur chooses a high level of effort (e_H). A high level of effort is considered to be efficient, i.e.:[7]

(2.1) $e_H < (p_H - p_L)X = \pi X$.

(*Lack of intellectual property rights protection*). Property rights on the innovation are not entirely protected, because e.g., the idea is not sufficiently developed in order to meet the requirements for patent or copy right filing, or because contractual agreements such as trade secrets and non-disclosure provisions might not be (entirely) enforceable − due to excessively high verification and/or enforcement costs. The incumbent investor (Old) has experienced the progress of the innovation in the first stage and might partly use the idea for his own purposes if the relationship with the entrepreneur is terminated in $t=1$. Old may also transfer the idea to another portfolio firm he has a (bigger) stake in. In the case of termination, Old receives a fraction ω of the innovation's second stage marginal return in the good state of nature (in the bad one marginal return is zero), i.e. $\omega \cdot p(e)X$, with $0 < \omega < 1$. One can imagine that the fraction ω may increase with the cost to enforce intellectual property rights: $\omega = \omega(c)$ with $\delta\omega(c)/\delta c > 0$. We assume that enforcement costs are too high if the entrepreneur seeks financing with a new investor in the second stage:[8] $c > \omega \cdot p(e)X$. If the entrepreneur sticks with the incumbent investor, enforcement costs

[7] Thus, we assume that non-monetary utility can be measured in monetary units which is common in microeconomic theory. See Keeney and Raiffa (1976) on the requirements to do so.

[8] Otherwise it would pay to enforce. The hold-up problem does not occur.

are lower and Old is not able to infringe the property right; in section 3 we relax this assumption. If the investor steals the idea a high level of effort will not be efficient:

(2.2) $e_H \geq \pi(1-\omega)X$.

In the initial model, the incumbent investor holds debt or preferred stock with senior liquidation rights in liquidation which prevents him from dilution if a new investor enters in stage 2.[9] To keep the model simple, the face value of preferred stock is defined as $D = X$. In the second stage, common stock is issued. Thus, a potentially new investor can only benefit from the *additional* returns due to the further development of the idea in stage 2.

Figure 1 shows the structure of the model.

-- Insert Figure 1 here --

In the first-best world a high level of effort can either be contracted upon or intellectual property rights are entirely protected. Stage financing provides the option to stop the project in t=1 if a zero value occurs. Social surplus amounts to (Y_E, Y_{Old} denote the individual surplus of the entrepreneur and incumbent investor, respectively):

(2.3) $Y_{E+Old} = Y_E + Y_{Old} = -(1+p)I/2 + p\left[(1+p_H)X - e_H\right]$.

[9] The hold-up problem also occurs with other forms of financing like equity or debt-equity or debt. However, then there is also a dilution effect making the model less transparent.

2.3 Stage financing and investor hold-up

In *t=1*, the entrepreneur asks the outside investor New for an offer for the second stage. If New expects that the incumbent investor who financed the first stage may take advantage of the weak intellectual property rights he takes into account that cooperative surplus may be reduced by the amount $\omega p(e)X$. Let us assume that it still pays to provide the second stage capital infusion, that is $I/2 < p(e)(1-\omega)X$.[10] Thus, in order to earn a zero profit, New demands for the second-stage investment:

$$(3) \qquad q^{New} = \frac{I/2}{p(e)\left[(2-\omega)X - D\right]} = \frac{I/2}{p_L(1-\omega)X}.$$

Note that the incumbent investor holds preferred stock with *D = X*. q^{New} denotes the outside investor's fraction on the second stage return. In case of stealing the idea the entrepreneur is not willing to exert high effort (see (2.2)), that is $p(e) = p_L$.

Still, the entrepreneur prefers to stick with the old investor if (4) holds (note: with the incumbent investor there is no stealing):

$$(4) \qquad (1-q^{Old})p_L X \geq (1-q^{New})\left[p_L(1-\omega)X\right] \text{ or, by rearranging:}$$

$$q^{Old} \leq q^{New} + \omega(1-q^{New}).$$

Thus, the old (incumbent) investor may even ask for a *larger* fraction of the second stage surplus than the new investor since with the new investor cooperative surplus is lower. However, the old investor knows that with less expensive financial terms ($q^* < q^{Old}$) the entrepreneur is willing to exert a high level of effort, that is, the "size of

[10] If this condition does not hold, New will not make an offer and the incumbent investor as a monopolist would be able to extract all the surplus.

the pie" is larger. The entrepreneur works hard if individual marginal benefits exceed marginal costs, that is if holds:

(4.1) $(1-q)\pi X \geq e_H$ or: $q \leq q_E^{IC} = 1 - \frac{e_H}{\pi X}$.

Hence, in *t=1*, Old compares his *individual* surplus for the opportunistic bid with the surplus for the incentive compatible bid q_E^{IC}. Old asks for q^{Old} if (5) holds:

(5) $-I/2 + q^{Old} p_L X \geq -I/2 + q_E^{IC} p_H X$ or $q^{Old} > q_E^{IC} \frac{p_H}{p_L}$.

Result 1:

Other things being equal, the old investor's incentive to hold up the entrepreneur and demand opportunistic financial terms in stage 2 is stronger

- the smaller the fraction p_H/p_L, i.e., the lower the benefit from high effort ($\pi X = (p_H - p_L)X$),
- the larger the rents the old investor is able to appropriate from the invention (ω), i.e. the less the innovation's property rights are protected or the larger are enforcement costs (or the weaker is patent law),
- the larger the share that the new investor demands for financing the second stage, q^{New}. This share increases as ω increases, i.e., the larger the rents the old investor is able to appropriate (or the weaker is patent law).

Proof: see (4) and (5).

The opportunity to steal the entrepreneurial idea strengthens the old investor's opportunistic incentive in two ways. First, the threat of "stealing the idea" improves the old investor's negotiation power directly. Second, there is an indirect effect: Because the cooperative surplus is shrinking, a new investor will demand terms which are less favorable to the innovator. It is even possible that the new investor is not willing to finance the second stage at all, that is if $I/2 \geq p_L(1-\omega)X$ holds. In this case the old investor has monopolistic power and might be able to appropriate the *entire* return in the second stage.

The investor's profit in the second stage influences the terms in the first stage. Since an investor who accompanied the venture in the first stage may receive a positive return in the second, all investors are willing to incur losses in the first stage when there is perfect competition among venture capitalists. Thus, financial terms are more favorable to the entrepreneur in the first stage than in the first best solution. Still, there is no effect on social welfare. Section 4.1 discusses this point in more detail.

Social surplus with stage financing amounts to:

(6.1) $Y_{E+Old} = -(1+p)I/2 + p(1+p_L)X$, if (5) holds

(6.2) $Y_{E+Old} = -(1+p)I/2 + p\left[(1+p_L+\pi)X - e_H\right]$, if (5) does not hold.

If (5) holds, social surplus is lower by $p(\pi X - e_H) > 0$. The question is how to overcome this social loss.

2.4 Optimal contract with verifiable outcome (milestone) *in t=1*

Result 2:

A binding long-term contract is optimal and achieves first-best when the terms of future rounds are *contingent* on the verifiable outcome in *t=1*. If the outcome is zero in *t=1*, the venture is terminated. If the outcome is *X*, the investor provides another *I/2* in *t=1* and receives the quota *q* on the returns in t=2 exceeding his debt claim *D = X*. The range of *q* that meets both the investor's participation constraint and the entrepreneur's incentive compatibility constraint is given by:

$$(7) \qquad \frac{I - pX}{p(p_L + \pi)X} = q_{VC}^{PC} \leq q < q_E^{IC} = 1 - \frac{e_H}{\pi X}.$$

Proof: see appendix.

One can also derive contingent contracts for straight equity or straight debt financing or convertible securities. Note that the terms of future rounds are already fixed in *t=0*, thus, they also bind the investor. In venture financing it is quite common to agree ex ante that the investor's residual cash-flow-rights are contingent on the venture's revenue or on non-monetary verifiable "milestones" in the previous stage (see Kaplan and Strömberg, 2003, pp. 292-295). In the literature, this contractual provision is considered to mitigate *entrepreneurial* moral hazard and to induce the entrepreneur to put more effort into the venture (see Sahlman, 1990, Black and Gilson, 1998). In our model, however, such a binding provision prevents *investor* hold up. Thus, the model can explain the wide use of contingent contracts in the venture capital industry – with *investor* opportunism due to weak intellectual property rights.

Even if the outcome in *t=1* is not directly verifiable we can use a contingent contract. An investor would only agree on financing the second stage if it pays for him to do so. Thus, the willingness to provide additional funds is a verifiable signal for the outcome in *t=1*. Then, the contract is not contingent on the outcome but on the second stage capital infusion.

3. Model 2: Contingent contracts when the venture capitalist is able to steal the idea during the contractual relationship

3.1 Related literature

Cornelli and Yosha (2003) analyze the situation in which an entrepreneur, interested in continuation, may engage in "window-dressing" and bias positively the short-term performance of the project. An appropriately designed convertible security prevents such behavior because window-dressing also increases the probability that the venture capitalist will exercise a conversion option and will receive a substantial fraction of the project's equity. Schmidt (2003) analyzes a double sided moral hazard problem where the effort choice of neither the entrepreneur nor the venture capitalist is verifiable. He shows that convertible preferred stock might provide optimal incentives. Berglöf (1994) and Bascha and Walz (2000) investigate conflicts of interest when a venture capitalist wants to sell his stocks and show that convertible preferred stock might be useful to mitigate these conflicts. No paper explains the use of convertible securities on the basis of weak intellectual property rights.

3.2 The model

So far, we have assumed that the investor is not able to steal the idea if he sticks with the entrepreneur since there is close monitoring and verification and enforcement costs are sufficiently low. Now, we assume that those costs are too high and stealing is not verifiable. The VC is able to steal the idea within the contractual relationship. The question now is: which financial contract is most suitable to first, prevent stealing and second, to induce the entrepreneur to work hard? We will investigate this issue in more detail. For this question we do not need neither the two stage framework nor the outside investor anymore. Stealing is possible also in a one stage setting. We slightly modify the set of assumptions of model 1:

The wealth-constrained entrepreneur E is endowed with an innovative project in *t=0*. The project requires a total investment of *I*. The return in *t=1* is verifiable and random and amounts to X_H or X_L ($0 < X_L < I < X_H$), with probability *p* and *(1−p)*, respectively.

Again, the return depends on the entrepreneur's non-verifiable effort level (*e*):

(1) $p = p(e)$ with $e = \{e_L, e_H\}$ with $e_L = 0$ and $e_H > 0$ and

$$0 < p(e = e_L) = p_L < p(e = e_H) = p_H = p_L + \pi < 1.$$

For simplicity, *e* also denotes the cost of effort. The cost of low effort (e_L) is set to zero. A high level of effort is still considered to be efficient, i.e. $e_H < \pi(X_H - X_L)$. Expected return amounts to $X_L + p(e)(X_H - X_L) > I$, that is, the venture has a positive net present value.

(*Lack of intellectual property rights protection*) Property rights on the innovation are not entirely protected, for reasons that were already mentioned when we presented the first model. The venture capitalist is able to partly use the idea for his own purposes even if the relationship with the entrepreneur is not terminated. To keep the model simple, the investor

can appropriate part of the return in *t=1* in the good state of nature but not in the bad one, i.e. $\omega p(e)X_H$, with $0 < \omega < 1$. Enforcing intellectual property rights does not pay: $c > \omega p(e)X_H$. There is a social loss from stealing the idea, e.g., special efforts by the investor to make the stealing non-verifiable or special efforts by the entrepreneur to monitor the investor or just the expected loss due to fact that a competitor might arise. The social loss amounts to $\alpha\omega p(e)X_H$ with $1 < \alpha < 1/\omega$. Thus, the outcome in *t=1* is reflected by the random variable $\tilde{X}$ with realisations $X \in [X_L; (1-\alpha\omega)X_H; X_H]$. Even with stealing, the entrepreneur might be willing to exert high effort, thus, we do not restrict the analysis similar to the condition (2.2).

First, the entrepreneur decides on the effort level. After that, the investor decides on whether to steal the idea or not. Figure 2 shows the structure of the model.

--Insert Figure 2 here --

In the first-best world a high level of effort can either be contracted upon or intellectual property rights are entirely protected. Social surplus amounts to:

(8) $\quad Y_{E+VC} = -I + X_L + (p_L + \pi)(X_H - X_L)$.

3.3 Optimal contract

We enrich the set of contracts by allowing for (a) straight debt, (b) straight equity (common stock), (c) a debt-equity contract and (d) convertible preferred stock.

- With straight debt, the investor has a fixed claim D^{str} with $X_L < D^{str} \leq (1-\alpha\omega)X_H$. There is default in the bad state of nature but not in the good one.

- With straight equity (common stock), the investor yields a quota q^{Com} on the return $\tilde{X}$ in *t=1*, the entrepreneur receives the share $1-q^{Com}$.

- With a debt-equity contract the incumbent investor holds both debt (or preferred stock with senior cash flow rights in liquidation) and common stock. For simplicity and to allow for comparison with convertible preferred debt, we consider a face value $D = X_L$. Due to the common stock component, the investor additionally receives a quota q^{DE} on the return in *t=1* that exceeds $D = X_L$. This contract is similar to the one considered in model 1.

- With convertible preferred debt, the investor receives a fixed claim $D = X_L$, if $X \leq (1-\alpha\omega)X_H$, else a quota of q^{Pre} on the return $\tilde{X}$ in *t=1* considering $q^{Pre} \geq \dfrac{D}{(1-\alpha\omega)X_H}$.[11]

Figure 3.1 – 3.4 show the venture capitalist's return with these four financial contracts.

-- Insert Figures 3.1 – 3.4 here --

[11] The quota has to be sufficiently large to give an incentive for conversion, i.e. $q^{Pre}(1-\alpha\omega)X_H \geq D$. Similar to convertible preferred stock, convertible debt also promises a fixed dividend until conversion. Unlike debt, preferred shares are more like equity in that they carry votes and that they do not trigger liquidation if the firms fails to pay the promised dividend. But, unpaid dividends accrue and are senior to the dividends of common stock. Convertible preferred debt and convertible preferred stock might also be treated differently under the tax regime, see Gilson and Schizer (2002). However, in our model these differences are not important and convertible debt and convertible preferred stock are equivalent.

We solve the model by backward induction, thus, first looking at the venture capitalist's incentives, second at the entrepreneur's effort decision.

Result 3.1:

The venture capitalist will not steal the idea if he has high powered incentives, for instance, with common stock (Com), with a debt-equity mix (DE) or with convertible preferred stock (Pref).[12] The investor's incentive compatibility constraint is met for the three forms of financing, if holds:

$$(9.1) - (9.3) \quad q^{Com} \geq q^{Com}_{IC(VC)} = \frac{1}{\alpha}, \quad q^{DE} \geq q^{DE}_{IC(VC)} = \frac{1}{\alpha}, \quad q^{Pref} \geq q^{Pref}_{IC(VC)} = \frac{\omega X_H + D}{X_H}.$$

For straight debt, the venture capitalist will always steal the idea because it does not reduce the individual return. Thus, straight debt at least incurs a social loss of $p(e) \cdot \alpha \cdot \omega X_H$. Proof: see appendix.

Result 3.2:

The entrepreneur will choose the high effort level if holds (for common stock (Com), for a debt-equity mix (DE), for convertible preferred stock (Pref) and for straight debt, respectively):

$$(10.1) \qquad q^{Com} \leq q^{Com}_{IC(E)} = \begin{cases} 1 - \dfrac{e_H}{\pi(X_H - X_L)} & , q^{Com} \geq \dfrac{1}{\alpha} \\ 1 - \dfrac{e_H}{\pi\left[(1-\alpha\omega)X_H - X_L\right)\right]} & , q^{Com} < \dfrac{1}{\alpha}. \end{cases}$$

[12] Convertible preferred stock and participating preferred debt are widely used according to Kaplan and Strömberg (2003). They note that participating preferred debt is similar to a debt-equity contract in the context of the model.

$$(10.2) \qquad q^{DE} \le q^{DE}_{IC(E)} = \begin{cases} 1 - \dfrac{e_H}{\pi(X_H - D)} & , q^{DE} \ge \dfrac{1}{\alpha} \\ 1 - \dfrac{e_H}{\pi\left[(1-\alpha\omega)X_H - D)\right]} & , q^{DE} < \dfrac{1}{\alpha}. \end{cases}$$

$$(10.3) \qquad \begin{cases} q^{Pref} \le q^{Pref}_{IC(E)} = 1 - \dfrac{e_H}{\pi X_H} & , q^{Pref} \ge \dfrac{\omega X_H + D}{X_H} \\ D \le \pi\left[(1-\alpha\omega)X_H\right] - e_H & , q^{Pref} < \dfrac{\omega X_H + D}{X_H}. \end{cases}$$

$$(10.4) \qquad D \le (1-\alpha\omega)X_H - e_H / \pi \,.$$

Proof: see appendix.

Result 4:

Considering the venture capitalist's participation constraint,[13] the incentive compatibility constraints for both parties hold under the following conditions for common stock (Com), for debt-equity (DE) and for convertible preferred stock (Pref) (note that straight debt does not meet the VC's incentive compatibility constraint):

$$(11.1) \qquad \frac{1}{\alpha} \le \frac{I}{X_L + (p_L + \pi)(X_H - X_L)} \le 1 - \frac{e_H}{\pi(X_H - X_L)},$$

$$(11.2) \qquad \frac{1}{\alpha} \le \frac{I - D}{(p_L + \pi)(X_H - X_L)} \le 1 - \frac{e_H}{\pi(X_H - D)},$$

$$(11.3) \qquad \omega + \frac{D}{X_H} \le \frac{I - (1 - p_L - \pi)D}{(p_L + \pi)X_H} \le 1 - \frac{e_H}{\pi X_H}.$$

Proof: see appendix.

[13] The entrepreneur's participation constraint is automatically fulfilled since we assume a zero discount rate and $e_L = 0$.

What can we derive form these formal terms? Obviously, we will not reach the first-best with straight debt since the venture capitalist certainly steals the idea. Graph 3.1 shows clearly that the return to the VC does not drop if he steals the idea. With all other financial contracts there is a drop, that is, there is a financial sanction to the VC if he steals and the firm's return decreases from X_H to $(1-\alpha\omega)X_H$. Thus, the first best is achievable in principle. Comparing debt-equity with pure equity (common stock), we see that the incentive compatibility constraints look the same (recall: $D = X_L$). However, the VC's participation constraint is less rigid with debt-equity: since the VC has a fixed claim, he asks for a lower share on the residual claim other things being equal. Thus, it might be easier with debt-equity than with pure equity to meet both the VC's participation and the entrepreneurial incentive compatibility constraint.

Now let us compare debt-equity and convertible preferred stock. First, with convertible preferred the VC's incentive compatibility constraint does not depend on α which indicates the social loss from IPR infringement. In cases where $q^{DE} < 1/\alpha$ and $q^{Pref} \geq \omega + D/X_H$ hold, convertible preferred stock provides right incentives for the VC but not debt-equity. The entrepreneur's incentives are the same as one can see after rearranging the terms (11.2) and (11.3). To sum up, convertible preferred stock might induce efficient behavior by *both* parties in some scenarios where debt-equity or pure equity do not. Thus, the model might explain the use of convertible preferred stock, but it also shows that other forms of equity-related financing and even pure equity might be suitable financing tools to overcome both moral hazard problems. In fact, Kaplan and Strömberg (2003) suggest that convertible preferred stock and debt-equity mixes are the most used financial instruments in the U.S. venture capital industry. In a sample of 200 financial contracts, in 43.5 % of all cases

VCs hold convertible preferred stock, in 37,5% they hold so-called participating convertible preferred which they characterize as follows: "As a result, participating convertible preferred is better categorized as a position of straight preferred stock and common stock."[14] According to Kaplan and Strömberg, preferred stock grants a senior cash flow right upon liquidation or exit und thus, participating convertible preferred is very similar to the debt-equity mix in our context.

A numerical example serves for clarification. Let us assume $I = 100$, $X_L = 20$, $X_H = 200$, $p_L = 0.5$, $\pi = 0.4$. Then, the entrepreneurial incentive compatibility constraint and the VC's participation constraints will be met if holds $e_H \leq 32.4$ and $e_H \leq 36.4$ for straight equity and debt-equity, respectively. If, for instance the (additional) cost of high effort amount to 34, debt-equity provides proper incentives but not straight equity. With convertible preferred stock, the constraint is the same: $e_H \leq 36.4$. However, in cases, where the welfare loss is not sufficiently big ($\alpha < 2.03$), debt-equity does not prevent the VC from stealing the idea, but convertible preferred is able to, if $\omega \leq 0.44$ holds.

4 Discussion

4.1 Model 1

With regard to the first model there might be other ways to mitigate the hold-up problem if the optimal contract is not feasible: (1) syndication and (2) debt financing.[15] With syndication, many investors provide funds (see Lerner, 1994 and

[14] Kaplan and Strömberg (2003), p. 288.

[15] Black and Gilson (1998) argue that venture capitalists will not act opportunistically for reputational concerns. However, the reputation mechanism may not work perfectly if the entrepreneur founds a

Gompers and Lerner, 1999). Possibly, it is easier to prove that one investor has stolen the idea if another investor can observe the business of the company. Thus, we shall expect that enforcement costs tend to be lower if there is another investor unless all investors collude at the cost of the entrepreneur. If there are more than two investors, monitoring costs might increase again, as it becomes more difficult for an individual or group to monitor the actions of all the group.

Another question is whether debt financing in the second stage might be useful. In this model, we would obtain similar qualitative results because the incumbent investor's incentive is still able to negotiate better terms in the second period due to the lack of intellectual property rights. There is, however, an important difference between equity and debt financing from a legal point of view. In many countries, such as in many U.S. states or in France, Germany and in the United Kingdom, there is an interest rate ceiling limiting the extent to which an inside investor could hold up an entrepreneur. At first glance, interest rate ceilings may be considered to be inefficient since it restricts bargaining and the set of possible negotiation outcomes. In our model, however, it limits the investor's discretion to behave opportunistically and thus, may induce the entrepreneur to invest efficiently.

If non-monetary milestones are not (indirectly) verifiable and there is no suitable contractual provision to prevent investor opportunism an entrepreneur might stay away from the venture capital market, even though the venture is valuable. Therefore, the model may explain why there is only very little financing by professional venture capitalists in the very first stages of ventures (see also Berglund and Johansson, 2000, and the empirical evidence given by EVCA, 2003 and NVCA,

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firm only once in a life time or if she cannot inform other potential entrepreneurs of investor opportunism at a sufficiently low cost.

2003). So far, the literature argues that the venture capital market does not work very well in these stages since the *venture capitalists* stay away due to severe problems of hidden information and entrepreneurial moral hazard (see *Amit et al.*, 1990). The threat of expropriation might induce entrepreneurs to seek early stage financing by family, friends and business angels, if they are regarded as being more trustworthy. Although there is only little empirical data on business angel financing, some scholars estimate that business angels invest two to ten times as much money as professional venture capital firms do (see Berger and Udell, 1998 and Lerner, 1998).

We assume that there is no effort choice in the first period. If so, investor opportunism in the second period tends to make financing cheaper in the first period – for instance, under the assumption that investors yield a zero profit. Both investors anticipate in $t=0$ that the one who finances in the first period will receive a rent in the second period. Expecting the rent in the second stage, they are willing to accept losses in the first. Both investors offer cheap financial terms in $t=0$ which might induce the entrepreneur to work harder in the first period. Thus, the welfare loss in the second stage might be offset by a welfare gain in the first period. However, if project's expected returns increase with the effort level at *diminishing* rates − and that seems to be plausible case − in total, we still expect a welfare loss.

4.2 Model 2

Syndication might also mitigate the stealing problem in the second model. Debt financing causes investor opportunism in model 2 and is not suitable. We assume that the VC can only appropriate rents in the good state of nature, but not in the bad one. This assumption is not restrictive. Moreover, we assume that effort level is not

verifiable, however, the VC can observe it. We do not really need the latter assumption since the VC has a dominant strategy once his incentive compatibility constraint is met. This is true for all forms of financing except for straight debt.

4.3 The role of patent law

The existence and the basic principles underlying patent law can be derived mainly from the trade-off between setting incentives to innovate − by giving exclusive property rights on the invention − and restricting the monopoly power due to a patent (see Besen and Raskind, 1991 and Cooter and Ulen, 2000).[16]

There are additional costs and benefits to patent law. Let us have a look at some of these costs, neglecting administrative costs. Usually, for instance in the U.S., the entrepreneur who files first for a patent receives it. This may induce inefficient patent races, i.e. several entrepreneurs working on the same invention may overinvest in effort, time and money, but only one obtains the "prize" (see Besen and Raskind, 1991 and Scotchmer, 1998). Additionally, too strong patent protection may hamper future research based on former patents. When an entrepreneur receives a too large portion of the returns on future investment, research may not be undertaken.

Of course, there are benefits to patent law besides providing incentives to innovate. Since disclosure of the invention is generally[17] required, it is possible that other firms can use this new information for their own purposes, save costs in production or open up revenue sources by developing a new product based on the invention. Given that

[16] The extent of monopoly power also depends on additional factors, for instance whether there is competition between different technologies (see Kitch, 1998, p. 14) or whether there are network effects which may stabilise monopoly power (see Farrell , 1995).

[17] Except for inventions where the state has an interest not to disclose, for instance inventions for military purposes.

only the first entrepreneur obtains the patent there is an incentive to invent quickly. Thus, new technology is likely to be transmitted quickly and at low costs (see Kitch, 1998). If there were no patent law the entrepreneur generally would have incentive to keep an innovation secret.

Because of this trade-off between different benefits and different costs, patents are restricted with respect to duration and scope.[18] Moreover, the invention has to meet certain requirements before the entrepreneur receives patent protection.

This article suggests there may be an additional benefit to patent law. The more inventions are covered by patent protection or the earlier they are covered, or the lower the enforcement costs the weaker is the investor's incentive to appropriate rents by renegotiating the contract. With such protection it becomes more likely that the entrepreneur chooses an efficient level of effort. This facilitates the financing and development of inventions.

In the European Union, the entrepreneur's property rights will only be protected, if the invention is (a) technical, (b) sufficiently developed, (c) novel and (d) non-obvious for an expert (see Art. 52-57 EPA (European Patent Agreement)). Some inventions may not meet all of these requirements and thus, property rights are not protected by patent law. If copyright law does not apply either, there is no protection of property rights except on a contractual basis. Apparently, this is different in the U.S. where there is some protection granted even for so-called *undeveloped* ideas.[19]

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[18] From an economic point of view the patent should be granted until the marginal social costs of the patent (due to monopoly power) equal the marginal social benefits (incentive to innovate), see Cooter and Ulen (2000) pp. 128f. The optimal patent duration should depend on the specific invention. However, most patent laws grant a fixed period, usually 20 years, for the U.S. see Barrett (1999), p. 21.

[19] See Barrett (1999), pp. 83-86. Basic requirements are ”novelty“ and „concreteness“, i.e. the idea should be sufficiently developed. These criteria are applied differently in different U.S. states.

Not all inventions meet all of the aforementioned requirements. We will not go into detail but briefly sketch problems regarding the requirements (b) “sufficiently developed” and (d) “non-obvious for an expert”. Condition (b) requires that an expert should be able to successfully carry out the invention using the description in the documents the entrepreneur has to provide for in filing. The basic reasoning behind the result of the invention should be made clear. Smaller shortcomings are tolerated, however, the invention must have been sufficiently tested already. In practice this requirement can be an obstacle for filing.

Condition (d) requires that the invention should be non-obvious to an expert of average proficiency and average knowledge. Some inventions which are beyond the state of the art but not sufficiently so, are excluded from patent protection. Of course it is hard to measure and judge whether an invention is obvious or not to an expert. Thus, it is not surprising that courts decisions and patent authorities on this criterion are sometimes considered to be hardly predictable. Hence, the entrepreneur may delay filing until the innovation is sufficiently developed. It is then more likely that it is considered to be non-obvious. However, when the entrepreneur waits she may run the risk of someone stealing the idea.

With copyright law, the requirements are (slightly) different, however, intellectual property rights protection is not perfect either. The law on intellectual property rights directly affects the parameter ω in our model. The parameter α that indicates the scale of welfare losses might be influenced by the level of IPR protection, but also by characteristics of the industry or the nature of the innovation. If patent or copyright law do not grant perfect protection against infringement the parties will try to find contractual solutions to minimize the social loss.

5. Conclusion

This paper presents two models that deal with the issue of weak intellectual property rights in the context of venture financing. Model 1 looks at stage financing. Possibly, the staging of capital is the most salient feature of venture financing. Staging may, however, induce investor opportunism. After the first stage, the investor may ask for a higher share of the future cash flows, threatening not to continue the venture. The entrepreneur may be forced to accept the investor's offer, when she will lose something by switching to another (new) investor. For instance, if the property rights on the invention are not protected – because the entrepreneur has not filed for a patent or the invention does not yet meet the legal requirements for patent protection – the incumbent investor might use the idea for his own purposes once the entrepreneur terminates the relationship. This threat might force the entrepreneur to continue although the incumbent investor demands a graeter share of the returns. As a consequence, she sticks with the incumbent investor, she might, however, choose an inefficiently low level of effort.

The hold-up-problem may be mitigated by contractual contingent provisions binding the investor. For instance, in venture financing it is quite common to agree ex ante that the investor's residual cash-flow-rights are contingent on the venture's revenue or on non-monetary verifiable "milestones" in the previous stage. So far, these provisions have been considered to mitigate *entrepreneurial* moral hazard.

The second model is a one-period model where the entrepreneur chooses his effort level first and then, the VC decides whether to steal the idea or not. We analyze under which circumstances financial contracts induce both parties to choose the

efficient decision. In some scenarios, convertible preferred stock turns out to outperform a debt-equity mix or straight equity. Straight debt is not efficient.

The impact of patent law is important. In the law and economics literature patent law is primarily seen as an instrument balancing the trade-off between setting incentives to innovate and limiting monopoly power of patent holders. It, however, overlooks the fact that an entrepreneur's idea often only develops to a market product with the help of investors providing financial resources. Thus, I argue that there is an additional goal of patent law. Patent law mitigates conflicts in the venture financing process thereby making innovations more likely.

Appendix

Proof of Result 2:

The entrepreneurial incentive compatibility constraint can be derived from (4.1). The entrepreneurial participation constraint is automatically met if the incentive compatibility constraint holds since we assume a zero discount rate and $e_L = 0$. The investor's participation constraint can be derived from:

$$(12) \quad -I + pD + p \cdot p(e) \cdot q_{VC}^{PC}(2X - D) + p(1 - p(e))q_{VC}^{PC}(X - D) \geq 0,$$

where *D* denotes the investor's fixed claim and *q* reflects the investor's quota on the return exceeding *D*. Since we assume $D = X$ and since $p(e) = p_H = p_L + \pi$ holds in equilibrium, rearranging yields:

$$(12.1) \quad q_{VC}^{PC} \geq \frac{I - pX}{p(p_L + \pi)X}.$$

Proof of Result 3.1:

With common stock, the venture capitalist has no incentive to steal the idea and to appropriate an expected rent of $p(e) \cdot \omega \cdot X_H$, if holds:

$$(13.1) \quad p(e)\omega X_H + q^{Com}\left[p(e)(1 - \alpha\omega)X_H + (1 - p(e))X_L\right] \leq q^{Com}\left[p(e)X_H + (1 - p(e))X_L\right].$$

Note that *p(e)* is given since the entrepreneur moves first. With debt-equity, the venture capitalist's incentive compatibility constraint is reflected by:

$$(13.2) \quad p(e)\omega X_H + D + p(e)q^{DE}\left[(1 - \alpha\omega)X_H - D\right] \leq D + p(e)q^{DE}\left[X_H - D\right].$$

With convertible preferred stock, the venture capitalist has proper incentives if holds:

(13.3) $p(e)\omega X_H + D \le p(e) \cdot q^{Pref} \cdot X_H + (1 - p(e))D$.

Rearranging (13.1) to (13.3), we yield the inequalities given in (9.1) − (9.3). With straight debt, the investor's incentive compatibility constraint is not met, since there is no benefit to the venture capitalist from not behaving opportunistically:

(13.4) $p(e)\omega X_H + D \le D$ does not hold due to $p(e) > 0$, $\omega > 0$, $X_H > 0$.

Proof of Result 3.2:

Let us first deal with the case that the venture capitalist's incentive compatibility constraint holds such that he does not steal the idea. With common stock, the entrepreneur works hard, if holds:

(14.1) $(1 - q^{Com})\left[(p_L + \pi)X_H + (1 - p_L - \pi)X_L\right] - e_H \ge (1 - q^{Com})\left[p_L X_H + (1 - p_L)X_L\right]$.

With debt-equity, the entrepreneur's incentive compatibility constraint is reflected by (note: $D = X_L$):

(14.2) $(1 - q^{DE})\left[(p_L + \pi)(X_H - D)\right] - e_H \ge (1 - q^{DE})p_L(X_H - D)$

With convertible preferred stock, the entrepreneur has proper incentives if holds:

(14.3) $(1 - q^{Pref})(p_L + \pi)X_H - e_H \ge (1 - q^{Pref})p_L X_H$.

Rearranging (14.1) to (14.3), we yield the inequalities given in (10.1) − (10.3). If the venture capitalist steals the idea, the return in the good state of nature drops from

X_H to $(1-\alpha\omega)X_H$ and the entrepreneurial incentive compatibility constraints change as indicated by the second line in (10.1) − (10.3). Note that in this case, the VC has a fixed claim with convertible preferred stock (no conversion) With straight debt, however, the venture capitalists definitely will steal the idea and, thus, the entrepreneur only works hard if holds:

(14.4) $(p_L+\pi)\left[(1-\alpha\omega)X_H-D\right]-e_H \geq p_L\left[(1-\alpha\omega)X_H-D\right].$

Proof of Result 4:

The venture capitalist's participation constraints, that is zero profit, for common stock (Com), for a debt-equity mix (DE) and for convertible preferred stock (Pref) considering a high entrepreneurial effort level are reflected by (15.1) − (15.3):

(15.1) $$I = q_{PC(VC)}^{Com}\cdot\left[X_L+(p_L+\pi)(X_H-X_L)\right],$$

$$\text{thus:}\quad q_{PC(VC)}^{Com}=\frac{I}{X_L+(p_L+\pi)(X_H-X_L)},$$

(15.2) $$q_{PC(VC)}^{DE}=\frac{I-D}{(p_L+\pi)(X_H-D)},$$

(15.3) $$q_{PC(VC)}^{Pref}=\frac{I-(1-p_L-\pi)D}{(p_L+\pi)X_H}.$$

Figures

Figure 1: Stage financing: sequence of events

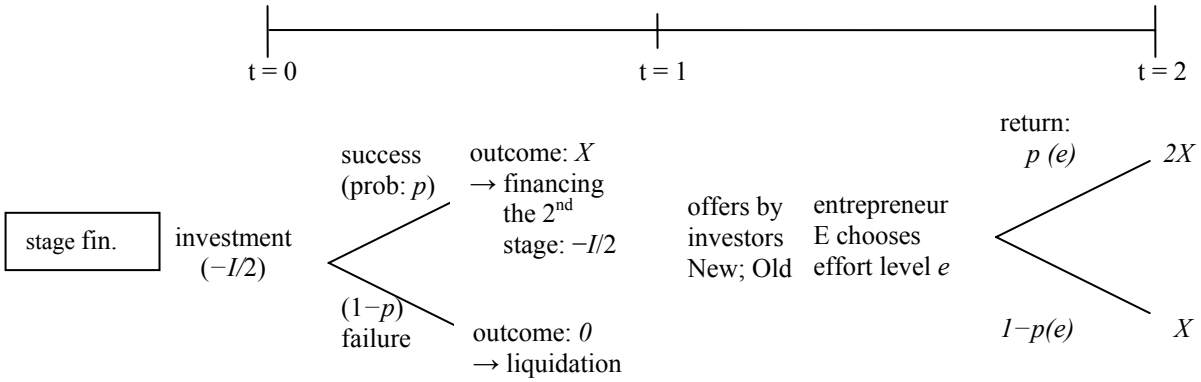


Figure 2: Sequence of events in model 2

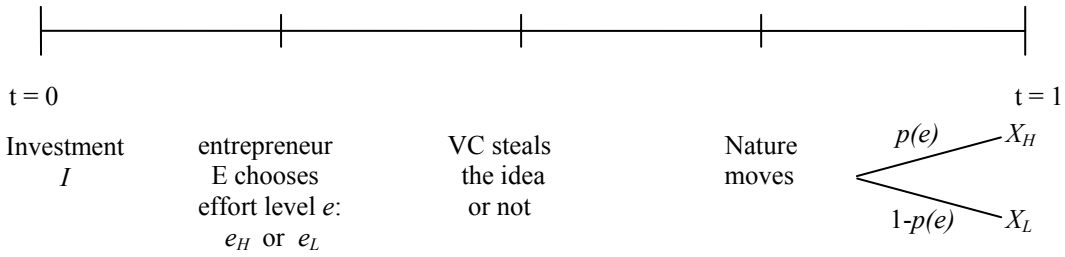
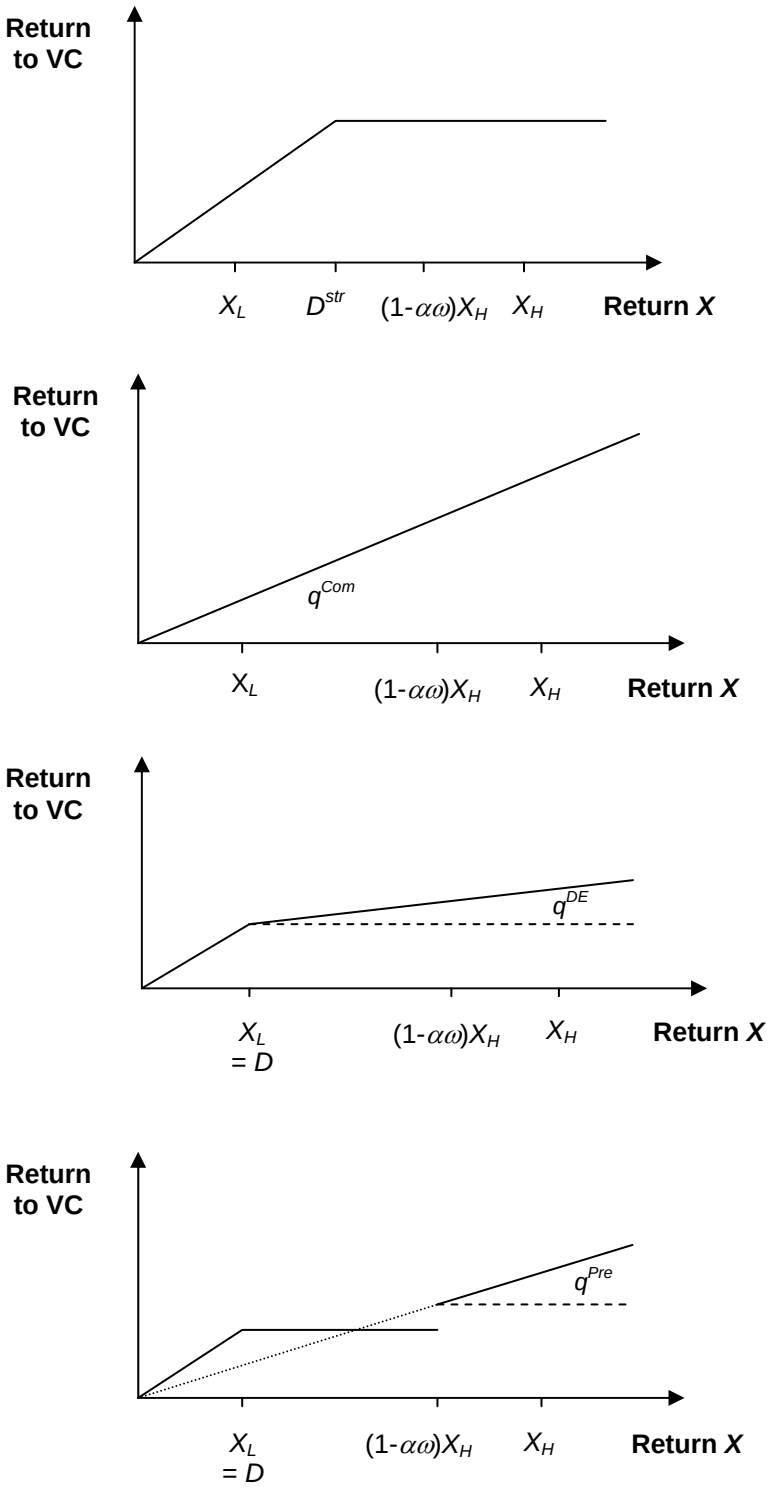


Figure 3.1 − 3.4: Return to the venture capitalist with straight debt, common stock, debt-equity and convertible preferred stock



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