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Staging of Venture Financing, Investor Opportunism, and Patent Law

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Abstract:

Ventures are often financed in several stages. Stage financing provides a real option valuable when facing external uncertainty. However, stage financing may also induce investor opportunism, if the property rights on an invention are not sufficiently protected. We look at the case where the incumbent investor demands a greater share on the venture's return before financing the next stage. If the entrepreneur does not agree, the investor might use the idea for his own purposes. This threat may force the entrepreneur to continue under less favorable financial terms. As a consequence, however, she might choose an effort level that is too low (*underinvestment*).

Investor opportunism is less likely to occur, if investor's residual cash-flow-rights are contingent on verifiable "milestones" in the previous stage. Such provisions are quite common.

The impact of patent law is important. So far, it has primarily been seen as an instrument balancing the trade-off between setting incentives to innovate and limiting the monopoly power of patent holders. I argue there is an additional goal of patent law: Namely, mitigating conflicts of interest in the venture financing process, thereby making innovations more likely.

Staging of Venture Financing, Investor Opportunism, and Patent Law

1. Introduction

One salient feature of venture financing is the staging of capital infusions (*Sahlman*, 1990, *Gompers/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/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.

The staging of capital, however, may also induce *investor* opportunism. When the entrepreneur and the investor renegotiate the terms of the financial contract before a new stage is financed the investor may appropriate rents, knowing the entrepreneur will lose something when she would switch to another, new investor. There are several reasons why the entrepreneur may lose. *First*, the entrepreneur may (partly) lose the benefits of specific investments, *e.g.* the human capital she contributed. *Second*, switching to a new investor may cause her to incur transaction costs, for instance, search costs and costs to overcome informational asymmetries. *Third*, the entrepreneur may lose some private, non-monetary benefits from running the venture. Maybe a new investor would restrict entrepreneurial actions, especially when the new investor assumes that poor entrepreneurs are more likely to switch than good ones. *Fourth*, if the entrepreneur failed to file for patent protection, or if patent protection is not yet available since the invention does not entirely meet the legal requirements of patent law, or if intellectual property rights are not sufficiently protected by other means (e.g., by trade secrets) - maybe due to problems of enforcement - the entrepreneur has to take into account the possibility that the investor may "steal" the idea and use it for his own purposes or the purposes of other ventures in which he has a stake.

This paper focuses on the fourth point, i.e. on the investor hold-up problem due to weak patent protection. The threat of theft may force the entrepreneur to stick with the incumbent investor although he demands a higher share. As a consequence,

however, she may reduce her non-contractible effort level even it is not efficient to do so (*underinvestment*). Stage financing might induce costs due to the investor hold-up problem, as well as the low entrepreneurial effort level which may potentially arise therefrom.

In the case of *full financing* the hold-up problem does not arise, since the investor binds himself to complete the venture if it is reasonable. With full financing the investor provides all the money right at the beginning of the venture and the parties enter a long-term contract. However, full financing does not make use of the option to exit that is especially valuable in the face of much external uncertainty. Thus, full financing induces costs as well. If the cost due to investor opportunism exceeds the benefits due to the option to exit, the parties will choose full financing in equilibrium, otherwise stage financing. Stage financing is more beneficial the more valuable is the option to exit, that is, the less precise one can predict how market demand will develop and competitors may emerge. Full financing is more likely to be chosen when the protection of intellectual property rights is weaker, i.e. when an idea is less developed or there are higher enforcement costs.

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).

The impact of patent law is important. In the law and economics literature patent law is primarily seen as an instrument balancing the trade-offs between setting incentives to innovate and the need to limit the monopoly power of patent holders (see *Kitch*, 1998, *Cooter/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.

This paper distinguishes itself from the venture capital literature in several ways. First, it shows that stage financing might induce *costs*, whereas the literature stresses its benefits (see *Sahlman*, 1990, *Gompers/Lerner*, 1999). It also shows that there might be trade-offs between stage financing and full financing. Second, it provides a new explanation for contingent cash-flow rights. Third, it looks at investor moral hazard only, whereas the literature focuses mainly on opportunistic behavior by a

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. *Cornelli/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. Finally, *Admati/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/Pfleiderer* do not study hold-up by the lead-investor, they mention the possibility of it transpiring.[2]

In what follows, we present a model in section 2 showing when stage financing may be beneficial, as well as when full financing may be preferable. Full financing may be preferable when the incumbent investor can extract rents due to weak intellectual property rights. A long-term contingent contract turns out to be efficient. Section 3 shows the economics of patent law and provides a closer look at the requirements for patent protection. Section 4 serves as a conclusion.

2. A model on investor opportunism due to weak protection of intellectual property rights

2.1 Assumptions

We set out the following three sets of assumptions (M1) to (M3).

(M1) (*Set of investment strategies*) A wealth–constrained, risk-neutral entrepreneur E needs funds for developing an innovation which takes two periods. A fixed investment of $2I$ $(I > 0)$ is required in order to fully develop the innovation.

Monetary returns are verifiable and occur in $t=1$ and $t=2$. In either stage, returns amount to X or 0 $(X > I > 0)$, with probability p and $(1-p)$, respectively. If there is zero return 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. If the venture

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[2] *Admati/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."

has succeeded at the first stage (return of *X*), the probability of receiving an additional *X* in stage 2 depends on the entrepreneur's effort level (*e*):[3]

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

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

For simplicity, *e* also denotes the cost of effort. The cost of low effort (e_L) is set to zero. With $0 < e_L < e_H$, we obtain very similar qualitative results, the presentation becomes more complex, though. To keep the model simple, we neglect effort choice in the first stage (see discussion in section 2.4).

According to (1), there are three possible outcomes in *t=2*: either *2X* (probability: $p \cdot p(e)$), or *X* (probability: $p \cdot (1 - p(e))$) or *0* (probability: *1- p*). Expected return amounts to $p[1 + p(e)]X$.

It is favorable to undertake the venture even with a low level of effort, i.e., it holds:

(2.1) $p(1 + p_L)X > 2I.$

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.:[4]

(2.2) $e_H < (p_H - p_L)X = \boldsymbol{p}X.$

The effort level is not contractible, maybe because third parties such as a court cannot verify it (at sufficiently low costs).

(M2)   (*Set of financing strategies*) The risk-neutral investors Old and New are able to contribute funds in *t=0* and/or *t=1*. There is strong competition among investors, such that the cooperative surplus entirely goes to the entrepreneur. There are two ways of finance:

- In the case of *full financing* (index: *FF*) one investor contributes the investment *2I* entirely in *t=0*. The entrepreneur accepts the more favorable offer. In the case of equal financial terms she chooses the offer by Old.

- In the case of *stage financing* (index: *SF*) the initial investor Old provides *I* in *t=0* and possibly, an additional capital infusion of *I* in *t=1*, if the entrepreneur yielded a high return of *X* in the first stage. If not, it does not pay to continue the venture. Old then saves the second investment in *t=1*, due to the exit option.

  In *t=1*, the entrepreneur might also accept the offer by New if it is more favorable to her.

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[3] 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.

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

Full and stage financing lead to the same *gross* returns, if the effort level is not affected - with stage financing, however, the investment is split. Since venture financing is often equity-linked, we consider equity financing:[5] In the case of full financing, an investor receives the quota q^{FF} on the overall return (with $0 < q^{FF} \leq 1$). In the case of stage financing, the quota is q_t^{SF} on the return of the stage the investor has financed ($0 < q_t^{SF} \leq 1$, $t = 1,2$). Entrepreneur E receives $1 - q^{FF}$ $(1 - q_t^{SF})$. The parties agree both upon the quota and the type of financing in the contract in $t=0$.

(M3) (*Lack of patent 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 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. Investor Old, who has experienced the progress of the innovation at the first stage, might partly use the idea for his own purposes if the relationship with the entrepreneur is terminated in $t=1$. In the case of termination, Old receives a fraction **w** of the innovation's second stage value, i.e. $w \times (p(e)X - I)$, with $0 < w < 1$. One can imagine that the fraction **w** may increase as the cost to enforce intellectual property rights increases, that is $w = w(c)$ with $dw(c)/dc > 0$.

We are looking at the case

(2.3) $\quad c > w \times (p(e)X - I),$

that is, where enforcement costs are too high.[6] If the entrepreneur switches to investor New in $t=1$, the cooperative surplus is then reduced to $(1 - w)(p(e)X - I)$. If she sticks with the incumbent investor Old, enforcement costs are lower since the entrepreneur can observe and control for them much more easily; (2.3) does not hold.[7] (2.3) does not hold either for full financing where the entrepreneur sticks with the incumbent investor entirely for the two periods.

Cases. The entrepreneur exerts a high level of effort at the second stage if her fraction of the second stage cash flow is sufficiently large, i.e. if the investor's quota q is small enough:

(3.1) $\quad (1-q)pX \geq e_H - e_L = e_H \qquad$ or $\qquad q \leq q^* = 1 - \dfrac{e_H}{pX}$.

In order to yield a zero surplus, the quota an investor demands is equal to:

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[5] See for a similar assumption *Kirilenko* (2001). In section 2.3, we discuss other standard financial contracts such as debt and debt-equity mixes.

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

[7] There are two other cases: (2.3) holds with both stage and full financing, that is, the investor will appropriate rents anyway. Stage financing is preferable then, since it offers the option to exit. (2.3) does not hold, neither with both stage nor with full financing. The investor will not appropriate rents. Again, stage financing is preferable.

(3.2) $\quad I = q(p_L + \boldsymbol{p})X \qquad\qquad$ or $\qquad q = \dfrac{I}{(\,p_L + \boldsymbol{p}\,)X}$.

If the investor does not demand a larger quota than (3.1), the entrepreneur will exert a high level of effort. In what follows we assume that this holds (else there is low level of effort even in the case where intellectual property rights are strongly protected):

(4) $\qquad \dfrac{I}{p_H X} = \dfrac{I}{(\,p_L + \boldsymbol{p}\,)X}$ £ $q^* = 1 - \dfrac{e_H}{\boldsymbol{p}X}$.

Graph 1 shows the structure of the model.

Graph 1: Structure of the model with stage financing and full financing
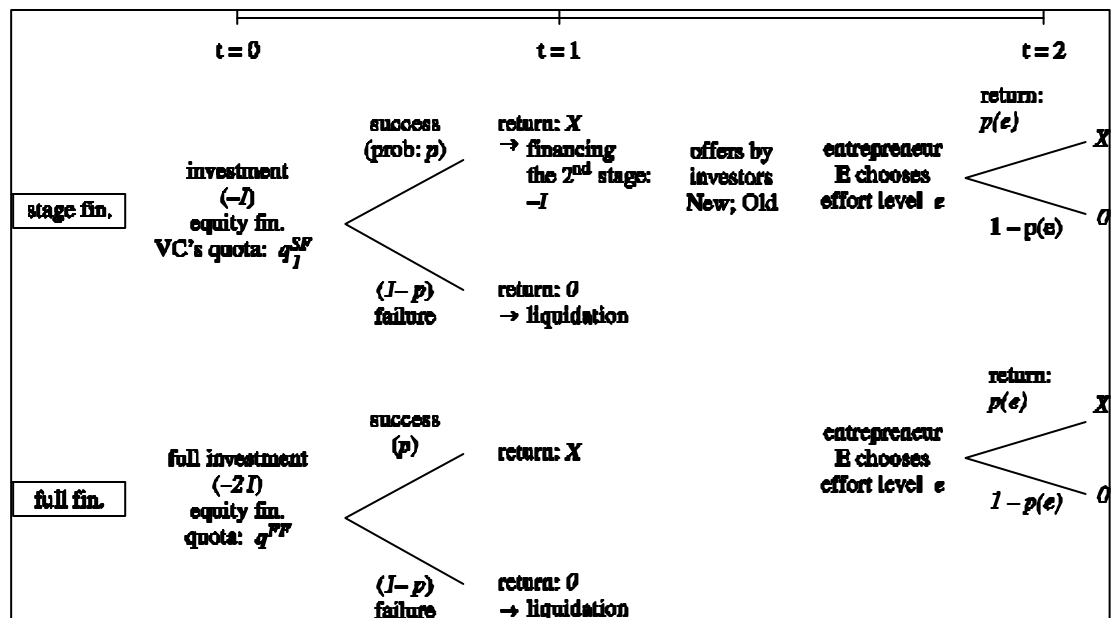
2.2 Analysis

2.2.1 First-best solution

In the first-best world a high level of effort can either be contracted upon or intellectual property rights are entirely protected. Due to (4) the entrepreneur chooses the high level of effort. Compared to full financing, there is no cost to stage financing, but a benefit. Staging allows the saving of part of the investment when the bad state of nature occurs in $t=1$ – with probability $1-p$. Social surplus amounts to (Y_E, Y_{Old} denote the individual surplus of the entrepreneur and incumbent investor, respectively):

(5) $Y_{E+Old} = Y_E + Y_{Old} = -(1+p)I + p[(1+p_H)X - e_H]$.

However, due to assumption (M1) *and* (M3) effort is not contractible and intellectual property rights are not sufficiently protected. With stage financing, the incumbent investor may hold-up the entrepreneur threatening to steal the idea. The hold-up problem weakens the entrepreneur´s incentives to work hard. With full financing the investor does not steal and there is no hold-up problem. Thus, effort level is supposed to be high. However, since total investment is sunk in $t=0$ full financing does not allow the saving of part of the investment when the bad state of nature arises in $t=1$. In the following sections 2.2.2 and 2.2.3 we derive individual surpluses and social surplus with full and stage financing.

2.2.2 Full financing

Under full financing the parties write a long-term contract and Old invests all the money ($2I$) in $t=0$ and accompanies the venture until $t=2$. Old is not able to extract rents from stealing the idea (see M3). Since total investment is sunk in $t=0$, there is no value to the option to exit if the bad state of nature realizes in $t=1$. The investor's surplus is equal to:

(6) $Y_{Old} = -2I + q^{FF}p(1 + p_H)X$,

assuming that the investor's quota is sufficiently low and incentive-compatible:

(7) $q^{FF} = \dfrac{2I}{p(1+p_H)X} \pounds q^*$.

If (7) does not hold (maybe because the probability of success in the first stage, p, is sufficiently low), entrepreneur E is not willing to exert a high level of effort even

with full financing. If (7) holds E chooses a high effort level. Social surplus amounts to:

(6.1) $Y_{E+Old} = -2I + p[(1+p_H)X - e_H]$, if (7) holds ($q^{FF} \pounds q^*$),

(6.2) $Y_{E+Old} = -2I + p(1+p_L)X$.   , if (7) does not hold.

Result 1:

Compared to the first-best scenario, social surplus is lower by *(1- p)I* since investor Old contributes a higher investment volume than in the first-best case. If (7) does not hold, the entrepreneur does not exert a high level of effort and social surplus is even lower by an amount $p(\boldsymbol{p}X - e_H)$.

2.2.3 Stage financing

With stage financing the incumbent investor who financed the first stage may take advantage of the weak intellectual property rights in period 2. The old investor may credibly threaten to appropriate rents if the entrepreneur switches to another new investor. How much he can extract from this threat depends on the entrepreneur's outside option, i.e. on the terms a new investor would offer. Investor New takes into account that cooperative surplus may be reduced by the amount $\boldsymbol{w}[p(e)\cdot X - I]$ according to assumption (M3). Thus, in order to earn a zero profit, New demands for the second-stage investment:

(8) $q_2^{New} = \dfrac{I}{p(e)X - \boldsymbol{w}[p(e)X - I]}$.

Obviously, the entrepreneur will only exert a high level of effort if New's fraction q_2^{New} does not exceed the threshold level *q** according to (3.1), that is if the following holds:

(9) $\dfrac{I}{p_H X - \boldsymbol{w}(p_H X - I)} \pounds q^* = 1 - \dfrac{e_H}{\boldsymbol{p}X}$ or rearranging:

$\boldsymbol{w} \pounds w^* = \dfrac{p_H X}{p_H X - I} - \dfrac{I\boldsymbol{p}X}{(\boldsymbol{p}X - e_H)(p_H X - I)}$.

Thus, if the old investor were be able to expropriate a larger fraction than *w** from the project's net present value, an entrepreneur would *not* choose the efficient effort
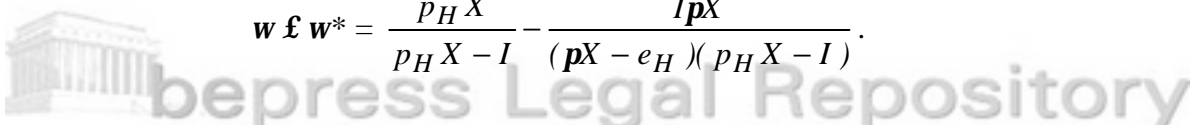
level. Note that **w** tends to increase as intellectual property rights are less protected or as enforcement costs increase.

We can distinguish between two cases: First the share demanded by New exceeds q^* in (3.1) (i.e., $w > w^*$), second it does not ($w \pounds w^*$). In the latter case the entrepreneur will exert a high level of effort (probability of success: $p(e) = p_H$), in the former she will not ($p(e) = p_L$). Let us take a closer look at the more interesting first case.[8] Thus, New demands a share of:

$$(10) \qquad q_2^{New} = \frac{I}{p_L X - w(\, p_L X - I\,)}.$$

Still, the entrepreneur prefers to stick to the old investor if (11) holds:

$$(11) \qquad (\,1 - q_2^{Old}\,)p_L X \geq (\,1 - q_2^{New}\,)[p_L X - w(\, p_L X - I\,)] \qquad \text{or, by rearranging:}$$

$$q_2^{Old} \leq q_2^{New} + \frac{(\,1 - q_2^{New}\,)w(\, p_L X - I\,)}{p_L X}.$$

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 ($q^* < q_2^{Old}$) the entrepreneur is willing to exert a high level of effort, that is the "size of the pie" is larger. Hence, Old compares his *individual* surplus for the opportunistic bid $q_2 = q_2^{Old}$ with the surplus for the incentive compatible bid $q_2 = q^*$. The old investor tends to demand q_2^{Old} if (12) holds:

$$(12) \qquad -I + q_2^{Old} p_L X > -I + q^* \cdot p_H X \qquad \text{or:}$$

$$q_2^{Old} > q^*(p_H/p_L).$$

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[8] In the second case, New expects a high level of effort. Thus, p_L in (10) is to be replaced by p_H and New offers more favorable terms to the entrepreneur than in the first case. Still the old investor could hold-up the entrepreneur, however, to a lesser extent. If the opportunistic quota of Old exceeds the incentive compatible quota q^* and if Old is better off with the opportunistic quota, the entrepreneur will also not exert a high effort level in the second case.

Result 2:

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 ($\boldsymbol{p}X = (p_H - p_L)X$),

- the larger the rents the old investor is able to appropriate from the invention ($\boldsymbol{w}$), i.e. the less the innovation's property rights are protected or the larger are enforcement costs,

- the larger the share that the new investor demands for financing the second stage, q_2^{New}. This share increases as $\boldsymbol{w}$ increases, i.e., the larger the rents the old investor is able to expropriate.

We can derive the last two statements from (11) by looking at the partial derivatives:

$$(13) \qquad \frac{\partial q_2^{Old}}{\partial \boldsymbol{w}} > 0 \quad \text{and} \quad \frac{\partial q_2^{Old}}{\partial q_2^{New}} > 0.$$

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. In this case the old investor is able to appropriate the *entire* cooperative surplus in the second stage.

How does this affect the entrepreneur´s effort level? If the old investor asks for a higher share in the second stage the entrepreneur is more likely to underinvest. Thus far, we have been investigating the case, where the share demanded by the new investor New exceeds the threshold q^* in (3.1) (i.e., if $\boldsymbol{w} > \boldsymbol{w}^*$ holds). Then, entrepreneur E underinvests for sure, since Old demands an even larger share according to (11). In the second case ($q_2^{New} £ q^* \text{ or } \boldsymbol{w} £ \boldsymbol{w}^*$), underinvestment may not necessarily occur, it becomes, however, more likely the less the innovation's property rights are protected.

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.

If the hold-up problem does not affect the entrepreneurial level of effort − because the rent the incumbent investor can appropriate is too small ((12) does not hold) − the first-best scenario is still achievable. Stage-financing then outperforms full financing. However, if the problem of expropriation is too severe ((12) holds), the entrepreneur will exert a low level of effort. Social surplus with stage financing amounts to:

(14.1) $Y_{E+Old} = - (1+p)I + p(1 + p_L)X$, if (12) holds

(14.2) $Y_{E+Old} = - (1+p)I + p((1+ p_L + \boldsymbol{p})X - e_H)$, if (12) does not hold.

If (12) holds, social surplus is lower by $p(\boldsymbol{p}X - e_H)$.

Result 3:

If the entrepreneur might not exert a high level of effort in the second stage with stage financing, full financing might be preferable, if social losses are lower, that is, if (7) and (12) and (15) hold:

(15) $(1-p)I < p(\boldsymbol{p}X - e_H)$.

If either (7), (12) or (15) does not hold stage financing outperforms full financing.

Since the investor yields zero profit by assumption (M2) the entrepreneur's fraction of the project's equity is larger with stage financing if (7) or (12) or (15) does not hold. The following table shows the optimal form of financing and social welfare in the different scenarios.

Table 1: The choice between stage financing and full financing in different scenarios

Condition (7) (entrepreneurial effort choice with **full financing**)	Condition (12) (**stage fin**.: terms chosen by Old and effort choice)	Condition (15) (welfare loss with full stage financing)	Preferable form of financing
(7) does not hold: low effort with full financing	(12) does not hold (high effort with stage fin.)	——	Stage financing (welfare loss: 0)
	(12) holds (low effort with stage fin.)		Stage financing (loss: $p(\boldsymbol{p}X - e_H)$)
(7) holds: high effort with full financing	(12) does not hold: high effort	——	Stage financing (loss: 0)
(7) holds: high effort	(12) holds: low effort	(15) does not hold: welfare loss larger with full financing	Stage financing (loss: $p(\boldsymbol{p}X - e_H)$)
(7) holds: high effort	(12) holds: low effort	(15) holds: welfare loss larger with stage financing	Full financing (loss: $(1-p)I$)

Condition (7): shows the critical investor's fraction of the project's equity (in $t=0$) which induces the entrepreneur to work hard under *full financing*.

Condition (12): shows when the incumbent investor Old demands "opportunistic" financial terms in $t=1$ with *stage financing* (instead of incentive compatible terms).

p: (success) probability of a high return X; $1-p$ is the probability of failure (zero return)
I: investment volume sunk with full financing
$\boldsymbol{p}$: additional probability of yielding a high return X if high effort is chosen
e_H: additional costs for entrepreneur when choosing high effort

2.3   Optimal contract

So far we considered only two types of contract: full financing and stage financing. We now introduce a third form: a binding long-term contract where the terms of future rounds are *contingent* on the outcome in $t=1$. 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.[9] In the literature, this contractual provision is considered to mitigate *entrepreneurial* moral hazard and induce the entrepreneur to put more effort into the venture (see *Sahlman*, 1990, *Black/Gilson*, 1998). In this model, however, hold up by the *investor* may be eliminated by such a binding provision.

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[9] See *Kaplan/Strömberg* (2003), pp. 292-295.

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Result 4:

The optimal contract is long-term and contingent on the outcome in *t=1*. If the entrepreneur achieves the verifiable return *X* in *t=1*, the investor receives a quota in the second round that does not exceed the incentive compatible quota *q**. If the return is zero in *t=1*, the venture is terminated. This contract achieves the first-best solution.

The parties first benefit from the option to exit and second, mitigate the hold-up problem in the second stage. Thus, the model can explain the wide use of contingent contracts in the venture capital industry[10] – with *investor* opportunism and weak intellectual property rights.

Note that this contract also works if there is no monetary return in *t=1* but a verifiable, non-monetary breakthrough in *t=1* (*milestone*). 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.

If milestones are *not* verifiable, a contingent contract is not possible and the investor may still hold up the entrepreneur in the second stage. In this case the analysis in 2.2 applies. Under certain conditions, full financing outperforms stage financing then.

2.4 Discussion

If the optimal contract is not feasible there might be other ways to mitigate the hold-up problem: (1) syndication and (2) debt financing.[11] With syndication, many investors provide funds (see *Lerner*, 1994 and *Gompers/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.

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[10] See *Kaplan/Strömberg* (2003), pp. 292-295.

[11] *Black/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 firm only once in a life time or if she cannot inform other potential entrepreneurs of investor opportunism at a sufficiently low cost.

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Another question is whether debt or hybrid financing might be useful. The incumbent investor's incentive to negotiate better terms in the second period is due to the lack of intellectual property rights protection and not to the type of financing- also due to the specification of the pay-off structure. The choice of effort level is, nevertheless, efficient with non-risky debt financing. However, non-risky debt financing is usually not possible with ventures. Thus, even with debt financing or mixed financing we would obtain similar qualitative results. 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 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/Johansson*, 1999 and the empirical evidence given by *EVCA* (2002) and *NVCA* (2001)). 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/Glosten/Muller*, 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/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 – 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.

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/Raskind*, 1991 and *Cooter/Ulen*, 2000).[12]

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/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[13] 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 only the first entrepreneur obtains the patent there is an incentive to invent quickly. Thus, new technology is likely to be transmitted quite 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 kinds of benefits and different kinds of costs, patents are restricted with respect to duration and scope.[14] 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

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[12] 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)).

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

[14] 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/Ulen* (2000), pp. 128f. Of course, 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.

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.[15]

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.

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[15] 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.

4.   **Conclusion**

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 higher 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 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.

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 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.

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