

Staging of Venture Financing, Moral Hazard, and Patent Law

Jochen Bigus*

University of Hamburg,

Institute for Law and Economics

July, 8th, 2002

Abstract: The literature on venture financing mainly focuses on entrepreneurial moral hazard. The investor, however, may behave opportunistically, too. We look at the case where the investor demands a higher share on the venture's return before financing the next stage. Possibly, the staging of capital is the most salient feature of venture financing. The entrepreneur may be forced to accept the investor's offer, when she is supposed to lose something by changing the investor.

For instance, if the property rights on the invention are not sufficiently protected – because the entrepreneur has not filed for a patent or the invention does not meet the legal requirements for patent protection – the investor may use the idea for his own purposes once the entrepreneur terminates the relationship. This threat may force the entrepreneur to continue although the investor demands a higher share. As a consequence, she sticks with the investor, however, she may not choose the efficient level of specific investments, rather she underinvests.

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: mitigating conflicts in the venture financing process thereby making innovations more likely.

JEL-Classification: G 24, K 11, G 32, G 31

Keywords: venture capital, stage financing, moral hazard by investor, patent law

*Dr. Jochen Bigus, Assistant Professor, University of Hamburg, Institute for Law and Economics, Edmund-Siemers-Allee 1 (Flügelbau West), 20146 Hamburg, j-bigus@jura.uni-hamburg.de. For helpful discussions and comments on earlier drafts I would like to thank Hans-Peter Grüner, University of Mannheim, Tina Heubeck, University of Hamburg and participants of the Economics seminar, the seminar on Law and Economics and the seminar on Banking at Finance at the University of Hamburg. Financial support by the Deutsche Forschungsgemeinschaft, Bonn, Germany, is gratefully acknowledged.

Staging of Venture Financing, Moral Hazard, and Patent Law

1. Introduction

One salient feature of venture financing is the staging of capital infusions.¹ There are two benefits of staging both due to the “option of waiting”. 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 emerge suddenly. The option to stop is valuable to both the investor and the entrepreneur. Second, the staging of capital allows to mitigate opportunistic behavior by the entrepreneur.² Since the entrepreneur usually hardly provides funds by her own she may be interested in continuation although the termination of the venture would be efficient, for instance when she receives a private benefit from running the venture.³ The option to wait is valuable to the investor.

The staging of capital, however, may also induce opportunistic behavior by the *investor*. When entrepreneur and investor renegotiate the terms of the financial contract before a new stage is financed the investor may expropriate rents knowing the entrepreneur will lose when she would terminate the relationship and choose 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. her human capital she contributed, her effort for providing information and developing prototypes to make the (old) investor agree on the continuation of the venture. *Second*, transaction costs may occur when the entrepreneur looks for a new investor. They may be both non-monetary (stress, uncertainty) and monetary, for instance, costs of searching and costs to overcome informational asymmetries.⁴ *Third*, the entrepreneur may lose some private, non-monetary benefits when she switches to another investor. Maybe a new investor would restrict entrepreneurial freedom, especially when the new investor assumes that rather bad entrepreneurs 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 trade secrets, for instance, due to problems of enforcement, the

¹ See *Sahlman* (1990), pp. 560f., *Gompers/Lerner* (1999), pp. 139-169.

² See *Gompers/Lerner* (1999), pp. 140-145, *Neher* (1999), pp. 269f., *Schmidt, K.* (2000), p. 9.

³ See the empirical study of *Arnold* (1989), pp. 224-279 for different sources of non-monetary benefits of German entrepreneurs (of small and medium sized enterprises).

⁴ See *Bigus* (2002).

entrepreneur has to take into account that the investor may “steal” the idea and use it for his own purposes or for other ventures.

The investor who is aware of these possible entrepreneurial losses may take advantage and may demand a higher share on the venture’s future return before financing the next stage. If it is more costly to acquire alternative funds, the entrepreneur may have to accept the investor’s offer, though. In this article, we focus on the fourth point, i.e. on hold-up due to weak patent protection. If the property rights on the innovation are not sufficiently protected the old investor may use the idea or parts of the innovation for his own purposes, maybe for other ventures he has a stake at. This threat may force the entrepreneur to continue although the investor demands a higher share. As a consequence, the entrepreneur may be forced to stick with the investor, however, she may reduce her level of specific investments even it would not be efficient do to so (*underinvestment*).

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: mitigating conflicts in the venture financing process thereby making innovations more likely.

There is a large body on literature on incentive problems due to specific investments.⁵ With respect to venture financing, there are the contributions of *Neher* (1999), *Aghion/Tirole* (1994), *Hansmann/Kraakman* (1992) and *Schmidt* (2000). *Neher* (1999) refers to *Hart/Moore* (1994) and analyses the opportunistic behavior of a wealth-constrained entrepreneur. Without the entrepreneur’s human capital the venture receives no return. Since the investor provides all the funds the entrepreneur may renegotiate the contract threatening to withdraw her human capital. Note that this is a kind of *entrepreneur’s* moral hazard which is commonly analyzed in the literature. *Aghion/Tirole* (1994) ask whether a research unit (here: the entrepreneur) or the investor should own the property right on the invention, when both parties make specific investments simultaneously and the property right is not divisible. They conclude that the party who invests more should own the property right. However, they do not consider the special incentive problems which may occur due to stage financing. The same is true for *Hansmann/Kraakman* (1992) and *Schmidt* (2000), who analyze the question how to allocate cash flow rights when the parties

⁵ See, for instance, *Williamson* (1983), *Grossman/Hart* (1986), *Hart* (1995).

invest in a sequence, but not simultaneously: first the entrepreneur invests, then the investor.

There are also plenty contributions to the question to which extent patent law should protect the property rights on inventions.⁶ However, there is only a piecemeal literature addressing the question how venture financing may be affected when the entrepreneur faces potential losses with regard to (other) transaction costs of switching except for those arising from specific investments. *Aghion/Bolton* (1992) and *Laux* (1996) investigate the role of entrepreneurial non-monetary benefits more generally, however, not in the context of stage financing of ventures. *Bigus* (2002) shows that the entrepreneur may be locked-in if an inside investor has superior information on the entrepreneur's or the venture's quality. Thus, an inside investor may expropriate some rents due to his information monopoly.⁷

In what follows, we first present a model in section 2 showing how the old investor may act opportunistically and renegotiate the contract if property rights on the innovation are not sufficiently protected by contractual or legal provisions. Section 3 shows how the model relates to the law and economics literature on patent law and provides a closer look to the requirements for patent protection under current German and European patent codes and Section 4 concludes.

2. A model on investor's moral hazard due to weak protection of innovation's property rights

2.1 Description of the model

We want to know under which circumstances the investor may have an incentive to expropriate the entrepreneur when they negotiate on the financial terms of the next stage. If property rights on the innovation are not sufficiently protected, for instance because the idea does not yet entirely meet the legal requirements for patent protection, the investor may demand better financial terms in the second stage. In case the entrepreneur does not accept the investor may threaten to use the idea for his own purposes, for instance for another venture. Thus, the entrepreneur may be forced to accept the less favorable terms. But she may reduce her level of specific investments in the next stage although a higher level would be efficient (*underinvestment*). The important point is that the entrepreneur is somewhat "locked-

⁶ See, for instance, *Besen/Raskind* (1991), *Dam* (1994), *Kitch* (1998).

⁷ See for a similar hold-up problem in the context of bank financing *Fischer* (1990) and *Rajan* (1992).

in”, since property rights on the innovation are not sufficiently protected and she can lose something in case of termination or switching to new investor.

In order to analyze the problem we assume the following:

(M1) (*Set of investment opportunities*) Entrepreneur A is wealth-constrained and has the opportunity to undertake a venture in $t=0$. There are two stages. In $t=0$ and $t=1$, the same fixed investment I ($I > 0$) is required. Returns occur in $t=2$ and $t=3$, respectively. For simplicity, in $t=2$ and $t=3$, there are only two possible outcomes: success and failure. In case of success, return amounts to X ($X > I > 0$), in case of failure there is zero return.

The success probability p in both stages especially depends on the entrepreneur’s specific investments (e):⁸

$$(1) \quad p = p(e) \quad \text{with } e = \{e_L, e_H\} \text{ with } e_L = 0 \text{ and } e_H > 0 \text{ and} \\ 0 < p(e = e_L) = p_L < p(e = e_H) = p_H = p_L + \pi < 1.$$

Even with a low level of specific investments it is favorable to undertake the venture, i.e. it holds:

$$(2.1) \quad p_L X > I.$$

Success probability increases if the entrepreneur chooses a high level of specific investments (e_H). A specific investment can be the effort the entrepreneur puts into the venture. Thus, in what follows, we also use the term “effort”. Specific investment by the entrepreneur are supposed to be efficient, i.e.:⁹

$$(2.2) \quad e_H < \pi X.$$

The parties cannot contract upon specific investments. This assumption seems to be plausible, if it is not possible (or prohibitively costly) to precisely describe the entrepreneurial effort ex ante, especially, when effort is comprised of several dimensions and actions, e.g. management and technical issues. Furthermore, effort is not contractible if a court cannot verify the effort level.

(M2) (*Set of financing opportunities*) The entrepreneur has no funds, however, investors have sufficient funds to provide I in $t=0$ and/or $t=1$. For simplicity, we consider only equity financing:¹⁰ an investor receives a share s ($0 < s \leq 1$) on the future returns of the relevant investment, the entrepreneur the share $1-s$. Since there are two investments, two financial transactions are required. There is strong competition among venture capitalists such that the cooperative surplus entirely goes

⁸ For 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. We obtain very similar results assuming $0 < e_L < e_H$, however, the presentation becomes more complex.

⁹ Thus, we assume that non-monetary utilities can be measured in monetary units which is common in microeconomics theory. See for the restrictive requirements to do so *Keeney/Raiffa* (1976).

¹⁰ The qualitative results do not change assuming debt financing or a mix of debt and equity financing (hybrid financing).

to the entrepreneur. In $t=3$, the venture is liquidated (e.g., by an initial public offering).

(M3) (*Lack of patent protection*) Property rights on the innovation are not entirely protected, for instance, because the idea is not sufficiently developed in order to meet the requirements for patent filing or because contractual agreements such as trade secrets may not be (entirely) enforceable, may be due to high enforcement costs or due to verification problems. The investor may partly use the invention for his own purposes if the relationship with the entrepreneur is terminated in $t=1$. In case of termination, the investor receives a portion ω of the innovation's second stage value, i.e. $\omega(pX-I)$, with $0 < \omega < 1$. The entrepreneur may continue with a new investor N , however, cooperative surplus is then reduced to $(1-\omega)(pX-I)$.¹¹ If she sticks with the old investor O , O cannot appropriate rents in the second period since she can observe and control for that. After the second period, no investor cannot appropriate rents from the idea anymore, for instance, because then the idea is sufficiently developed in order to meet the requirements of patent law.

(M4) (*Information structure*) The investor cannot control the level of specific investments. He may observe the effort level in the first period, but external players, e.g. a court, cannot. Since return in $t=2$ is either X or 0 , it is not possible to derive the chosen effort level from the payoff level. Apart from that, information is distributed symmetrically. There are homogeneous expectations with regard to the entrepreneur's project set and the projects' returns.

(M5) (*Participation constraints*) Both, entrepreneur and investor only agree on a contract when they at least receive zero expected utility or zero profit, respectively. The rate of return for risk-free investments is 0% . All players are risk-neutral.¹² Each player is interested in maximizing (expected) individual wealth in $t=3$.

The entrepreneur exerts high effort, only if her share on future cash flows is sufficiently large, i.e. if the investor's share s is small enough:

$$(3.1) \quad (1-s)\pi X \geq e_H - e_L = e_H \quad \text{or} \quad s \leq s^* = 1 - \frac{e_H}{\pi X}.$$

In order to yield a zero profit at least, the minimum share an investor demands equals to:

$$(3.2) \quad I = s(p_L + \pi)X \quad \text{or} \quad s = \frac{I}{(p_L + \pi)X}.$$

¹¹ We assume that the a new investor takes into account opportunistic behavior by the (old) investor and assesses ω in the same way as the entrepreneur. If there are heterogeneous estimations with respect to ω , the analysis becomes more complicate without changing the qualitative results.

¹² Investors, for instance venture capitalists, may have a well diversified portfolio of investments. Thus, one may justify the assumption of risk neutrality. The entrepreneur usually is not able to diversify, however, they may not be risk averse in general, since often they quit a quite safe job in order to start their own business, see *Black/Gilson* (1998). The qualitative results do not change significantly assuming risk aversion.

If the investor demands a lower share than in (3.1), the entrepreneur will exert high effort. In what follows we assume that this holds:

$$(4) \quad \frac{I}{(p_L + \pi)X} \leq s^* = 1 - \frac{e_H}{\pi X}.$$

Thus, we focus on the case where it pays for the entrepreneur to exert high effort when there is no moral hazard by the investor. To sum up, the sequence of the game may be described as follows:

1st period: An entrepreneur E needs funds for her venture consisting of a project in the first and a project in the second stage.

An investor O offers a financial contract for the investment I in the first stage. Since the investment volume is fixed, the offer refers to the required share s_1 . There is tough competition among venture capitalists such that O only earns a zero profit.

The entrepreneur chooses the level of specific investments.

The project of the first stage is undertaken.

2nd period: After financing the first period, the (old) investor O has got known the entrepreneur's idea. O can appropriate some rents since the property rights on the idea are not entirely protected.

O makes an offer to finance the project in the second stage. Entrepreneur E can refuse and terminate the relationship with O. Instead, a new investor N could finance the project. Again, the financial offers refer only to the share, O or N requires (s^O or s^N , respectively).

The entrepreneur accepts the more favorable offer.

The entrepreneur chooses the level of specific investments.

The project of the second stage is undertaken.

3rd period: In case of success, the outcome of the investment in $t=0$ is X, in case of failure, it is 0.

4th period: In case of success, the outcome of the investment in $t=1$ is X, in case of failure, it is 0.

Graph 1: Model structure



2.2 Analysis

First-best:

The first-best-solution can be derived very easily. Since the investor does not appropriate rents in the second stage although property rights are not entirely protected, in equilibrium, O demands a share

$$(3.2) \quad s = \frac{I}{(p_L + \pi)X},$$

and – due to the assumption in (4) – the entrepreneur chooses a high effort level. This holds for the second stage as well as for the first stage. Thus, social surplus amounts to:

$$(5) \quad Y_E + Y_O = Y_E = 2(p_L X - I + \pi X - e_H).$$

Because of tough competition, the investor receives a zero return.

Moral Hazard by the (old) investor:

We now assume that the old investor who financed the first stage may take advantage of the weak intellectual property rights. Because of backward induction we start with period 2. With weak intellectual property rights, 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. A new investor N takes into account that cooperative surplus may be reduced by the amount $\omega(pX - I)$ according to assumption (M3). Thus, in order to finance the second stage, N demands at least (that means even in the case the entrepreneur exerts high effort):¹³

$$(6) \quad s_2^N = \frac{I}{p(e)X - \omega[p(e)X - I]}.$$

Obviously, the entrepreneur will only exert high effort if s_2^N does not exceed the critical value s^* according to (3.1), that is if holds:

$$(7) \quad \frac{I}{p_H X - \omega(p_H X - I)} \leq s^* = 1 - \frac{e_H}{\pi X} \quad \text{or rearranging:}$$

¹³ The entrepreneur exerts high effort, if the share demanded by N does not exceed s^* in (3.1).

$$\omega \leq \omega^* = \frac{p_H X}{p_H X - I} - \frac{I \pi X}{(\pi X - e_H)(p_H X - I)}$$

Thus, if the old investor would be able to expropriate a larger portion than ω^* from the project's net value, an entrepreneur will not choose the efficient effort level. These are the two cases now: first the share demanded by N exceeds s^* in (3.1) (i.e., $\omega > \omega^*$), second it does not. In the latter case the entrepreneur will exert high effort, in the first case she will not.

Let us have a closer look to the more interesting first case. Thus, N demands a share of:

$$(6.1) \quad s_2^N = \frac{I}{p_L X - \omega(p_L X - I)}.$$

The entrepreneur prefers to stick with the old investor if (8) holds:

$$(8) \quad (1 - s_2^O) p_L X \geq (1 - s_2^N) [p_L X - \omega(p_L X - I)] \quad \text{or, by rearranging:}$$

$$s_2^O \leq s_2^N + \frac{(1 - s_2^N) \omega (p_L X - I)}{p_L X}.$$

Thus, the old investor may even ask for a higher share than the new investor since with the new investor the cooperative surplus is lower. Since the old investor may benefit from a high effort level, he will not demand s_2^O in any case. Rather, he compares his individual surplus for the opportunistic bid $s_2 = s_2^O$ with the surplus for the lower bid $s_2 = s^*$ which is incentive compatible. The old investor tends to demand s_2^O if (9) holds:

$$(9) \quad -I + s_2^O p_L X \geq -I + s^* p_H X \quad \text{or:}$$

$$s_2^O \geq s^* (p_H / p_L).$$

Thus, other things being equal, the old investor's incentive to demand a higher share in stage 2 is the stronger,

- the lower the proportion p_H / p_L is, i.e., the larger the benefit from high effort is ($\pi = p_H - p_L$),
- the more the old investor can appropriate rents from the invention (ω), i.e. the less the innovation's property rights are protected,

- the larger the share s_2^N the new investor demands for financing the second stage. This share increases as ω increases, i.e, the more rents the old investor is able to expropriate.

We can derive the last two propositions from (8):

$$(10) \quad \frac{\partial s_2^O}{\partial \omega} > 0 \quad \text{and} \quad \frac{\partial s_2^O}{\partial s_2^N} > 0.$$

The opportunity to “steal” the innovator’s idea strengthen 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 even able to appropriate the *entire* cooperative surplus in the second stage.

How does this affect the level of specific investments by the entrepreneur ? If the old investor asks for a higher share in the second stage the entrepreneur is more likely to underinvest. We were investigating the first case, where the share demanded by the new investor N exceeds s^* in (3.1). In this case, E underinvests for sure, since O demands an even higher share according to (8). In the second case, underinvestment may not necessarily occur, however, it becomes more likely, the less the innovation’s property rights are protected. Compared with the first-best-situation, there may be a social loss in the second stage due to weak property rights – despite of the assumption that the investors earn zero profit.

The investor’s profits in the second stage influence 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 one all investors are willing to accept losses in the first stage when there is perfect competition among venture capitalists. Thus, financial terms are even more favorable to the entrepreneur in the first stage than in the first best solution. Therefore, there is no underinvestment in the first stage with tough competition among venture capitalists.

Without tough competition, the entrepreneur’s surplus tends to increase as the investor’s portion on the cooperative surplus in the first stage increases, i.e. the lower the degree of competition among venture capitalists is. If the degree of competition is sufficiently low, the entrepreneur’s gains in the first stage may not cover her loss in the second stage and thus, she may abstain from the venture capital market even

though the venture is valuable. Therefore, the model may explain why there is only a little financing by venture capitalists in the very first stages of ventures.¹⁴ Some also argue that the venture capital market does not work very well in these stages since the quality of the *entrepreneur* and/or the venture is hardly assessable and entrepreneurs have much discretion to behave opportunistically.¹⁵

Are the results still robust in the case of debt or hybrid financing ? The old, inside investor's incentive to negotiate better terms in the second period is due to the lack of intellectual property rights protection but not to the type of financing. Thus, debt financing or mixed financing would not significantly change the qualitative results of the analysis. There is, however, an important difference between equity and debt financing. From a legal point of view, there is an upper bound on the interest rate creditors can demand thereby limiting the extent to which an inside investor could hold up an entrepreneur. According to the jurisdiction to § 138 of the German civil code ("usurious interest") interest rates exceeding a certain threshold are supposed to violate the law.¹⁶ At first glance, this provision 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. Note that there are similar legal provisions in other jurisdictions, too, e.g. in many US-states.¹⁷

3. The role of patent law

The existence and the basic principles underlying patent law can be mainly derived from the trade-off¹⁸ between setting incentives to innovate by giving exclusive property rights on the invention and restricting the monopoly power due to a patent.¹⁹

There are additional costs and benefits to patent law. Let us have a look at the costs neglecting administrative costs.²⁰ Usually, the entrepreneur who first files for a

¹⁴ Empirical evidence is given by *EVCA* (2002) and *NVCA* (2001).

¹⁵ See *Amit/Glosten/Muller* (1990).

¹⁶ See *Palandt* (1999), pp. 120-122. A contractual interest rate which is either more than double the „market rate“ or exceeds the market rate by 12 percentage points at least is supposed to be immoral und thus illegal.

¹⁷ See *Stehle* (1984).

¹⁸ See *Besen/Raskind* (1991), p. 5, *Cooter/Ulen* (1997), pp. 119f, 123f.

¹⁹ 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)).

²⁰ *Dam* (1994), pp. 286-292, presents possible costs of patent law and how the U.S. jurisdiction, in particular, addresses them.

patent receives it.²¹ 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 "price".²² 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.²³

Of course, there are benefits to patent law besides providing incentives to innovate. Since a disclosure of the invention is generally²⁴ 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. Since only the first entrepreneur obtains the patent there is an incentive to invent quickly. Thus, a new technology is likely to be transmitted quite quickly and at low costs.²⁵ If there was no patent law the entrepreneur generally would have had an incentive to keep the innovation secret.

Because of this trade-off between different kinds of benefits and different kinds of costs patents are restricted with respect to duration²⁶ and scope. Moreover, the invention has to meet certain requirements before the entrepreneur receives patent protection.

This article shows, that there may be an additional benefit to patent law, which – to my knowledge – have not been explicitly mentioned yet in the literature. The more inventions are covered by patent protection and the earlier they are covered the weaker is the investor's incentive to appropriate rents by renegotiating the contract. On the other hand, the more likely the entrepreneur chooses the efficient level of specific investments. This makes it easier to finance and develop inventions.

In the European Union and in Germany, the entrepreneur's property rights will only be protected, if the patent authority (European Patent Agency in Munich) grants a patent. Otherwise there is no protection of property rights except on a contractual

²¹ In the U.S., the one who files first obtains the patent, see *Besen/Raskind* (1991), p. 7.

²² See *Besen/Raskind* (1991), p. 6 and *Scotchmer* (1998), p. 275.

²³ See *Alpen* (2000).

²⁴ Except inventions where the state has an interest not to disclose, for instance inventions for military purposes.

²⁵ See *Kitch* (1998), S. 15.

²⁶ 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* (1997), pp. 123f. Of course, the optimal patent duration should depend on the specific invention. However, most patent laws grant a fixed period, mostly 20 years, for the U.S. see *Barrett* (1999), p. 21, for Germany see § 16 I 1 PatG (German patent code).

basis. Apparently, this is different in the U.S. where the jurisdiction grants some protection even for so-called undeveloped ideas.²⁷

In what follows we focus on the German patent law and have a closer look on the requirements. In case that not all requirements are met the investor may be able to steal the idea. Of course, this is also possible if the entrepreneur do not (correctly) file for patent protection although the invention would meet the requirements. The requirements are (see §§ 1-5 PatG (German patent code) and Art. 52-57 EPA (European Patent Agreement)): the invention should be (a) technical, (b) sufficiently developed, (c) novel and (d) non-obvious for an expert. As we will show now, some inventions may not meet these requirements and thus, the property rights are not protected by patent law.

An invention is technical when a specific problem can be resolved by using nature forces. The German patent code (§ 1 II PatG, see also Art. 52 II EPA) denies explicitly the technical character for discoveries, scientific theories, non-technical instructions, games, doing business and computer programs. Let us have a look at two important fields of research: gene technology and information technology. Inventions with respect to gene technology are considered to be technical.²⁸ Inventions in the field of information and communication technology are technical when they are not computer programs,²⁹ but when they can be described by a program. This definition is not clear-cut. To give an impression: an anti-block-system for car brakes³⁰ and a X-ray-apparatus both controlled by a computer were considered as being technical.³¹ A patent for a computer-management-system was granted, too,³² however, not for a program on the exchange of securities, not for a spelling program either.³³ In some cases it may not be clear whether an invention is technical or not,³⁴ thus protection of property rights is uncertain and may hamper the entrepreneur to ask an investor for funds. Note, however, that a computer program may be protected under copy right code.

²⁷ 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.

²⁸ See *Schulte* (1994), p. 65.

²⁹ See *Bernhardt/Krasser* (1986), p. 94 and *Schulte* (1994), p. 26.

³⁰ See *Bernhardt/Krasser* (1986), p. 94, decision by the German supreme court.

³¹ See *Singer/Stauder* (2000), p. 108, decision by the European Patent Agency.

³² See *Singer/Stauder* (2000), p. 109.

³³ See *Bruchhausen et al.* (1993), p. 208,

³⁴ See *Ilzhöfer* (2000), p. 33. With respect to computer programs both jurisdiction and patent authorities tend to grant patents more and more in not clear-cut cases, see *Singer/Stauder* (2000), p. 109.

Moreover, the invention must be sufficiently developed, i.e. an expert should be able to successfully carry out the invention using the description in the documents the entrepreneur has to provide for filing.³⁵ The basic reasoning behind the result of the invention should be made clear. Smaller shortcomings are tolerated, however, the invention have been sufficiently tested already.³⁶

The invention must be new and sufficiently beyond the state of the art (see § 3 I 1 1 and § 4 I PatG; Art. 54 I and Art. 56 I EPA. The state of the art is defined by the publicly available knowledge at the date of filing. It does not matter where, how and when the knowledge was disclosed.³⁷ Of course, other patents are part of this knowledge. An entrepreneur will not receive patent protection when the invention already exists abroad. Part of this knowledge is also the information the entrepreneur already provided, e.g. on fairs. Thus, she should file for a patent before.

Finally, 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, are excluded from patent protection.³⁸ 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 the decisions of courts and patent authorities on this criterion are sometimes considered to be hardly predictable.³⁹ Thus, the entrepreneur may wait with the filing until the innovation is sufficiently developed. Then it is more likely that it is considered to be non-obvious. However, when the entrepreneur waits she may be afraid of that somebody steals the idea.

To sum up, property rights are only protected when the invention meets the requirements of patent law. At the date of filing the entrepreneur obtains some preliminary property rights. After the patent authority has entirely checked the requirements the patent can be granted. The period between filing date and granting date may take several months or even years. In the meanwhile, the entrepreneur cannot exclude others from using the invention, however she can demand appropriate compensation. After the patent is granted the property rights are stronger, she can exclude others from using the invention. Note, however, that there is no protection of property rights before filing, at least in Germany and in the European Union. This may be different in the U.S. Thus, other things being equal, entrepreneurs may

³⁵ See *Bernhardt/Krasser* (1986), p. 109, *Bruchhausen et al.* (1993), p. 164.

³⁶ See *Bruchhausen et al.* (1993), p. 165.

³⁷ See *Bernhardt/Krasser* (1986), p. 140.

³⁸ This is the impression of *Bernhardt/Krasser* (1986), p. 163.

³⁹ See *Bernhardt/Krasser* (1986), S. 167.

contact investors earlier since the threat of renegotiation is less severe. In order to evaluate the process of patent granting and its impact of venture financing it is not sufficient to look at the law, but also how the legal provisions are interpreted by patent authorities in different countries.

4. Conclusion

Possibly, the staging of capital is the most salient feature of venture financing. This feature, however, may induce opportunistic behavior by the investor. After the first stage, he may ask for a higher share on future cash flows threatening not to continue the venture. The entrepreneur may be forced to accept the investor's offer, when she is supposed to 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 meet the legal requirements for patent protection – the investor may use the idea for his own purposes once the entrepreneur terminates the relationship. This threat may force the entrepreneur to continue although the investor demands a higher share. As a consequence, she sticks with the (old) investor, however, she may not choose the efficient level of specific investments, rather she underinvests.

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: mitigating conflicts in the venture financing process thereby making innovations more likely.

Appendix: List of Symbols

E	entrepreneur's name
e	level of entrepreneur's specific investment: high and low level: $e_H > 0$, $e_L = 0$
I	(fixed) investment volume
N	name of a new investor who has not financed the first stage
O	name of the old investor who already financed the first stage
p	(success) probability for a high return X; $1-p$ is the failure probability (zero return)
p_L (p_H)	success probability with low (high) level of specific investment

s	investor's share on future returns
$s_2^N, (s_2^O)$	share of the new (old) investor on the future returns on the second investment in $t=1$
s^*	critical share level: if an investor requires more than s^* , the entrepreneur chooses a low inefficient level of specific investments
X	return of an investment in case of success
Y_E, Y_O, Y_N	expected utility of entrepreneur A, investor O, investor N
π	additional success probability with a high level of specific investments component ($\pi = p_H - p_L$).
ω	portion of the innovation's net value which the old investor would expropriate if the entrepreneur chooses a new investor and if the property rights on the invention are not sufficiently protected; $0 \leq \omega < 1$

References

- Aghion, Ph./ Bolton, P.* (1992): An Incomplete Contracts Approach to Financial Contracting, in: *Review of Economic Studies*, Vol. 59, pp. 473-494.
- Aghion, Ph./ Tirole, J.* (1994): The Management of Innovation, in: *Quarterly Journal of Economics*, Vol. 109, pp. 1185-1209.
- Alpen, D.* (2000): Zur Ökonomik blockierender Patente, Wiesbaden 2000, Ph.D. thesis, University of Hamburg 1999.
- Amit, R./ Glosten, L./ Muller, E.* (1990): Entrepreneurial Ability, Venture Investments, and Risk Sharing, in: *Management Science*, Vol. 36, No. 10, pp. 1232-1245.
- Arnold, W.* (1989): Anforderungen mittelständischer Unternehmen an Beteiligungskapital, Frankfurt am Main et al. (1989), Ph.D. thesis, University of Bayreuth, 1986.
- Barrett, M.* (1999): Intellectual Property – Patents, Trademarks and Copyrights, 3rd ed., New York et al. 1999.
- Bernhardt, W./ Krasser, R.* (1986): Lehrbuch des Patentrechts, 4. Auflage, München 1986.
- Besen, St. M./ Raskind, L. J.* (1991): An Introduction to the Law and Economics of Intellectual Property, in: *Journal of Economic Perspectives*, Vol. 5, pp. 3-27.
- Bigus, J.* (2002): Moral Hazard by Inside Investors in the Context of Venture Financing, Working Paper, University of Hamburg, March 2002.
- Black, B.S./ Gilson, R.J.* (1998): Venture Capital and the Structure of Capital Markets: Banks versus Stock Markets, in: *Journal of Financial Economics*, Vol. 47, pp. 243-277.
- Bruchhausen, K./ Rogge, R./ Schäfers, A. / Ullmann, E.* (1993): Kommentar Patentgesetz, Gebrauchsmustergesetz, München 1993.
- Cooter, R. / Ulen, Th.* (1997): Law and Economics, 2nd ed., Reading (Mass.) et al. 1997.
- Dam, K. W.* (1994): Die ökonomischen Grundlagen des Patentrechts, in: Ott, C./ Schäfer, H.-B. (eds.): *Ökonomische Analyse der rechtlichen Organisation von Innovationen*, Tübingen 1998, pp. 283-321.
- EVCA* (European Venture Capital Association): Yearbook, Zaventem, Belgium 2002.
- Farrell, J.* (1995): Arguments for Weaker Intellectual Property Protection in Network Industries, in: *Stanford View*, Vol. 3, pp. 46-49.

- Fischer, K.* (1990): Hausbankbeziehungen als Instrument der Bindung zwischen Banken und Unternehmen – eine theoretische und empirische Analyse, Ph.D. thesis, University of Bonn, 1990.
- Gompers, P./ Lerner, J.* (1999): *The Venture Capital Cycle*, Cambridge (Mass.), 1999.
- Grossman, S./ Hart, O.* (1986): The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, in: *Journal of Political Economy*, Vol. 94, pp. 691-719.
- Hansmann, H./ Kraakman, R.* (1992): Hands-Tying Contracts: Book Publishing, Venture Capital Financing, and Secured Debt, in: *Journal of Law, Economics, and Organisation*, Vol. 8, N3, pp. 628-655.
- Hart, O.* (1995): *Firms, Contracts and Financial Structure*, Oxford 1995.
- Hart, O./ Moore, J.* (1994): A Theory of Debt Based on the Inalienability of Human Capital, in: *Quarterly Journal of Economics*, Vol. 109, pp. 841-879.
- Ilzhöfer, V.* (2000): *Patent-, Marken- und Urheberrecht*, München 2000.
- Kaplan, St./ Strömberg, P.* (2000): *Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts*, NBER Working Paper, April 2000.
- Keeney, R.L./ Raiffa, H.* (1976): Decisions with multiple Objectives, in: *Operations Research*, Vol. 29, pp. 1105-1120.
- Kitch, E.W.* (1998): Patents, in: Newman, P. (ed.): *The New Palgrave Dictionary of Economics and The Law*, Vol. 3, pp. 13-17.
- Laux, Ch.* (1996): *Kapitalstruktur und Verhaltenssteuerung*, Wiesbaden 1996, Ph.D. thesis, University of Frankfurt/Main.
- Neher, D.* (1999): Staged Financing: An Agency Perspective, in: *Review of Economic Stud*, Vol. 66, pp. 255-274.
- NVCA (National Venture Capital Association): *Yearbook*, Arlington, Virginia, 2001.
- Palandt* (1999): *Commentary Bürgerliches Gesetzbuch*, edited by *Bassenge, P./ Diederichsen, U. / Edenhofer, W.* et al., 58th ed., Munich 1999.
- Rajan, R.G.* (1992): Insiders and Outsiders: The Choice between Relationship and Armslength Debt, in: *Journal of Finance*, Vol. 47, pp. 1367-1400.
- Sahlman, W. A.* (1990): The Structure and Governance of Venture-Capital Organizations, in: *Journal of Financial Economics*, Vol. 27, pp. 473-521.
- Schmidt, K.* (2000): *Convertible Securities and Venture Capital Finance*, Working Paper, University of Munich, May 2000.
- Schulte, R.* (1994): *Patentgesetz mit Europäischem Patentübereinkommen*, Kommentar, 5th ed., Cologne et al. 1994.
- Scotchmer, S.* (1998): Incentives to Innovate, in: Newman, P. (ed.): *The New Palgrave Dictionary of Economics and The Law*, Vol. 2, pp. 273-276.
- Singer, M./ Stauder, D.* (2000): *Europäisches Patentübereinkommen*, commentary, 2nd ed., Cologne et al. 2000.
- Stehle, R.* (1984): Zum gegenwärtigen Stand der Forschung auf dem Gebiet „Small Business Finance“, in: *Albach, H./ Held, T.* (eds.): *Betriebswirtschaftslehre mittelständischer Unternehmen*, Stuttgart 1984, pp. 311-325.
- Williamson, O. E.* (1983): Credible Commitments: Using Hostages to Support Exchange, in: *American Economic Review*, Vol. 73, pp. 519-540.